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NANKAI UNIVERSITY

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"KAZAKHSTAN-CHINA: DIGITAL ECONOMY AND "ONE BELT, ONE ROAD "- 2026"

May 23, 2026

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Section 1. DIGITAL TRANSFORMATION OF ECONOMIC SECTORS: TRENDS, TOOLS AND IMPLEMENTATION MECHANISMS

UDC (336)

BANKS' DIGITAL TRANSFORMATION FOR SCO-BRI FINANCE

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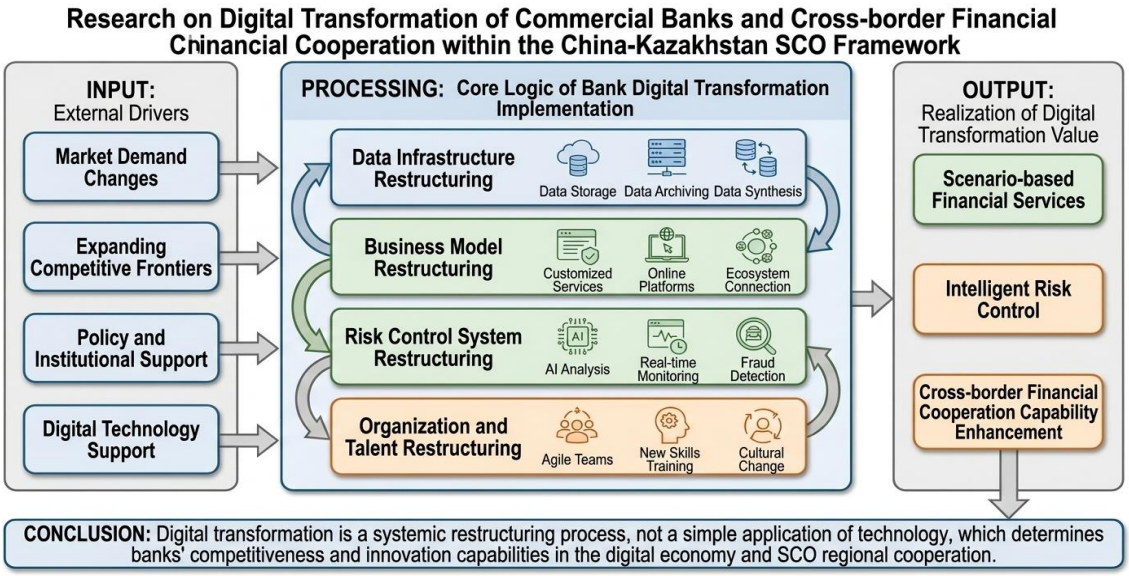
Annotation. This paper is written for 2026 SCO University Forum, which is staged achievement of author's master thesis "Digital Transformation and Innovative Development of Banking Industry in Context of Digital Economy", and combining six years of frontline practice in state-owned bank, this paper systematically analyzes driving factors and implementation logic of commercial bank digital transformation, thereby focusing on studying practice, risks and optimization paths of China-Kazakhstan banking digital cooperation under SCO framework. This study found that digital transformation of banking industry has entered stage of business, risk control and organizational systematic reconstruction. SCO and Belt and Road Initiative (BRI) provide institutional support for cross-border export of digital capabilities of Chinese banking industry, and China-Kazakhstan cooperation has formed replicable sample, but still faces constraints such as cross-border data flow and regulatory differences. This article provides practical reference for digital financial cooperation in SCO region.

Key words: Digital Economy; Commercial Banks; Digital Transformation; SCO; BRI; China-Kazakhstan Financial Cooperation; Risk Governance.

1. Introduction

Digital economy has become core engine of global economic restructuring and Shanghai Cooperation Organization regional cooperation. Declaration of Council of Heads of Member States of Shanghai Cooperation Organization on Strengthening Cooperation in Field of Digital Economy (2025) clearly proposes to promote digital cooperation in finance and facilitation of cross-border trade among member states [1], which defines core direction for regional banking transformation. For commercial banks, digital transformation has evolved from channel onlineization to systematic reconstruction, and it is inevitable choice to cope with market competition and serve real economy [2].



As founding member states of SCO, and first batch of countries achieving strategic docking under BRI, China and Kazakhstan's bilateral trade maintains continuous growth, while demand for cross-border digital financial services is increasingly rigid [3, 4]. Current research mostly focuses on domestic transformation of banking industry, with practical analysis of cross-border cooperation scenarios in SCO region being insufficient. Based on this, combining core framework of master's thesis with forum theme, this article disassembles internal logic of banking industry's digital transformation, and analyzes practice and constraints of China-Kazakhstan cooperation, thereby proposing optimization path adapting to regional cooperation [5, 6].

2. Drivers and Core Implementation Logic of Commercial Banks' Digital Transformation

2.1 Core Drivers of Transformation

Digital transformation of banking industry is systemic change driven by multiple factors: first, market demand has undergone fundamental change, with enterprise and individual users' demand for convenient, scenario-based and personalized financial services growing increasingly; second, boundaries of industry competition are expanding, as fin-tech companies and technology platforms have already entered banks' traditional core business, thereby forcing them to accelerate promotion of digital transformation; third, policy guidance is clear, and regulatory policies and SCO multilateral rules provide institutional support for transformation and cross-border innovation. Fourth, digital technology provides underlying support, which includes big data, AI and block chain, breaking through information processing bottleneck of traditional banking business.

2.2 Core Implementation Logic of Transformation

Value realization of transformation depends on collaborative reconstruction of four dimensions, fully matching core framework of master's thesis. First, infrastructure reconstruction of data requires breaking data silos, establishing unified

data governance system, and constructing underlying support of transformation with data elements as core, while second, business model reconstruction transforms from traditional deposit and loan service provider to scenario-based and ecological comprehensive financial service provider, thereby embedding financial services into whole process of real economy [7, 8]. Third, risk control system reconstruction shifts from traditional manual review and post-event disposal to full-process intelligent risk control [1, 2], which achieves real-time identification, early warning and precise pricing of risks, with fourth, organization and talent reconstruction establishing cross-departmental agile teams, thus cultivating compound talents with financial, technical and cross-border business capabilities [5, 8].

3. Practice and Development Space of China-Kazakhstan Banking Digital Cooperation Under the SCO Framework

Financial cooperation between China and Kazakhstan has good institutional foundation, where bilateral local currency settlement agreement signed by central banks of two countries and SCO multilateral cooperation mechanism have cleared institutional obstacles for digital cooperation, with bilateral trade continuing to grow, thereby generating strong demand for cross-border digital payment and intelligent trade finance, which is core driving force of cooperation.

Core cooperation practices implemented include: First, digital upgrading of cross-border payment, where Bank of Beijing launched first Tenge trade cross-border payment business in Qingdao SCO demonstration zone, achieving direct online settlement between RMB and Tenge; China UnionPay cooperated with Halyk Bank of Kazakhstan, and first time launched UnionPay QR code payment service in Central Asia, thereby achieving interconnection of retail payment. Second, digitalinnovation of trade finance, with banks of two countries establishing cross-border trade financial platform through blockchain technology, achieving online verification and traceability of trade documents, thus solving information asymmetry problem. Third, fintech experience sharing, where China's bank transformation experience provided reference for Kazakhstan counterparts, while cooperation between fintech enterprises of two countries continues to deepen .Future cooperation has broad space: on one hand, relying on SCO framework, bilateral cooperation experience can be extended to other member countries to build regional digital financial ecosystem, while on the other hand, customized cross-border digital financial products can be constructed around key fields such as cross-border e-commerce and energy cooperation, thereby promoting cross-border output of bank digital capabilities [5, 6].

4. New Risks and Governance Difficulties in Digital Transformation

While bringing opportunities, transformation also breeds new risks, and in cross-border scenarios, risk transmission is further strengthened. First, data governance and security risks, where the phenomenon of data silos is widespread, while quality is insufficient, with cross-border data flow facing compliance constraints of both countries [3]. Second, network security and operational resilience risks, as banking

business is highly dependent on information systems, and network attacks and system failures may trigger regional financial risks. Third, there also exist model and algorithm risks, where AI risk control models have 'black box problem', with interpretability being insufficient, and most banks' model governance systems are imperfect. Fourth, third-party technology dependency risks, where cooperation with external technology service providers brings concentration risks and outsourcing risks, which are amplified in cross-border scenarios. Fifth, cross-border regulatory adaptation risks, as regulatory rules among SCO member countries have differences, while regulatory coordination lags behind innovation, thereby restricting deepening of cooperation [3, 7].

5. Optimization Paths of Transformation Adapted to Regional Cooperation

In view of above risks and demands, five core optimization paths are proposed. First is to consolidate data foundation, improve whole-process data governance system, and establish data security management mechanism adapted to cross-border business. Second is to focus on real economy scenarios, closely follow demands of China-Kazakhstan economic and trade cooperation, thereby deepening cross-border digital payment and supply chain financial innovation. Third is to improve intelligent risk control system, strengthen model governance, algorithm review and network security protection, thus balancing innovation and risk prevention. Fourth is to promote organization and talent upgrading, establish cross-departmental agile teams, and cultivate interdisciplinary talents adapted to cross-border business. Fifth is to strengthen regulatory communication, promote regional regulatory coordination under SCO framework, which creates good compliance environment for cross-border financial innovation [5, 6].

6. Conclusion

Digital transformation is inevitable trend of commercial banks' development in digital economy era, and is also core starting point for deepening BRI financial cooperation under SCO framework. Research found that digital transformation of banking industry is never simple technology application, but systematic reconstruction of data and business as well as risk control and organization. SCO and BRI institutional support provide broad space for cross-border output of Chinese banking industry's digital capabilities, while cooperation practice between China and Kazakhstan verified role of digital transformation in promoting bilateral economic and trade cooperation.

Limitation of this paper lies in focusing on China-Kazakhstan cooperation, while future research can be extended to comparative studies of other SCO member countries, which is also core direction of author's subsequent master's thesis. In future, commercial banks should be based on cooperation needs of SCO region, and take digital transformation as starting point, thereby deepening cross-border financial innovation under premise of strictly adhering to risk bottom line, so as to realize their own high-quality development and provide financial support for SCO digital economy cooperation and BRI construction [3, 4].

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UDC (336)

COMMERCIAL BANKS' DIGITAL TRANSFORMATION EMPOWERING BRI FINANCIAL COOPERATION UNDER THE SCO FRAMEWORK

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Annotation. Shanghai Cooperation Organization has become core multilateral implementation platform of Belt and Road, thereby promoting continuous growth of trade, investment and infrastructure interconnection as well as industrial cooperation between China and member states led by Kazakhstan. These cross-border activities have generated strong and multi-dimensional demand for efficient, safe and inclusive financial services, especially in areas of cross-border payment, trade finance, supply chain finance and cross-border risk management In digital economy era, digital transformation of commercial banks provides core solutions for pain points of traditional cross-border financial services, which also supports high-quality Belt and

Road financial cooperation under framework of Shanghai Cooperation Organization [1, 2]. Combining author's practice, that is, 6 years of cross-border business frontline work experience in a large state-owned commercial bank, this article systematically analyzes core mechanisms of commercial banks' digital transformation empowering SCO region BRI financial cooperation, practical challenges and targeted optimization paths, where research discovers some patterns, as digital banks empower BRI cooperation through four core mechanisms: reducing cross-border transaction costs, alleviating information asymmetry, expanding inclusive finance boundaries, and strengthening cross-border risk collaborative prevention and control. However, commercial banks in practice also face prominent challenges, including significant regulatory differences among SCO member states, cross-border data governance dilemmas, uneven regional digital infrastructure, cross-border credit information asymmetry, and network security risk transmission, with these findings leading to targeted optimization paths adapting to SCO region proposed in this article. Research believes that digital transformation can enable commercial banks to become core institutional bridge of SCO BRI cooperation, and its effectiveness depends on synergy of technology application, regulatory compliance, risk management and regional real economy demand.

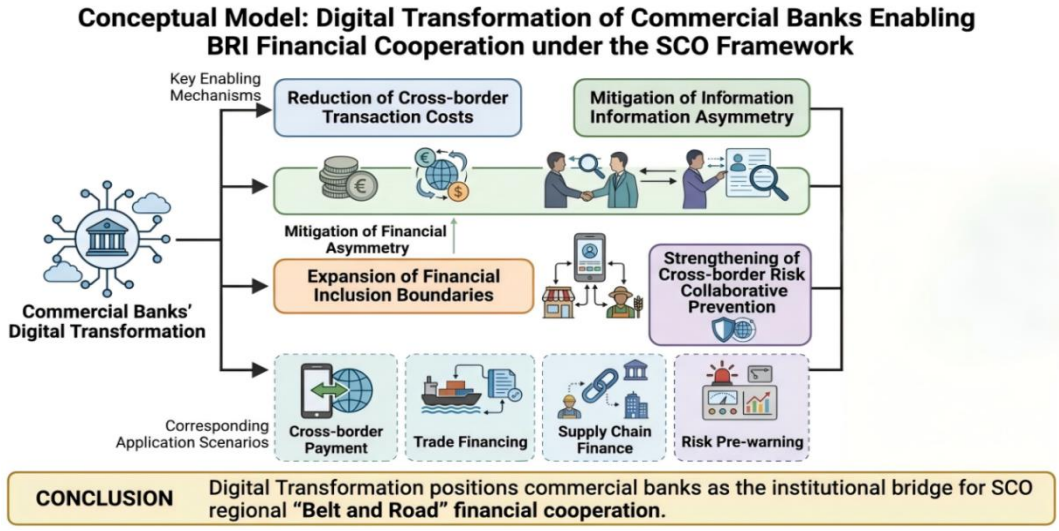
Key words: commercial banks; digital transformation; Belt and Road Initiative (BRI); Shanghai Cooperation Organization (SCO); cross-border finance; trade finance; China-Kazakhstan financial cooperation.

1. Introduction

Over more than ten years, Belt and Road Initiative has built broad platform for economic and trade cooperation between China and countries along routes, while Shanghai Cooperation Organization, as largest regional multilateral cooperation mechanism in Eurasian region, has become core implementation carrier of BRI construction [3]. In 2025, bilateral trade volume between China and Kazakhstan exceeded 40 billion USdollars, with China having maintained position as Kazakhstan's largest trading partner for consecutive years, and cross-border trade in SCO region, infrastructure investment and industrial chain cooperation continue to deepen, thereby generating rigid demand for high-quality cross-border financial services.

However, traditional cross-border financial services still have prominent pain points and cannot fully adapt to BRI cooperation needs of SCO region. As author observed, in frontline practice of Bank of China Tianjin Branch, nearly 30% of foreign trade enterprises with Kazakhstan business in Beijing-Tianjin-Hebei region generally reflect that traditional cross-border payment has long settlement cycles [4, 5], high handling fees and dual exchange rate fluctuation risks, while trade financing heavily relies on paper documents and manual review, with low efficiency and high fraud risk, and SMEs along route face severe financing constraints due to insufficient

collateral and weak credit records [6, 7]. These pain points not only restrict trade facilitation in SCO region, but also limit deepening of BRI cooperation.



As core entity of cross-border financial services, digital transformation of commercial banks provides feasible solutions for above pain points. Current related research mostly focuses on digital transformation of banks themselves, while specialized research on how digital transformation empowers BRI financial cooperation in SCO region is relatively insufficient, especially analysis combined with frontline business practice. Based on this, author combines frontline practice and closely focuses on core theme of 2026 SCO University Forum, systematically analyzes empowerment mechanism and challenges of digital transformation on BRI financial cooperation as well as optimization paths, which not only provides practical support for academic exchange of forum, but also lays foundation for extended research on cross-border scenarios in author's master thesis [2, 8].

2. Core Financial Demand of BRI Cooperation Under the SCO Framework

Deepening of economic and trade cooperation among SCO member states has given birth to multi-level cross-border financial needs, which is core starting point for commercial banks to promote cooperation through digital transformation. First, low-cost, high-efficiency cross-border payment and settlement needs, with continuous growth of bilateral trade in SCO region requiring secure, convenient and low-cost cross-border payment channels, especially strong demand for direct settlement between RMB and member states' local currencies to avoid double exchange rate fluctuation risks brought by USD transit [4, 5]. Second, full-chain, inclusive trade financing needs, as cross-border trade enterprises generally face cash flow, pressure and counterparty risks, and have strong demand for trade financing services such as letters of credit, supply chain finance and factoring, especially low-threshold, high-efficiency financing services for SMEs [6, 7]. Third, long-term, specialized project financing needs, with infrastructure projects such as transportation, energy and logistics under BRI framework having characteristics of large investment scale, long

return cycle and complex risk structure, thereby requiring commercial banks to provide professional project financing, risk assessment and supporting financial services [2, 7]. Fourth, full-process, comprehensive cross-border risk management needs, as cross-border cooperation involves multiple risks such as exchange rate risk, country risk, political risk and compliance risk, while enterprises need commercial banks to provide comprehensive risk management services such as risk hedging products, compliance consulting and risk warning [3, 8].

3. Mechanisms of Digital Transformation Enabling BRI Financial Cooperation in the SCO Region

Different from internal transformation logic of commercial banks, digital transformation promotes cooperation of BRI finance through four independent core mechanisms, which have been fully verified through author's front line business practice.

3.1 Cross-border Transaction Cost Reduction Mechanism

Traditional cross-border payment usually involves 3-5 intermediary institutions, with the settlement cycle being 3-5 working days, while the handling fee rate is 0.5%-1%, and enterprises also need to bear risk of exchange rate fluctuation.

Digital transformation constructs point-to-point cross-border payment system, which improves straight-through processing rate, thereby realizing direct online settlement in local currency, thus greatly reducing intermediate links and transaction costs [4]. For example, direct online settlement of RMB and Tenge between banks of China and Kazakhstan has reduced handling fee rate to below 0.1%, and shortened settlement cycle from 3 working days to real-time arrival, thereby greatly reducing settlement costs and exchange rate risks of foreign trade enterprises in SCO region.

3.2 Information Asymmetry Alleviation Mechanism

In traditional cross-border financial services, banks find it difficult to obtain real operating information of overseas enterprises, and also difficult to obtain their credit status, which is core reason for SMEs financing difficulties and low efficiency of trade finance, while digital transformation has integrated full-chain data from trade contracts, orders, logistics and customs to payment, and through block chain technology realized traceable and tamper-proof documents. Banks can accurately verify authenticity oftran saction background, comprehensively assess credit status of enterprises, thereby fundamentally alleviating information asymmetry in cross-border finance, and according to 2025 Asian Development Bank survey, digital trade finance can increase approval rate of SME financing applications by more than 40% [6].

3.3 Financial Inclusion Boundary Expansion Mechanism

Some SCO member countries' financial infrastructure development lags behind, and large numbers of SMEs and individual groups find it difficult to obtain formal financial services, thus making them unable to participate in BRI cross-border trade [7, 8]. Digital banking breaks through geographical limitations of physical branch institutions through mobile banking, remote account services as well as online credit granting and digital payment, thereby expanding coverage scope of financial services

in SCO region to groups and areas that traditional finance finds difficult to reach, which enables more SMEs to participate in BRI cross-border trade and investment [8].

3.4 Cross-border Risk Collaborative Prevention and Control Mechanism

Cross-border finance faces risks far more complex than domestic business, while traditional risk control models are difficult to achieve real-time identification and early warning of cross-border risks [4, 8]. Digital transformation through big data and artificial intelligence technology constructs intelligent cross-border risk management system, which can monitor enterprise transaction behavior in real time, market fluctuations and national risk changes, thereby realizing real-time early warning of credit risk, exchange rate risk and compliance risk [2]. At same time, through block chain technology, it can realize risk information sharing among member countries' banks, and construct cross-border risk collaborative prevention and control system, thus improving overall financial risk prevention and control capability of SCO region.

4. Core Practical Challenges

Although digital transformation has significant promoting effect, commercial banks still face series of core challenges in practice of serving BRI cooperation in SCO region, with these challenges being completely different from internal risks of bank transformation. Significant regulatory differences exist among member countries, which is obvious, as SCO member countries have huge differences in financial regulation, cross-border capital flow management, data protection, anti-money laundering and financial consumer protection rules, with commercial banks conducting cross-border digital financial services needing to simultaneously comply with regulatory requirements of multiple jurisdictions, thereby greatly increasing compliance costs and limiting cross-border application of digital financial innovation [4, 9].

Outstanding Dilemma in Cross-border Data Governance: Digital financial services highly depend on cross-border data flow, which involves data sovereignty, privacy protection and legal jurisdiction and other core issues, while SCO member countries have huge differences in data governance rules, with some countries having strict restrictions on cross-border data flow, thereby leading to commercial banks facing potential legal risks and reputation risks in cross-border data applications.

Development of digital infrastructure in region is uneven, as there exists huge gap in development level of digital infrastructure among SCO member countries. China and Russia and other countries possess complete digital payment systems, network infrastructure and digital identity systems, while some Central Asian countries face problems such as low network coverage rate, incomplete digital financial infrastructure, incomplete e-government systems, thereby seriously restricting large-scale promotion of digital banking services [3].

Cross-border credit system is not perfect. Among SCO member countries, there are significant differences in accounting standards, legal systems and credit reporting

systems, where banks find it difficult to obtain authentic and complete credit information of overseas enterprises, while cross-border credit information sharing mechanism has not yet been established. This makes it difficult for banks toassess cross-border credit and price risks, thereby limiting coverage of digital cross-border financial services [6].

Network security and risk propagation risk: this issue needs attention, as cross-border digital financial services highly rely on information systems and cross-border network connections. Network attacks, system failures and data leakage will not only affect operation of individual banks, but will also spread rapidly within region through cross-border financial networks, thereby triggering regional financial risks, which puts extremely high requirements on banks' network security protection and operational resilience.

5. Targeted Optimization Paths Adapted to the SCO Region

In response to above core challenges, combining SCO framework and BRI cooperation practice, this paper proposes targeted optimization paths for commercial banks and regional collaboration, which are completely independent of internal transformation paths of banks.

Build integrated digital cross-border financial platform of SCO region: commercial banks should cooperate with financial institutions of SCO member countries to jointly build digital cross-border financial platform integrating cross-border payment, trade financing and supply chain finance, risk management and customer service. Under premise of compliance, platform should connect with customs, logistics and enterprise systems of various countries, thereby building data-driven cross-border financial service ecosystem adapted to SCO region [5, 8].

Innovate scenario-based digital financial products adapted to SCO region: commercial banks should focus on core trade scenarios between China and key member countries such as Kazakhstan, and innovate electronic letters of credit, online factoring, digital guarantees and block chain trade financing products, while developing online credit products for foreign trade SMEs based on transaction data, thereby improving inclusiveness of cross-border financial services. At the same time, promote digital direct settlement between RMB and member countries' local currencies, thus reducing exchange rate risks for enterprises [2, 6].

Deepen cross-border supply chain finance cooperation in SCO region: Commercial banks should deepen cooperation with core enterprises of key industries in SCO region, logistics companies and cross-border e-commerce platforms, relying on full-chain data of cross-border supply chain to provide precise financing services for upstream and downstream small and medium-sized enterprises, thereby stabilizing cross-border industrial chain and supply chain of SCO region, which supports BRI industrial cooperation to go deeper and more solid [7].

Promoting regulatory coordination and rules docking in SCO region requires commercial banks to actively strengthen communication and docking with regulatory

institutions of SCO member countries, while at same time adapting to changes in regulatory rules in timely manner.

Relying on SCO multilateral financial cooperation mechanism, promote coordination of regulatory rules among member countries in fields of payment standards, anti-money laundering, data protection, digital identity and financial consumer protection, thereby establishing cross-border regulatory cooperation to create good regulatory environment for digital financial cooperation.

Support co-construction of digital infrastructure in SCO region: relying on BRI framework, commercial banks should cooperate with financial institutions and technology enterprises of member countries, thereby supporting construction and upgrade of digital payment systems, network infrastructure and credit reporting systems in countries along route, which also need to narrow regional digital divide, thus laying infrastructure foundation for promotion of digital financial services.

Cultivating talents requires cross-disciplinary perspective and international dimension. Commercial banks should strengthen talent team construction, thereby cultivating cross-disciplinary talents who master international finance, digital technology, foreign language ability, cross-border legal rules and national risk management capability, in order to provide long-term talent support for high-quality BRI financial cooperation [1].

6. Conclusion

Digital transformation of commercial banks provides high-quality development solution for BRI financial cooperation under SCO framework. Author combines front line cross-border business practice,thereby systematically analyzing four core mechanisms of digital transformation empowering BRI financial cooperation, which sorts out core challenges in practice and proposes targeted optimization paths adapting to SCO region.

Research finds that digital transformation can fundamentally solve pain points of traditional cross-border financial services such as high cost, low efficiency and insufficient inclusiveness, and effectively supports deepening of BRI trade, investment and industrial cooperation in SCO region, however, it also faces multiple challenges such as regulatory differences, data governance and infrastructure imbalance, thus requiring collaborative efforts of commercial banks, national regulatory institutions and multilateral cooperation mechanisms[5,7].

In future, commercial banks should base themselves on real needs of BRI cooperation in SCO region, taking digital transformation as starting point, thereby deepening innovation of cross-border financial products and services, and actively promoting regional regulatory coordination and infrastructure co-construction.

Under premise of strictly adhering to risk bottom line, commercial banks can better play role of financial support, which makes contributions to cooperation of SCO digital economy and high-quality development of BRI construction [1].

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UDC (338.4)

THE «DIGITAL SCENE+» PARADIGM: DEVELOPMENT MODELS AND INNOVATION PATHS IN DIGITAL CULTURAL AND CREATIVE INDUSTRIES

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Annotation. The «Digital Scene+» paradigm proposed in this paper offers a new theoretical tool for explaining variations in industrial growth performance within the global digital economy. It elevates «scene» from everyday discourse to an analytical category in economics, revealing how digital technologies drive the transformation of economic behavior and industrial innovation through the mediation of scenes. Building on this foundation, the paper further explores the development models and innovation paths of digital cultural-creative industries, using the digital

culture sector as a case to validate the paradigm's explanatory power. This provides a reference framework for countries advancing their digital economic transformation.

Key words: Digital Scene+; development models; digital economy; digital culture.

Introduction

The global digital economy is shifting from «technology-driven» to «scene-driven». In digital cultural-creative industries, digital technology is becoming a «scene builder» that reshapes user experience and value creation. This paper proposes the «Digital Scene+» paradigm and argues that digital scenes are the core engine of industrial innovation.

Global Digital Cultural-Creative Industries: Definition and Current Status

Academic Definition and Research Gap

Digital cultural-creative industries are defined along two paths: UNESCO views digital culture as a digital extension of traditional cultural resources; the other emphasizes business models enabled by technologies (e.g., online games, short videos). Neither treats «scene» as an independent analytical unit. Fewer than 200 Web of Science papers contain «digital scene» related to cultural industries, lacking systematic economic construction. This reveals a gap: no framework explains how digital technologies drive innovation through «scenes».

Market Size and Demand Characteristics

Digital cultural-creative industries are a major part of the global digital economy. According to an IIM report [1], the digital culture and entertainment market is expected to exceed $2.8 trillion in 2025, with China contributing over 34%. On the demand side, over 65% of streaming users are guided by algorithms, and about 40% of Generation Z spend more than 15 hours weekly on interactive games or immersive performances. Users are shifting from «watching» to «being present» and «creating» [1]. The divergence in industrial growth originates from differences in «scene-building capability».

Limitations of the Old Model and the Rise of a New Paradigm

Limitations of the Traditional Model

The traditional «technology-industry» binary model has three limitations: technological homogenization leads to «technology without scenes»; user attention capture efficiency declines; value capture paths are singular. Scene-based projects can achieve more robust economic contributions through multiple channels.

Three Driving Forces of the New Paradigm

To overcome these limitations, the new paradigm requires three driving forces. On the consumer demand side, MIT economist Eric von Hippel argues that innovation originates from users, not from the market [2]. On the technology supply side, the maturity of 5G and AI has significantly reduced the cost of building digital scenes. On the policy side, China's 15th Five-Year Plan identifies «AI + Scenes» as a national strategic direction [3].

The «Digital Scene+» Paradigm: Concepts and Framework

Defining the Digital Scene

This paper proposes a normative definition: a digital scene is a factor allocation unit and value interaction interface formed under specific spatiotemporal conditions, supported by digital technologies and driven by specific demands. Its connotations include demand embeddedness, functional multidimensionality, and dynamic evolution.

Multiple Business Types of Digital Culture and Scene Typology

Digital cultural-creative industries cover diverse business forms such as digital games, music, video, and publishing, all of which are scene-centric. According to function, they fall into four types: economic transaction scenes (e.g., e-commerce), public governance scenes (e.g., government platforms), cultural experience scenes (e.g., digital museums, games), and social life scenes (e.g., online healthcare). These types can overlap and integrate.

The «Demand–Scene–Growth» Triadic Framework

This paper constructs a «Demand–Scene–Growth» triadic framework. Digital scenes are the interface where demand meets technology, the basic unit of factor allocation, and a new engine of economic growth. Scenes act as converters, filters, and amplifiers: they turn general technologies into solutions, screen high-value directions via user data, and amplify returns through factor coordination. This framework overcomes the limitations of traditional «technology-industry» binary thinking.

Conclusion

Digital scenes are the basic unit of industrial growth in the digital economy era. The «Demand–Scene–Growth» framework corrects traditional binary thinking, making scene-building capability an independent source of competitiveness. Digital scenes will shape the future of global digital cultural-creative industries. Future research should explore how scenes identify diverse demands and contribute to economic growth. Mastering scene-building capability may be key to industry growth.

In addition, the «Digital Scene+» paradigm highlights that future industrial competitiveness will increasingly depend on the ability of firms and governments to design and manage complex digital environments rather than merely develop technologies. In this context, scene construction becomes a strategic capability that integrates technological infrastructure, user behavior, and value creation mechanisms into a unified system.

Moreover, digital scenes are not static structures but continuously evolving ecosystems. Their development is influenced by rapid changes in user preferences, technological upgrades, and platform governance models. This dynamic nature requires adaptive management approaches, where continuous feedback loops and real-time data analytics play a central role in refining and optimizing scene performance.

From a policy perspective, governments play a crucial role in supporting the development of digital scenes through regulatory frameworks, infrastructure investment, and innovation incentives. Policies that encourage platform integration, data sharing, and cross-industry collaboration can significantly enhance the efficiency of scene-based economic models, particularly in cultural and creative industries.

At the same time, the expansion of digital scenes raises important issues related to data security, platform monopolization, and algorithmic governance. As scenes become more data-intensive and user-driven, ensuring transparency, fairness, and ethical use of digital technologies becomes essential for sustainable development of the digital economy.

Furthermore, the international dimension of digital scenes is becoming increasingly important. Cross-border digital platforms enable the global circulation of cultural content and services, but also create challenges in terms of regulatory harmonization and digital sovereignty. Countries that can effectively balance openness and control in digital scene development will gain a competitive advantage in the global digital economy.

Finally, future research should focus on the quantification and measurement of scene value creation, as well as the development of standardized indicators for evaluating scene efficiency and innovation capacity. A deeper understanding of how different types of scenes interact and co-evolve will further strengthen the theoretical foundation of the «Digital Scene+» paradigm and expand its practical applicability across industries.

In addition, the «Digital Scene+» paradigm helps bridge the gap between technological innovation and cultural value creation by emphasizing the role of interactive environments in shaping user engagement. Unlike traditional models that focus primarily on production factors or technological advancement, this approach highlights how value emerges dynamically within digital scenes through continuous interaction between users, platforms, and content.

Furthermore, the paradigm provides a more flexible analytical framework for understanding the heterogeneity of growth patterns across different countries and industries. It explains why similar levels of technological development can lead to different economic outcomes depending on how effectively digital scenes are designed, managed, and integrated into broader industrial ecosystems.

The study also contributes to the theoretical development of the digital economy by introducing «scene» as a measurable and operational unit of analysis. This allows for a more nuanced assessment of innovation processes, enabling researchers and policymakers to better identify the mechanisms through which digital transformation translates into economic growth.

Finally, the findings of this research have important implications for policy design and industrial strategy. By focusing on scene-building capabilities, governments and enterprises can more effectively foster innovation, enhance user

participation, and accelerate the development of competitive digital cultural-creative industries in the global economy.

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UDC (338.242)

EVALUATION OF ENTERPRISE COMPETITIVENESS IN THE GLOBAL COMPETITION: A CASE STUDY OF NEW ENERGY VEHICLE INDUSTRY

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Annotation. Against the backdrop of intensifying geopolitical conflicts, frequent global market shocks, and the deepening of digital transformation worldwide, the competitive environment of enterprises has entered a typical VUCA (volatile, uncertain, complex, ambiguous) stage. Traditional enterprise competitiveness evaluation systems, which rely heavily on static financial indicators, can no longer fully reflect the real viability and development potential of enterprises in the new era. Especially for technology-intensive and capital-intensive industries such as the new energy vehicle industry, which is deeply involved in the Belt and Road cooperation between China and Kazakhstan, it is urgent to establish a more comprehensive, dynamic, and forward-looking evaluation system. This paper constructs an enterprise competitiveness assessment framework that integrates three core dimensions: digitalization, ESG (environmental, social, governance) performance, and organizational resilience [1]. Based on the structure-function analysis method, this study clarifies the efficiency optimization function of digitalization, the social legitimacy acquisition function of ESG, and the risk buffering function of organizational resilience. Using panel data of global new energy vehicle enterprises from 2019 to 2025, this paper empirically tests the impact of the three core dimensions on enterprise competitiveness through a dynamic econometric model. The results show that digitalization, ESG performance, and organizational

resilience all have a significant positive impact on enterprise competitiveness, and the comprehensive framework has stronger explanatory power than the traditional single financial index system. This research provides a theoretical reference and practical decision-making basis for enterprises in China and Kazakhstan to enhance competitiveness under the background of digital economy and Belt and Road cooperation.

Key words: Enterprise Competitiveness; Digital Transformation; ESG; Organizational Resilience; New Energy Vehicle Industry; Belt and Road Initiative.

1. Introduction

With the accelerated evolution of the fourth industrial revolution and the continuous advancement of the Belt and Road Initiative, the economic and trade cooperation between China and Kazakhstan is developing in the direction of digitization, greening, and intelligence. The new energy vehicle industry, as a key area of cooperation between the two countries, has become an important carrier for promoting industrial upgrading, green development and international competitiveness. However, in recent years, the global industrial chain and supply chain have been repeatedly impacted, and the competitive pressure faced by related enterprises has increased sharply. Traditional competitiveness evaluation methods over-emphasize short-term financial performance, while ignoring long-term value creation capabilities such as digital construction, sustainable development and risk resistance. This leads to the inability to accurately judge the long-term development potential of enterprises, and even causes enterprises to misallocate resources in strategic decision-making [2].

In order to make up for the shortcomings of existing research, this paper introduces digitalization, ESG and resilience into the unified analysis framework of enterprise competitiveness. On the one hand, digitalization helps enterprises improve operational efficiency, optimize production processes and expand cross-border business channels. On the other hand, ESG performance helps enterprises obtain social recognition, reduce policy risks and enhance brand value. In addition, organizational resilience enables enterprises to maintain stable operation and rapid recovery when facing external shocks such as supply chain disruption and market fluctuation. The three complement each other and jointly support the long-term sustainable competitiveness of enterprises. This study takes the new energy vehicle industry, which is closely related to the Belt and Road cooperation, as the research object, and provides a practical and feasible evaluation tool for enterprises in China and Kazakhstan to enhance their comprehensive competitiveness under the background of digital economy.

2. Literature review

The study of enterprise competitiveness has gone through three main stages: external structure theory, internal resource theory and dynamic capability theory. In

the 1980s, Porter's five forces model focused on the influence of external industrial structure on enterprise competitiveness, emphasizing the importance of market positioning and industrial barriers. However, this paradigm ignores the differences within enterprises and cannot explain the obvious performance differences among enterprises in the same industry [3].

Since the 1990s, the resource-based view (RBV) has gradually become the mainstream. Barney proposed the VRIN framework, arguing that enterprises with valuable, scarce, difficult to imitate and irreplaceable resources can obtain sustainable competitive advantages. However, the resource-based view focuses on static resource ownership and lacks sufficient explanation for the dynamic evolution of competitiveness in a changing environment.

In the 21st century, the dynamic capability theory pioneered by Teece emphasizes that enterprises should have the ability to perceive opportunities, integrate resources and reconstruct assets in a rapidly changing environment. In recent years, influenced by global emergencies and geopolitical changes, more and more scholars have begun to pay attention to the importance of resilience. Fainshmidt et al. (2020) defined enterprise competitiveness as the ability to maintain value creation under extreme uncertainty. Li (2024) empirically proved that digital transformation can significantly improve enterprise performance [4].

Although existing studies have recognized the importance of digitalization, sustainability and resilience, most studies still focus on a single dimension, and few integrate the three into a quantitative evaluation framework. In particular, there is a lack of targeted research on strategic emerging industries such as new energy vehicles under the background of the Belt and Road Initiative between China and Kazakhstan. This study aims to fill this gap.

3. Methodology

3.1 Theoretical Framework

This paper adopts the structure-function analysis method to construct the theoretical framework of enterprise competitiveness. Digitalization is responsible for optimizing operational efficiency and reducing information asymmetry; ESG is responsible for obtaining social legitimacy and reducing external constraints; resilience is responsible for buffering risks and maintaining system stability. The three dimensions together constitute the core driving force of enterprise competitiveness in the VUCA era.

3.2 Variable Selection

The explained variable is enterprise competitiveness, which is comprehensively measured by market performance, profitability and growth capacity. The core explanatory variables are digitalization level, ESG score and organizational resilience index. The control variables include enterprise size, age, asset-liability ratio, ownership and other traditional indicators [5].

3.3 Data Source

The research sample is global new energy vehicle enterprises, and the research period is 2019–2025. Data are obtained from enterprise annual reports, ESG rating databases, financial statistics databases and public information disclosure platforms. After eliminating missing values and abnormal samples, a total of more than 200 valid observed values were obtained.

4. Empirical results and analysis

4.1 Descriptive Statistics

The descriptive statistics show that there are obvious differences in competitiveness, digitalization level, ESG performance and resilience among different enterprises. The digitalization level and ESG score of enterprises in China and Kazakhstan have increased significantly in recent years, indicating that the two countries are accelerating the pace of digital and green transformation.

4.2 Regression Results

The regression results show that the digitalization level is significantly positive at the 1% level, indicating that digital transformation can effectively improve enterprise competitiveness. The ESG performance coefficient is significantly positive, which verifies that good sustainable development ability helps enterprises gain competitive advantage. The resilience index is also significantly positive, showing that the ability to resist risks and recover quickly is crucial for enterprises to maintain stable operation in an uncertain environment. The control variables such as enterprise size and profitability are in line with expectations, indicating that the model is robust.

4.3 Robustness Test

This paper uses the method of replacing explanatory variables and shrinking the sample interval to conduct robustness test. The results show that the core conclusions remain unchanged, which proves that the research results have high reliability and stability.

5. Discussion

The empirical results confirm that digitalization, ESG and resilience are the key sources of enterprise competitiveness in the new era. For China and Kazakhstan, which are deepening Belt and Road cooperation, the new energy vehicle industry, as a key cooperation area, should pay more attention to the coordinated improvement of the three dimensions.

First, enterprises should accelerate digital transformation, apply advanced technologies such as big data and artificial intelligence to optimize production and operation, and expand cross-border e-commerce and intelligent manufacturing. Second, enterprises should attach importance to ESG construction, actively fulfill social responsibilities, reduce environmental costs, and enhance brand image and policy support. Third, enterprises should cultivate resilience, establish a diversified supply chain, improve risk early-warning mechanism, and enhance the ability to cope with external shocks [6].

The integrated framework constructed in this paper makes up for the deficiency of traditional methods, and can more comprehensively reflect the real competitiveness of enterprises. It has important reference value for enterprise strategic decision-making, industrial upgrading and policy formulation.

6. Conclusion

This study constructs a dynamic enterprise competitiveness evaluation framework integrating digitalization, ESG and resilience, and takes the new energy vehicle industry, which is important for China-Kazakhstan Belt and Road cooperation, as the research object for empirical test. The results show that the three core dimensions have a significant positive impact on enterprise competitiveness, and the comprehensive evaluation effect is better than the traditional financial index system.

This research expands the theoretical perspective of enterprise competitiveness research, provides a quantitative analysis tool for the integration of non-financial factors, and also provides practical guidance for Chinese and Kazakh enterprises to enhance their competitiveness under the background of digital economy and Belt and Road cooperation. In the future, with the further development of digital economy and green economy, the framework can be further optimized and applied to more industries and fields [7].

This study also has some limitations. The sample scope is limited to the new energy vehicle industry, and the indicator system can be further expanded. Future research can carry out comparative analysis of different industries and explore the interaction mechanism among digitalization, ESG and resilience.

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DIGITAL INNOVATION AND EFFICIENCY IMPROVEMENT IN THE INTELLIGENT LOGISTICS INDUSTRY

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Annotation. Digital innovation is transforming the intelligent logistics industry by enhancing operational efficiency, reducing costs, and improving service quality. This article examines the role of modern digital technologies such as the Internet of Things (IoT), big data analytics, artificial intelligence (AI), and blockchain in optimizing logistics processes. These technologies enable real-time tracking, intelligent route planning, automated warehouse management, and improved supply chain transparency. The study highlights that the integration of digital solutions significantly increases the speed and accuracy of logistics operations while minimizing human error and resource waste. In addition, intelligent logistics systems contribute to better decision-making through data-driven insights and predictive analytics [1]. Despite these advantages, the implementation of digital innovations faces challenges such as high initial investment costs, cybersecurity risks, and the need for skilled personnel. However, the long-term benefits outweigh these limitations, making digital transformation a key factor in the development of modern logistics. Overall, digital innovation plays a crucial role in improving the efficiency, flexibility, and competitiveness of the intelligent logistics industry in the context of global economic development.

Key words: digital innovation, intelligent logistics, efficiency improvement, Internet of Things (IoT), big data, artificial intelligence (AI), blockchain, supply chain management, automation, smart logistics systems.

The global logistics industry, which serves as a critical backbone of modern commerce, is undergoing a profound transformation driven by digital innovation. Traditional logistics models, often characterized by information asymmetry, fragmented operations, and reactive decision-making, are becoming increasingly inadequate in the face of growing demand complexity, volatility, and the need for high speed. The convergence of advanced digital technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Big Data analytics, Blockchain, and autonomous systems is giving rise to the «Intelligent Logistics» paradigm. This new paradigm envisions logistics networks that are interconnected, self-optimizing, and predictive. This paper explores the core digital innovations shaping intelligent

logistics and analyzes their multifaceted impact on operational and economic efficiency. It argues that digital innovation is not merely an incremental improvement tool but a fundamental driver of systemic efficiency gains across the logistics value chain, ultimately enhancing competitiveness and sustainability [2, 3].

Intelligent logistics is built upon a synergistic technology stack, where each component addresses specific inefficiencies in traditional systems.

Internet of Things (IoT) and Real-Time Visibility. IoT sensors installed on shipments, vehicles, containers, and warehouses provide continuous real-time data on location, temperature, humidity, shocks, and container status. This creates a «digital twin» of the physical supply chain, eliminating blind spots. Efficiency improvements include reduced loss and theft, optimized asset utilization, proactive quality control (e.g., for perishable goods), and dynamic Estimated Time of Arrival (ETA) calculations.

Big Data Analytics and Artificial Intelligence (AI). Massive data streams from IoT and other sources (transactions, traffic, weather data) are processed using Big Data platforms. AI and Machine Learning (ML) algorithms are used for predictive and prescriptive analytics. Key applications include:

Demand forecasting: improves accuracy and reduces the bullwhip effect while optimizing inventory levels.

Predictive maintenance: analyzes vehicle sensor data to prevent failures before they occur, reducing downtime.

Intelligent route optimization: AI algorithms calculate optimal delivery routes based on real-time traffic, weather, and order data, reducing fuel consumption and delivery time [4].

Blockchain for Transparency and Trust. Blockchain technology provides a secure, immutable, and decentralized ledger for recording transactions and asset movements. In logistics, it simplifies documentation processes, reduces fraud, automates payments via smart contracts, and ensures end-to-end traceability of goods. This reduces administrative costs, delays, and enhances trust among supply chain participants.

Automation and Robotics. In warehouse operations, automation is a key efficiency driver. Automated Guided Vehicles (AGVs), Autonomous Mobile Robots (AMRs), and robotic picking systems significantly increase speed and accuracy while reducing labor costs and physical strain. These systems are supported by AI-powered Warehouse Management Systems (WMS) that optimize storage and workflows in real time.

Cloud Computing and Platformization. Cloud-based logistics platforms integrate fragmented systems and enable seamless data exchange among shippers, carriers, warehouses, and customers. This reduces IT infrastructure costs, improves scalability, and transforms traditional linear supply chains into agile, interconnected ecosystems.

These innovations improve efficiency through several interconnected pathways.

Operational Efficiency

Real-time tracking, AI-based routing, warehouse automation, and predictive maintenance reduce costs and improve productivity. Studies show that AI-based route optimization can reduce transportation costs by 10–30% [5].

Economic Efficiency

Digital platforms improve the matching of supply and demand (transport capacity, warehouse space), reduce inventory levels, and free up working capital, enhancing financial performance.

Environmental Efficiency

Route optimization reduces fuel consumption and carbon emissions, while improved resource utilization supports sustainability goals.

Resilience and Risk Management Efficiency

Enhanced visibility and predictive capabilities improve supply chain resilience by enabling early detection of disruptions and supporting scenario planning.

Despite its advantages, intelligent logistics faces several challenges. High initial investment costs limit adoption among small and medium-sized enterprises, creating a digital divide. Cybersecurity and data privacy risks increase with system interconnectivity. Lack of interoperability and standardized protocols hinders integration. Additionally, there is a shortage of skilled professionals capable of managing advanced digital systems. Finally, regulatory frameworks for autonomous vehicles, drones, and cross-border data flows are still developing [6].

Conclusion

Digital innovation is fundamentally transforming the logistics industry from a mechanistic and transactional model into an intelligent and cognitive system. The integration of IoT, AI, Big Data, Blockchain, and automation delivers comprehensive efficiency improvements across operational, economic, environmental, and strategic dimensions. These technologies create a virtuous cycle in which data enhances visibility, visibility enables analytics, and analytics drive optimized and automated actions. Although challenges remain, the direction of development is clear. Future competitive advantage in logistics will depend on the effective use of digital innovation to build smarter, more resilient, and more sustainable supply chain ecosystems.

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CHINA'S AGRICULTURAL MODERNIZATION DEVELOPMENT

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Annotation. Over the past decade, China's agriculture has witnessed a landmark strategic development period. Constrained by shrinking arable land, aging rural labor force and frequent extreme weather, China has empowered agriculture with cutting-edge technologies including artificial intelligence, big data, the Internet of Things and intelligent equipment. It has accomplished a historic shift from extensive traditional farming to modern precise and intelligent production. This decade, marked by steady growth in grain output, has seen agricultural modernization evolve from scattered technological trials to large-scale nationwide application, providing solid support for national food security.

Key words: Internet of Things (IoT) monitoring, drone-based crop protection and smart irrigation.

Development Process: Three Stages of High-Tech Agricultural Integration

1. 2015–2020: Initial Exploration and Decentralized Technological Breakthroughs

This phase featured preliminary trials of single technologies such as IoT monitoring, drone plant protection and intelligent irrigation. Agricultural drones expanded from laboratories to fields. In 2018, 40,000 drones covered an operating area of 200,000 square kilometers; by 2020, the figure rose to 100,000 drones and 670,000 square kilometers, making China the world's largest agricultural drone market [1].

Regions including Beidahuang and Shouguang piloted Beidou autonomous tractors and smart greenhouses to realize preliminary precision farming and intelligent management. During this period, China's total grain output remained above 650 million tons with moderate annual growth, and AI began to boost grain production and reduce post-harvest losses.

2. 2021–2024: Systematic Integration and Large-Scale Popularization

Modern agriculture entered a rapid development stage, shifting from single-link applications to full-industry and sky-ground integrated systems. By 2024, the number of agricultural drones reached 251,000, with over 100,000 agricultural IoT demonstration sites nationwide. AI achieved an accuracy rate of over 95% in pest and disease identification. Grain output exceeded 700 million tons for the first time, with artificial intelligence serving as a core growth driver.

3. 2025: Ecosystem Maturity and AI Large Model Empowerment

Since 2025, smart agricultural ecosystems have taken shape, with AI large models, agricultural robots and digital twins widely applied to foster new quality productive forces. The smart agriculture market reached 1200 billion yuan, and agricultural drones exceeded 300,000 units, covering 310,000 square kilometers annually.

The Shennong Large Model developed by the Chinese Academy of Agricultural Sciences supports 74 crop varieties. Intelligent breeding robots shorten the breeding cycle from 10 years to 2–3 years and raise efficiency by over 40%. AI laser weeding robots can remove 100,000 weeds per hour without pesticide pollution. In 2025, China's grain output stabilized at 700 million tons, with per capita grain possession over 500 kilograms and 100% self-sufficiency in staple foods.

III. Benchmark Cases of High-Tech Empowered Agriculture

1. Large-Scale Farming: Beidahuang Smart Granary Since 2017, Beidahuang has adopted Beidou autonomous tractors, satellite remote sensing and soil sensors to achieve centimeter-level precise farming. In 2025, 3 million mu of rice fields achieved full AI coverage. The per mu yield increased by 15%, labor costs dropped by 60%, building a national model of digital grain production.

2. Protected Agriculture: Shouguang Intelligent Greenhouses

Equipped with temperature, humidity, light and carbon dioxide sensors as well as AI control systems, 500,000 mu of protected farmland in Shouguang realized fully automatic management in 2025 [2]. Cucumber output rose by 40% and tomato production doubled, supplying more than 30% of China's vegetables with year-round stable output.

3. Intelligent Breeding: Breeding Robots by China Agricultural University

Equipped with the Fengdeng Seed Industry AI Large Model, intelligent breeding robots operate in Jilin's corn fields to realize all-weather autonomous pollination and phenotypic monitoring. Single-flower pollination time was shortened from 3 minutes to 15 seconds, with a 12-fold efficiency increase and 60% cost reduction, accelerating the cultivation of high-yield and disease-resistant crop varieties.

4. Smart Plant Protection: DJI Unified Pest Control

With over 150,000 agricultural drones in 2025, DJI covers 90% of China's grain-producing areas and operates across 200,000 square kilometers annually. It enables large-area unified prevention and control, improving pesticide utilization by 35% and cutting pesticide consumption by 30%, becoming core equipment for green agricultural production.

IV. Challenges and Future Prospects

Regional imbalance remains prominent in China's agricultural modernization. The AI penetration rate exceeds 50% in eastern coastal areas and the Northeast Plain, while it is below 20% in central and western hilly regions. High application thresholds also restrict development. Although intelligent equipment costs have dropped to 4,000 yuan per set, small-scale farmers lack sufficient funds and technical capabilities [3].

In the future, China will focus on intelligent breeding, precision planting, green prevention and smart warehousing. By improving policies, talent training and industrial standards, the country will promote the comprehensive integration of digital technology and agriculture, and consolidate the foundation for building an agricultural power and safeguarding food security.

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UDC (004.8)

THE DRIVING FORCE AND TRANSFORMATION OF ARTIFICIAL INTELLIGENCE (AI) ON ENTERPRISE COMPREHENSIVE BUDGET MANAGEMENT IN THE CONTEXT OF DIGITAL TRANSFORMATION

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Annotation. Amid the wave of digital transformation, enterprise budget management is undergoing unprecedented change. Shifting from «manual calculation

and drafting» to «artificial intelligence», and from the «HanSteel Experience» to «calculation-based operation», traditional budget preparation methods reliant on empiricism have struggled to adapt to the rapidly changing market environment. The rise of Artificial Intelligence (AI) technology offers new possibilities for enterprise budget management. It introduces the highlights and application cases of comprehensive budget management in the AI environment, aiming to assist enterprises in initiating a new chapter of intelligent budget management.

Key words: Artificial Intelligence; Calculation-Based Operation; Comprehensive Budget; AI; Management Innovation; Machine Learning; HanSteel Experience.

The year 2026 marks the 30th anniversary of Eurasian National University in Kazakhstan and the 30th anniversary of the State Council of the People's Republic of China officially issuing Document No. 3 (1996), which promoted the nationwide study and implementation of the «HanSteel Experience». Thirty years ago, the «HanSteel Experience», centered on «simulating market accounting and implementing cost veto», opened a door to the market for Chinese state-owned enterprises during the economic transition [1]. Market-oriented management concepts such as «comprehensive budget, full participation», «everyone carries a heavy burden with their own indicators on their shoulders», and «the main factory carries the beam, everyone helps together» provided a continuous driving force for enterprise competition and survival in the market environment of that time. Over the years, profound changes in the economic environment, market entities, production factors, social demands, internal conditions, and competitive landscapes have imposed greater pressure and challenges on enterprise production, operations, and budget management, gradually revealing some limitations of traditional budget management.

I. The Evolution and Challenges of Comprehensive Budget Management

As a crucial tool for corporate strategy execution, comprehensive budget management has long played a key role in resource allocation, performance evaluation, and risk control. However, traditional budget management models often rely on historical data and experiential judgment, proving inadequate when confronted with complex and volatile market environments. With increasing global economic uncertainty, enterprises demand greater precision and flexibility from budget management, and the limitations of traditional models have become increasingly prominent.

During the traditional budget preparation process, financial personnel spend significant time collecting, organizing, and analyzing data, which is susceptible to subjective influences, leading to substantial deviations between budgets and actual execution. According to surveys, over 60% of enterprises believe the accuracy rate of traditional budget forecasting is below 70% [2]. Such low accuracy not only affects resource allocation efficiency but may also lead to strategic decision-making errors.

Against this backdrop, the introduction of AI technology has brought revolutionary change to comprehensive budget management.

II. Comparison of Accuracy Rates Between Traditional and Intelligent Forecasting

(A) Limitations of Traditional Forecasting

Traditional budget forecasting primarily depends on the experience and judgment of financial personnel, combined with simple statistical methods. While intuitive, this approach has significant limitations. First, human cognitive capacity is limited, making it difficult to simultaneously consider the complex interactions of multiple variables. Second, experiential judgment is prone to cognitive biases, such as overconfidence and anchoring effects, causing forecasts to deviate from reality.

(B) Advantages of Intelligent Forecasting

In contrast, AI-powered intelligent forecasting employs machine learning algorithms to analyze massive datasets, identifying complex nonlinear relationships and hidden patterns, thereby substantially improving forecast accuracy. According to multiple research studies, in sales forecasting, the average accuracy rate of traditional methods is approximately 65%-75%, while AI-powered intelligent forecasting can achieve 85%-95% accuracy. In cost forecasting, traditional methods typically achieve 70%-80% accuracy, whereas AI-powered intelligent forecasting can exceed 90%.

(C) Comparison of Forecast Accuracy

Taking a specific manufacturing enterprise as an example, prior to adopting an AI comprehensive budget system, its quarterly sales budget forecast had an average error of ±15%. After introducing AI technology, the forecast error was reduced to within ±5%. This enables the enterprise to more accurately plan production schedules, inventory management, and capital allocation, effectively lowering operational costs and enhancing resource utilization efficiency. Similarly, in cash flow forecasting, the application of AI technology elevated forecast accuracy from 75% to 92%, providing a more reliable basis for enterprise treasury management.

III. Implementation Pathway for AI-Powered Comprehensive Budget Management

For enterprises to successfully implement AI-driven comprehensive budget management, a systematic implementation pathway must be followed. First, enterprises should identify pain points and objectives in budget management and assess the value AI technology can deliver. Second, a robust data governance framework must be established to ensure data quality and consistency, which forms the foundation for successful AI budget management. Third, enterprises should select AI budget management tools or platforms that suit their needs, considering functionality, usability, and scalability. Fourth, a cross-departmental implementation team comprising finance, IT, and business personnel should be formed to ensure all stakeholder requirements are adequately addressed. Finally, implementation should proceed in phases, starting with key business areas and gradually expanding enterprise-wide [3]. During implementation, enterprises must also pay attention to

personnel training and change management. AI budget management represents not only a technological change but a transformation in management philosophy and processes. Enterprises need to assist financial personnel in transitioning from traditional data collection and organization roles to data analysis and business advisory roles, fully leveraging the decision-support function of AI systems. The empowerment of AI in enterprise budget management is not the result of a single technology but a system formed by the synergy of multi-dimensional technologies.

IV. Application Advantages of Artificial Intelligence (AI) Technology in Comprehensive Budget Management

AI technology, particularly the rapid development of machine learning algorithms, has injected new vitality into comprehensive budget management. Machine learning can analyze vast amounts of historical data to identify complex patterns and correlations that are difficult for humans to discern, thereby enabling more accurate budget forecasting [4]. Compared with traditional budget management, AI comprehensive budget, as an industry-leading intelligent budget management solution, is helping enterprises achieve digital transformation in budget management through its core highlights.

V. Case Study Analysis of AI-Powered Comprehensive Budget Management

(A) Basic Enterprise Profile

Before implementing the AI comprehensive budget system, a large manufacturing group faced challenges such as long budget preparation cycles, low forecast accuracy, and difficulties in data integration. The group has multiple business segments and subsidiaries, resulting in high complexity in budget management, where traditional Excel-based budgeting could no longer meet management requirements. Through the introduction of the AI comprehensive budget system, the group achieved a comprehensive upgrade of its budget management.

(B) AI Application Effectiveness

During the implementation process, the group first streamlined its budget management processes and optimized the budget model design. Subsequently, leveraging the powerful data integration capabilities of AI comprehensive budget, seamless interfacing with the group's ERP system was achieved, ensuring the accuracy and consistency of budget data. After the system went live, the group's budget preparation cycle was reduced from the original 45 days to 15 days, and the budget forecast accuracy increased from 70% to over 90% [5].

Utilizing the machine learning forecasting function of AI comprehensive budget, the group improved its sales forecast accuracy by 25 percentage points, enabling more precise production planning and increasing inventory turnover by 30%, significantly reducing operational costs. Furthermore, the real-time budget execution monitoring and analysis functions provided by the system allowed management to promptly detect deviations and take corrective actions, effectively enhancing the group's overall management level and decision-making efficiency.

In practical applications, AI-powered comprehensive budget management can utilize various machine learning techniques, including time series analysis, regression analysis, and neural networks, to forecast key budget items such as sales, costs, and cash flow. These techniques can not only consider historical trends but also incorporate external factors like macroeconomic indicators, industry dynamics, and competitor behavior, thereby providing more comprehensive and accurate budget forecasts.

VI. Conclusion

With the continuous development and application of AI technology, comprehensive budget management is undergoing a transformation from empiricism to data-driven approaches. By integrating advanced machine learning algorithms and a flexible platform architecture, AI comprehensive budget provides enterprises with intelligent, efficient, and precise budget management solutions.

As stated in *The Book of Rites: The Doctrine of the Mean*, «Preparedness ensures success, and unpreparedness spells failure». In this new era of digital-intelligent transformation, during the critical period of budget planning, enterprises should continue to actively promote the innovative, adaptive, and practical spirit of the «HanSteel Experience» - pushing down walls to enter the sea, daring to be first, and being courageous in practice [6]. By implementing AI-powered comprehensive budget management, enterprises can improve budget forecast accuracy, optimize resource allocation, enhance strategic execution, and gain sustained competitive advantage in the fierce market competition.

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RESEARCH ON THE REFERENCE OF DIGITAL ECONOMY DEVELOPMENT EXPERIENCE OF GUANGDONG-HONG KONG-MACAO GREATER BAY AREA FOR CHINA-KAZAKHSTAN ECONOMIC COOPERATION UNDER THE BELT AND ROAD INITIATIVE

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Annotation. Under the framework of the Belt and Road Initiative (BRI), China-Kazakhstan economic cooperation has entered a new stage of high-quality development, with digital economy becoming the core growth engine of bilateral cooperation. As a leading benchmark of China's digital economy development, the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) has formed a mature set of experience in top-level collaborative design, digital infrastructure interconnection, deep integration of digital and real economy, and institutional opening-up of cross-border digital trade. This paper systematically sorts out the core replicable experience of the GBA's digital economy development, analyzes the current status and bottlenecks of China-Kazakhstan digital economic cooperation, and proposes targeted reference paths for bilateral cooperation. The research aims to provide practical solutions for deepening China-Kazakhstan economic and trade cooperation under the BRI, and promote the high-quality development of the Digital Silk Road between the two countries.

Key words: Digital Economy; Guangdong-Hong Kong-Macao Greater Bay Area; Belt and Road Initiative; China-Kazakhstan Economic Cooperation; Digital Silk Road.

1. Introduction

2026 marks the 13th anniversary of the Belt and Road Initiative, and Kazakhstan, as the first country to respond to and actively participate in the BRI, has maintained a comprehensive strategic partnership with China for many years. Bilateral trade volume exceeded USD 42 billion in 2025, hitting a record high, and the cooperation scope has expanded from traditional energy and infrastructure to emerging fields such as digital economy, artificial intelligence and cross-border e-commerce [1].

The Republic of Kazakhstan has clearly identified digital transformation as a national strategic priority through the Digital Kazakhstan State Program, and has a strong demand for advanced digital technology, development experience and cross-

border cooperation resources. The GBA, as China's core engine of digital economy development, contributes more than 12% of China's total digital economy scale with less than 5% of the country's population, and has formed a complete development system from digital infrastructure, industrial digitization to institutional innovation.

This paper takes the GBA's digital economy development experience as the research object, combines the actual needs of China-Kazakhstan economic cooperation under the BRI, explores the feasible path of experience replication and promotion, and fills the research gap of regional digital economy experience applied to bilateral cross-border cooperation between China and Central Asian countries. This research fully fits the core themes of this conference: digital transformation of economic sectors, and China-Kazakhstan economic cooperation under the BRI framework.

2. Core Replicable Experience of Digital Economy Development in the GBA

After years of development, the GBA has formed four core replicable and scalable experience systems, which are highly compatible with the development needs of China-Kazakhstan digital economic cooperation:

2.1 Top-level Design and Cross-regional Collaborative Governance Mechanism

The GBA has established a multi-level collaborative governance system led by the Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area, with inter-provincial and inter-city coordination mechanisms, cross-border policy docking working groups, and a unified market access system. This system effectively breaks down administrative barriers and policy differences between 9 mainland cities and 2 special administrative regions, realizing the coordinated layout of digital economy planning, standard unification and factor flow. This experience provides a reference for solving the problem of policy and institutional docking in bilateral cross-border cooperation between China and Kazakhstan [2].

2.2 Prior Layout of Digital Infrastructure Interconnection

The GBA has built a world-class digital infrastructure network, achieving full coverage of 5G network in urban areas, a cross-border optical cable network connecting the Chinese mainland, Hong Kong and Macao, and a national integrated big data center cluster. The region has taken the lead in launching pilot projects for cross-border data flow, and built a safe and efficient digital interconnection system. This «infrastructure first» model is the core foundation for the development of cross-border digital economy, and is fully applicable to the construction of the China-Kazakhstan Digital Silk Road.

2.3 Deep Integration of Digital Industry and Real Economy

The GBA has formed a complete digital industry ecosystem, with a number of world-leading digital technology enterprises, and has realized the full penetration of digital technology in manufacturing, agriculture, trade and other real economic fields. The region's industrial digitization rate exceeds 65%, and it has built a number of intelligent manufacturing demonstration parks and digital industrial clusters. This experience of «empowering the real economy with digital technology» is highly

consistent with Kazakhstan's demand for industrial transformation and upgrading, and is the core direction of China-Kazakhstan industrial cooperation [3].

2.4 Institutional Opening-up of Cross-border Digital Trade

Relying on Qianhai, Hengqin and other free trade pilot zones, the GBA has carried out a series of institutional innovations in cross-border digital trade, including mutual recognition of digital standards, cross-border e-commerce supervision innovation, digital RMB cross-border settlement, and cross-border financial service opening. These innovations have effectively reduced the cost of cross-border digital trade, and formed a set of replicable institutional opening-up experience, which can provide a practical sample for China-Kazakhstan cross-border digital trade cooperation.

3. Current Status and Bottlenecks of China-Kazakhstan Digital Economic Cooperation Under the BRI

3.1 Current Status of Bilateral Cooperation

In recent years, China-Kazakhstan digital economic cooperation has achieved initial results under the BRI framework. The two countries have completed the construction of the China-Kazakhstan cross-border optical cable trunk line, signed a number of cooperation documents on digital economy and network security, and launched cooperation projects in 5G network construction, e-commerce, smart city and other fields. Cross-border e-commerce trade between the two countries has maintained an annual growth rate of more than 30% since 2023, and digital economy has become a new growth point of bilateral economic and trade cooperation.

3.2 Core Bottlenecks Restricting Cooperation

Compared with the development potential and strategic needs of the two countries, China-Kazakhstan digital economic cooperation still faces four core bottlenecks, which are exactly the problems that the GBA's experience can effectively solve:

(1). Lack of systematic top-level design and collaborative mechanism: Bilateral digital economy cooperation is still scattered in individual projects and fields, lacking a unified medium and long-term development plan, and a stable cross-departmental and cross-border collaborative governance mechanism, resulting in low efficiency of policy docking and project implementation.

(2). Insufficient level of digital infrastructure interconnection: The cross-border digital infrastructure between China and Kazakhstan is still in the initial stage, with insufficient coverage of high-speed communication network, backward construction of cross-border data centers, and no breakthrough in cross-border data flow pilot projects, which cannot support the large-scale development of bilateral digital economy cooperation.

(3). Low level of industrial cooperation and insufficient integration with real economy: The current bilateral digital cooperation is mostly concentrated in the field of cross-border trade and communication infrastructure construction, with less

cooperation in industrial digitization, intelligent manufacturing, digital agriculture and other fields, and fails to form a complete digital industry cooperation ecosystem.

(4). Incomplete institutional system for cross-border digital trade: There are obvious differences between China and Kazakhstan in digital technical standards, data supervision, cross-border e-commerce customs clearance and digital financial supervision, and the institutional barriers to cross-border digital trade have not been effectively eliminated, which restricts the scale expansion of bilateral digital trade [4].

4. Reference Paths of GBA Experience for China-Kazakhstan Economic Cooperation

Based on the core experience of the GBA and the actual bottlenecks of China-Kazakhstan cooperation, this paper proposes four targeted reference paths, which are highly operable and in line with the strategic needs of both countries:

4.1 Improve the Top-level Design and Cross-border Collaborative Governance Mechanism

Drawing on the GBA's multi-level collaborative governance experience, the two countries should formulate a Medium and Long-term Plan for China-Kazakhstan Digital Economy Cooperation Under the BRI, which connects China's Overall Layout Plan for Digital China Construction and Kazakhstan's Digital Kazakhstan State Program. A special China-Kazakhstan digital economy cooperation working group should be established, with regular consultation mechanisms, to coordinate policy docking, standard unification and major project layout, and break down institutional barriers to bilateral digital economy cooperation.

4.2 Accelerate the Construction of Cross-border Digital Infrastructure Interconnection

Referring to the GBA's «infrastructure first» model, the two countries should jointly promote the upgrading of the China-Kazakhstan cross-border optical cable network, expand the bandwidth of cross-border data transmission, and build a China-Kazakhstan joint big data center. The two sides should carry out pilot projects for cross-border data secure flow, promote the co-construction and sharing of 5G and Internet of Things infrastructure, and build a high-speed, safe and efficient digital interconnection system between the two countries, laying a solid foundation for the development of bilateral digital economy cooperation.

4.3 Deepen the Integration of Digital Industry and Real Economy Cooperation

Learning from the GBA's experience of digital empowerment of real economy, the two countries should build a China-Kazakhstan digital economy industrial cooperation park, and promote the cooperation between Chinese digital technology enterprises and Kazakhstan's manufacturing, agriculture, energy and other industries. The focus should be on promoting the digital transformation of Kazakhstan's real economy, carrying out cooperation projects in intelligent manufacturing, smart agriculture, smart energy and other fields, and cultivating a complete cross-border

digital industry ecosystem, so as to realize the upgrading of bilateral industrial cooperation from traditional trade to digital empowerment [5].

4.4 Promote Institutional Innovation of Cross-border Digital Trade

Drawing on the GBA's experience of institutional opening-up of cross-border digital trade, the two countries should build a China-Kazakhstan cross-border digital trade demonstration zone, and carry out institutional innovation in mutual recognition of digital technical standards, cross-border e-commerce customs clearance facilitation, digital RMB cross-border settlement, and cross-border digital financial services. The two sides should establish a coordinated supervision mechanism for cross-border data security, reduce the institutional cost of bilateral digital trade, and promote the scale and high-quality development of China-Kazakhstan cross-border digital trade.

5. Conclusion

The Guangdong-Hong Kong-Macao Greater Bay Area has formed a mature and replicable digital economy development system in top-level collaborative governance, digital infrastructure construction, deep integration of digital and real economy, and institutional opening-up of cross-border digital trade, which has important reference value for deepening China-Kazakhstan economic cooperation under the Belt and Road Initiative [6].

Under the background of the rapid development of global digital economy, China and Kazakhstan should take the Digital Silk Road as the carrier, fully learn from the development experience of the GBA, improve the top-level design of bilateral digital economy cooperation, accelerate the interconnection of digital infrastructure, deepen the digital empowerment of real economy, and promote the institutional innovation of cross-border digital trade. Through the above paths, the two countries can break through the current bottlenecks of cooperation, cultivate new growth points of bilateral economic and trade cooperation, and promote the high-quality development of China-Kazakhstan comprehensive strategic partnership under the BRI framework.

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UDC (330)

OPTIMIZATION OF PRODUCTION COSTS AS A FACTOR OF ECONOMIC EFFICIENCY: MECHANISMS, PRACTICAL PATHWAYS, AND APPLICATION OF THE PROFIT-CONTENDING MODEL

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Annotation. Based on a systematic review of various theoretical areas, including standard cost calculation, activity-based cost calculation, strategic cost management, value chain cost calculation, and lean cost management, this article proposes an integrated analytical system that combines four interrelated effects: cost structure change, process efficiency improvement, and information improvement. The decision-making process and organizational synergy are enhanced. This concept aims to analyze how optimizing production costs leads to increased efficiency in terms of the technological mechanism.

Key words: production cost optimization; economic efficiency; profit-contending model; lean management; functional mechanism.

1 Introduction

1.1 Background of the study and problem statement

In this article, we will build an integrated analytical system based on a systematic review of the theoretical evolution of cost management, and conduct an empirical study based on typical examples of enterprises.

1.2 Research Purpose and Significance

The purpose of this study consists of three stages. First, a systematic review of the main theoretical schools in the field of cost management and cost-effectiveness research, identifying shortcomings in existing explanations of the mechanisms. Secondly, to build a theoretical functional structure of the mechanism for optimizing production costs as a factor of economic efficiency, including the «Profit Struggle

Model» in an analytical perspective and explaining its methodological contribution. Thirdly, to test and enrich the theoretical base by studying examples from the practice of lean enterprise management and extracting generalizing practical ideas.

1.3 Research Method and Structure

This paper adopts a research approach combining theoretical construction with case analysis. The theoretical part primarily employs literature synthesis and logical deduction to construct an analytical framework for how production cost optimization affects economic efficiency, while also elaborating on the core concepts and operational logic of the Profit-Contending Model. The case analysis part selects Nannan Aluminium-based New Materials Group and New Beiyang Digital Technology as analytical objects, drawing on primary sources such as project reports to dissect the implementation pathways and effects of cost optimization at the enterprise level [1].

2 Literature Review

2.1 The Evolution of Cost Management Theory

The standard Cost accounting system has integrated cost management into the production process, providing precise control over materials, labor, and production overheads through a closed loop of setting standards, measuring deviations, analyzing causes, and implementing improvements. Shi Xinwu, in his systematic research, convincingly noted that modern cost management is a comprehensive cost management that should cover the entire process, all positions and all elements, and positions strategic cost management as an advanced cost management model [2]. Research by Mu Linjuan and Jia Qi shows that inter-organizational resource integration can effectively contribute to enterprise modernization, which means that cost optimization requires not only tapping internal capacity, but also identifying opportunities within the supply chain interaction [3]. Table 1 summarizes the main ideas and methodological features of the main theories of cost management.

Table 1 Comparison of Major Cost Management Theories [4, 5, 6, 7]

Theoretical Perspective	Core Idea	Methodological Feature	Representative Scholars
Standard Cost Management	Achieve ex-ante planning, in-process control, and post-event analysis through standard setting	Variance analysis, quota management	Shi Xinwu, Meng Fansi
Activity-Based Cost Management	Treat activities as the accounting object; products consume activities, activities consume resources	Cost driver analysis, activity chain optimization	Cooper, Kaplan, Ma Qing
Value Chain Cost Management	Transcend enterprise boundaries; manage costs from a whole supply chain perspective	Value chain analysis, cross-organizational synergy	Mu Linjuan, Ma Zixuan
Strategic Cost Management	Cost management serves the enterprise's strategic positioning and competitive advantage	Strategic positioning analysis, cost driver management	Shi Xinwu, Lu Xin

Lean Cost Management	Focus on waste elimination; pursue continuous improvement and full employee participation	Value stream mapping, 5S, TPM, improvement projects	Wu Zhiqi, Hou Junfang

2.2 Research on the Impact of Cost Management on Enterprise Economic Efficiency

Existing research confirms the positive role of cost management in improving economic efficiency from various perspectives. An analysis of Nannan's new aluminum-based materials shows that due to the systematic cost reduction, the cost of recycling foil for batteries is expected to decrease by 14%, which will directly affect the profitability of the enterprise. New Beiyang Digital Technology's practice shows that from April to December, 5,117 reasoned proposals were submitted to all employees using the professional development proposal system, with an average of 6.2 proposals per person, which creates an atmosphere of continuous improvement in the organization.

2.3 Theoretical Gaps in Existing Research and Positioning of This Paper

Summarizing the above literature, we can identify three main gaps in modern cost management research, which are the theoretical starting point for this article: first, there is a «black box» dilemma in explaining the mechanism. Secondly, there is a tendency towards fragmentation of methodologies. Although various cost management methods (standard costing, ABC, strategic cost management, lean management, etc.) have internal logical connections, there is no integrative structure that would combine them within a single analytical perspective. Third, there is a gap between strategy and execution. In many enterprises, cost management stagnates at the data accounting level in the finance department, which makes it difficult to effectively transfer strategic cost optimization intentions to the operational level.

3 Theoretical Analytical Framework

3.1 The Functional Mechanism of Production Cost Optimization on Economic Efficiency

This article discusses a functional mechanism for optimizing production costs. First, it is a change in the cost structure. Optimizing production costs by re-identifying and controlling cost-determining factors changes the proportional relationships and patterns between different cost items in an enterprise. Secondly, it is an increase in the efficiency of the process. Thirdly, the information content of the decision-making process is improving. Fourthly, it is the effect of strengthening organizational synergy.

3.2 Methodological Positioning and Core Logic of the Profit-Contending Model

The profit-oriented model developed by the author is a structured cost management methodology that combines strategic goals with on-site improvements. Its basic logic manifests itself on the following levels.

First, an improvement from a financial point of view. Unlike the traditional logic of «starting from production and using improvements to reduce costs», the profit-driven model uses financial data as a starting point.

Secondly, the cascading of indicators from level to level and the transfer of responsibility. The profit-oriented model emphasizes that business indicators should be gradually subdivided into managerial and operational indicators, ensuring vertical penetration from «Group—Company—Department—Team—Position».

Third, project-based management with instrumental support. The profit-driven model transforms cost reduction into manageable projects classified by importance into S, A, and B-level projects, and applies a PDCA cycle and an eight-step improvement method for standardized management.

Fourth, talent development and organizational capacity building. The sustainability of a profit-oriented model depends on the development of a talent attraction system.

4 Empirical Analysis: Enterprise Lean Cost Management Cases

4.1 Nannan Aluminium-based New Materials Group: Systemic Cost Reduction Driven by Challenges

The Nannan New Materials Group of companies, based on aluminum, is a large manufacturing company engaged in the production of aluminum foil for batteries, and constantly supplies products to leading battery companies such as CATL and BYD. From the point of view of cost management, the main problems faced by the company were: the inability to take full advantage of the production chain, persistently high internal losses and low profitability; low level of workshop management, team management and standardization of work.

During the analysis of the company's profits and losses, the author and the team identified two key areas where there is potential for cost reduction. Firstly, calculations based on an ideal product range showed that the break-even point for the first division is a monthly production volume of 4,170 tons, which is approximately 50,000 tons per year, which places clear requirements on the efficiency of production facilities. Secondly, by comparing alternatives, a possible improvement path was identified: «increase production capacity efficiency by 10%, reduce variable costs by 14%», while the cost of refining should decrease from 3,950 yuan per ton to 3,400 yuan per ton.

By developing a mathematical model for calculating costs based on activities and dynamic channels for collecting cost data in real time, create a standard cost system and focus on reaching consensus on profits, as well as explore the possibilities of using digital tools such as a digital cost twin and an artificial intelligence deviation diagnostic assistant. In terms of assessing the impact of the project, the plan sets clear quantitative indicators: reducing variable costs by 14% and increasing production capacity efficiency by 10%.

4.2 New Beiyang Digital Technology: Enhancing Cost Competitiveness Driven by Lean Transformation

New Beiyang Digital Technology is a medium-sized manufacturing company. The implementation of the lean management project demonstrates the logic of implementing a full cycle of processes, from strategic planning to on-site

implementation. The project's starting point was the planning of the company's strategic map, the joint determination of annual strategic indicators with the company's management, covering key aspects such as speed of delivery, first-cycle productivity, reduction of processing costs and production safety, as well as the division of strategic goals into 3 S-level and 5 A-level projects. projects and 4 key initiatives of the platform. Cost reduction at New Beiyang Digital Technology has demonstrated the distinctive features of project-based management and full employee engagement. As part of a special initiative to transform intelligent sheet metal production into lean manufacturing, the focus has been on advancing cost-related projects such as production process efficiency data collection, schedule sequencing management, SMED flexibility, deceleration inventory planning, rationalization of control standards, and technology discipline enforcement.

As for the full-fledged participation of employees, New Beiyang has implemented an effective proposal submission system, resulting in 5,117 valid proposals received from April to December, which is an average of 6.2 proposals per person, thereby creating an atmosphere of «everyone participates in improvement» in the organization. The leaders of the integrated teams achieved an 11.4% increase in the average management level after four months of training. Analyzing the results of the transformations, New Beiyang's practice demonstrates the possibility of lean cost management in the transition from a «short-term campaign» to a «long-term mechanism».

4.3 Case Comparison and Mechanism Verification

Nannan Aluminum has optimized its product range and adjusted its cost strategy from a financial point of view, analyzing the ratio of costs, production volume and profit and setting targets for processing costs; New Beiyang has implemented cost targets into the overall strategic structure of the company through strategic tools. planning and decomposition of key performance indicators. Nannan has focused on standardizing work, managing the shop floor, and implementing a standard cost system.; While New Beiyang has focused on the planning and optimization of operations, the management of SMED and TPM equipment reflects the various levers of increasing process efficiency in various industries. Nannan's concept of creating an intelligent cost model is aimed at obtaining visualized cost data in real time. New Beiyang provided periodic feedback and decision support through objective analysis groups and a multi-level meeting mechanism.

Table 2 Comparison of Cost Optimization Pathways in the Two Cases

Mechanism Dimension	**Nannan Aluminium-based New Materials**	**New Beiyang Digital Technology**
Cost Structure Reshaping	Profit-and-loss analysis & target cost setting	Strategic map & KPI decomposition
Process Efficiency Activation	Standard work, shop floor management, quota control	Planning & operations optimization, SMED, TPM

Decision Information Improvement	Intelligent cost model, digital twin	Objective review board, tiered meetings
Organizational Synergy Strengthening	Project-based problem-solving, BU profit-contending analysis	Full employee proposals, tiered talent development

The common experience from the two cases shows that successful cost optimization is not the application of any single tool in isolation, but the result of the synergistic action of multiple mechanism dimensions. Simultaneously, the quantified decomposition and tier-by-tier cascading of strategic objectives form the pivotal hub for achieving effective transmission from «top management decisions» down to «frontline execution». This finding also corroborates the methodological value of the Profit-Contending Model—through its closed-loop management of «financial objectives—process indicators—improvement projects—tools and methods—effect verification», it provides an integrative operational framework for simultaneously activating the fourfold effects at the enterprise level.

5 Conclusion and Outlook

5.1 Core Conclusions

The four—pronged effect scheme — «changing the cost structure — increasing process efficiency — improving awareness of decision-making - enhancing organizational synergy» proposed in this study provides a preliminary analytical approach to uncovering the «black box» between cost optimization and economic efficiency. The «profit Struggle Model» represents a significant innovation in cost management methodology. This model uses financial data as a starting point and, thanks to the four-dimensional relationship between the implementation of indicators, project management, expansion of digital opportunities and talent development, ensures effective achievement of strategic goals and on-site improvement. The successful practice of cost optimization in an enterprise demonstrates the excellent characteristics of the synergy of several mechanisms and the full participation of employees.

5.2 Theoretical Contributions and Practical Implications

At the theoretical level, a functional cost optimization mechanism is proposed that combines the four effects and provides a verifiable conceptual model for subsequent research. On a practical level, it is useful for business leaders to: get out of the trap of short-term cost reduction and explore their own cost management methods in terms of the mechanism and ways to achieve them; choose the dominant cost optimization path in accordance with the company's capabilities and competitive strategy, paying special attention to creating a joint organizational structure. culture and information infrastructure; and he attaches great importance to the «human factor», considering cost optimization as a process of developing talents and building organizational capacity, and not just as the use of technical tools.

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UDC (340.1)

IP-INFRINGEMENT RISK PREVENTION IN DIGITAL INDUSTRIAL INNOVATION: AN ECONOMIC ANALYSIS BASED ON COST–BENEFIT ASYMMETRY

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Annotation.

The development of the digital economy has reshaped the pattern of industrial innovation and affected the cost–benefit structure of intellectual property infringement activities. From an economic perspective, this paper analyzes the asymmetric characteristics and causes of infringers' «low cost, high benefit» and rights holders' «high cost, low benefit» in digital industrial innovation. The study shows that digital technologies have greatly reduced the costs of duplication and dissemination, leading to frequent infringements. Meanwhile, rights holders face

difficulties in evidence collection and high litigation costs, which reduce their expected returns from rights protection. The above asymmetry hinders enterprises' innovation motivation, triggers negative externalities and market failure in the innovation market, and restricts the development of new-quality productive forces and the high-quality development of the digital industry. Governance paths should focus on raising infringement costs through punitive damages, reducing rights protection costs by means of criminal incidental civil litigation and technology empowerment, strengthening asset recovery and comprehensive protection to stabilize innovation returns, and reconstructing cost–benefit balance to restore innovation incentives.

Key words: Digital Industrial Innovation; Intellectual Property; Infringement Risk; Cost–Benefit Analysis; Asymmetry.

1. Introduction

The digital economy is an economic form with data as the core production factor. Its high permeability and easy replicability have promoted cross-industry innovation and the development of new business forms and models, but also exposed digital innovation achievements to high infringement risks [1]. In the traditional economic perspective, rational actors make decisions based on the measurement of costs and benefits. However, the application of digital technologies has changed the original equilibrium state, leading to new economic characteristics of intellectual property infringement. As the digital economy reduces enterprises' search costs, duplication costs and dissemination costs, digital innovation achievements can be easily copied, diffused and misappropriated for free, increasing the risk of intellectual property infringement 0. Strengthening intellectual property protection in emerging fields is an urgent need to promote innovation and development in emerging fields, and a strategic choice to seize the initiative of development and enhance competitiveness 0. Based on the «cost–benefit» framework, this paper aims to analyze the formation mechanism of infringement risks in digital industrial innovation and propose governance paths to correct the asymmetry, so as to provide theoretical support and practical reference for intellectual property governance and innovation incentives under the background of digital economy.

2. Low Cost and High Benefit for Infringers: The Logical Starting Point of Asymmetry

From the perspective of infringers, the digital industrial innovation environment provides them with extremely low behavior costs and considerable economic benefits, constituting the economic incentive for risk generation.

First, the cost of infringement implementation has been greatly reduced. Digital technologies are characterized by replicability, easy dissemination and high spillover, making innovation achievements vulnerable to imitation and infringement 0. The replicability and low-cost characteristics of data in the process of digital transformation have fueled intellectual property infringement 0. Technological

innovation in the digital economy industry is characterized by high externalities, easy imitation and infringement, and innovation achievements are prone to «free-riding» and misappropriation 0. Compared with traditional physical products, digital products can be duplicated at a very low marginal cost without expensive production equipment and logistics investment, which greatly lowers the infringement threshold. Judicial data also show that online intellectual property infringement crimes account for 37.3% of all intellectual property infringement cases, and some cases form contact-free production and sales chains, further concealing operation costs and increasing the difficulty of investigation 0.

Table 1 – Proportion of Online Crimes in Intellectual Property Infringement Crimes in 2025

Indicators	Data	Explanation
Number of cases involving online implementation	3,408 cases	Accounting for 37.3% of the total number of prosecuted cases
Characteristics of criminal chains	Contact-free production, sales, ordering and delivery	Increasing the difficulty of punishment

Second, infringement benefits have become huge. Weak protection of innovation achievements will weaken innovation expectations and R&D investment intensity, and weaken the role of digital economy in promoting industrial transformation and upgrading 0. Infringers quickly occupy the market by imitating core technologies or pirating best-selling products and seize illegal business amounts. For example, cases of infringing trade secrets have increased, and the technical information involved in some cases is worth hundreds of millions of yuan, while the cost paid by infringers to obtain such technical information is very low. In the case of Zhou and others manufacturing and selling counterfeit «Jo Malone» perfume with registered trademarks, the sales amount reached 123.5 million yuan 0. Driven by such low infringement costs and huge benefits, it has an obvious driving force for infringers from the perspective of economic rationality.

3. High Cost and Low Benefit for Rights Holders: The Practical Dilemma of Asymmetry

Contrary to infringers, rights holders face dual pressures of rising costs and loss of benefits in protecting intellectual property rights in the digital environment, leading to frustrated willingness to protect rights.

On the one hand, the cost of rights protection is high. Intellectual property infringements involving big data are highly concealed, with problems such as inconsistent protection judgment standards, difficult evidence collection and high

litigation costs 0. The digital economy has the problem of «easy infringement, difficult rights protection» 0. Rights holders need to spend a lot of manpower and material resources on evidence collection, technical appraisal and litigation. Especially in cases involving complex technologies, assistance from technical investigators and other relevant personnel is required in the handling process, increasing time and financial costs 0. In addition, due to the geographical dispersion and Internet virtuality of infringement subjects, it is difficult to recover stolen money and goods, which also increases the cost of rights protection. In 2025, 11,341 cases involving 25,160 people suspected of intellectual property infringement crimes were submitted to procuratorial organs for examination and prosecution nationwide, indicating a huge market for rights protection and great difficulty in rights protection 0.

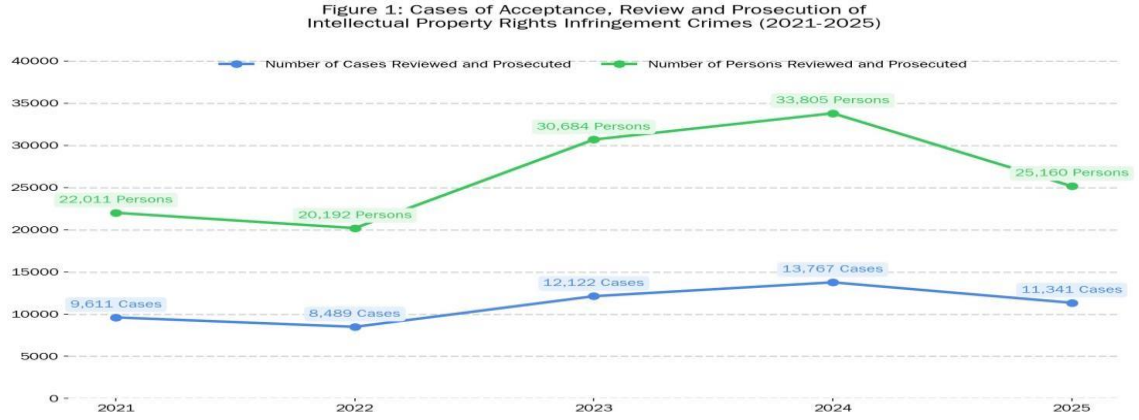

Figure 1 – Cases of Acceptance, Review and Prosecution of Intellectual Property Rights Infringement Crimes (2021-2025)

On the other hand, innovation benefits are facing the risk of loss. Enterprise innovation activities have knowledge spillover. Without effective protection, technologies are easily infringed and leaked 0. Misappropriation of innovation achievements by non-contributing enterprises will lead to a gap between innovation returns and social returns, reducing enterprises' enthusiasm for innovation 0. Weak intellectual property protection will greatly reduce innovation achievements in the pharmaceutical and chemical industries 0, indicating that when the expected returns of rights holders shrink sharply due to infringement risks, their motivation for R&D investment will be seriously weakened. Problems such as low infringement costs and great difficulty in rights protection have become important factors restricting technological innovation in the digital industry 0.

4. Asymmetry Induces Innovation Suppression and Market Failure

Such cost–benefit asymmetry directly leads to negative externalities in the innovation market. Weak intellectual property protection will reduce imitation costs, lead to widespread infringement and plagiarism, and inhibit innovation investment 0. When more and more people «free-ride», the R&D achievements invested by «pioneers» cannot get due rewards, and even be driven out of the market, the market mechanism will fail. While promoting technological progress, the development of

digital economy will also lead to problems such as «free-riding» and dampen the enthusiasm of innovators 0[0]. In the long run, it will hinder the breakthrough of key core technologies, is not conducive to the development of new-quality productive forces, and ultimately harm public interests and national competitiveness 0.

5. Governance Paths to Correct Asymmetry

Based on economic analysis, the key to governing intellectual property infringement risks is to reconstruct the cost–benefit structure, raise infringement costs, reduce rights protection costs, and protect innovation benefits.

First, raise infringement costs and implement punitive damages. Strengthening intellectual property protection can increase the cost of infringement and violations, and reduce the risk of innovation achievements being infringed 0. The proportion of civil public interest litigation cases in which procuratorial organs filed claims for punitive damages has increased year by year, reaching 43.8% in 2025 0. Through high fines and compensation, infringers are made to pay economic costs far higher than their illegal gains, so as to deter infringement motives.

Second, reduce rights protection costs and improve judicial relief channels. Procuratorial organs reduce rights protection costs and alleviate the litigation burden of rights holders by guaranteeing rights holders to file criminal incidental civil litigation. In 2025, 898 cases were guaranteed for rights holders to file criminal incidental civil litigation, accounting for 9.8% of the total, effectively reducing the financial burden of rights holders to file separate civil litigation 0.

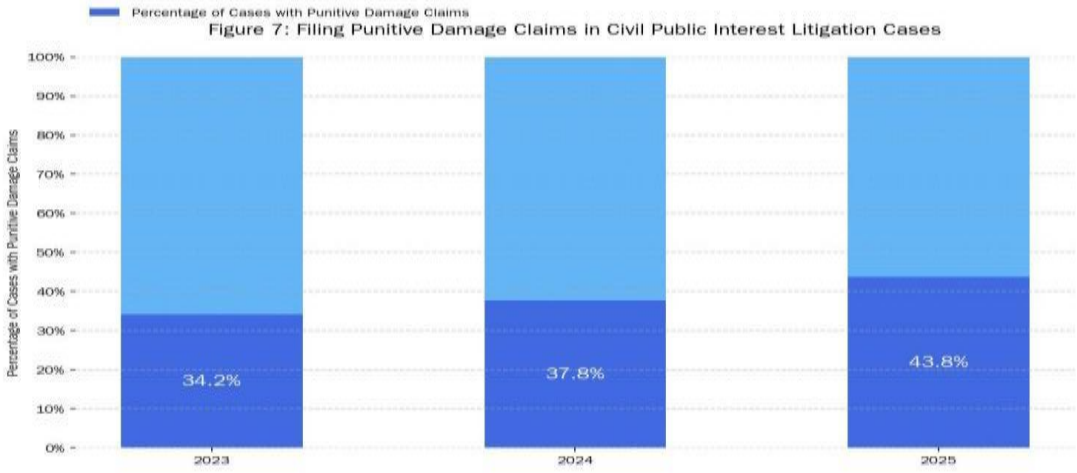

Figure 2 – Filing Punitive Damage Claims in Civil Public Interest Litigation Cases

Establish mechanisms for rapid acceptance and classification of claims, launch the «Green Channel for Intellectual Property Protection Involving Enterprises», and shorten the rights protection cycle of rights holders. At the same time, technologies such as blockchain and artificial intelligence are used to build intellectual property rights protection platforms to solve the problems of difficult evidence collection,

fixation and identification, and realize timely protection and efficient rights protection 0.

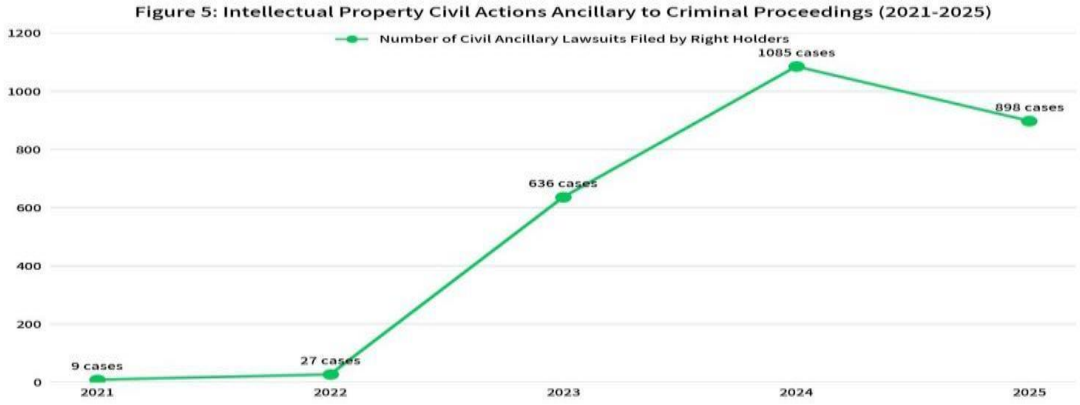

Figure 3 – Intellectual Property Civil Actions Attached to Criminal Proceedings (2021-2025)

Third, protect innovation benefits and strengthen comprehensive protection effectiveness. Improving intellectual property protection can effectively stop infringements, protect innovation profits, and create a good innovation environment 0. Procuratorial organs have strengthened asset recovery to recover economic losses for enterprises and ensure that innovation achievements are transformed into actual economic benefits. For example, in the case of Wang Jia, Wang Yi and other three people infringing trade secrets, the procuratorial organs facilitated the infringer to compensate the rights holder more than 58 million yuan, resolving civil disputes and recovering economic losses in one package 0. Intellectual property protection can improve the economic return of innovation, incentivize enterprise R&D investment, and form a virtuous cycle of innovation 0. Only when the innovation benefits of rights holders are firmly guaranteed can the economic incentives for infringement risks be fundamentally eliminated and the sustainable development of digital industrial innovation be realized.

6. Conclusion

The risk of intellectual property infringement in digital industrial innovation is essentially a cost–benefit structural imbalance caused by technological changes. Digital technologies reduce infringement costs and amplify infringement benefits, while pushing up rights protection costs and eroding innovation benefits, forming an asymmetric pattern that inhibits innovation. Economic analysis shows that only by repairing the asymmetry through institutional regulation, raising infringement costs through punitive damages, reducing rights protection costs through criminal incidental civil litigation and technology empowerment, and protecting innovation benefits through comprehensive protection and asset recovery, can the equilibrium of innovation incentives be rebuilt. This is not only a practical need to improve judicial

relief for intellectual property rights, but also an inevitable choice to escort the high-quality development of digital economy and cultivate new-quality productive forces.

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UDC (338.24:336.76)

DIGITAL TRANSFORMATION AND COMPLIANCE MANAGEMENT OF SPORTS LOTTERY: MARKET IMPACTS AND FUTURE PROSPECTS UNDER THE BELT AND ROAD INITIATIVE

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Annotation. Against the background of global digital economy and China–Kazakhstan economic cooperation within the Belt and Road framework, this paper examines compliance sales management in China's sports lottery from legal, economic, social and technological dimensions. Using case studies from Qinghai, Shenzhen, Shanghai and other regions, it analyzes how digital supervision, big data monitoring and artificial intelligence training reshape market order, improve resource allocation and enhance public trust. The study constructs an institutional–technological–cultural integrated framework for sustainable development, providing

implications for cross-border financial regulation, digital governance and responsible gaming cooperation between China and Kazakhstan.

Key words: Economic Dimension, Institutional Restraint, Multidimensional Market, Social Dimension, Digital-Driven Future Prospects.

1. Introduction

Rapid expansion of the sports lottery market has raised concerns about irregular sales such as unauthorized online platforms, external terminals and sales to minors. Strict regulation based on the Lottery Regulations has become essential to maintain public trust and financial stability. Meanwhile, digital transformation drives innovation in supervision tools and mechanisms, aligning with global trends in financial governance and cross-border economic cooperation. This paper explores the market impacts of compliance management and future prospects linked to digital economy, investment policy and international trade under the Belt and Road Initiative [1, 2, 3].

2. Multidimensional Market Impacts of Compliance Sales

2.1 Legal Dimension: Institutional Restraint and Order Reconstruction

Compliance management clarifies rights and obligations of sales agencies under a unified legal framework. Practices in Shenzhen show zero-tolerance enforcement against illegal internet lottery and unlicensed vendors reduces violations and stabilizes public welfare funds. Tianjin's intelligent monitoring and manual inspection system cut complaints by 40% and improved regulatory efficiency by 30% in 2025, demonstrating that digital legal governance lowers systemic risk [4, 5].

2.2 Economic Dimension: Resource Allocation and Industrial Value

Qinghai's all-product, all-channel compliance strategy optimizes network structure and raises sales of compliant outlets by 15% annually, 8 percentage points above the average. Ningxia's responsible lottery practices lifted the public welfare fund contribution rate to 35% while reducing social costs from excessive betting, achieving Pareto improvement of economic and social benefits.

2.3 Social Dimension: Trust Building and Consumer Behavior

Shanghai's research indicates that every 10% improvement in compliance increases consumer trust by 12% and encourages repeated purchases. Sichuan's strict ban on underage sales and betting limits reduced related complaints to zero and cut negative incidents by 60%, easing conflicts between public welfare and speculative risks.

3. Digital-Driven Future Prospects

3.1 Technological Empowerment: Intelligent Supervision Systems

Blockchain enables tamper-proof record-keeping, and big data supports real-time anomaly detection, achieving minute-level response. AI assistants provide personalized legal consulting, risk alerts and scenario training, replacing formal one-size-fits-all programs.

3.2 Institutional Innovation: Multi-Stakeholder Co-Governance

A government-industry-public supervision triangle is formed by drawing on Ningxia's multi-party cooperation model. Compliance is embedded into product design, channel expansion and marketing, shifting governance from ex post punishment to ex ante prevention [6].

3.3 Cultural Renewal: Responsible Lottery Consensus

Compliance culture campaigns and rational-buying mini-programs promote entertainment-oriented participation, strengthening the social foundation of responsible sales.

4. Conclusions and Implications for International Cooperation

Compliance management in sports lottery represents a systematic project of institution, technology and culture, with short-, medium- and long-term effects of ordering, restructuring and value upgrading. For China–Kazakhstan cooperation under the Belt and Road, shared experience can strengthen digital financial regulation, risk management and cross-border service trade. Policy suggestions include accelerating unified legislation, building national big data platforms and upgrading tiered training systems.

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UDC (338.4)

FROM RESORSE DEPENDENCE TOWARD EFFICIENCY-DRIVEN CAPABILITY: AI AND SUSTAINABILITY IN ENERGY ENTERPRISES

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Annotation. This paper argues that beneath these operational improvements lies a less examined shift: the accumulation of enterprise capabilities that may reduce the structural vulnerabilities inherent in resource dependence. Drawing on three Chinese energy cases from 2025, the paper demonstrates how AI-driven efficiency gains can, under certain conditions, translate into durable organizational capabilities.

Key words: Energy Dependence, Efficiency-driven, Production Optimization, Operation and Maintenance Management, Trading Operation.

Resource-based enterprises face a fundamental sustainability paradox: competitive advantage derives from resource ownership, yet this dependence creates structural vulnerability. Price cycles, reserve depletion, and substitution risks threaten long-term viability. These threats share a common feature: the enterprise cannot control them. Can such enterprises cultivate capabilities independent of the resources they own?

AI's rapid penetration into energy operations provides a window for examining this question. AI applications have delivered tangible efficiency gains.

Analytical Framework: From Resource Dependence to Efficiency-Driven Capability. Resource-dependent growth derives value from the resource itself — volume extracted and grade processed. Its viability rests on endowments the enterprise cannot control: price cycles, depletion, and substitution risks. This exposure constitutes the core unsustainability of the resource-enterprise model.

An alternative logic rests on what this paper terms efficiency-driven capability: organizational capabilities emerging as byproducts of sustained efficiency-seeking behavior. Unlike resource-based advantages, these are learned rather than endowed. They include: data governance capacity (integrating fragmented operational data into enterprise-wide assets), knowledge codification capacity (converting engineers' diagnostic experience into transferable algorithmic models), and human-AI collaboration capacity (redefining decision boundaries between human judgment and algorithmic recommendations). Once established, these capabilities can be redeployed across different assets and functions. Unlike physical assets, organizational capabilities are learned routines that are not bound to specific equipment or sites. This is precisely what dynamic capability theory terms

«reconfigurability» (Teece et al., 1997) — the ability to transfer existing competences to new contexts. Ayoub & Sopuru (2026) provide empirical evidence that AI-enabled dynamic capabilities exhibit precisely this property, with performance effects that propagate across business functions.

AI occupies a catalytic role. No algorithm creates oil. But AI accelerates the shift from resource dependence toward efficiency-driven capability by improving operational efficiency while compelling the organizational learning through which these capabilities are acquired.

Empirical Cases: Efficiency Gains from AI Applications. Three cases from China's energy sector illustrate how AI enhances operational efficiency.

Production optimization. At Dalian West Pacific Petrochemical, an AI-driven real-time optimization system reduced process parameter fluctuation variance by over 40% while increasing aviation kerosene and diesel yields by 0.86%, with optimization efficiency improving over 80% compared to manual methods. Annual benefits reached approximately 68.6 million yuan (China Chemical Industry News, 2025; Dalian Daily, 2025). The significance lies in improved resource conversion efficiency: identical crude inputs generate higher-value outputs, reducing exposure to price volatility.

Maintenance operations. Longyuan Power, one of China's largest wind power operators, deployed its "Qingyuan" large language model across nine regions. Fault resolution time fell from four days to four hours — a 95% improvement — while report generation accelerated by 80% and inspection labor hours decreased by 60%. Equipment availability increased from 90% to over 95% (China Energy News, 2025). AI enables a technology multiplier effect: larger asset bases managed by leaner teams, with expert knowledge embedded in algorithms.

Trading operations. Longshine Technology launched its "Jiugong" AI energy model. In 2025, it supported transactions exceeding 6 billion kWh — threefold year-on-year growth — with load forecasting accuracy reaching 97% and price prediction accuracy exceeding 90% (CCTV, 2025; Xinhua News, 2025). Transaction scale expanded without proportional headcount growth. AI-assisted decision-making extends the frontier of decision-making beyond the real-time processing capacity of human traders.

Across the three cases — production, maintenance, and trading — a common pattern emerges: efficiency gains precede and enable capability accumulation.

From Efficiency to Capability: Mechanisms and Conditions. Efficiency improvements alone do not constitute sustainable transformation. Three mechanisms enable the transition from efficiency to durable capability. First, AI-driven efficiency lowers breakeven thresholds, expanding the survival zone during price downturns. Second, pursuing efficiency compels organizational learning: integrating fragmented data builds data governance capacity; converting engineers' experience into training data builds knowledge codification capacity; human-AI collaboration capacity, which

defines the respective domains of human judgment and algorithmic decision-making. Third, superior efficiency-driven capabilities become a competitive moat over time.

However, three conditions determine whether efficiency translates into capability. First, data should be integrated across departments. If production, equipment, and trading data remain locked in separate silos, AI can only optimize narrow fragments, enterprise-wide capability cannot be built. Second, AI usage cannot depend on a few technical champions. If the capability resides in a few individuals, it leaves when they do. AI should be embedded into routine decision processes, and the organization should tolerate mistakes when its recommendations are followed and prove wrong. Third, performance metrics should reflect efficiency, not just volume. If a plant manager is measured only on tons produced, there is no incentive to invest in data integration or knowledge codification. Currently, these conditions remain incompletely met. Efficiency is improving and capabilities are accumulating, but the threshold from episodic gains to durable capability has not yet been crossed.

Three conclusions emerge. First, AI enables resource enterprises to reduce structural dependence by improving efficiency and building transferable capabilities. Second, three Chinese energy cases demonstrate measurable gains in production, maintenance, and trading — micro-level evidence of enhanced sustainability. Third, converting efficiency into durable capabilities requires enterprise-wide data integration, institutionalized learning, and aligned metrics — conditions that remain incompletely met. The pathway beyond resource dependence is incremental and conditional, yet AI illuminates a direction worthy of continued attention. For Belt and Road economies such as Kazakhstan, where resource dependence remains a structural feature, AI-driven efficiency capability building may offer a pathway worth exploring through bilateral cooperation.

Resource endowments are subject to depletion, price volatility, and technological substitution. What persists over time is the organizational capability that enterprises develop through sustained efficiency-seeking. An economy dependent solely on its resource base faces inherent temporal limits. In contrast, an economy whose firms have cultivated efficiency-driven capabilities can maintain performance across fluctuating resource cycles. Such capabilities cannot be mandated by macro-level policy; they should be accumulated at the micro-level, one firm at a time. Thus, micro-level capability building is a necessary foundation for the macro-level sustainability of resource-dependent economies.

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UDC (338.242.2:330.341.1:004)

POLICY-DRIVEN EVOLUTION OF INNOVATION ECOSYSTEMS IN HIGHLY REGULATED DIGITAL INDUSTRIES

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Annotation. Highly regulated digital industries are critical for integrating the digital economy and public services. Drawing on innovation ecosystem theory, evolutionary economics, and policy-driven analysis, this study develops a four-in-one framework and a four-stage progressive evolution model. Using internet medicine, medical big data, and medical imaging AI as empirical cases, we analyze 41 authoritative policy texts (2012–2025) — including national strategies, regulatory measures, and payment rules — and industry data from credible institutions to identify evolutionary patterns and driving mechanisms. Findings indicate that the ecosystem evolves through four phases: Pilot Exploration, Standard Establishment,

Scale Expansion, and High-Quality Development. Transitions between stages are driven by the dynamic coordination of policy, technology, payment, and market demand. All three cases validate the model, with evolution closely aligned with policy milestones. Accordingly, we provide targeted implications for China–Kazakhstan digital health cooperation under the Belt and Road Initiative.

Key words: innovation ecosystem; policy-driven evolution; highly regulated digital industries; internet medicine; medical big data; China–Kazakhstan cooperation.

The digital economy has emerged as a key engine of global growth. In 2024, China's core digital industries accounted for over 10% of GDP [1]. Highly regulated sectors such as internet medicine integrate digital attributes with public welfare, supported by policy and technological advancements. China's internet medicine market - encompassing online diagnosis, telemedicine, and digital health management - expanded from 325 billion yuan (2017) to 422 billion yuan (2024), driven by early telemedicine pilots (2012) and the 2025 Beijing online first-visit pilot [2, 3].

Against the backdrop of the Belt and Road Initiative, China–Kazakhstan digital cooperation is deepening. Kazakhstan's Digital Kazakhstan 2030 strategy identifies digital health as a priority, targeting 60% coverage of remote areas with telemedicine services by 2030 [4]. However, Kazakhstan lacks mature regulatory experience in digital medical industries, and existing research offers limited cross-border comparative perspectives and multi-case validation. This study addresses this gap.

Theoretically, this research constructs a policy-centered four-stage evolution model that accounts for regulatory constraints in public service-oriented industries, expanding the application scenario of innovation ecosystem theory. Practically, it provides decision-making support for China–Kazakhstan digital health cooperation and the high-quality development of digital health sectors.

Theoretical framework and evolution model

Highly regulated digital industries are policy-dominated sectors with public welfare attributes, strict government supervision, and clear public service orientation (e.g., digital medical care, digital education). Innovation ecosystem is a dynamic collaborative network involving governments, enterprises, medical institutions, payment institutions, and users, with policy as the core guiding factor.

The four-in-one analytical framework includes:

Subject layer: Government (regulator), service providers (enterprises/hospitals), payment institutions (medical insurance), users (patients).

Resource layer: Medical data, digital technology, capital investment.

Rule layer: Industrial policies, medical insurance payment rules, data security standards.

Value layer: Medical service efficiency, public health welfare, industrial sustainable development.

The innovation ecosystem in highly regulated digital industries follows a policy-driven progressive evolution path. Stage transitions are guided by policy, enabled by technological innovation and payment mechanism improvement, and pulled by market demand.

Table 1. Four-Stage Progressive Evolution Model of Innovation Ecosystems

Stage	Time Period	Core Features
Pilot Exploration	2012–2017	Early telemedicine pilots; self-payment; basic internet tech; isolated data systems
Standard Establishment	2018–2019	Formal policy systems; AI medical device approval; initial data standardization
Scale Expansion	2020–2024	Epidemic-driven policy support; comprehensive insurance coverage; 5G+AI application
High-Quality Development	2025–present	Beijing online first-visit pilot; value-based payment; secure standardized data sharing

Empirical analysis

This study uses 41 authoritative policy texts (2012–2025) screened by excluding duplicates, local non-core documents, and invalid drafts. Industry data includes market size, number of internet hospitals, medical imaging AI penetration rate, and big data maturity indicators from credible institutions [3, 13]. Empirical cases include the Beijing online first-visit pilot, medical imaging AI (radiological auxiliary diagnosis), and big national medical data platforms.

Pilot Exploration (2012–2017): Policies focused on encouraging local trials. Telemedicine services were launched in major hospitals, while medical data remained scattered across isolated systems. Medical imaging AI was limited to laboratory research. By 2018, only 55 internet hospitals existed nationwide, with services fully self-paid [15].

Standard Establishment (2018–2019): The issuance of Opinions on «Internet Plus Healthcare» clarified the policy system and access rules [14]. Medical insurance began covering online follow-up services, and national medical data standards were initially established. The first batch of medical imaging AI devices obtained official approval, with 148 internet hospitals operating by the end of 2019 [15].

Scale Expansion (2020–2024): Epidemic-related policies strongly supported large-scale online medical services [15]. Insurance coverage expanded to chronic disease management [12], and 5G+AI technologies were widely applied — medical big data supported epidemic prevention, and imaging AI entered routine clinical practice. By March 2021, the number of internet hospitals exceeded 1,100 [15], and the market size reached 422 billion yuan in 2024 [3].

High-Quality Development (2025–present): The 2025 Beijing online first-visit pilot broke through traditional service bottlenecks [2]. AI deeply empowered clinical diagnosis, medical big data realized secure standardized sharing, and radiological auxiliary diagnosis AI was included in medical insurance. The penetration rate of large medical models in radiological imaging auxiliary diagnosis reached nearly 40% [13]. All three cases confirm the four-stage evolution path, with each transition closely linked to policy, technology, and payment milestones.

Implications for China–Kazakhstan cooperation

China possesses mature experience in policy system construction, technological application, and ecological governance [5, 15]. By 2024, internet medicine services covered 80% of county-level regions. Kazakhstan boasts strong market demand, clear strategic support from the Digital Kazakhstan 2030 plan, and sound data security laws [4].

Targeted Cooperation Suggestions:

Short term (1–2 years): Strengthen policy experience exchange; launch cross-border telemedicine pilots in border regions.

Medium term (3–5 years): Jointly construct medical big data platforms adhering to both countries' data security standards; promote the export and localization of China's imaging AI technology.

Long term (5+ years): Co-develop cross-border digital medical service standards; explore cross-border medical insurance settlement mechanisms.

Conclusion

Innovation ecosystems in highly regulated digital industries follow a clear policy-driven four-stage evolution path: Pilot Exploration → Standard Establishment → Scale Expansion → High-Quality Development. Transitions between stages depend on the dynamic coordination of policy, technology, payment, and market demand. This model is validated by three empirical cases (internet medicine, medical big data, medical imaging AI). Under the Belt and Road Initiative, China and Kazakhstan have complementary advantages in digital health cooperation. Strengthening policy experience sharing, technical collaboration, and cross-border standard alignment is expected to facilitate the sustainable development of cross-border digital health. Future research can extend to other highly regulated fields such as digital education and digital governance.

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UDC (338.2)

RESEARCH ON INNOVATION POLICIES AND INVESTMENT EFFICIENCY OF DIGITAL ECONOMY DRIVING GREEN ECONOMIC DEVELOPMENT

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Annotation. Against the background of high-quality economic development, the deep integration of the digital economy and the green economy has become a key pathway toward sustainable growth. Digital technologies such as big data, artificial intelligence, and blockchain have demonstrated significant potential in green production, carbon accounting, and energy management. However, a notable

efficiency gap persists between policy design and investment implementation. Focusing on innovation policies, investment efficiency, and green economic performance, this paper proposes improvement pathways based on theoretical mechanisms, practical challenges, quantitative frameworks, and policy optimization, aiming to enhance the effectiveness of the digital economy in driving green development.

Key words: digital economy; green economy; innovation policy; investment efficiency

Introduction

With the transition to high-quality economic development, green and low-carbon transformation has become a central strategic priority. Digital technologies such as big data, artificial intelligence, and blockchain are rapidly evolving, and their applications in energy monitoring, carbon accounting, smart energy systems, and green production are expanding continuously. These developments provide strong technological support for the advancement of the green economy.

However, despite these advancements, the integration of digitalization and green transformation remains insufficient. There is a clear efficiency gap between policy design and actual investment outcomes. Key challenges include the low effectiveness of policy instruments, weak interdepartmental coordination, inconsistencies between the scale and efficiency of green investment, and insufficient incentives for the application of digital technologies in green sectors. Therefore, studying innovation policies and investment efficiency in the context of digital economy-driven green development is of both theoretical and practical importance.

The integration of the digital and green economies is supported by several theoretical frameworks. The concept of the green economy emphasizes the balance between economic growth and environmental sustainability, focusing on low resource consumption, low emissions, and high efficiency. Sustainable development theory highlights the importance of meeting present needs without compromising the ability of future generations to meet their own needs. At the same time, technological innovation and policy incentive theories underline the role of innovation as a key driver of industrial upgrading and efficiency improvement, while effective policy tools help reduce costs, correct market failures, and guide capital toward environmentally sustainable sectors.

Digital technologies contribute to green economic development through multiple mechanisms. First, they enhance resource allocation efficiency by reducing waste and improving coordination across production, circulation, and consumption processes. Second, they promote industrial transformation by enabling traditional industries to adopt low-carbon and intelligent production models. Third, they improve environmental governance through real-time monitoring and early warning systems based on IoT and artificial intelligence. Fourth, digital tools increase investment

efficiency by reducing information asymmetry and improving project evaluation and risk management. Finally, the development of data as an economic asset enables the valuation and monetization of environmental data, creating incentives for green investment. As shown in Figure 1, the level of digitalization is directly associated with improvements in green investment efficiency.

In China, the scale of green investment has expanded significantly in recent years, driven by both policy support and market demand. Financial instruments such as green credit, green bonds, and ESG investments are developing rapidly, while investment in clean energy and low-carbon technologies continues to grow steadily [1]. Government policies increasingly emphasize the coordinated development of digitalization and greening, forming a comprehensive framework to support green innovation and guide investment [2]. Digital applications such as smart grids, intelligent manufacturing, and environmental data platforms are becoming more widespread, strengthening the role of digital technologies in green economic development.

Despite these positive developments, several practical challenges remain. The effectiveness of digital infrastructure varies significantly across regions, creating a threshold effect in investment efficiency. Regions with strong industrial foundations and advanced digital capabilities benefit more from digital investments, while less developed regions face resource misallocation and lower returns. These regional differences are presented in Table 1.

Table 1 – Regional differences in digital green investment efficiency

Region Type	Digital Infrastructure	Investment Efficiency	Key Characteristics
Developed regions	High	High	Strong industry base, advanced data governance
Transitional regions	Medium	Moderate	Partial digital adoption
Less-developed regions	Low	Low	Weak infrastructure

Source: compiled by the author based on [1, 2]

In addition, the application of advanced technologies such as generative artificial intelligence remains limited, resulting in high uncertainty and low success rates in green investment projects. Policy tools also show uneven effectiveness, with excessive focus on hardware investment and insufficient attention to standardization and data governance. Furthermore, the absence of a unified framework for evaluating cross-regional investment efficiency leads to suboptimal resource allocation. The lack of a comprehensive system for valuing green data assets weakens market incentives, while incomplete risk management mechanisms discourage private capital participation.

The overall mechanism of how digital technologies influence green economic development is illustrated in Figure 1.

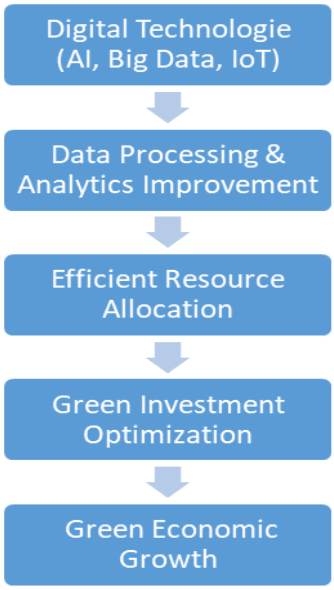

Figure 1 – Mechanism of digital economy driving green development
Source: compiled by the author

To address these issues, several policy optimization pathways can be proposed. Green investment should be aligned with regional characteristics and digital readiness. The application of artificial intelligence should be expanded to improve decision-making accuracy. Policy frameworks must prioritize standardization and governance systems over simple financial subsidies. In addition, the development of green data asset markets and improved risk management mechanisms are essential for attracting private capital and ensuring sustainable investment.

Conclusion

The digital economy serves as a crucial driver of high-quality green economic development. Although initial progress has been achieved, significant challenges remain, particularly the efficiency gap between policy design and investment implementation. This study demonstrates that regional disparities in investment efficiency are influenced by differences in digital infrastructure and industrial capacity, while emerging technologies such as artificial intelligence can improve outcomes.

In the future, it is necessary to strengthen the integration of digital and green development strategies, improve policy coordination, and enhance investment efficiency mechanisms. The formation of a market-driven system for green investment, supported by digital technologies, will be essential for achieving carbon neutrality goals and ensuring sustainable economic growth.

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UDC (338.24)

TECHNOLOGICAL-EMPLOYMENT TRANSFORMATION UNDER THE NEW MODEL OF GLOBAL GROWTH: MECHANISM FOR JOB STABILIZATION, TALENT DEVELOPMENT AND TALENT RESHAPING LED BY PARTY BUILDING IN STATE-OWNED ENTERPRISES

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Annotation. Driven by artificial intelligence, automation and demographic structural change, the new model of global growth is profoundly reshaping factor allocation in traditional industries. The superposition of the capital-labor substitution effect and workforce aging exerts a structural shock on labor-intensive enterprises such as environmental sanitation services. Taking the Bioenergy Recycling Branch of a Shanghai Waste Disposal Co., Ltd. (hereinafter «Bioenergy») as a case, this paper analyzes the mechanism of job stabilization and talent reshaping led by Party building in state-owned enterprises (SOEs) in the course of digital transformation.

Key words: new model of global growth; digital economy; Party building in state-owned enterprises; internal labor market; human resources.

1. Introduction

Current global economic growth is in a phase of accelerated coordinated transformation toward digital technology and demographic structure. Artificial intelligence and automation raise total factor productivity (TFP) while inevitably generating skill-biased technological change (SBTC), thereby inducing structural unemployment risk. Population aging and the contraction of the working-age population further intensify the skill gap. As an industry combining public services and market competition, environmental protection is inevitably subject to the triple constraints of efficiency improvement, green transition and employment security during transformation.

2. Constraints Under the New Model of Global Growth and the Leading Role of Party Building

2.1 Dual Constraints of Technology and Demography

Under the new global growth model, technological innovation may reduce the marginal product of labor in the short run due to capital deepening. The «Automation and New Tasks» model by Acemoglu and Restrepo (2019) shows that automation directly displaces routine manual labor, while newly created tasks require matching high-skilled labor. Coupled with the trend of machine substitution for labor driven by population aging, low-skilled labor faces an accelerating risk of marginalization.

2.2 Party Building in SOEs as an Institutional Buffer

In the Coasean theory of the firm, technological change raises the renegotiation cost between labor and capital. Party building in SOEs is not merely a political activity but a «bond» embedded in corporate governance to reduce frictions. On the one hand, Party organizations alleviate employees' psychological discount toward technological substitution through value reshaping; on the other hand, they provide professional non-market compensation mechanisms based on digitalization, effectively mitigating social problems arising from market-oriented layoffs.

3. Practical Mechanism of «Party Building + Digital Transformation»

3.1 Structural Mismatch Between Supply and Demand for New Position

Competencies

As the largest wet waste treatment project in East China, Bioenergy faces job anxiety caused by automation in the shift from labor-intensive to digital-intelligent operation. The mismatch between employees' existing capabilities and new job requirements, combined with skill gaps and psychological concerns, cannot be eliminated by market-oriented training alone due to psychological barriers.

3.2 Party Building Leading to Mitigate Skill Polarization

In response to job polarization marked by shrinking operational posts and growing information and central control positions, the company adheres to no external layoffs and achieves smooth internal job transfer through an internal labor reservoir mechanism. The Party branch strengthens political leadership and organizational cohesion, closely aligning corporate transformation goals with employees' personal development, and gives full play to the fighting fortress role of Party organizations and the exemplary vanguard role of key Party members. First, the Party secretary conducts heart-to-heart talks and grassroots visits to listen to employees' demands, ease ideological concerns and build confidence in transformation. Second, the company implements «one-on-one» and «many-to-one» precise mentoring by Party members, signs mentoring agreements and clarifies training objectives. Third, a talent incubation room is established, adopting digital training, VR simulation, 3D printing and other diversified learning models to enhance employees' human-machine collaboration capabilities, and realizing flexible job conversion through cross-line rotation and auxiliary position adaptation [1].

A mechanism combining incentives and constraints is established simultaneously, linking skill improvement and position adaptation directly to salary distribution and performance evaluation, forming a full-process closed-loop management to ensure orderly technological substitution and a «soft landing» for employees.

4. Governance Effectiveness of Synergy Between Digital Transformation and Party Building

4.1 Smooth Transition, Expansion and Quality Improvement of Employment Structure

The company has not only achieved a 100% smooth transition for employees affected by the pandemic but also transcended the zero-sum game of machine substitution for labor. Meanwhile, the completion and operation of Phase III has realized a generational technological leap. The cluster deployment of new technologies such as the digital twin management platform, precise deodorization and full-process automation raises higher requirements for automatic control accuracy and data analysis capabilities, directly generating rigid demand for a number of high-skilled positions. Led by Party building, technological dividends are transformed into an engine for employment expansion. Through AI-assisted and offline simultaneous interviews, the company recruited more than 50 new employees and introduced one high-tech doctoral talent across regions between 2020 and 2025.

4.2 Dual Upgrading of Total Factor Productivity and Human Resources

The introduction of digital technologies has broken the traditional manual operation mode. Digital drivers such as intelligent scheduling and automatic sorting have significantly improved material circulation and energy conversion efficiency, effectively verifying the substitution effect of digital capital on traditional labor and its output-boosting effect. Meanwhile, relying on the «Party Building + Project» matrix, the company has achieved a structural leap of human capital from labor-intensive to digital-skill-intensive, and cultivated a group of interdisciplinary talents for intelligent operation and maintenance [2].

Table 1 Productivity Effects of Digital Transformation at Bioenergy

Transformation Project	**Transformation Project**	**Stability Improvement**
Automatic intelligent sorting	100%	Centralized control scheduling; single-line processing cycle shortened by 20%
Intelligent security system	-	Material waiting time reduced by 40% monitoring
QR code point-to-point inspection	-	Faster uploading of inspection information

5. Long-Term Path for SOEs to Lead Talent Development in the Digital Economy Era

Given continuous technological change, SOEs need to build a long-term governance mechanism. Break the low-end lock-in of the environmental sanitation industry, continuously invest in intelligent equipment and algorithm models, and build a full data closed loop from the «physical layer» to the «decision-making layer». Transform the mobilization of Party organizations into a pillar of internal training, establish a linked evaluation system of «skill level – salary incentive – political honor», and guide employees to take the initiative to resolve skill mismatches.

In the tension between efficiency and equity, standardize the process of «job transfer training – skill compensation – position restructuring», closely integrate Party building assessment with employment stabilization, internally absorb the negative externalities of technological change, and truly achieve inclusive growth.

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UDC (339.5)

TRADEDIGITAL ECONOMY ENABLES SUSTAINABLE DEVELOPMENT OF CHINA-KAZAKHSTAN AGRICULTURAL COOPERATION UNDER THE BELT AND ROAD INITIATIVE

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Annotation. Under the framework of the «the Belt and Road» initiative, agricultural cooperation has become a key pillar of economic and trade exchanges between China and Kazakhstan, with remarkable achievements in recent years. This paper focuses on the practice and development of China-Kazakhstan agricultural cooperation, analyzes the complementary advantages of the two countries in agricultural resources, technology and market, explores the role of digital economy in promoting bilateral agricultural cooperation, and uses data charts to visualize the growth trend of agricultural trade and investment. Finally, it puts forward targeted suggestions to further deepen bilateral agricultural cooperation, providing reference for the high-quality development of China-Kazakhstan economic and trade relations under the background of digital transformation.

Key words: Economic and Trade Relations; China-Kazakhstan Agricultural Cooperation; Cross-border Trade; Digital Transformation.

1. Introduction

As a core cooperative partner of China in Central Asia, Kazakhstan has a long history of agricultural cooperation with China. With the in-depth advancement of the «the Belt and Road» initiative(BRI), the two countries have further strengthened policy coordination, resource complementarity and technological exchanges in the agricultural field, forming a win-win cooperation pattern covering planting, breeding, processing, logistics and other links. In recent years, the digital transformation of the global economy has brought new opportunities for bilateral agricultural cooperation. The application of digital technologies such as artificial intelligence, Internet of Things and big data has effectively solved the pain points of low efficiency, backward technology and inconvenient circulation in traditional agricultural cooperation, injecting new vitality into the sustainable development of China-Kazakhstan agricultural cooperation. This paper sorts out the current situation of China-Kazakhstan agricultural cooperation, analyzes the role of digital drive, and puts forward relevant suggestions based on actual data, so as to provide support for deepening bilateral agricultural cooperation. Based on the research framework of Xu,

W.C. (2024), this study focuses on the practice of China-Kazakhstan agricultural cooperation and explores the enabling effect of the digital economy under the BRI framework [1].

2. Complementary Advantages and Current Situation of China-Kazakhstan Agricultural Cooperation

Kazakhstan, known as the «granary of Central Asia», possesses superior agricultural conditions, with approximately 70% of its land suitable for agriculture and animal husbandry, and abundant in crops such as wheat, cotton; in the first half of 2024, Kazakhstan's total agricultural output value reached approximately 3.4 billion US dollars, representing a year-on-year increase of 3.4%. Within this, the livestock sector contributed approximately 3.2 billion US dollars, while crop cultivation accounted for approximately 200 million US dollars [2]; however, its agricultural modernization level remains relatively low, characterized by outdated machinery, limited adoption of advanced technologies, and low production efficiency, which constrains the sector's development. In contrast, China has mature experience in agricultural technology, machinery manufacturing, water-saving irrigation, and agricultural product processing, along with strong advantages in the R&D and application of digital agricultural technologies, as well as a vast consumer market that provides broad opportunities for the export of Kazakhstan's agricultural products. The complementary advantages of the two countries in agricultural resources, technology, and markets have laid a solid foundation for deeper agricultural cooperation. In recent years, China-Kazakhstan agricultural cooperation has shown a steady growth trend, with expanding scale and diversification of fields. In terms of trade, the total agricultural trade volume maintained rapid growth, reaching USD 1.4 billion in 2024, a year-on-year increase of 10%; in the first five months of 2025, trade volume reached USD 736.9 million, up 36% year-on-year, of which Kazakhstan's exports to China grew 35% to USD 513.4 million. Key Kazakh exports to China include feed, vegetable oil, and wheat, with feed exports surging 485% year-on-year in 2024 to 1.2 million tons, and vegetable oil rising 26% to 173,300 tons. In investment, there are four Chinese-funded agricultural projects in Kazakhstan, with a total investment of approximately USD 2.8 billion, covering planting, processing, animal husbandry, and agricultural logistics. Additionally, the two countries have deepened cooperation in agricultural technology R&D and promotion—for example, the first China-Kazakhstan Agricultural Technology and Export Development Science and Technology Park was established in North Kazakhstan region, focusing on new variety breeding, digital and automated applications, and deep processing of agricultural products. China's water-saving drip irrigation technology has also been widely adopted in Kazakhstan, contributing to increased yields of crops such as sugar beets.

3. The Role of Digital Economy in Promoting China-Kazakhstan Agricultural Cooperation

The digital economy has become a new driving force for China-Kazakhstan economic and trade relations. The application of technologies like the Internet of Things and precision agriculture has enhanced farming efficiency. For example, at a joint agricultural base in North Kazakhstan, soil testing and digital monitoring systems have enabled a shift from «relying on weather» to «relying on technology». China's smart farm machinery has also been introduced, boosting productivity and supporting agricultural modernization in Kazakhstan. Logistics digitization has improved cross-border agricultural trade. Leveraging the China-Europe Railway Express, a digital logistics system has shortened transport time to under ten days and increased annual trade volume significantly. Cross-border e-commerce platforms further provide direct sales channels, reducing intermediaries and raising product value. Digital tools also foster agricultural technology exchange. Remote training, joint research, and digital courses are now common. The China-Kazakhstan Agricultural Technology Park, for instance, has introduced 32 Chinese crop varieties for trial planting and helps local farmers master advanced techniques through online training, enhancing overall agricultural capacity.

4. Analysis of China-Kazakhstan Agricultural Cooperation Data (2020-2025)

To objectively and intuitively reflect the development trends and growth characteristics of China-Kazakhstan agricultural cooperation under «the Belt and Road» initiative, this article compiles core data on bilateral agricultural product trade from 2020 to 2025. The data is presented in a table format, complemented with textual analysis to uncover underlying patterns.

Table 1 Core Data on Bilateral Agricultural Product Trade, 2020-2025

Year	Total Agricultural Product Trade Volume (in USD 100 million)	Year-on-year growth rate	Kazakhstan's Export Value to China (in USD 100 million)	Kazakhstan's Export Share to China
2020	8.5	—	6.2	72.9%
2021	9.8	15.3%	7.3	74.5%
2022	11.2	14.3%	8.5	75.9%
2023	12.7	13.4%	9.8	77.2%
2024	14	10.2%	11.0	78.6%
2025	17.68	26.3%	12.32	69.7%

Data source: General Administration of Customs of the People's Republic of China. 2020—2025 Statistical Data on Agricultural Import and Export between China and Kazakhstan [4].

Based on the tabular data and related trade details, the development features of China-Kazakhstan agricultural cooperation can be analyzed from three dimensions:

First, the scale of bilateral agricultural trade continues to expand, demonstrating strong growth resilience. From 2020 to 2024, the total trade volume increased from $850 million to $1.4 billion, with a cumulative growth of 64.7% and an average annual growth rate of 13.2%. The trade volume in 2025 is projected to exceed $1.7 billion, with a year-on-year growth rate accelerating to 26.3%, indicating a stage of rapid expansion.

Second, the trade structure exhibits a pattern of «Kazakhstan-led exports supplemented by Chinese supplies». Between 2020 and 2024, Kazakhstan's agricultural exports to China grew from $620 million to $1.1 billion, an increase of 77.4%, with its share of total bilateral trade consistently exceeding 72% and peaking at 78.6% in 2024. This confirms China as a core export market for Kazakhstan's agricultural products, with agricultural exports becoming a key driver of bilateral economic cooperation. In 2025, Kazakhstan's export share is expected to slightly decrease to 69.7%, reflecting a more balanced trade structure as China's exports of agricultural machinery and supplies to Kazakhstan increase.

Third, the growth momentum of key export products is significant, with cooperation focusing on core areas. From 2023 to 2024, Kazakhstan's feed exports to China surged by 485%, while vegetable oil exports increased by 26%. During the period from September 2024 to April 2025, grain exports (primarily wheat and barley) grew by 27% year-on-year, accounting for 42.3% of Kazakhstan's total agricultural exports to China. Meanwhile, China's exports of agricultural machinery and irrigation equipment to Kazakhstan reached $180 million in 2024, a year-on-year increase of 31%, effectively addressing equipment gaps in Kazakhstan's agricultural modernization and forming a mutually complementary trade structure.

5. Challenges in China-Kazakhstan Agricultural Cooperation

China-Kazakhstan agricultural cooperation has achieved progress yet faces three main challenges: limited digital transformation, persistent cross-border inspection barriers, and underdeveloped high-value-added processing.

To address these, four policy directions are proposed: advancing digital agricultural collaboration through technical support and training; updating bilateral inspection protocols to streamline customs processes; expanding joint processing to extend value chains; and strengthening policy coordination with enhanced investment support, fostering a more conducive environment for sustained bilateral cooperation.

6. Conclusion

Under BRI framework, leveraging their complementary strengths in agricultural resources, technology, and markets, China and Kazakhstan have achieved remarkable results in agricultural cooperation. The digital economy has played a vital role in optimizing agricultural production efficiency, enhancing the circulation efficiency of agricultural products, and promoting technological innovation in agriculture, thereby injecting new momentum into the sustainable development of bilateral agricultural

collaboration. Data show that trade in agricultural products between the two countries has grown steadily, with the scope of cooperation continuously expanding. In the future, by strengthening cooperation in digital technologies, streamlining customs clearance procedures, and expanding collaboration in high value-added processing, China and Kazakhstan can further deepen their agricultural partnership. This will enable both sides to achieve mutual benefit and make greater contributions to the high-quality development of bilateral economic and trade relations.

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FROM RESOURCES TO KINETIC ENERGY: AN ANALYSIS OF THE PATHWAY FOR BIG DATA-DRIVEN INTELLIGENT TRANSFORMATION IN MANUFACTURING

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Annotation. From the point of view of the digital economy, this study provides a three-step theoretical framework covering "information resources - information assets - data-driven momentum." Using the example of the BOE Technology Group and the NAURA Group, two manufacturing enterprises in the electronic industry where the author works, we analyze the internal mechanisms and ways to implement intelligent transformations in production based on big data. The study shows that BOE is optimizing manufacturing operations with its "Blue Whale Display Large

Model" and AI-powered factories, while NAURA is creating a closed ecosystem from research and development to service delivery through its twin-engine "intelligent manufacturing + data middleware" strategy. These companies are an example of two different paradigms of using big data in production: a process-oriented approach and a product-oriented approach. Based on the results of the case study, the document describes a transformation path encompassing technological integration, organizational adaptation, and ecosystem synergy, as well as recommendations on data management, optimizing staff structures, and institutional support systems.

Key words: Big data; Intelligent transformation of manufacturing industry; Electronic information industry; Data elements; BOE; NAURA.

I. Introduction

The explicit inclusion of data as a factor of production is a promising institutional innovation formed by China based on the development of its digital economy [1]. The Chinese government's work report for 2026 clearly states: "The potential of information technology is increasingly being revealed, and the added value of the main sectors of the digital economy is more than 10.5% of GDP." Nevertheless, in the context of the digital landscape, the digital transformation of production still faces noticeable disadvantages: the transformation mainly consists in the fact that these factors affect productivity. The main focus is on intelligent production processes, which makes it difficult to effectively disseminate and apply data in practice and thus does not lead to tangible development results, which has become an urgent practical problem that needs to be addressed in the industry [2].

In this study, the BOE Technology Group and Hua Chuang Group, subsidiaries of the same parent company, were selected as examples based on two key considerations: both companies occupy key positions in the electronics supply chain, specializing in displays and integrated circuit equipment, respectively, and demonstrate typical characteristics of industries that require large amounts of data.; In addition, their transformation models correspond to process-oriented manufacturing and product-oriented manufacturing, respectively, offering significant comparative value. By analyzing their big data implementation practices, this article aims to clarify the basic logic of how big data contributes to value creation in production, and explore viable ways to transform data resources into a growth momentum.

II. Theoretical Logic of Big Data-Driven Manufacturing Transformation

(I) Value Creation Mechanism of Data Elements

Existing research generally divides the process of enterprise data valorization into two major stages: data assetization and data valorization. The former completes the transformation of raw data into standardized and usable assets, while the latter achieves the practical conversion of data assets into operational benefits. The «Guidelines for Typical Scenarios of 'Data Elements X' in the Industrial Manufacturing Sector» released by the China National Data Bureau further points out that data elements empower value creation in manufacturing through three core

pathways: intelligent upgrading of production operations, product innovation and service-oriented transformation, and integrated development of industrial and supply chains [3]. These three aspects are not in a unidirectional progressive relationship but are mutually coupled and synergistically empowered, collectively constructing a comprehensive system for multidimensional value creation in manufacturing.

(II) A Three-Stage Framework from «Data Resources» to «Data Momentum»

Drawing on manufacturing industry development practices, this study categorizes data-driven industrial transformation into three progressive stages: infrastructure development, chain integration, and closed-loop formation [4]. The first stage focuses on establishing a data resource system through comprehensive data aggregation and standardized governance to ensure data accessibility, applicability, and high reliability. The second stage involves optimizing data circulation mechanisms by breaking down internal and external data barriers within enterprises, transforming fragmented data resources into shareable and reusable data assets. The third stage emphasizes data value realization by deeply embedding algorithm-driven intelligent applications throughout R&D, production, supply chain management, and marketing services, ultimately forming a closed-loop industrial value system.

III. Industry Characteristics and Transformation Needs of the Electronic Information Industry

As the cornerstone and pioneering sector of the digital economy, the electronics information industry encompasses core domains such as semiconductors, display panels, and communication equipment. Its industrial characteristics—including precision manufacturing processes, massive production line data volumes, rapid product iteration cycles, and stringent supply chain coordination requirements—create inherent compatibility with big data technologies, positioning it as a frontrunner in manufacturing digital transformation. Compared to traditional manufacturing, the electronics information industry demonstrates heightened data-driven demands in critical areas like yield control, R&D innovation, and supply chain collaboration. Conventional experience-based management models have become inadequate for meeting the high-quality development requirements of this industry.

The digital transformation of the electronic information industry currently faces significant bottlenecks, with data governance challenges being particularly prominent. Discrepancies in systems, protocols, and formats among multi-source data make cross-domain integration challenging. Quality issues such as data gaps, inaccuracies, and inconsistent statistical standards directly undermine the effectiveness of data-driven decision-making. These pain points are especially concentrated and acute within the industry.

IV. Case Study: Big Data-Driven Practices of BOE and NAURA

(I) BOE Group: AI Factory and Blue Whale Large Model

As a globally leading semiconductor display company, BOE's Fuzhou 8.5-generation production line is the only display-related «lighthouse factory» in Chinese mainland [5], serving as a significant demonstration model for digital transformation

practices. The company has established a core digital strategy based on the industry's competitive landscape, leveraging the industry-specific Blue Whale Display Industrial Large Model as its technological foundation to build an AI-powered factory that empowers the entire production process. This enables intelligent upgrades in critical areas such as smart production scheduling, yield control, and defect detection, shifting production decision-making from manual experience to model-based inference, significantly enhancing problem-solving efficiency, and facilitating the explicit representation and large-scale application of process knowledge [5].

At the levels of product innovation and corporate operations, BOE is driving the transformation of its display products into smart terminals, leveraging AI technology to significantly accelerate the R&D of new materials, while utilizing large-scale models for market analysis and supply chain risk management, thereby establishing a data-driven modern operational system. The company has formulated a substantial R&D and procurement investment plan for the next three years, with dedicated funds allocated for AI technology development, fully demonstrating its strategic commitment and determination to achieve high-quality transformation through big data-driven approaches [6].

(II) NAURA Group: Data Middle Platform and Full-Chain Closed Loop

As a leading enterprise in China's integrated circuit equipment industry, NAURA focuses its digital transformation on product research and development and technological innovation, which stands in sharp contrast to BOE's process optimization orientation. Since 2018, the company has established a dual-driven system of «intelligent manufacturing + data middle platform», coordinating data collection, governance, and sharing. By forming IT and OT integration teams and applying visual analysis tools, it has created a closed-loop data decision-making process [7]. Meanwhile, data assets have been incorporated into core strategies, with specialized governance systems established and full IoT connectivity achieved across production line equipment, laying a solid foundation for data governance from the source.

In technological R&D, NAURA has restructured its innovation model through big data analytics. By conducting in-depth mining of process data, the company achieves parameter optimization and defect prediction, driving breakthroughs in core technologies for high-end equipment while significantly shortening product development cycles. Aligning with global industry leaders, the enterprise focuses on building an independently controllable digital technology framework. It actively implements innovative applications such as process simulation and remote equipment maintenance, continuously strengthening technological autonomy and core competitiveness in advanced equipment manufacturing.

(III) Comparison and Implications of Two Transformation Paths

The practices of BOE and NAURA have established two typical paradigms for leveraging big data to empower manufacturing transformation [8]. BOE adopts a process-driven approach, utilizing AI to conduct real-time analysis and decision-

making on process-related big data within large-scale continuous production scenarios, thereby systematically optimizing production scheduling, product yield, and energy consumption while comprehensively enhancing total factor productivity. NAURA follows a product-driven model, tailored to the manufacturing characteristics of high-end equipment involving diverse product varieties and small batch sizes. By implementing a data middle platform that integrates the entire business chain, the company has upgraded its business model from equipment sales to data value-added services.

The transformation practices of these two enterprises exhibit notable commonalities. Firstly, both companies integrate digitalization efforts with holistic corporate strategies, establishing digital capabilities as their core competitive edge. Secondly, they adhere to systematic data governance while abandoning fragmented technological application models. Thirdly, they promote deep integration of data capabilities with core business operations, effectively avoiding digital formalism. These practical experiences provide valuable insights for similar manufacturing enterprises undergoing transformation and upgrading.

V. The Path System for Big Data-Driven Transformation of the Manufacturing Industry

Based on the aforementioned theoretical analysis and case studies, this paper summarizes the pathway framework for big data-driven intelligent transformation in manufacturing into three interlocking tiers.

(I) Technical Integration Path: From Data Collection to Intelligent Decision-Making

Technical embedding serves as the foundational element for intelligent transformation in manufacturing, with its core focus on equipping the entire production process with data collection, transmission, and processing capabilities to establish a data-driven intelligent decision-making system [9]. The practices of BOE and NAURA demonstrate that comprehensive equipment IoT integration, heterogeneous data fusion governance, industrial large model deployment, and digital twin system construction constitute the key technological pillars at this stage. It is crucial to clarify that technical embedding transcends mere device networking and algorithmic applications. Enterprises often encounter challenges such as inefficient data utilization and insufficient algorithmic precision. Only through deep integration of technology with production processes can enterprises achieve tangible results from technological empowerment.

(II) Organizational Adaptation Path: From «Rule by Man» to «Rule by Data»

The core constraint hindering intelligent transformation in manufacturing lies not in technological bottlenecks, but rather organizational system incompatibility. Data-driven decision-making models will compel enterprises to implement systemic reforms across organizational structures, job functions, talent systems, and incentive mechanisms. BOE's initiative to transform production managers into data analysts and NAURA's establishment of IT-OT integrated teams to break down departmental

silos both demonstrate the practical value of organizational transformation. Based on the author's professional experience, the key to digital transformation success lies in organizational acceptance of data-driven decision-making authority. The conflict between algorithmic decisions and human expertise fundamentally requires deep structural adjustments in corporate power dynamics. Transitioning from experience-based «rule by man» to data-driven «rule by numbers» demands not only managerial role redefinition but also comprehensive optimization of internal institutional frameworks.

(III) Ecological Synergy Path: From Corporate Silos to Industrial Networks

The author contends that the value-added potential of big data can ultimately be realized through collaborative optimization across the industrial chain. Secure and trustworthy sharing of core data—including inventory levels, production capacity, and logistics information—among upstream and downstream players drives the transformation of industrial collaboration models from traditional linear chains to networked, parallel, real-time coordination. This characteristic is particularly evident in the electronics and information industry: data interoperability between panel manufacturers and end-product suppliers, as well as between integrated circuit equipment manufacturers and wafer fabs, has enhanced delivery efficiency and enabled preventive equipment maintenance. Meanwhile, the continuous advancement of new infrastructure such as industrial internet big data centers provides robust institutional and technical foundations for coordinated data utilization across industries.

VI. Challenges and Countermeasures

While big data has significantly empowered the intelligent transformation of manufacturing industries, the sector still faces multiple practical challenges: enterprises generally possess ample data reserves but lack standardized governance systems for data security and compliance, there is insufficient supply of interdisciplinary process data professionals, and the long-term high investment in digitalization coupled with difficulties in quantifying short-term returns directly impacts corporate transformation decisions. To address these issues, the author proposes three optimization strategies: elevating data governance to corporate strategic levels to establish end-to-end lifecycle management systems; deepening industry-academia-research collaboration to cultivate interdisciplinary industrial-data talents; and implementing scientific ROI evaluation mechanisms with scenario-based phased implementation approaches. Adopting BOE's pilot validation model featuring value reuse and gradual scaling proves far more robust and feasible compared to reckless large-scale one-off investments.

VII. Conclusion

Big data-driven intelligent transformation of manufacturing represents the inevitable path for high-quality development in the digital economy era. The practices of BOE and NAURA demonstrate that this transition involves not superficial equipment upgrades or technological replacements, but systematic restructuring of

technical architecture, organizational models, and industrial ecosystems. The value conversion of data—from resources to assets and then to growth drivers—requires strategic top-level design, scenario-based implementation, and coordinated support from technological innovation and institutional frameworks.

Looking ahead, as the «AI+» initiative gains deeper implementation and industrial internet infrastructure continues to improve, big data's empowering role in manufacturing will become increasingly prominent. However, it is crucial to recognize that the core value of technology lies in addressing operational pain points and creating tangible value, rather than the technology itself. China's manufacturing sector still faces a long and arduous journey toward intelligent transformation. The key challenge lies not in achieving technological breakthroughs, but in steadily advancing transformation practices with long-term vision to achieve sustainable industrial upgrading.

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OVERCOMING BORDER BOTTLENECKS: A CASE STUDY OF DIGITAL CUSTOMS INTEGRATION ON THE KAZAKHSTAN-CHINA ROUTE

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Annotation. Logistics efficiency along the Kazakhstan-China corridor is no longer just a matter of physical tracks but of data velocity. This paper examines the practical impact of AI-driven platforms—specifically «Keden» and «TezCustoms» - on cross-border trade under the «One Belt, One Road» initiative. Moving beyond theoretical benefits, we analyze empirical data showing a radical compression of processing times and a corresponding surge in transit volumes. The results underscore that digital integration, rather than just infrastructure expansion, is now the primary engine of sustainable economic cooperation in Central Asia.

Key words: Digital Logistics; Customs Integration; Cross-Border Trade; Middle Corridor; Belt and Road Initiative.

Introduction

In today's trade environment, the competitive edge of a land bridge depends as much on its bit-rate as its freight-rate. For Kazakhstan, the geographic heart of the «One Belt, One Road» initiative, modernizing the transport sector has shifted from a policy goal to a survival necessity. While the Kazakhstan-China route offers the fastest overland link between East and West, it has historically been choked by manual customs hurdles and data silos. This study focuses on how recent digital breakthroughs are dismantling these bottlenecks, specifically within the Khorgos Gateway and the Trans-Caspian International Transport Route (TITR).

The Evolution of Digital Customs Infrastructure

The departure from the legacy «Astana-1» system marks a watershed moment for Kazakhstan's border management. Launched in 2024, the «Keden» platform was not merely an upgrade; it introduced high-performance server clusters capable of running machine learning algorithms for automated risk assessment. This was further sharpened in 2026 with the deployment of «TezCustoms». Unlike previous iterations, these systems prioritize pre-arrival data processing, allowing for a «green light» environment where human intervention is the exception rather than the rule [1].

Case Study Analysis: Efficiency Gains and Throughput

The shift from administrative friction to digital flow is most evident at the China-Kazakhstan border points. As illustrated in Figure 1, the data from 2026 reveals a paradigm shift: the average processing time for a standard freight consignment has plummeted from 8 hours to a mere 30 minutes—a 93.7% gain in operational velocity.

Additionally, the «Middle Corridor» (TITR) benefits from secure VPN channels enabling rapid, cross-border document transmission. This specific upgrade reduced container inspection times from 9 hours to just 40 minutes. The direct correlation between decreased transit delays and increased trade volume is clearly observable in recent throughput metrics [2].

As depicted in Figure 2, the enhanced digital environment has stimulated a significant surge in transit traffic. During the first quarter of 2026, the number of container trains transiting the Middle Corridor reached 125, representing a robust 34.4% increase compared to the 93 trains recorded in the same period in 2025.

Additionally, it should be noted that the achieved efficiency gains have a multiplier effect on the entire logistics ecosystem of the region. The reduction in cargo processing time enables operators to increase rolling stock turnover, optimize schedules, and make more efficient use of infrastructure capacity. This, in turn, lowers transportation costs and makes the route more attractive to international shippers.

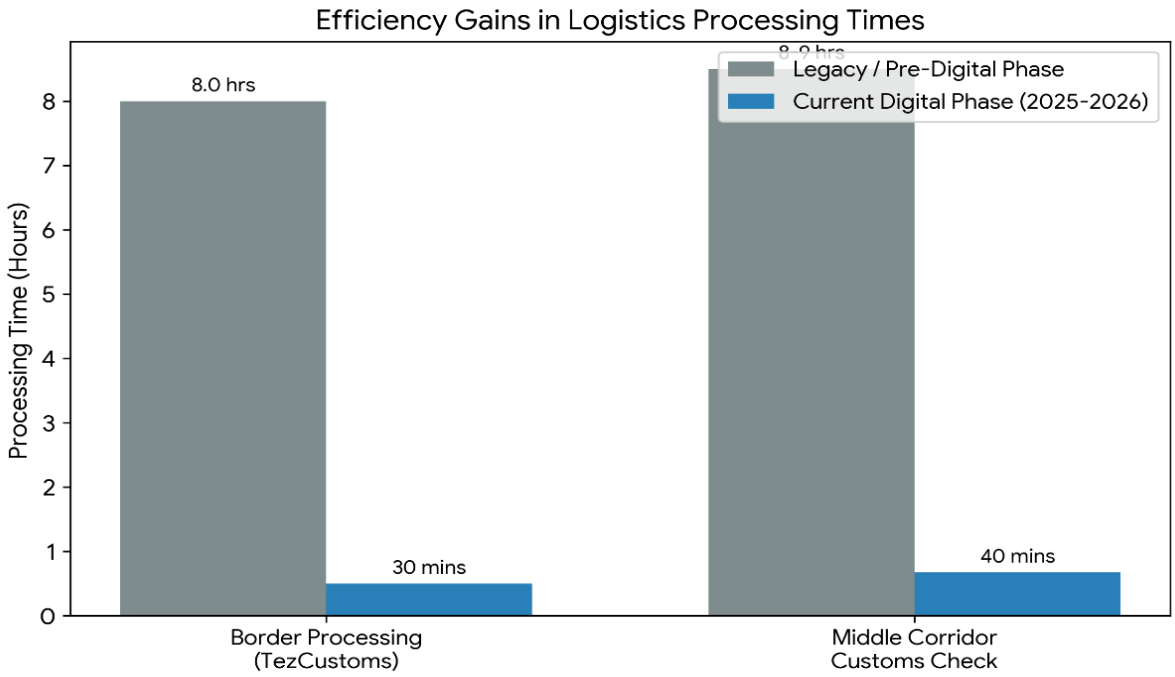

Figure 1. Efficiency gains in logistics processing times before and after digital transformation

Equally important is the improvement in the predictability of logistics processes. Thanks to digital platforms, supply chain participants gain access to real-time

information on cargo status. This reduces uncertainty, simplifies planning, and allows companies to respond more quickly to potential disruptions or route changes.

A positive impact is also observed in the investment attractiveness of the transport corridor. Increased transparency and operational efficiency create favorable conditions for attracting private capital and developing related infrastructure, including logistics hubs, terminals, and warehousing facilities. This contributes to strengthening the region's role as a key transit node between East and West.

In the long term, maintaining positive momentum will depend on the consistent implementation of new digital solutions and the expansion of international cooperation. The harmonization of standards, integration of information systems, and further automation of processes will become key factors for sustainable growth in transit capacity and the overall competitiveness of the route [3].

Consequently, the overall container traffic along the TITR surged by 36% in 2025, pushing total freight transit across the country to a sustainable 36.9 million tons. These metrics empirically validate that digital transformation is not merely an administrative upgrade, but a primary driver of operational throughput.

Conclusion

The digitalization of the Kazakhstan-China trade route offers a robust, scalable model for international logistics transformation. Integrating AI-driven customs platforms like Keden and TezCustoms has successfully converted traditional bottlenecks into high-speed transit corridors. For the continued success of the «One Belt, One Road» initiative, these technological advancements are essential to maintaining global supply chain competitiveness. Future strategic development should prioritize the complete regional standardization of electronic documents to catalyze deeper economic cooperation [4].

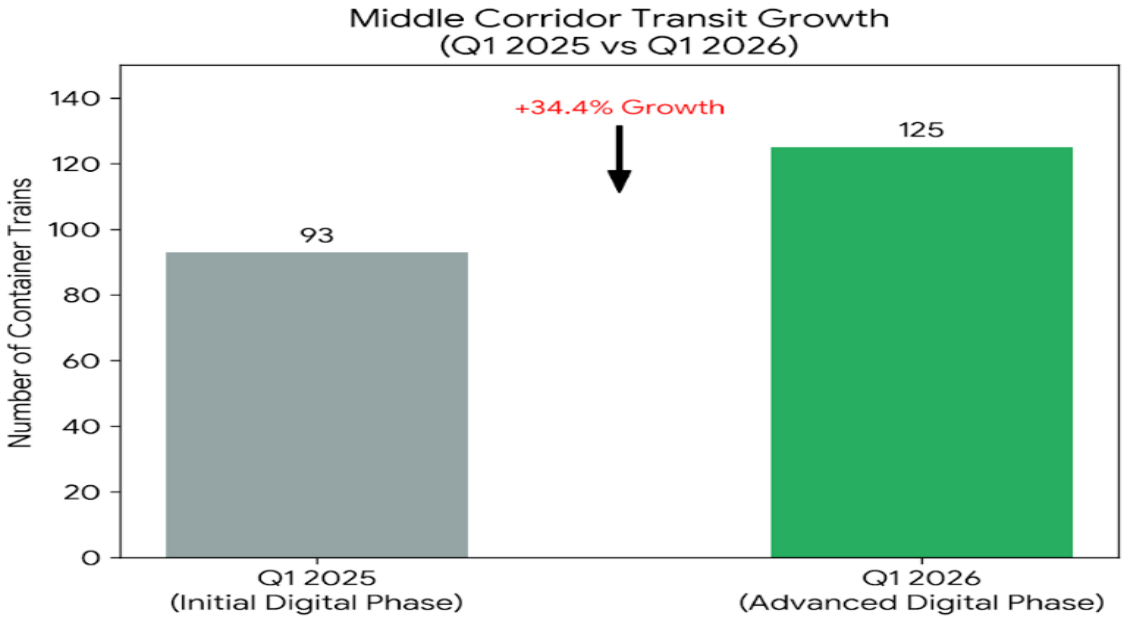

Figure 2. Growth in Middle Corridor container train transit
(Q1 2025 vs. Q1 2026)

In addition to the above, it should be emphasized that the digital transformation of customs and logistics procedures contributes not only to accelerating operations but also to reducing administrative barriers for participants in foreign economic activity. Process automation minimizes the human factor, reduces errors, and increases the level of trust between partner countries.

Particular importance is attached to the synchronization of information systems between Kazakhstan and China, which ensures seamless real-time data exchange. Such integration creates a unified digital space in which the transparency of cargo flows is enhanced and control over their movement is strengthened. As a result, risk management becomes more effective and business costs are reduced.

Moreover, the implementation of intelligent platforms opens up new opportunities for analytics and forecasting. The use of big data makes it possible to more accurately assess trade flow dynamics, identify potential bottlenecks, and make timely management decisions. This makes the logistics system more adaptive to external economic changes.

An important aspect is also the environmental dimension of digitalization. Route optimization, reduced idle time, and increased transportation efficiency contribute to lowering carbon emissions and reducing environmental impact. Thus, the development of digital solutions aligns with the principles of sustainable development.

In the future, further deepening of digital integration may serve as a foundation for expanding cooperation with other Central Asian countries and beyond. The dissemination of successful practices from Kazakhstan and China will create the prerequisites for establishing a unified Eurasian digital logistics system capable of ensuring a high level of connectivity and global competitiveness for the region.

Thus, the comprehensive implementation of digital technologies in logistics and customs administration acts as a key factor for long-term economic growth. The consistent realization of these initiatives will not only strengthen Kazakhstan’s position as a transit hub but also enhance the overall efficiency of international trade.

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UDC (004.8:330.34:502.131.1)

THE ROLE OF ARTIFICIAL INTELLIGENCE IN ACCELERATING THE TRANSITION TO A GREEN AND INCLUSIVE DIGITAL ECONOMY: CHALLENGES AND PROSPECTS FOR KAZAKHSTAN

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Annotation. This article examines the role of artificial intelligence (AI) as a transformative driver in accelerating the transition toward a green and inclusive digital economy, with a particular focus on Kazakhstan. The study explores how AI contributes to environmental sustainability through applications in energy efficiency, smart resource management, precision agriculture, and industrial optimization. It also analyzes AI's potential to foster inclusive economic development by expanding access to financial services, healthcare, and education, especially for underserved and rural populations. Special attention is given to Kazakhstan–China cooperation within the framework of the Digital Silk Road, highlighting opportunities for technology transfer, infrastructure development, and joint innovation in AI applications. At the same time, the paper identifies key risks associated with AI deployment, including algorithmic bias, environmental costs of computing, labor market disruptions, and data governance challenges. The research emphasizes the necessity of a comprehensive policy framework that integrates digital infrastructure development, human capital investment, ethical standards, and international cooperation. The article concludes that while AI holds significant promise for achieving sustainable development goals, its impact will depend on effective governance, strategic partnerships, and the equitable distribution of technological benefits.

Key words: artificial intelligence, green economy, digital economy, sustainable development, inclusive growth, Kazakhstan, Digital Silk Road, environmental sustainability, AI governance, financial inclusion.

Introduction.

The contemporary global economy stands at a critical juncture where technological innovation and sustainability imperatives converge. Artificial intelligence, as a general-purpose technology, is increasingly recognized not simply as an instrument of productivity enhancement but as a foundational element in the transition toward sustainable economic models. The United Nations Sustainable Development Goals for 2030 encompass 17 interconnected objectives that demand transformative changes in production, consumption, and governance patterns

worldwide. Within this context, AI technologies offer capabilities that extend far beyond conventional automation. They enable real-time environmental monitoring, predictive resource management, intelligent infrastructure optimization, and data-driven policymaking that collectively hold the potential to reconcile economic growth with ecological boundaries and social equity considerations. The Republic of Kazakhstan, as the largest economy in Central Asia and an active participant in China's Belt and Road Initiative, occupies a unique position to capitalize on AI-driven sustainable development. This paper investigates the specific mechanisms through which AI contributes to green economic transition and inclusive growth, analyzes the opportunities presented by Kazakhstan-China digital cooperation, and identifies the policy prerequisites for maximizing AI's sustainable development dividend while mitigating its attendant risks.

AI and the Green Economy: Mechanisms of Environmental Sustainability. The environmental dimension of sustainable development arguably presents the most urgent challenge for contemporary economies. Climate change, biodiversity loss, and resource depletion threaten to undermine decades of economic progress. AI technologies address these challenges through multiple channels. In the energy sector, machine learning algorithms enable smart grid management systems that balance supply and demand in real time, integrating intermittent renewable sources such as solar and wind power with greater efficiency than conventional control systems. Google's DeepMind, for instance, reduced the cooling energy consumption of data centers by 40 percent through AI-optimized control of cooling systems, demonstrating the substantial efficiency gains achievable through intelligent automation. In the industrial domain, AI-powered predictive maintenance systems anticipate equipment failures before they occur, reducing downtime, extending asset lifespans, and minimizing the resource waste associated with premature replacement and emergency repairs. Furthermore, computer vision and sensor fusion technologies facilitate automated sorting in recycling facilities, substantially increasing material recovery rates and reducing contamination in recycling streams. In agriculture, which accounts for approximately 10 percent of Kazakhstan's GDP, AI-driven precision farming represents a transformative opportunity. Satellite imagery analyzed by deep learning models can assess crop health at the individual plant level, enabling targeted application of water, fertilizers, and pesticides. This reduces chemical runoff into water systems, lowers greenhouse gas emissions from excess fertilizer decomposition, and conserves scarce water resources in Kazakhstan's arid and semi-arid regions. The cumulative environmental impact of such applications, when deployed at scale, could significantly accelerate Kazakhstan's progress toward its nationally determined contributions under the Paris Agreement.

AI and Inclusive Economic Development: Bridging Divides. Sustainable development is inherently incompatible with persistent inequality. AI possesses significant potential to democratize economic opportunity, though this outcome is contingent upon deliberate policy design. In the financial inclusion domain, AI-based

alternative credit scoring models utilize non-traditional data sources such as mobile phone usage patterns, utility payment histories, and social network characteristics to assess creditworthiness for individuals lacking formal banking relationships. This expands access to capital for small entrepreneurs and rural populations who have historically been excluded from formal financial systems. In Kazakhstan, where rural residents constitute approximately 40 percent of the population and face significant barriers to financial services, AI-enabled fintech solutions could unlock substantial latent economic potential. In healthcare, AI diagnostic support systems extend specialist-level diagnostic capabilities to primary care settings in remote regions. Deep learning models trained on medical imaging data can detect pathologies such as tuberculosis, diabetic retinopathy, and certain cancers with accuracy comparable to experienced radiologists. For a country with Kazakhstan's geographic expanse and uneven distribution of medical specialists, telemedicine platforms augmented by AI triage and diagnostic assistance could substantially improve health outcomes while reducing the cost and travel burden associated with accessing specialist care. In education, adaptive learning platforms powered by AI personalize instructional content to individual students' proficiency levels and learning styles. Such systems have demonstrated effectiveness in improving educational outcomes in underserved communities across multiple countries. Kazakhstan's ongoing digitalization of its education system, coupled with AI-powered adaptive learning tools, could help bridge the persistent urban-rural educational attainment gap. The gig economy and digital labor platforms, while presenting regulatory challenges regarding worker protections, also create income-generating opportunities accessible to individuals regardless of geographic location, provided adequate digital infrastructure exists.

The Belt and Road Digital Silk Road: Kazakhstan-China AI Cooperation. The Belt and Road Initiative has evolved beyond its initial focus on physical infrastructure to encompass the Digital Silk Road, emphasizing telecommunications networks, data centers, smart city technologies, and digital services. Within this framework, Kazakhstan-China cooperation on AI presents mutually beneficial opportunities. China has emerged as a global leader in AI research output, patent filings, and commercial deployment, with companies such as Baidu, Alibaba, Tencent, and Huawei investing heavily in AI capabilities spanning natural language processing, computer vision, autonomous systems, and cloud AI services. Kazakhstan possesses complementary advantages: abundant renewable energy potential to power energy-intensive AI computing infrastructure, a strategic location as a transit hub between China and European markets, and a young, increasingly digitally literate population. Concrete cooperation areas include joint development of AI-powered logistics optimization systems for the trans-Eurasian rail corridors that traverse Kazakhstan, reducing transit times and carbon emissions from freight transport. Smart agriculture collaborations could adapt Chinese AI farming technologies to Kazakhstan's specific climatic conditions and crop patterns. Smart city partnerships could deploy AI for traffic management, energy efficiency, and public safety in

Kazakhstan's rapidly urbanizing centers such as Astana and Almaty. Capacity-building initiatives, including joint research programs, scholarship exchanges, and vocational training in AI-related disciplines, would support Kazakhstan's development of indigenous AI talent and reduce technological dependency. However, such cooperation must be structured to ensure genuine technology transfer, data sovereignty protection, and alignment with Kazakhstan's national development priorities rather than purely serving external commercial or strategic interests.

Risks, Challenges and Governance Imperatives. The deployment of AI for sustainable development entails significant risks that demand proactive governance. Algorithmic bias represents a fundamental concern: AI systems trained on historical data may perpetuate or amplify existing social inequalities if training data reflects historical discrimination patterns. In credit scoring, biased algorithms could systematically disadvantage particular demographic groups, contradicting the inclusive growth objective. The environmental footprint of AI itself warrants scrutiny. Training large-scale deep learning models consumes substantial computational resources and electricity. A 2019 study estimated that training a single large natural language processing model could emit as much carbon dioxide as five automobiles over their entire lifetimes. As AI adoption expands, the aggregate energy consumption of AI infrastructure could become environmentally significant unless powered by renewable energy sources. Labor market disruption constitutes a further challenge. While AI creates new employment categories, the transition may be painful for workers in automatable occupations. Without adequate reskilling programs and social safety nets, AI-driven automation could exacerbate inequality and generate political resistance to technological adoption. Data privacy and cybersecurity concerns are magnified in AI systems that aggregate and analyze vast quantities of personal and sensitive data. Kazakhstan must develop robust data protection legislation and enforcement capacity commensurate with its AI ambitions. Addressing these challenges requires a comprehensive national AI governance framework encompassing ethical guidelines, regulatory standards, impact assessment requirements, and multi-stakeholder oversight mechanisms. International cooperation on AI governance standards, particularly through platforms such as the Belt and Road Initiative and the Shanghai Cooperation Organization, can help Kazakhstan benchmark its approaches against emerging global norms while asserting its specific national interests.

Conclusion and Recommendations. Artificial intelligence constitutes a powerful but double-edged instrument for sustainable economic development. Its capacity to optimize resource utilization, democratize access to essential services, and enable data-driven environmental management positions AI as potentially transformative for achieving the SDGs. Kazakhstan, through strategic deployment of AI technologies and constructive cooperation with China within the Belt and Road framework, can accelerate its transition toward a green, inclusive digital economy. However, realizing this potential demands more than technological acquisition. It requires an integrated

policy approach encompassing investment in digital infrastructure and renewable energy, substantial commitments to education and workforce reskilling, development of robust data governance and AI ethics frameworks, and proactive measures to ensure equitable distribution of AI-generated benefits. Future research should prioritize the development of metrics and methodologies for systematically assessing the net sustainability impacts of specific AI applications. Longitudinal studies tracking the employment, environmental, and distributional effects of AI deployment in emerging economy contexts would provide an evidence base for adaptive policymaking. Comparative analyses of AI governance approaches across Belt and Road Initiative participating countries could identify transferable best practices. Ultimately, AI's contribution to sustainable development will be determined not by technological capabilities alone but by the wisdom of the policies, institutions, and international partnerships that shape its development and deployment. Kazakhstan's choices in the coming years will significantly influence whether AI serves as a genuine driver of broad-based sustainable prosperity or merely reinforces existing patterns of uneven development.

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UDC (338.4)

RESEARCH ON THE MECHANISM OF SERVICE INDUSTRY TRANSFORMATION AND UPGRADING DRIVEN BY DIGITAL PLATFORM EMPOWERMENT AND DATA ELEMENT FLOW

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Annotation. In the context of the deep integration of the digital economy and the real economy, the transformation of traditional service industries into modern service industries is the core task for the high-quality development of the industry. Digital platforms serve as the organizational carrier, and data elements are the core production factors. The synergy between these two elements constitutes the key driving force for the transformation and upgrading of the service industry. This study is based on the theory of the digital economy and the logic of industrial upgrading, and deeply analyzes the internal mechanism and transmission path of the dual-drive transformation of the service industry. It systematically sorts out the current practical problems and proposes optimization strategies. The research results show that digital platforms achieve carrier empowerment through resource integration and ecosystem construction, and data elements release value through efficient circulation. Together, they form a complete transmission chain. Currently, the transformation of the service industry faces problems such as insufficient platform collaboration efficiency, barriers in data circulation, insufficient integration of business models, and lagging governance systems. To address these issues, measures such as platform integration, marketization of elements, integration of business models, and improvement of governance systems need to be implemented to promote the transformation of traditional service industries into modern service industries that are digitalized, integrated, and high-end.

Key words: Digital platform; Data element; Transformation and upgrading of service industry; Synergistic drive; Marketization of elements.

I. Introduction

Digital technology has fully permeated various industries. As a pillar industry of the national economy, the transformation efficiency of the service sector directly affects the effectiveness of the modern industrial system. According to data from the National Bureau of Statistics, in 2024, the added value of China's service industry reached 76,558.3 billion yuan, accounting for 56.7% of the GDP and contributing 56.2% to the growth of the national economy, making it the core driving force of

economic growth. However, traditional service industries still have problems such as low efficiency, single business models, and resource misallocation. Breaking through the constraints of traditional factors and organizations is the key to their transformation. Data from the China Academy of Information and Communications Technology indicates that in 2024, China's digital economy scale reached 59.2 trillion yuan, accounting for 43.8% of the GDP, and the synergy of digital platforms and data elements has become a key measure to solve the bottleneck of transformation. Digital platforms have reshaped the connection logic between service supply and demand, and data elements have restructured the value creation mechanism. The synergy of the two constitutes the core driving force for solving the transformation predicament. Most existing studies have analyzed the role of platforms or data elements separately, lacking a systematic explanation of the coordination mechanism. Based on the practice of the digital economy, this paper constructs a dual-wheel driving framework to explore the mechanism and path of service industry transformation and upgrading, providing theoretical support for the modernization development of the service industry.

II. The Theoretical Mechanism of Digital Platforms and Data Elements Driving the Transformation of Service Industries

(1) The Enabling Mechanism of Digital Platforms

Digital platforms are the core carriers for the digital transformation of service industries. Their enabling effect is manifested in three dimensions: resource integration, value creation, and boundary crossing. The digital economy reconfigures the production function through platforms, breaking down the geographical segmentation and information barriers of traditional service industries and achieving resource-intensive allocation [1]. Digital platforms drive industrial upgrading with the dual forces of technology and organization, forming a data-driven value creation model and providing organizational support for the transformation of traditional service industries [2].

The platform transforms from a transaction intermediary to an ecosystem builder, prompting the service industry to shift from a linear operation model to a networked ecological model, alleviating the «cost disease» problem and improving the operational efficiency of the industry.

(II) The Driving Mechanism of Data Elements

The realization of the value of data elements relies on efficient flow. Market-based allocation is the core driving force for the transformation of the service industry. The digital economy optimizes resource allocation through data elements and promotes the shift of service supply from being driven by experience to being driven by data [1]. Data elements facilitate the precise matching of supply and demand and the optimization of service processes, thereby enhancing the quality and efficiency of traditional service industries. They have achieved remarkable empowerment effects in fields such as culture, sports, tourism, and rural tourism [3, 4]. Data circulation breaks down industry silos, promotes cross-border integration of

elements, accelerates the upgrading of the service industry structure, and helps traditional service industries transition to modern service industries [5].

(III) The Conduction Mechanism of Dual-wheel Collaboration

Digital platforms and data elements form a complementary coupling relationship. The platform serves as the carrier for data circulation, while data is the core for platform empowerment. The platform reduces the cost of data circulation, and data enhances the efficiency of platform empowerment. The two collaborate to drive the service industry to achieve changes in efficiency, momentum, and quality [2]. The conduction path is: the platform integrates service resources → efficient allocation of data elements → innovation in service processes and business models → upgrading of the service industry structure. This mechanism has been verified in the fields of culture, sports, and tourism, as well as rural tourism [4, 5]. Digital infrastructure provides support for the conduction process and further amplifies the dual-wheel driving effect [3].

III. Realistic Challenges in the Transformation of the Service Industry

1. Insufficient coordination among platform ecosystems. The construction of service industry platforms is fragmented, with weak connectivity across industries and regions. Small and medium-sized service enterprises find it difficult to access high-quality resources, and the scale-enhancing effect of the platform is hard to be realized [1, 2].

2. Inefficient circulation of data elements. Data ownership is ambiguous, industry barriers are prominent, and circulation rules are lacking. Data silos are widespread, and the value of elements cannot be fully released, which hinders the transformation pace [1, 5].

3. Insufficient depth of business model integration. The digitalization of traditional service industries mostly stops at superficial online transformation. The integration of digital technologies and service businesses is not deep, and the cultivation of high-end business models lags behind [4, 5].

4. Lack of a collaborative governance system. Platform supervision, data security, and compatibility with transformation are insufficient. There is a lack of a unified governance framework, making it difficult to balance innovation and risks [6].

IV. Optimization Path for the Transformation and Upgrade of the Service Industry

(1) Integrating Platform Ecosystem and Strengthening Carrier Support

Break through the barriers between industry and regional platforms, build cross-domain comprehensive service platforms, and enhance the capabilities of resource integration and collaborative empowerment [1, 2]. Focus on the development of specialized platforms for productive and service-oriented industries, promote the transformation of platforms into ecosystem builders, and strengthen digital empowerment for small and medium-sized service enterprises.

(II) Improve the mechanism for data element circulation and unleash driving efficiency

Improve the systems and rules regarding data ownership, circulation, and security, remove barriers to data circulation within different industries, and promote the orderly flow of data [1, 5]. Build a public data sharing platform to facilitate the integration of government and industry data, enhance data allocation efficiency, and support the precise and high-end transformation of the service industry.

(3) Promote deep integration of business models and accelerate the transformation process

Relying on platforms and data elements, promote the deep integration of traditional service industries with digital technologies, and cultivate new business models such as intelligent services and customized services [4, 5]. Take tourism and culture, retail, and logistics as breakthrough points to create demonstration scenarios and promote the deep digital transformation of the service industry.

(4) Improve the collaborative governance system and ensure the effectiveness of the transformation

Build a unified technology governance framework, integrate the efforts of multiple entities, and improve the platform supervision and data security governance system [6].

V. Conclusion

The dual-wheel collaborative mechanism, which is formed by empowering digital platforms and facilitating the flow of data elements, has become the core driving force for the transformation of traditional service industries into modern ones. Digital platforms provide supportive infrastructure, while data elements unleash their inherent driving force. The two work together to break through the bottlenecks of traditional service industry development and achieve the goals of efficiency improvement, business model innovation, and structural optimization.

Currently, the transformation of the service industry still faces many challenges such as fragmented platforms, obstacles in data circulation, low degree of business model integration, and incomplete governance systems. We need to address these issues from four dimensions: platform integration, marketization of elements, business model integration, and governance improvement. By fully leveraging the effectiveness of the dual-wheel drive, we can enhance the efficiency of service industry transformation and achieve sustainable development.

In the future, as digital technologies continue to evolve and the reform of the marketization of elements progresses, the collaborative effect of the two will become more significant, providing lasting impetus for the high-quality development of modern service industries.

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DIGITAL ECONOMY AND «BELT AND ROAD» PERSPECTIVES: RISKS AND OPPORTUNITIES OF KAZAKH INVESTORS IN CHINA'S REAL ESTATE MARKET

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Annotation. Based on literature analysis, case study and practical work experience, this paper systematically examines the investment environment of China's real estate market for Kazakh investors during 2018–2025. The study analyzes the influence of digital transformation on investment decision-making and risk management and identifies major risks, including policy uncertainty, market differentiation, legal system differences, digital adaptation barriers, and RMB–Tenge exchange-rate fluctuations. At the same time, the paper highlights opportunities generated by the "Belt and Road" Initiative, urbanization upgrading, and digital technologies. The research finds that digital adaptation barriers represent the core challenge faced by Kazakh investors compared with other foreign investment entities, while China–Kazakhstan Digital Silk Road cooperation provides an important

mechanism for reducing these risks. Finally, the study proposes practical recommendations from the perspectives of policy coordination, portfolio optimization, digital cooperation, and financial risk hedging in order to improve the sustainability and efficiency of cross-border real estate investment.

Key words: digital economy; Belt and Road Initiative; China's real estate market; Kazakh investors; cross-border investment; investment risk; investment opportunities; risk hedging.

Introduction

As an important component of China–Kazakhstan economic cooperation under the "Belt and Road" Initiative (BRI), cross-border real estate investment has gradually become a new driver of bilateral economic interaction. Along with the acceleration of global digital transformation and the restructuring of China's real estate market, Kazakh investors are facing both significant opportunities and increasingly complex risks. Therefore, studying the investment behavior of Kazakh investors in China's real estate market under the digital economy framework has strong theoretical and practical significance.

Existing studies mainly focus on Chinese outward investment into Kazakhstan, especially in infrastructure and energy sectors, while research on reverse investment from Kazakhstan into China remains limited [1]. In addition, most analyses of foreign investment in China's real estate market focus on European, American, or Southeast Asian investors, while the characteristics of Central Asian investors are largely ignored [2]. This paper attempts to fill this research gap by combining the perspectives of digital economy and the "Belt and Road" Initiative to analyze the risks and opportunities faced by Kazakh investors.

This study adopts literature analysis, case study, and comparative analysis methods. Literature analysis is used to summarize existing research on cross-border investment, digital economy, and China–Kazakhstan cooperation. Case studies of representative Kazakh enterprises investing in China's real estate market are applied to examine practical investment experiences. Comparative analysis is employed to identify the specific characteristics of Kazakh investors compared with other foreign investors.

In recent years, with the continuous deepening of China–Kazakhstan strategic cooperation, Kazakh investment in China's real estate market has shown a stable growth trend. According to the Ministry of Commerce of the People's Republic of China, cumulative Kazakh investment in China's real estate sector reached approximately 12.8 billion yuan during 2018–2024, with an average annual growth rate of 7.2% [11]. Most investments are concentrated in first-tier cities such as Beijing, Shanghai, and Guangzhou, while an increasing proportion has also entered new first-tier cities including Chengdu and Chongqing.

Commercial real estate remains the dominant investment area, accounting for 53% of total investment. Logistics parks account for 27%, particularly in transport corridors connected with the China–Kazakhstan railway network, while long-term rental housing accounts for 20%. These trends indicate that Kazakh investors increasingly prefer assets with stable cash flow and long-term operational value.

At the practical level, several representative cooperation projects demonstrate the diversification of China–Kazakhstan real estate cooperation. In 2022, KazMunayGas invested approximately 1.5 billion yuan in cooperation with Vanke to develop a commercial complex in Shanghai. In 2023, Samruk-Kazyna participated in the construction of a logistics park in Xi'an International Trade and Logistics Park, while Astana Investment Group invested in long-term rental housing projects in Guangzhou. These cases indicate that China–Kazakhstan cooperation has gradually expanded from traditional energy cooperation toward diversified urban and industrial investment.

However, Kazakh investors also face considerable risks associated with policy adjustment and digital transformation. China's real estate market remains strongly influenced by regulatory policy. Between 2018 and 2024, more than 300 regulatory measures related to purchase restrictions, financing supervision, and commercial real estate control were introduced [12]. Such policy adjustments directly influence the financing costs and investment strategies of foreign investors.

At the same time, regional differentiation within China's real estate market has become increasingly evident. According to the 2024 China Real Estate Market Report published by Jones Lang LaSalle (JLL), vacancy rates in commercial real estate exceeded 28% in some third-tier cities, while first-tier cities maintained significantly lower vacancy levels [8]. This uneven market recovery increases the risk of asset depreciation for foreign investors.

A major challenge for Kazakh investors is the digital adaptation barrier. China's real estate industry is rapidly integrating big data, artificial intelligence, blockchain, and digital management systems into project evaluation, marketing, and risk control. However, most Kazakh investment institutions still rely on traditional investment analysis methods. Only around 35% of Kazakh investment organizations have introduced digital project evaluation tools, while less than 20% possess digital risk-management systems.

Table 1. Main Risks Faced by Kazakh Investors in China's Real Estate Market

Risk Type	Main Characteristics	Impact on Investors
Policy uncertainty	Frequent regulatory adjustments	Increased financing pressure
Market differentiation	Uneven regional market recovery	Asset depreciation risk
Legal system differences	Institutional and legal gaps	Higher transaction costs

Digital adaptation barriers	Weak digital transformation capability	Lower decision-making efficiency
Exchange-rate fluctuations	RMB–Tenge volatility	Reduced investment returns
Exit mechanism limitations	Long capital withdrawal cycle	Liquidity constraints

Digital adaptation barriers are mainly reflected in three dimensions. First, Kazakh investors often lack access to localized big-data analysis systems, which weakens project evaluation accuracy. Second, they have limited experience with digital marketing channels commonly used in China, such as livestreaming and short-video promotion. Third, most investors lack AI-based risk warning systems, reducing their ability to identify operational risks in a timely manner.

Exchange-rate risk also remains a major issue. According to the State Administration of Foreign Exchange, the fluctuation range between the RMB and Kazakh tenge reached nearly 15% during 2018–2024 [13]. Such fluctuations directly influence investment returns after currency conversion and increase uncertainty for long-term projects.

Despite these risks, the "Belt and Road" Initiative creates substantial opportunities for Kazakh investors. Bilateral investment protection agreements and cross-border cooperation zones provide preferential tax policies, simplified customs procedures, and financing support. For example, the China–Kazakhstan Horgos International Border Cooperation Center facilitates the free movement of goods, personnel, and capital within the cooperation zone.

At the same time, China's urbanization process continues to generate stable long-term demand for commercial real estate, logistics infrastructure, and rental housing. According to the National Bureau of Statistics of China, the country's urbanization rate reached 66.2% in 2024 and is expected to continue rising in the coming years [12]. Urban renewal projects and industrial upgrading also provide new investment opportunities for foreign investors.

Digital transformation further expands investment possibilities. Technologies such as blockchain, AI, and big-data analysis improve project evaluation efficiency, operational management, and financial supervision. Smart property management systems can significantly reduce operational costs and improve project efficiency. Therefore, digital transformation should be viewed not only as a challenge but also as an important opportunity for Kazakh investors.

To improve investment performance, Kazakh investors should strengthen policy research and establish professional analytical teams capable of monitoring China's regulatory environment. Cooperation with Chinese universities, consulting institutions, and legal organizations can reduce institutional uncertainty.

In addition, investors should actively adopt digital technologies and cooperate with Chinese real estate technology enterprises to establish digital investment and

operation systems. Strengthening digital talent training and improving data analysis capabilities are essential for adapting to China's rapidly digitalizing real estate industry.

Kazakh investors should also make greater use of bilateral cooperation platforms and joint-investment mechanisms. Cooperation with Chinese enterprises can reduce operational risks and improve access to local market knowledge. The China–Kazakhstan production capacity cooperation fund and cross-border cooperation zones can further reduce financing costs and improve investment efficiency.

For financial risk management, diversified hedging instruments should be introduced, including currency swaps, forward exchange contracts, and portfolio diversification. At the same time, investors should explore diversified exit mechanisms such as REITs, asset securitization, and equity transfer channels.

Conclusion

Under the framework of the digital economy and the "Belt and Road" Initiative, Kazakh investors in China's real estate market face both significant opportunities and substantial risks. Policy uncertainty, digital adaptation barriers, and exchange-rate fluctuations remain the major challenges affecting investment efficiency and long-term sustainability. However, policy support, urbanization upgrading, and digital transformation provide favorable conditions for future cooperation.

This study demonstrates that digital adaptation capability has become a decisive factor influencing the competitiveness of Kazakh investors in China's real estate market. Therefore, strengthening digital cooperation, improving institutional coordination, and establishing effective risk-hedging mechanisms are essential for enhancing investment efficiency and sustainability.

Overall, China–Kazakhstan cooperation in the real estate sector not only contributes to bilateral economic development but also supports broader regional integration and Digital Silk Road cooperation under the "Belt and Road" Initiative.

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UDC (331.5)

DIGITAL TRANSFORMATION AND EMPLOYMENT STRUCTURAL ADJUSTMENT: THE SPECIFICS OF STATE LABOR MARKET REGULATION IN CHINA

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Annotation. This paper investigates the contemporary challenges of unemployment within China's evolving labor market, characterized by a structural mismatch between emerging digital demands and the existing workforce's skill set. By analyzing recent macroeconomic indicators and state-led policy interventions, this study delineates the specific characteristics of China's labor market regulation. The findings reveal that the Chinese government has pivoted towards active, digital-era

governance—leveraging fiscal incentives, large-scale vocational reskilling, and targeted support for vulnerable groups. This state-centric and adaptive regulatory model not only stabilizes domestic employment but also offers valuable insights for developing nations navigating the dual pressures of technological disruption and economic transition.

Key word: Unemployment, Labor Market, State Regulation, Digital Economy, China

1. Introduction

The confluence of global economic fluctuations and aggressive domestic technological upgrading has placed unprecedented pressure on China's labor market. As the world's second-largest economy undergoes a critical transition towards a digital and innovation-driven model, the phenomenon of structural unemployment has become increasingly pronounced. Traditional industries, such as manufacturing and conventional retail, are contracting, while the digital economy—encompassing e-commerce, artificial intelligence, and green energy—is expanding rapidly.

Addressing domestic employment stability is not merely a domestic concern but a prerequisite for China's sustained role as a vital economic partner within the «Belt and Road» initiative (BRI. A stable workforce ensures robust consumption and provides the necessary human capital for outbound investment and international cooperation, particularly with partner countries like Kazakhstan.

This paper aims to analyze the current landscape of unemployment in China and critically evaluate the specific mechanisms of state labor market regulation. By moving beyond passive relief efforts, China has developed a unique, proactive governance model tailored to the digital age. This study contributes to the broader understanding of how large economies can effectively manage labor market transitions amidst technological disruption [1, 2].

2. Theoretical Framework and Methodology

Theoretically, this study is grounded in the concept of structural unemploymentand active labor market policies(ALMPs). Traditional economic theories, such as Okun's Law, establish a direct correlation between GDP growth and employment rates. However, the digital transformation introduces a nuanced variable: productivity gains from automation may decouple economic growth from traditional job creation, necessitating state intervention to facilitate labor reallocation.

Methodologically, this research employs a qualitative policy analysis combined with a quantitative assessment of recent labor market data (covering the period from 2020 to 2024). The primary data sources include official reports from the National Bureau of Statistics (NBS) of China, the Ministry of Human Resources and Social Security (MOHRSS), and authoritative national economic censuses [3].

3. The Current Landscape of Unemployment in China

Despite global economic headwinds, China's overall employment situation has remained remarkably stable, thanks to robust macroeconomic momentum and

targeted policy interventions. According to the NBS, the average national urban survey unemployment rate stood at 5.1% in 2024, slightly decreasing by 0.1 percentage points compared to the previous year. Furthermore, the unemployment rate for rural migrant workers—a highly vulnerable demographic—averaged 4.6% in 2024, marking a 0.3 percentage point decline year-on-year.

However, beneath this stable macro-surface lies a significant structural challenge driven by digitalization. The proliferation of automation and the platform economy has triggered a dual effect of «job displacement» and «job creation». On one hand, traditional low-skilled positions in manufacturing and routine services are being rapidly automated. On the other hand, the digital economy has emerged as a formidable engine for employment. Data from the Fifth National Economic Census reveals that by the end of 2023, China's core digital economy sectors comprised 2.916 million corporate entities, employing 36.159 million people, and generating 48.4 trillion RMB in revenue. Additionally, the broader digital industry recorded 20.6 million direct employees in 2024 [4].

The core challenge, therefore, is not a lack of jobs, but a severe skills mismatch. The labor market is experiencing a paradox where industries struggle to fill newly created high-tech positions due to a shortage of qualified talent, while a surplus of low-skilled workers face displacement. This structural friction disproportionately affects younger generations and older, less adaptable workers.

4. The Specifics of State Labor Market Regulation in China

The Chinese government's response to these challenges is characterized by a centralized, multi-tiered, and highly adaptive regulatory framework. The state has shifted from a passive welfare approach to an active, market-oriented governance model. The specifics of this regulation can be categorized into three primary mechanisms:

4.1 Fiscal, Monetary, and Enterprise Incentives

The state actively manipulates fiscal and monetary levers to encourage private enterprises—the primary engines of job creation—to retain and expand their workforce. In 2024, the government implemented a series of aggressive pro-employment financial policies. Notably, the government reduced the unemployment insurance premium rate to 1% and provided substantial subsidies to enterprises. By the end of 2024, the state had distributed 38.6 billion RMB in unemployment insurance funds to stabilize and expand employment across 6.65 million enterprise accounts. Additionally, over 10 billion RMB in employment subsidies were allocated to 2.63 million enterprises. These «direct-to-business» financial injections have been highly effective in maintaining low layoff rates in the private sector [5, 6].

4.2 Institutional Adaptation for the Platform and Gig Economy

Recognizing the rapid rise of the platform economy (e.g., food delivery, ride-hailing, live-streaming e-commerce), Chinese regulators have pioneered new legal and social frameworks to protect gig workers. Traditional labor laws, designed for full-time employees, struggled to accommodate the flexible nature of digital platform

work. In response, the state introduced pilot programs for occupational injury insurance specifically tailored for gig-economy workers, ensuring that this burgeoning, flexible workforce retains access to fundamental social security nets. This regulatory adaptation has been crucial in legitimizing and stabilizing the millions of jobs created by digital platforms.

4.3 Large-Scale Educational Reskilling and Targeted Youth Programs

To directly combat structural unemployment, the state has heavily invested in vocational training and youth employment initiatives. The government launched the «1 Million Employment Trainee Positions Plan» in 2024, aiming to provide substantial internship and training opportunities for young people struggling to enter the formal job market. Concurrently, large-scale government-funded digital literacy and vocational training programs have been deployed nationwide. In 2024 alone, 51.3 billion RMB in skill-enhancement subsidies were issued to 3.1 million individuals, equipping the workforce with the necessary competencies to thrive in the digital economy [7].

5. Discussion and Policy Implications

The efficacy of China's state-led labor market interventions lies in its pragmatic blend of market forces and state oversight. Unlike the purely laissez-faire models that rely solely on market correction, or the antiquated welfare states that foster dependency, China's model emphasizes employabilityand structural adaptation. The proactive fiscal subsidies successfully incentivized businesses to absorb the initial shock of technological upgrading without massive layoffs.

However, limitations persist. While the overall unemployment rate remains stable, youth unemployment continues to pose a significant social challenge, prompting the government to temporarily suspend the publication of specific youth unemployment data in August 2023 to recalibrate its statistical approach. Nevertheless, the state's agile policy corrections—such as the intensive rollout of the «Spring Breeze Action» and public job fairs providing over 30 million job opportunities in early 2024 - demonstrate a highly responsive regulatory apparatus [8].

For other Belt and Road Initiative countries, particularly developing nations in Central Asia like Kazakhstan that are also undergoing digital transitions, China's experience offers several key takeaways:

Proactive Reskilling is Non-Negotiable Governments must anticipate technological disruptions and invest heavily in aligning workforce skills with future industry needs.

Flexible Labor Protections: As the gig economy grows globally, creating hybrid social security models that protect flexible workers without stifling platform innovation is essential.

Financial Incentives Work: Direct fiscal transfers and tax breaks for SMEs are highly effective tools for rapid employment stabilization during periods of economic volatility.

6. Conclusion

In conclusion, China's labor market is navigating a profound structural transformation fueled by digitalization and global economic shifts. While challenges such as youth unemployment and skills mismatches persist, the Chinese government's regulatory response has been remarkably adaptive. Through a sophisticated toolkit of enterprise subsidies, innovative gig-economy protections, and massive vocational reskilling programs, the state has successfully maintained overall employment stability [9]. This state-centric, digitally-aware, and highly targeted regulatory model provides a compelling case study for developing economies. As China continues to deepen its economic integration with Belt and Road partners, the stability of its domestic labor market will undoubtedly serve as a robust foundation for sustained international cooperation and shared regional prosperity.

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UDC (334.021.1)

DIGITAL TRANSFORMATION OF ECONOMIC SECTORS: TRENDS, TOOLS AND IMPLEMENTATION MECHANISMS

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Annotation. Digital transformation has become the core driving force of global economic development, reshaping production methods, business models and competitive landscapes across sectors. This paper analyzes trends, tools and mechanisms of digital transformation, focusing on China-Kazakhstan cooperation under the Belt and Road Initiative. It argues that transformation requires coordinated policy, technology and organizational change to drive sustainable growth.

Key words: Digital Transformation; Economic Sectors; Digital Technology; Implementation Mechanism.

Digitalization is accelerating economic restructuring worldwide. Kazakhstan and China prioritize digital transformation under the Belt and Road Initiative to boost high-quality development. This study examines key trends, enabling tools and effective mechanisms to support policy and enterprise action.

The main trends of digital transformation:

- Full-process digital penetration: End-to-end integration of R&D, production and services, as seen in manufacturing digital twins.
- Data-driven decision-making: Big data analytics enables precise forecasting and personalized services in finance and retail.
- Intelligent upgrading: AI/ML optimizes industrial processes, moving sectors from automation to autonomy.
- Cross-sector synergy: Industrial digitalization and digital industries co-evolve to build new ecosystems [1, 2].

Key technical tools:

– Big Data & Cloud Computing: Scalable storage/analysis lowers barriers for SMEs via cloud-based services.

– AI & Machine Learning: Optimizes production quality, risk control and customer interaction.

– Blockchain: Enhances cross-border trade trust and transparency between China and Kazakhstan.

– IoT: Connects devices in agriculture/energy for real-time monitoring and efficiency gains.

Implementation mechanisms:

1. Policy and institutional support: Governments should offer subsidies, tax incentives and legal frameworks for data security.

2. Enterprise strategy and agility: Align transformation goals with organizational change to break silos.

3. Ecosystem collaboration: Partner with universities, tech firms and supply chain stakeholders.

4. Talent development: Upskill workforces and adjust education curricula for digital competencies [3, 4].

Digital transformation offers significant opportunities for economic growth but requires coordinated action across policy, enterprise and education sectors. China-Kazakhstan cooperation under the Belt and Road Initiative can accelerate progress through shared best practices and technology transfer. Future research should focus on measuring transformation impact and scaling inclusive solutions.

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UDC (314)

THE IMPACT OF DEMOGRAPHIC STRUCTURE CHANGE ON RESIDENT INCOME IN CHINA

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Annotation. Demographic structure change provides an important perspective for understanding resident income growth and labour market adjustment. This paper examines the relationship between changes in the working-age population and resident income in China using annual data from 2000 to 2024. A multiple linear regression model is employed to assess the impact of demographic variables on per capita disposable income, controlling for economic structure, urbanisation and

technological factors. The results indicate a stable positive relationship between the working-age population and income levels. However, with the gradual decline of the demographic dividend, future income growth will increasingly depend on productivity improvements rather than labour supply expansion.

Key words: demographic structure; resident income; working-age population; China; economic growth.

Introduction

Demographic change provides a critical lens for understanding long-term economic growth and income dynamics. Since the reform and opening-up period, China's rapid economic development has been strongly supported by a large and expanding working-age population. The abundance of labour supply facilitated industrialisation, increased employment, and contributed significantly to rising resident income levels.

In recent years, however, demographic trends have shifted markedly. Declining birth rates, rising life expectancy, and population ageing have led to a reduction in the size of the working-age population. According to data from the National Bureau of Statistics, the population aged 15–64 decreased from 1.009 billion in 2016 to 962 million in 2023 [5]. This trend reflects not only a contraction in labour supply but also signals a transition away from the traditional growth model driven by demographic expansion [1].

Nevertheless, a decline in the working-age population does not necessarily lead to a reduction in income levels. During the study period, China's per capita disposable income continued to grow steadily, suggesting that income dynamics are influenced by multiple factors, including economic development, industrial upgrading, technological progress, and institutional changes in income distribution. Therefore, this study focuses on the working-age population as a key indicator of demographic change and examines its relationship with resident income.

This paper employs national annual data for China from 2000 to 2024. Changes in demographic structure are measured by the size of the working-age population (aged 15–64), while income levels are represented by per capita disposable income. A multiple linear regression model is applied, controlling for time trends, industrial structure, urbanisation, and technological innovation.

To analyse the relationship between demographic change and resident income, the following model is specified:

$$\ln Y_t = \beta_0 + \beta_1 \ln X_t + \gamma \text{Control}_t + \varepsilon_t \quad (1)$$

where Y_t denotes per capita disposable income, X_t represents the working-age population, Control_t includes time trend, tertiary-sector share, urbanisation rate, and R&D intensity, and ε_t is the error term. Logarithmic transformation is applied to reduce heteroscedasticity and enable elasticity interpretation.

To verify robustness, an alternative model is constructed:

$$\ln G_t = \alpha_0 + \alpha_1 \ln X_t + \delta \text{Control}_t + \varepsilon_t \quad (2)$$

where G_t denotes per capita GDP. This specification tests whether the results depend on the choice of dependent variable.

Table 1 – Baseline Regression Results

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-151.3158***	-26.4643***	-28.3199***	-27.9749***	-27.8251***
ln_x	14.0151***	3.0393***	3.1884***	3.1486***	3.1440***
Trend	—	0.0952***	0.0919***	0.0882***	0.0934***
Tertiary	—	—	0.4006	0.4959	0.4052
Urban	—	—	—	0.2196	0.1835
R&D	—	—	—	—	-5.5876
R^2	0.5241	0.9983	0.9984	0.9984	0.9984
Adj. R^2	0.5034	0.9982	0.9981	0.9981	0.9980
Observations	25	25	25	25	25

Note: ***, **, * indicate significance at 1%, 5%, and 10% levels.

Table 1 demonstrates that the coefficient of the working-age population variable (ln_x) is positive and statistically significant across all model specifications, indicating a stable positive relationship between demographic structure and resident income. Although the magnitude of the coefficient decreases after controlling for time trends, its significance and direction remain robust, suggesting that demographic factors continue to play an important role in income determination.

To further verify the reliability of the results, robustness tests are conducted by replacing the dependent variable with per capita GDP and using the share of the working-age population as an alternative explanatory variable.

Table 2 – Robustness Test Results

Variable	Test 1: Per Capita GDP	Test 2: Population Share
Constant	-31.2577***	3.9897***
ln_x	3.5487***	—
x_share	—	0.0518***
Trend	0.0942***	0.0962***
Tertiary	-1.1503***	1.0011**
Urban	0.6497	0.5185
R^2	0.9987	0.9972
Adj. R^2	0.9984	0.9967
Observations	25	25

Note: ***, **, * indicate significance at 1%, 5%, and 10% levels.

The robustness results confirm that the working-age population remains positively associated with economic performance. However, given the limited sample size and the absence of unit root and cointegration tests, the findings should be interpreted as indicative of statistical relationships rather than strict causal effects.

Conclusion

This study shows that demographic structure remains an important determinant of resident income growth in China. The working-age population continues to have a significant positive impact on income levels, even after controlling for structural and technological factors. However, as the demographic dividend gradually weakens, China must transition toward a productivity-driven growth model.

Policy implications include increasing labour force participation, especially among underrepresented groups, enhancing labour productivity through education and technological innovation, and improving income distribution and social security systems. These measures are essential to mitigate the economic impact of demographic ageing and sustain long-term income growth.

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CYBER RISK MANAGEMENT IN THE CONTEXT OF DIGITALIZATION OF BANKING

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Annotation. The digitalization of banking has improved service efficiency and customer interaction, but it has also increased banks' exposure to cyber risks. This paper examines the main categories of cyber risks in digital banking and reviews international approaches to cyber risk management. The study is based on literature review, comparative analysis, and regulatory materials. The findings show that cyber risk management in banking should be viewed not only as a technical task, but also as a governance, compliance, and resilience issue.

Key words: banking digitalization, cyber risk, cybersecurity, digital resilience, banking sector.

Digital transformation has become a major trend in banking. Mobile banking, digital payments, cloud services, artificial intelligence, and fintech cooperation have improved financial services, but also increased banks' vulnerability to cyber threats.

Cyber risk is now one of the key challenges for banks. Cyber incidents may cause financial losses, service disruptions, reputational damage, customer distrust, and regulatory sanctions. Therefore, cyber risk management has become an essential part of banking stability.

This paper aims to identify the main cyber risks arising in the context of digitalization of banking and to examine international approaches to their management.

Banking digitalization expands both the scale and complexity of cyber risks. One major category is data breach risk, since digital systems store large volumes of sensitive customer and transaction data. Unauthorized access may lead to financial, legal, and reputational losses.

Another important category is malware, ransomware, and phishing attacks, which can disrupt banking systems and critical operations. In addition, third-party and supply chain risks are becoming increasingly important because banks rely on cloud providers, software vendors, fintech partners, and outsourced service companies.

Digital banking also creates risks related to payment systems, remote authentication, and open interfaces. Thus, digitalization increases cyber exposure and strengthens the need for digital resilience.

International practice shows that cyber risk management in banking requires an integrated approach including governance, risk assessment, internal control, incident response, business continuity planning, and regulatory cooperation.

The Basel Committee and the BIS emphasize operational resilience and sound risk management [1]. The NIST Cybersecurity Framework structures cyber risk management around identification, protection, detection, response, and recovery [2]. ISO/IEC 27001 supports information security management systems [3], while DORA in the European Union strengthens ICT risk governance, incident reporting, and third-party oversight [4].

These frameworks show that effective cyber risk management depends not only on technology, but also on governance quality and institutional responsibility.

Despite international standards, banks face several practical challenges. Cyber threats evolve rapidly, while digital ecosystems are increasingly complex and dependent on multiple providers. Another challenge is balancing innovation and security, since rapid digital development may outpace cybersecurity investment.

Uneven cyber risk disclosure across institutions and jurisdictions further complicates assessment and coordination.

Therefore, cyber risk management in digital banking requires not only technological adaptation, but also stronger governance and resilience-oriented regulation.

The digitalization of banking has significantly increased banks' exposure to cyber risks. Data breaches, ransomware, phishing, third-party vulnerabilities, and infrastructure failures represent major threats to banking operations, customer trust, and financial stability.

The analysis shows that cyber risk management in the context of digitalization of banking should be treated as a governance and resilience issue rather than a purely technical one. As banking digitalization deepens, effective cyber risk management will remain essential for secure and sustainable banking development.

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UDC (332.8:004.7)

TECHNOLOGICAL EMPOWERMENT AND RISK BOUNDARIES: AN EVALUATION OF DIGITAL APPLICATIONS IN THE UTILITY SECTOR OF URBAN HOUSING

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Annotation. The rapid development of the Internet of Things, big data, and artificial intelligence technologies has accelerated the implementation of smart water meters, smart electricity meters, and smart lock systems in urban housing. These technologies are becoming essential components of smart cities and digital residential infrastructure. The article analyzes the current application of smart devices in urban housing and evaluates their benefits and risks from the perspectives of efficiency, security, user convenience, and governance. The study demonstrates that smart

metering and access systems improve management efficiency, optimize resource use, and increase service transparency. At the same time, they create risks related to data privacy, cybersecurity, digital inequality, and technological dependence. The article argues that sustainable development of smart housing systems requires a balance between technological innovation and legal regulation.

Key words: smart water meter, smart electricity meter, smart lock, urban housing, Internet of Things, digital governance.

1. Introduction

Urban housing management is experiencing rapid digital transformation. Traditional water and electricity meters based on manual reading are gradually being replaced by smart metering systems capable of remote monitoring and automated data transmission. Smart locks and access control systems are also replacing traditional key management mechanisms. These technologies are changing the technological foundation of urban housing and creating new models of interaction between residents, landlords, and service providers.

The expansion of smart housing technologies is closely connected with the broader concept of smart cities. In China, local governments increasingly support the integration of digital infrastructure into residential buildings. Shenzhen introduced the «Action Plan for Accelerating the Promotion and Industrial Development of Whole-House Smart Systems» (2026–2028), encouraging large-scale installation of smart meters and access systems in residential areas [1]. Guangzhou also requires new residential buildings to integrate smart gateways, smart locks, and digital utility systems [2]. These initiatives show that smart housing technologies are shifting from experimental implementation to large-scale deployment.

At the same time, digital transformation generates important social and legal concerns. Smart locks record information about users and access time, while smart meters continuously collect detailed energy consumption data. Such information may reveal residents' behavioral patterns and create risks of surveillance and privacy violations. In addition, remote control functions may allow landlords or operators to disconnect utilities in case of payment disputes, raising ethical and legal questions.

This article analyzes the current application of smart water meters, smart electricity meters, and smart lock systems in urban housing. It evaluates the main benefits and risks associated with these technologies and proposes recommendations for improving digital governance and regulatory mechanisms.

2. Current Application of Smart Housing Technologies

2.1 Global Development Trends

The global market for smart housing equipment has grown rapidly during the last decade. Smart metering systems are increasingly used in apartment buildings, residential complexes, and rental housing. According to Silicon Labs, NextCentury deployed more than 2.8 million smart meters in the United States and Canada by

2025, with approximately 40,000 new apartment units connected monthly [3]. This demonstrates that wireless smart metering technologies have become economically viable for large-scale deployment.

Russia also demonstrates active development of smart housing infrastructure. Rostelecom's «Key» platform operates in more than 6,100 buildings across 335 cities and serves over 1.2 million users [4]. The platform integrates smart intercoms, video surveillance, access control, and smart utility management into a unified digital ecosystem.

In China, the smart home industry is expanding rapidly. Shenzhen hosts more than 300 smart home enterprises, and the local industry scale exceeded 180 billion yuan in 2024 [5]. Smart locks and smart utility meters are now considered among the most practical digital technologies in apartment management systems [6].

2.2 Smart Water and Electricity Meters

The main advantage of smart water and electricity meters is remote monitoring and automated data collection. Two main technological models are currently used.

The first model is based on LoRaWAN wireless local networks. In this system, devices transmit data through local gateways connected to cloud platforms. This approach is suitable for newly constructed residential complexes and centralized apartment systems.

The second model uses NB-IoT technology. Each smart meter contains an independent communication module connected directly to cellular infrastructure. This model is more suitable for decentralized apartment systems and older residential areas [7].

Modern smart meters perform functions beyond simple data collection. Digital management platforms provide real-time information on electricity and water consumption, detect abnormal usage patterns, and generate maintenance alerts. According to research by the U.S. Environmental Protection Agency, smart metering systems can identify water leakage and significantly reduce resource waste.

2.3 Smart Locks and Access Systems

Unlike smart metering systems, smart locks primarily address problems of access management and operational efficiency. Traditional key systems involve high administrative costs, duplication risks, and delays in permission control. Smart locks replace physical keys with digital authorization systems.

Current smart lock technologies include remote password generation, Bluetooth access, temporary permissions, and digital records of all door-opening events. In rental housing, these systems significantly simplify the check-in and check-out process. Apartment operators report that move-in procedures can be reduced from several hours to only a few minutes.

Access control systems are increasingly integrated into broader residential security networks. Shenzhen policies encourage installation of smart surveillance and fire alarm systems connected to digital housing platforms. Consequently, smart access systems are evolving from isolated devices into elements of integrated urban

security infrastructure.

3. Benefit-Risk Analysis

3.1 Efficiency and Cost Reduction

From the perspective of property management, smart technologies significantly improve operational efficiency. Automation reduces labor requirements associated with meter reading, payment collection, and key management.

Under traditional management models, operators managing large apartment portfolios required dedicated personnel for utility monitoring and tenant services. Smart systems reduce manual work and allow managers to supervise larger numbers of housing units more efficiently. Some apartment operators report management cost reductions of 30–50% after implementing digital systems [8].

Smart utility systems also improve financial management. Prepaid models allow tenants to pay before using utilities, improving cash flow and reducing unpaid debts. Automated reminders and remote service control mechanisms help operators manage payments more effectively.

However, these advantages are accompanied by technological dependence. Once operators adopt a specific platform, switching to another provider may become expensive because of incompatible standards and closed data systems. This creates long-term dependence on individual technology suppliers.

3.2 Convenience and User Experience

Smart housing technologies improve transparency and convenience for tenants. Residents can monitor real-time electricity and water consumption, receive digital invoices, and track utility expenses through mobile applications. Such transparency reduces disputes related to billing and resource consumption.

Smart locks also increase flexibility and convenience. Tenants can enter apartments without physical key exchange, while maintenance personnel can receive temporary digital access rights. Digital repair requests and real-time notifications improve communication between tenants and management companies [9].

Nevertheless, technological systems may also create new forms of vulnerability. Equipment failures, software errors, or communication interruptions can disrupt access to housing and utilities. Reports of lock malfunctions, inaccurate meter readings, and delayed technical support demonstrate that technological reliability remains an important challenge.

Moreover, remote disconnection functions may be abused in conflicts between landlords and tenants. In the absence of clear legal safeguards, utility shutdowns may become tools of pressure rather than legitimate management mechanisms.

3.3 Privacy and Cybersecurity Risks

Smart housing systems continuously collect large amounts of personal data. Smart electricity meters record consumption patterns that may reveal residents' daily routines and occupancy schedules. Smart locks store detailed information about access time and user identity.

The legal status of such data remains unclear in many countries. Questions

related to data ownership, third-party access, and commercial use remain insufficiently regulated. Some operators may use collected information for credit evaluation, behavioral analysis, or targeted marketing without explicit user consent.

Cybersecurity threats represent another major concern. Weak encryption, insecure cloud storage, and software vulnerabilities increase the risk of hacking and unauthorized access. If smart lock systems are compromised, physical security may be threatened. Manipulation of utility data may also lead to financial losses and operational disruption.

The Russian experience demonstrates that large-scale smart housing platforms require security standards comparable to financial infrastructure systems. However, many low-cost devices currently available on the market lack advanced security protections.

3.4 Digital Divide and Social Inequality

The expansion of smart technologies may unintentionally increase social inequality. Elderly residents often experience difficulties using smartphone-based systems and digital payment platforms. Although some policies mention age-friendly adaptation measures, many smart housing services remain oriented toward younger users.

Digital inequality also affects low-income groups. Apartment systems requiring smartphone access and online payments may indirectly exclude tenants with limited digital skills or restricted access to technology [10].

Prepaid utility systems may additionally increase financial pressure on households with unstable incomes. Under traditional billing systems, utility payments could be delayed temporarily. Prepaid models shift financial responsibility entirely to residents and may reduce access to essential services.

4. Conclusions and Recommendations

The study demonstrates that smart water meters, smart electricity meters, and smart lock systems provide important economic and managerial benefits for urban housing. These technologies reduce administrative costs, improve resource management, increase transparency, and optimize tenant services.

At the same time, the rapid expansion of smart housing infrastructure generates substantial risks associated with privacy protection, cybersecurity, technological dependence, and social inequality. The distribution of benefits and risks is uneven: management organizations receive efficiency gains, while users often bear privacy and security risks.

To ensure sustainable development of smart housing systems, several measures are necessary.

First, governments should establish clear data governance regulations distinguishing utility data, behavioral data, and biometric information. Sensitive data should be protected under strict legal standards.

Second, industry regulators should promote interoperability and unified technical standards to prevent supplier monopolies and reduce switching costs.

Third, emergency backup systems should remain available. Smart locks should preserve alternative unlocking methods, while manual payment channels should remain accessible for vulnerable populations.

Fourth, mandatory cybersecurity certification should be introduced for smart housing equipment. Security standards should include encryption requirements, regular software updates, and vulnerability disclosure mechanisms.

Future research should focus on comparative analysis of technological models, long-term social impacts of smart housing systems, and empirical evaluation of cybersecurity vulnerabilities.

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Section 2. SUSTAINABLE DEVELOPMENT AND DIGITAL INTEGRATION WITHIN THE FRAMEWORK OF "ONE BELT, ONE ROAD"

UDC （330.1）

ECONOMIC COOPERATION BETWEEN CHINA AND KAZAKHSTAN UNDER THE FRAMEWORK OF THE BELT AND ROAD INITIATIVE

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Annotation. Since the launch of the Belt and Road Initiative (BRI), economic cooperation betwee n China and Kazakhstan has deepened steadily, with bilateral trade and investment expanding significantly. This paper reviews the development history, key cooperation areas, and representative projects of China-Kazakhstan economic relations. It analyzes cooperation outcomes and trends in energy, transportation, and investment under the BRI framework. The findings indicate that China-Kazakhstan economic cooperation is highly complementary and strategically significant.

Key words: Belt and Road Initiative; China-Kazakhstan relations; economic cooperation; investment cooperation

Background of China-Kazakhstan Trade Development

On December 16, 1991, Kazakhstan declared its independence, and China subsequently recognized and supported Kazakhstan's independence.In January 1992, China officially established diplomatic ties with Kazakhstan, an act that heralded a new chapter in the evolution of bilateral trade between the two countries[1].Following the establishment of diplomatic relations, trade cooperation between China and Kazakhstan — the latter being China's second-largest neighbor — developed at an exceptionally rapid pace. Consequently, the total trade volume between China and Kazakhstan significantly exceeded that between China and any other Central Asian nation.In 1992, bilateral trade stood at less than US$400 million. After 2008, it reached US$12.2 billion. By 2025, trade had grown to US$48.7 billion — a record high and an 11% year-on-year increase. These figures reflect continuous progress, with China now Kazakhstan's largest trading partner.

Areas of China-Kazakhstan Economic Cooperation

Energy Cooperation

The rapid pace of global economic development has led to steadily increasing energy resource consumption and, consequently, rising demand for resources across nations. In light of the limited availability of such resources, energy issues have

commanded significant attention, and the rational utilization of energy has been designated as a priority development strategy by numerous countries[2].Kazakhstan is relatively rich in natural resources. Its economy is dominated by natural gas, oil, minerals, coal, and agriculture and animal husbandry, while its light and processing industries are relatively underdeveloped.China's economy, on the other hand, is primarily driven by the secondary industry. Its light industry is highly developed, and it possesses abundant human resources, but it is relatively deficient in per capita natural resources.Consequently, Kazakhstan exports substantial quantities of natural resources — notably natural gas and oil — to China, while China exports consumer goods, including textiles, footwear, and household appliances, to Kazakhstan. This arrangement maximizes the efficiency of resource utilization and fosters mutual benefit, win-win outcomes, and common development.

Transportation Cooperation

The Belt and Road Initiative traverses the three continents of Asia, Europe, and Africa. As a result of years of sustained cooperation between China and Kazakhstan, China has constructed seven national highways and numerous railway lines in Xinjiang, which run through various provinces and connect freight transshipment stations[3].Kazakhstan's well-developed transportation infrastructure enhances trade and logistics with China's Xinjiang region. On the one hand, its transport network extends to other neighboring countries, facilitating the export of domestic resources. On the other hand, it also allows for the re-export of goods imported from China to other Eurasian countries, thereby promoting international trade exchanges.Transportation cooperation has forged close linkages among western China, Kazakhstan, and other Eurasian countries. China has been steadily increasing its investment in China-Kazakhstan transport infrastructure, and as a result, transportation volumes have risen on an annual basis.

Investment Cooperation

During the 1990s, in an effort to stimulate economic recovery, Kazakhstan exported its abundant energy resources, sought to attract foreign investment, and provided support to its fledgling domestic industries[4]. Following years of macroeconomic regulation and adjustment, the scale of investment cooperation between China and Kazakhstan has grown progressively larger.More than a decade ago, the Vice Chairman of China's National Development and Reform Commission visited Kazakhstan, where Chinese and Kazakh entrepreneurs engaged in production capacity alignment in the resource and energy sectors, establishing more than 40 successful projects.After years of trade exchanges, the two countries have established numerous agreements, such as investment protection accords, which have gradually improved the trade system and led to a positive development trend in investment cooperation.

Digital Economy and Emerging Sectors Cooperation

The digital economy has become a new engine for China-Kazakhstan cooperation, aligning with Kazakhstan's "Digital Kazakhstan" national program and

China's "Digital Silk Road" initiative. In the field of e-commerce, Kazakhstan's national pavilion has been launched on major Chinese e-commerce platforms, enabling Chinese consumers to conveniently purchase Kazakh specialty products such as nuts, camel milk powder, and safflower seed oil. Cross-border e-commerce trade between the two countries has maintained rapid growth, and cooperative cross-border payment arrangements have been widely implemented. In the fintech sector, China has actively supported the development of the Astana International Financial Centre (AIFC). The Shanghai Stock Exchange and the Silk Road Fund have participated in cooperation with the center, and the China Development Bank has also established a representative office within it. These financial collaborations provide essential infrastructure for deepening bilateral investment and trade ties. In the field of digital infrastructure, the China-Kazakhstan cross-border digital integrated service platform has been continuously improved, helping to unlock the economic value behind data. Both sides are also exploring closer cooperation in areas such as artificial intelligence, the Internet of Things, and big data to accelerate industrial digitalization.

Future Trends in China-Kazakhstan Economic Cooperation

Continued Expansion of Trade

In 2024, bilateral trade reached US$43.8 billion, up 9.2% year-on-year. In 2025, it rose further to US$48.7 billion, an 11% increase and a new record. Both sides have set a strategic goal of doubling bilateral trade by 2030. To achieve this, they will optimize trade structures, balance growth in quantity and quality, and foster cross-border e-commerce, service trade, and digital trade to promote high-quality development. Bilateral trade reached US$21.8 billion in the first half of 2025, demonstrating a solid foundation for reaching this goal.

Diversification of Investment

According to Kazakh statistics, China has become Kazakhstan's fifth-largest source of investment, with total investment exceeding US$26 billion. A new, more robust investment protection agreement signed in 2025 will further upgrade bilateral investment cooperation[5].

Investment cooperation is shifting toward greater diversification and higher value-added activities. Beyond traditional energy, both sides are actively advancing renewable energy projects such as wind, solar, and hydropower. In April 2026, Shanghai Electric Group launched the Total Mirny 1GW wind power project in Kazakhstan, marking a new milestone in green energy cooperation. Emerging areas such as peaceful nuclear energy, green minerals, and artificial intelligence also hold broad prospects. In the digital economy, the Astana International Exchange has established a strategic partnership with the Shanghai Data Exchange, and cross-border e-commerce and warehousing logistics are growing rapidly.

Improving Investment Environment

The 2023 mutual visa exemption agreement has greatly facilitated business visits and commercial exchanges, accelerating the implementation of major projects.

Kazakhstan will continue to improve its investment climate through tax incentives, special economic zones, digital infrastructure development, and legal system enhancements.China's 15th Five-Year Plan (2026-2030) targets 4.5%–5% economic growth, shifting focus from high speed to high-quality, sustainable growth. This transition will create broader technical cooperation opportunities for Kazakhstan in industry, science, education, and beyond. The deep alignment of development concepts will provide a solid institutional foundation for long-term stable China-Kazakhstan economic cooperation.

Coordinated Development of Digital Economy and Green Transformation

The integration of the digital economy and green low-carbon transition is becoming a new growth pole for China-Kazakhstan economic cooperation. Under the Belt and Road Initiative, both sides are promoting cross-sector innovation that combines digital technologies with renewable energy, smart agriculture, and intelligent transportation to build green digital infrastructure. Kazakhstan's abundant wind and solar resources complement China's advanced digital energy management technologies. In smart cities, the two sides are cooperating to advance urban energy management, smart grids, and low-carbon transport, with Almaty already included in relevant pilots. In green finance, the Astana International Financial Centre is working with Chinese financial institutions to explore green digital bonds and digital carbon trading platforms, directing capital toward low-carbon digital projects. Both sides will also deepen cooperation in environmental big data monitoring, intelligent carbon accounting, and agricultural IoT, building a green, smart, and sustainable industrial and supply chain system. The coordinated advancement of the digital economy and green transformation will inject new momentum into bilateral cooperation, helping both countries address global climate challenges and achieve high-quality development.

Conclusion

Under the Belt and Road Initiative, China-Kazakhstan economic cooperation has achieved remarkable results, with expanding trade volume and broadening investment areas. Traditional sectors such as energy, transportation, and investment have yielded fruitful outcomes, while emerging sectors such as green energy, the digital economy, and agricultural processing are gaining momentum. Looking ahead, both countries should continue to uphold the principles of extensive consultation, joint contribution, and shared benefits — deepening policy coordination, improving cooperation mechanisms, expanding cooperation space, and advancing bilateral economic cooperation toward higher quality and greater heights, thereby contributing to an even closer China-Kazakhstan community with a shared future.

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A REVIEW OF RESEARCH ON CHINA-KAZAKHSTAN ECONOMIC COOPERATION UNDER THE BELT AND ROAD INITIATIVE

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Annotation. In light of the Belt and Road initiative, cooperation in economy between China and Kazakhstan continues to go on. This article introduces how this cooperation came into being and what sorts of models there are for it, also analyzing some accomplishments with regard to energy, infrastructure, trade & investment. Therefore, it is believed that the cooperation between China and Kazakhstan promotes mutual development as well as regional connection, which needs to be improved for further advancement.

Key words: “Belt and Road”; China-Kazakhstan economic cooperation; regional connectivity

This year marks a significant milestone since the launch of the Belt and Road Initiative. Over the past decade, the initiative has led to the signing of more than 200 cooperation agreements with over 150 countries and more than 30 international organizations, establishing itself as a vital platform for promoting international cooperation. As the birthplace of the initiative, Kazakhstan holds significant strategic importance. On September 7, 2013, President Xi Jinping proposed the initiative to jointly build the “Silk Road Economic Belt” during his visit to Kazakhstan, thereby ushering in a new phase of China-Kazakhstan cooperation.

From the year that China established diplomatic ties with Kazakhstan, which was 1992, up till the introduction of the Belt and Road Initiative in 2013, the relationship between them in terms of economic matters stayed at an ongoing improvement level. In the 1990's, the two parties started to set up some mechanism on energy and trade cooperation. After the founding of the Shanghai Cooperation Organization in 2001, there was an increase in interaction between China and Kazakhstan in terms of regional security and economic and trade relations. In 2005 the actual period of energy cooperation between China and Kazakhstan began. By around 2010, the bilateral trade kept increasing and cooperation was still mainly based on energy and resources trade.

On September 7th, 2013 President Xi Jinping proposed "Silk Road Economic Belt", thus entering the era of strategic alignment for China-Kazakhstan cooperation The same year, Kazakhstan put forward the proposal for the "Bright path", this plan was in line with the "Belt and road" initiative. Starting with 2014, the two countries started cooperation both on policy and project levels and they implemented projects like Lianyungang China Kazakhstan logistics base and Khorgos Eastern Gateway. In 2015, the China-Kazakhstan industrial capacity cooperation mechanism was set up which shifted the form of cooperation between the two countries from project cooperation to institutionalization. Gradually Kazakhstan became an important transit point for connection between Asia and Europe.

Since 2015, the partnership has gone through a period of full development. In 2016, the number of China – Europe freight trains kept increasing, and in 2017, at the Belt & Road Forum for International Cooperation, cooperation between both sides reached a stage of high quality. Since 2018, China-Kazakhstan cooperation has been constantly deepening in terms of infrastructure, the digital economy, and green energy; at the same time, the content structure of cooperation is no longer confined solely to traditional energy trade but gradually becomes diversified; both sides maintain steady progress in their bilateral relationship.

The economic cooperation between China and Kazakhstan under BRI comes from the strategy and top level arrangement which are promoted by their respective government. In 2013, with the introduction of the Belt and Road Initiative by China, cooperation between China and Kazakhstan happened almost immediately. In 2014, Kazakhstan's Bright Path program was in line with the BRI which laid down the groundwork for policy alignment. From then on, both sides keep going forward with coordinated efforts in terms of energies, infrastructures, industrial capacity cooperation etc by intergovernemental agreements and cooperative mechanisms.

Taking advantage of its location, the two have focused on the development of cross-border transportation and logistics. In 2014, the China-Europe Railway Express began to expand slowly and operate regularly, and various special economic zones like the "Horgos-East Gate" Special Economic Zone and logistics bases like the China-Kazakhstan Logistics Base were successively implemented. An overall

transportation network is in existence. It has laid down solid foundation for the two sides' economic cooperation.

The Chinese companies have wide involvement with energy development, mineral resources usage, infrastructure building etc., which promote the implementation of such projects. Such businesses take on responsibilities for investment, construction work as well as offering their technical knowledge and management insights which results in changes in how we cooperate – rather than relying solely upon governmental led efforts, there can be joint venture development with the government.

The Cooperation on Energy Resources is one of the main pillars for Economic Co-operation between China and Kazakhstan. Kazakhstan is a major energy powerhouse in central Asia, and over many years they have kept solid partnerships with china in the areas of oil,natural gas and minerals exploration. The two sides started to cooperate in terms of developing and delivering petroleum gas, as well as shipping and exporting oil and gas resources very soon after they started cooperating with each other, and such cooperation still continues deepening because of the Belt and Road. Energy secured by China also can be done in other way like Kazahkstan, which is a Central Asian state having cooperative project with China, can secure through this method [1].

By making use of its close proximity, China and Kazakhstan have gone on developing cross border rail , road and logistics systems. The China - Europe freight trains passing through Kazakhstan, it has become a very important link between Asia and Europe. Like the Khorgos—East Gate, it has boosted the logistics in Central Asia. And the Lianyungang China Kazhakstan's Logistics Base also did the same to improve logistics [2]. Infrastructure development is also an important part of the two countries to deepen their bilateral relations by improving the regional economic ties and supply chain.

In recent years, the scale of two-way trade has been expanding continuously, and the types of trade have gradually become more diversified, moving away from just focusing on energy and resources. With the rise of cross-border e-commerce there was also constant innovations happening to trading methods and research show that it became important driver for growth of trades [3]. In terms of the type of Chinese investment into Kazakhstan: manufacturing, logistics, transportation, infrastructure; It promotes the deep integration of industrial chain and market docking, and has been a main driving factor for the bilateral economy.

Financial cooperation is an important basis for China-Kazakhstan economic cooperation on the Belt and Road. And on both sides continue to advance cooperation with financial institutions, and the development of cross-border financial service system is also advancing, as well as actively developing local currency settlement, and exploration of investment and financing cooperation to improve the efficiency of fund flow and lower costs. According to some research, financial cooperation has an important supportive role in terms of the development of infrastructure and industry

investment [2], which is an important way to guarantee that cooperated projects go well.

People to people is education and culture which are getting better in order to have more mutual trust in the BRI. [1] On the side of science and technology, they have cooperated in fields like healthcare, farming, cross-border commerce. The cooperation is becoming more specific, such as orthopedic medicine [2]. With the development of cross-border e-commerce, it is also promoting continuous expansion of digital economy cooperation and adding new impetus to promote the development of Sino-US relationship [3].

Belt and Road is an amazing opportunity for Kazakhstan to boost up their economy with China. By way of infrastructure connection, increased trade and investments, the two nations are now building up a steady and effective neighborhood cooperation web and make some forward progress on topics including energy, finances, and personal ties. Looking ahead, it is necessary to further improve policy coordination and institutional innovation so that China-Kazakhstan economic cooperation can achieve more lasting progress at a higher level and better quality, providing firmer foundations for regional common prosperity.

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ENERGY TRADE TRANSFORMATION UNDER CARBON NEUTRALITY: PATHWAYS AND POLICY IMPLICATIONS FOR BELT AND ROAD COUNTRIES

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Annotation. This paper examines BRI energy trade transformation under China's carbon neutrality commitment. It identifies three pathways: trade structure shift to clean energy products, technology cooperation upgrading to integrated solutions, and financing mechanism innovation to diversified green finance. Findings highlight China's evolving role from participant to rule-shaper in global energy transition.

Key words: carbon neutrality; Belt and Road Initiative; energy trade transformation; green energy investment; renewable energy cooperation

Introduction

The relevance of this article is determined by the ongoing global transition toward carbon neutrality, which is fundamentally transforming the structure and dynamics of international energy trade. These changes are particularly significant for countries participating in the Belt and Road Initiative, as many of them play a crucial role as either major exporters of traditional energy resources or rapidly growing energy importers. The intensification of international climate policy and the introduction of carbon regulation mechanisms create both challenges and opportunities for these countries. On the one hand, economies heavily dependent on fossil fuel exports may face declining demand and stricter market access conditions. On the other hand, new opportunities emerge in the development of renewable energy, low-carbon technologies, and sustainable infrastructure.

The relevance of this study is further reinforced by the need to design effective public policies to adapt to the evolving global economic environment. This includes rethinking export strategies, diversifying energy portfolios, and strengthening integration into international sustainable development initiatives.

Under carbon neutrality targets, BRI energy trade is shifting from fossil fuels to clean energy. With a cumulative value exceeding $1.3 trillion and energy accounting for 35% of investment, BRI is the largest energy cooperation platform. Renewable investment first surpassed coal in 2022-2023. This paper identifies three pathways-trade structure, technology cooperation, and financing mechanism - to analyze this transformation.

Current Landscape of BRI Energy Trade

In 2025-2026, energy cooperation under the Belt and Road Initiative (BRI) reached record levels, exceeding USD 90–94 billion, the highest value since the initiative began, reflecting a strong recovery in global energy investment flows . Despite the global energy transition, oil and gas remain dominant, accounting for the largest share of energy-related projects, particularly in LNG infrastructure, pipelines, and upstream development.

At the same time, renewable energy investment is rapidly expanding, reaching approximately USD 18 billion, with significant growth in solar, wind, and hydropower projects and more than 20 GW of new installed capacity . This trend

reflects the development of the so-called “Green Silk Road” and the increasing integration of climate and sustainability goals into BRI energy cooperation.

Overall, the current BRI energy landscape is characterized by a dual-track model, where fossil fuel expansion and renewable energy development proceed in parallel, balancing energy security needs with long-term decarbonization objectives [1].

Historically, BRI energy cooperation has concentrated on oil and gas resource development, accounting for roughly 40% of total BRI investment over the past decade. Major Chinese oil and gas enterprises-PetroChina, Sinopec, and CNOOC-secured substantial equity stakes in Kazakhstan, Iraq, Brazil, and other resource-rich countries. In 2025 alone, Chinese enterprises signed contracts for over 10 oil and gas blocks across Central Asia, North Africa, Southeast Asia, and Latin America.

Nevertheless, this resource-dependent model exposes both sides to international price volatility and carbon lock-in risks, necessitating structural adjustment.

A fundamental shift is underway. According to the Fudan University Green Finance Research Center, green energy cooperation between China and BRI partner countries reached $9.7 billion in the first half of 2025, with new installed capacity of approximately 11.9 GW (wind, solar, and waste-to-energy). By end-2024, Chinese enterprises had completed power projects totaling 156 GW across BRI countries, with 70% concentrated in Asia and 15% in Africa [2].

The Boston University Global Development Policy Center confirmed that wind and solar investment first exceeded coal investment in 2022-2023, signaling the dominance of renewable energy in China's overseas energy portfolio. Concurrently, the "New Three" products-new energy vehicles, lithium batteries, and photovoltaic products-are experiencing rapid market penetration in partner countries, providing industrial chain support for renewable project deployment [3].

Three Pathways of Energy Trade Transformation

The transformation of energy trade within the Belt and Road Initiative (BRI) can be conceptualised through three key pathways: diversification, decarbonization, and digitalisation. First, diversification of energy supply and transport routes is driven by large-scale infrastructure development, enhancing connectivity and trade integration across participating countries. Second, decarbonization is reflected in the growing role of renewable energy investments, as BRI countries increasingly shift toward low-carbon energy systems to reduce emissions and improve energy security. Third, digitalisation plays a critical role in optimising energy systems and trade flows, as the adoption of digital technologies and fintech improves efficiency, resource management, and energy utilisation across BRI economies. Together, these pathways define the structural transformation of energy trade under the BRI framework [4].

Trade Structure: China is shifting from an energy importer to a clean technology exporter. The Uzbekistan 1 GW PV project - the first large-scale Chinese new energy project in Central Asia - exemplifies this shift

Technology Cooperation: Chinese firms have evolved from EPC contractors to integrated solution providers. The Brazil Belo Monte ±800kV project (2,539 km, fully Chinese standards) demonstrates UHV technology export. State Grid now operates in 51 countries with $19.5 billion in overseas investment.

Financing Mechanism: Financing has diversified from policy banks to market-oriented green finance. Non-recourse project financing (Uzbekistan 1 GW PV: 3.3 billion RMB, Sinosure-covered) and green bonds (Bank of China: $940 million for 13 countries' renewables) illustrate innovation.

Challenges and Policy Implications

Despite promising momentum, geopolitical risks, standard fragmentation, debt burdens, and local capacity gaps threaten project continuity. To navigate these, four priorities are essential: (1) leverage 34 energy partnerships and six regional platforms for policy coordination; (2) negotiate mutual recognition of green energy standards and promote Chinese technical standards internationally; (3) shift from project-level to full-lifecycle risk governance with diversified financial instruments; and (4) balance large projects with distributed solutions while embedding technology transfer obligations [5-6].

Conclusion

This paper identifies three pathways reshaping BRI energy trade under carbon neutrality. As China evolves from participant to rule-shaper, future success hinges on policy coordination, standard convergence, and risk governance maturation. Central Asia - with Kazakhstan and Uzbekistan as pivotal nodes -stands at the forefront of this transformation, where clean energy trade, technology cooperation, and green financing are reconfiguring regional energy governance and advancing shared sustainable development.

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OPPORTUNITIES AND STANDARDIZATION DEVELOPMENT OF TRADITIONAL CHINESE MEDICINE IN BELT AND ROAD INITIATIVE CROSS-BORDER TRADE

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Annotation. Under the framework of the Belt and Road Initiative, cross-border trade in traditional Chinese medicine (TCM) has stepped into a phase of rapid and high-quality growth. This study identifies key opportunities for TCM international trade, including favorable policy arrangements, rising global health demands, deepened industrial collaboration, and the rise of digital trade. Meanwhile, it reveals prominent constraints including fragmented international standards, complicated market access procedures, unstable quality control mechanisms, and insufficient global competitiveness. Accordingly, this paper proposes feasible pathways for the standardized development of TCM, such as perfecting international standard systems, advancing mutual recognition of norms and testing results, constructing a whole-chain quality traceability system, and promoting digital upgrading. The results indicate that standardization serves as the core driver for TCM to overcome trade barriers and realize sustainable development in the global market.

Key words: traditional Chinese medicine; Belt and Road; cross-border trade; standardization; international market access

The Belt and Road Initiative has boosted in-depth economic and trade exchanges between China and the participating countries. As an essential part of Chinese traditional culture, TCM presents distinctive merits in disease prevention, health maintenance, rehabilitation therapy, and chronic disease management. With the enhancement of global health consciousness and cultural integration, TCM products and services have gained growing recognition worldwide. Nevertheless, TCM encounters multiple bottlenecks in cross-border circulation, such as divergent regulatory regimes, the absence of unified quality benchmarks, and lengthy registration procedures. Standardization has become a critical measure to break through trade barriers and expand the global presence of TCM. This paper focuses on the development opportunities and standardization strategies of TCM in cross-border trade under the Belt and Road Initiative.

China has rolled out a series of supportive policies to facilitate the internationalization of TCM, including the High-Quality Development Plan for TCM Integration into the Belt and Road. China has signed TCM cooperation documents with over 40 governments and international organizations, and incorporated TCM into multiple free trade zone arrangements. These policies create a sound institutional environment for the steady development of TCM cross-border trade.

TCM has been introduced to more than 190 countries and regions. The global demand for herbal products, health supplements, and medical services continues to grow year by year. Public acceptance of natural medicine has significantly improved, and TCM has formed a stable consumer group in Central Asia, Southeast Asia, Europe, and other regions.

TCM cross-border trade covers medicinal herbs, extracts, patent Chinese medicines, healthcare products, and medical services, with a continuous expansion of export volume. Cross-border e-commerce has emerged as a new growth engine for TCM trade. Meanwhile, TCM service trade, including overseas medical centers, education and training, and health tourism, has developed rapidly.

Chinese enterprises have carried out cooperation in planting, processing, and production in countries along the routes. A number of overseas TCM centers and international cooperation bases have been established. Localized production helps cut logistics costs and adapt to local regulatory requirements, supporting the long-term development of the TCM industry.

TCM-related international standards are insufficient and lack consistency. Countries differ greatly in requirements for quality, safety, and labeling. The implementation of existing international standards is unsatisfactory, leading to high certification expenses and trade obstacles.

In many countries, TCM is categorized as dietary supplements rather than therapeutic drugs. The registration process is time-consuming and costly. Differences in laws and regulations increase the difficulty of market entry, limiting large-scale exports of TCM products.

The quality of TCM materials is affected by producing areas, cultivation techniques, processing methods, and transportation conditions. Adulteration and substandard products have impaired the international reputation of TCM. The full-chain traceability system is not widely applied, making it hard to ensure product quality in cross-border transactions.

Most TCM enterprises are small in scale with limited research and development capabilities. High-value-added products are in short supply. The international branding process is slow, and the ability to participate in the formulation of international rules is weak.

Centered on ISO/TC249, accelerate the formulation of standards for medicinal materials, preparations, testing methods, and healthcare products. Establish a unified standard system covering cultivation, production, circulation, and application.

Strengthen bilateral and multilateral cooperation to advance mutual recognition of standards, testing, and certification. Align with the regulatory systems of countries along the routes, simplify registration procedures, and reduce compliance costs.

Apply digital technologies including blockchain and the Internet of Things to realize traceability from planting to consumption. Establish origin protection and quality certification mechanisms to ensure the safety and stability of TCM products.

Develop digital standards and build specialized cross-border e-commerce platforms. Use artificial intelligence to assist quality identification and production control, improving the efficiency and standardization of the TCM industry.

Cultivate interdisciplinary talents who master TCM knowledge, international trade rules, and relevant laws and standards. Support leading enterprises to build international brands and enhance the global recognition of TCM.

The Belt and Road Initiative brings valuable opportunities for the development of TCM cross-border trade. Policy support, market expansion, and industrial cooperation lay a solid foundation for TCM to go global. Standardization is the key to addressing trade barriers and achieving high-quality development. By improving international standards, promoting mutual recognition, establishing traceability systems, and accelerating digital transformation, TCM can better integrate into the global trade system. In the future, TCM will play a more important role in public health and economic cooperation among countries along the routes.

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KAZAKHSTAN-CHINA ECONOMIC COOPERATION UNDER THE BELT AND ROAD INITIATIVE: OPPORTUNITIES AND CHALLENGES IN DIGITAL CROSS-BORDER TRADE

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Annotation. The Belt and Road Initiative (BRI) has become the core framework for economic and trade cooperation between China and Kazakhstan. As a key hub in the China-Central Asia corridor, Kazakhstan plays a vital role in cross-border trade. With global digital transformation, digital economy and cross-border e-commerce have become new drivers for bilateral cooperation. This paper analyzes the current situation of China-Kazakhstan digital cross-border trade under the BRI, summarizes opportunities and challenges, and puts forward development suggestions. The study shows that economic complementarity, policy support and logistics infrastructure lay a solid foundation, while institutional differences, digital gaps, regulatory barriers and talent shortage restrict further development. Finally, this paper puts forward suggestions in policy coordination, infrastructure connection, industrial cooperation and talent training.

Key words: Belt and Road Initiative; China-Kazakhstan Economic Cooperation; Digital Economy; Cross-Border Trade

1. Introduction

Since 2013, China-Kazakhstan economic and trade cooperation has developed rapidly. Kazakhstan is an important hub of the Eurasian Continental Bridge and a key partner of China in Central Asia. In 2025, bilateral trade volume reached 34.2 billion US dollars, an increase of 28.7%. China has been Kazakhstan's largest trading partner for 12 consecutive years.

Affected by global economic changes and trade protectionism, traditional trade faces uncertainties. The digital economy has become a new engine of international trade. Cross-border e-commerce, digital logistics and digital payment have become new highlights of China-Kazakhstan cooperation. In 2022, the two countries signed a cooperation plan on the Digital Silk Road, providing a policy basis for digital trade cooperation.

However, China-Kazakhstan digital cross-border trade is still in the early stage. Infrastructure, regulatory systems and industrial chains need to be further connected.

This paper studies the development path of digital trade under the BRI, which has theoretical and practical significance for deepening bilateral cooperation.

2. Theoretical and Policy Background

2.1 Digital Silk Road

The Digital Silk Road is an important part of the BRI. It promotes digital infrastructure connectivity, policy coordination, industrial chain integration and technological sharing. For Kazakhstan, the Digital Silk Road helps break geographical restrictions and reduce trade costs.

2.2 Policy System

China and Kazakhstan have signed more than 20 cooperation documents in e-commerce, customs clearance and logistics. Kazakhstan's Digital Kazakhstan program promotes internet popularization and e-commerce development. China has advantages in digital technology and cross-border e-commerce experience, forming strong complementarity with Kazakhstan.

3. Current Situation of China-Kazakhstan Digital Cross-Border Trade

3.1 Rapid Growth of Cross-border E-commerce

China has become the largest source of cross-border online shopping for Kazakhstan. In 2025, China accounted for 76% of Kazakhstan's cross-border e-commerce imports. Chinese platforms such as AliExpress and SHEIN are popular in Kazakhstan. Characteristic products of Kazakhstan, such as agricultural products and honey, have also entered the Chinese market through e-commerce.

3.2 Improvement of Logistics and Customs Clearance

Horgos Port realizes “two customs, one inspection” and shortens customs clearance time to less than 6 hours. China-Europe Railway Express passes through Kazakhstan, shortening transportation time from 45 days to 7–10 days, greatly reducing logistics costs.

3.3 Progress in Digital Payment

Local currency settlement in bilateral trade increased from 18% in 2020 to 42% in 2025. Alipay and WeChat Pay are used in major cities of Kazakhstan. The two countries are also exploring digital currency applications in cross-border settlement.

4. Opportunities for Cooperation

4.1 High Economic Complementarity

China has a complete manufacturing and digital industry chain. Kazakhstan has advantages in energy and agriculture. Digital trade helps both sides realize win-win results.

4.2 China-Central Asia Summit Mechanism

The summit provides a high-level platform for cooperation. Both sides take digital economy and cross-border e-commerce as key areas, which brings policy opportunities for enterprises.

4.3 Radiation to Eurasian Economic Union

Kazakhstan is a member of the EAEU. Cooperation with Kazakhstan can help Chinese enterprises enter the EAEU market with a population of 180 million

5. Challenges

5.1 Digital Infrastructure Gap

Rural internet coverage in Kazakhstan is only 57%. The construction of overseas warehouses and logistics parks is insufficient, which restricts the development of e-commerce.

5.2 Regulatory Differences

The two countries have different systems in data flow, intellectual property rights, tax and certification. These differences bring risks to cross-border e-commerce.

5.3 Talent Shortage

Both sides lack compound talents who understand language, law, e-commerce and cross-border trade.

5.4 External Uncertainties

Geopolitical changes and global economic fluctuations bring potential risks to bilateral cooperation.

6. Development Suggestions

6.1 Strengthen Policy Coordination

Improve top-level design, promote regulatory alignment and certification mutual recognition, and optimize customs clearance efficiency.

6.2 Accelerate Digital Infrastructure Connectivity

Support broadband, 5G and data center construction in Kazakhstan. Jointly build cross-border e-commerce parks and smart logistics systems.

6.3 Deepen Industrial Cooperation

Promote cooperation between e-commerce platforms and logistics enterprises. Expand the export of characteristic products. Cultivate new models such as live-streaming e-commerce.

6.4 Improve Talent Training

Establish joint education programs and carry out enterprise exchanges and training.

7. Conclusion

China-Kazakhstan digital cross-border trade under the BRI has achieved remarkable results and has huge potential. Economic complementarity, policy support and infrastructure lay a foundation. However, challenges such as digital gap, regulatory barriers and talent shortage still exist.

Both sides should strengthen policy coordination, accelerate infrastructure connectivity, deepen industrial cooperation and improve talent training. With the promotion of the Digital Silk Road and the China-Central Asia mechanism, bilateral digital trade will embrace a broader prospect and inject impetus into the high-quality development of the BRI.

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INNOVATION POLICY INCENTIVES IN THE DIGITAL ECONOMY: CATALYST OR BURDEN FOR CORPORATE FINANCIAL SUSTAINABILITY? — A CASE STUDY OF XIAMEN C&D INC

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Annotation: Does innovation policy fortify financial sustainability or impose hidden burdens? This paper examines Xiamen C&D Inc., a *Fortune* Global 500 supply chain leader, through the lens of the Resource-Based View and Signaling Theory. The analysis reveals a dualistic dynamic: policy incentives alleviate financing constraints and transmit positive market signals, acting as a catalyst, yet high-intensity subsidies coupled with persistent digital investment concurrently exert crowding-out pressures on financial slack. The net effect hinges critically on strategic congruence and absorptive capacity, underscoring the necessity for nuanced policy calibration.

Keywords: Digital Economy; Innovation Policy Incentives; Financial Sustainability; Xiamen C&D

1. Introduction

As digital transformation reshapes global competition, governments deploy R&D subsidies, tax incentives, and infrastructure investment to stimulate corporate innovation. Yet the empirical reality is fraught with tension: policy inducements may inadvertently fuel a "digital arms race," eroding cash flows and financial robustness. This dialectic between "catalyst" and "burden" constitutes the central problematic in evaluating innovation policy efficacy. Xiamen C&D Inc., a supply chain titan with revenues exceeding RMB 700 billion and a six-year presence on the *Fortune* Global

500, provides an archetypal case. Its multi-decade transformation journey and evolving financial architecture offer fertile ground for probing the genuine transmission mechanisms of policy incentives.

2. Theoretical Underpinnings and Literature Review

Scholarly discourse is polarized. The *promotion hypothesis* adduces evidence that subsidized firms exhibit superior R&D intensity and total factor productivity; digital tax incentives, for instance, enhance innovation durability by rectifying capital market distortions (Li, 2024). Conversely, the *inhibition hypothesis* warns of crowding-out effects, resource misallocation, and subsidy dependency, wherein external transfers supplant endogenous R&D commitments. This study draws on two pillars. The Resource-Based View posits that policy injects exogenous resources to overcome capability thresholds, though flawed design risks systemic misallocation. Signaling Theory emphasizes that policy endorsement functions as a market certification badge, mitigating informational asymmetries and easing financing frictions.

3. Xiamen C&D's Digital Transformation Trajectory

C&D's digital commitment has intensified markedly. In FY 2024, R&D expenses surged to RMB 285 million, a 20.69% year-over-year increase and a five-year high. The firm strategically positions digital-intelligent capabilities as the "core engine for empowering the supply chain ecosystem," aiming to integrate diagnostic decision-making, operations, and risk governance. Tangible initiatives include industrial internet platforms such as *C&D Cloud Steel*, *Paper Source Network*, *Pulp Easy Link*, and *Agri E-Point*, which embed AI-driven analytics across procurement, inventory, and risk workflows. In 2025, *Paper Source Network* and *Pulp Easy Link* were inducted into the Ministry of Commerce's *Digital-Intelligent Supply Chain Case Compendium*. Further cementing this trajectory, a RMB 100 million joint venture with ITG and XMXYG—*Xiamen Supply Chain Digital Intelligence Innovation Co., Ltd.*—was capitalized in March 2025, and C&D's proprietary *C&D Cloud Intelligence* AI platform secured A-grade national certification. These actions underscore strategic internalization rather than passive policy compliance.

4. The "Catalyst" Dimension

Xiamen's policy environment is notably supportive. The 2024 *Measures to Accelerate Integrated Development of Next-Generation IT and Manufacturing* delineates ten support vectors with subsidies up to RMB 10 million. The Torch High-Tech Zone's "New Six Articles" cover AI, metaverse, and open-source ecosystems, with provincial AI project subsidies covering up to 40% of R&D outlays. Moreover, C&D's Hainan subsidiary benefits from the Free Trade Port's "Double 15%" preferential tax regime, yielding projected 2025 tax savings exceeding RMB 50 million.

Catalytic effects manifest triply. First, policy injections directly augment the discretionary cash pool, diminishing the marginal cost of innovation and alleviating financing constraints for this asset-heavy (RMB 800+ billion) enterprise. Second,

national accolades—including 2024 recognition in the "Top 100 Chinese Industrial Digitalization Firms"—amplify signaling credibility, transmitting affirmative signals to capital markets and counterparties. Third, policy guidance catalyzes ecosystem synergy; the tripartite joint venture represents an evolutionary leap from isolated efforts to collaborative orchestration, validated by the Ministry of Commerce's *Action Plan for Accelerating Digital-Intelligent Supply Chains*.

5. Dynamic Appraisal of Financial Sustainability

C&D's financial sustainability exhibits a paradoxical amalgam. Resilience stems from a formidable balance sheet: total assets of RMB 767.867 billion and net assets of RMB 228.158 billion as of year-end 2024, with a "green tier" financing classification and a global footprint spanning 170+ countries and 50+ overseas entities. The "Specialization, Internationalization, Digital Intelligence" strategic blueprint provides directional ballast. Vulnerability, however, is equally evident. The adverse scissors gap between profit erosion and R&D escalation constrains financial error tolerance. The long-run yield of digital transformation remains inadequately reflected in conventional metrics, leaving open the question of whether near-term "growing pains" will translate into durable value accretion.

6. Concluding Remarks and Policy Implications

The C&D case demonstrates that innovation policy impacts are not monolithic but dynamically contingent. When policy objectives align with corporate strategy and absorptive capacity is robust, incentives serve as a catalyst, easing financing frictions and fostering ecosystem collaboration. Conversely, excessive intensity or herding behavior precipitates resource displacement and leverage accumulation. Three policy recommendations emerge. First, policymakers should eschew blanket subsidies in favor of tiered, step-down mechanisms to mitigate dependency. Second, firms must preserve strategic discipline, ensuring digital initiatives are impelled by operational exigencies rather than grant capture. Third, for Belt and Road nations, C&D's "Specialization + Internationalization + Digital Intelligence" mantra offers a reference architecture, though policy toolkits require contextual calibration, emphasizing instruments with lower administrative burdens and circumscribed rent-seeking avenues.

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ENHANCING CHINA–CENTRAL ASIA ECONOMIC AND TRADE COOPERATION UNDER THE BELT AND ROAD INITIATIVE

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Annotation. In recent years, China and Central Asia have achieved fruitful results in areas such as policy coordination, trade volume, infrastructure connectivity, and the digital economy. However, problems such as unbalanced trade structure, insufficient soft connectivity, digital divide and high cross-border transaction costs restrict the further improvement of cooperation quality. This paper puts forward paths to enhance cooperation including deepening strategic docking, promoting digital

integration, improving cross-border logistics system, optimizing trade and investment structure and strengthening risk prevention and control, so as to provide reference for promoting sustainable and high-quality development of China–Central Asia economic and trade cooperation under the Belt and Road framework.

Key words: Belt and Road; China–Central Asia; economic and trade cooperation; digital economy; cross-border trade; connectivity

1. Introduction

In recent years, economic and trade cooperation between China and Central Asia has maintained a good momentum of development. The total trade volume has increased steadily, the fields of cooperation have been expanding, and new forms of digital trade are booming. At present, it is of great practical significance to further enhance the level of economic and trade cooperation between China and Central Asia, smooth regional trade circulation, and promote common development. This paper focuses on the current situation, achievements, challenges and optimization paths of China–Central Asia economic and trade cooperation under the Belt and Road Initiative, and provides theoretical support and practical suggestions for deepening bilateral cooperation.

2. Realistic foundation and main achievements

2.1 Strategic docking and policy coordination are continuously strengthened

The Belt and Road Initiative is highly compatible with the national development strategies of Central Asian countries. The two sides have established a high-level dialogue mechanism, signed a number of cooperation documents in trade, investment, customs and other fields, and continuously optimized the institutional environment for economic and trade cooperation.

2.2 Trade and investment scale has grown rapidly

China has become the main trading partner and important investment source country of Central Asian countries. The trade volume has increased year by year, and the trade structure has been gradually optimized.

3. Main challenges in cooperation

3.1 Unbalanced cooperation structure and low added value

The trade between China and Central Asia is still dominated by resource products and primary processed products, and the proportion of high value-added products and service trade is low. The investment layout is relatively concentrated, and the investment in high-tech and modern service industries is insufficient, which affects the sustainability of cooperation.

3.2 Insufficient soft connectivity and high trade costs

There are differences in standards, certification, inspection and quarantine among countries, cross-border data flow is restricted, and logistics information sharing is insufficient. The cross-border payment and settlement system is not perfect, and the financing channels of small and medium-sized enterprises are limited, leading to high comprehensive trade costs.

4. Paths to enhance economic and trade cooperation

4.1 Deepen strategic docking and optimize institutional arrangements

Give full play to the role of high-level dialogue mechanisms, strengthen policy coordination, promote the alignment of development strategies, improve trade facilitation and investment protection systems, and create a stable and transparent cooperation environment.

4.2 Promote digital integration and cultivate new growth drivers

Accelerate the construction of digital infrastructure, promote the connection of e-commerce platforms, logistics and payment systems, strengthen digital technology cooperation and talent training, narrow the digital divide, and empower traditional economic and trade cooperation.

5. Conclusion

In the future, under the framework of the Belt and Road, the two sides should take enhancing economic and trade cooperation as the starting point, deepen strategic docking, promote digital integration, improve connectivity, optimize the cooperation structure and strengthen risk prevention and control. By continuously expanding the breadth and depth of cooperation, we can promote the high-quality development of bilateral economic and trade relations and inject strong impetus into the construction of a closer China–Central Asia community with a shared future.

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DIGITAL ECONOMY AND THE IMPROVEMENT OF ECONOMIC GROWTH QUALITY UNDER THE BELT AND ROAD INITIATIVE

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Annotation. Against the background of the deepening development of the “Belt and Road” Initiative and the accelerated expansion of the global digital economy, the digital economy has become the core driving force reshaping economic structure and improving the quality of growth. Traditional economic growth relies excessively on factor input and scale expansion, which can hardly support sustainable development. The digital economy, taking data as the key production factor and technological innovation as the driver, can effectively improve resource allocation efficiency, accelerate industrial transformation and upgrading, strengthen innovation capacity and promote green development. Based on the framework of the Belt and Road Initiative, this paper analyzes the mechanism of the digital economy in enhancing economic growth quality, combined with the cooperation practices between China and Kazakhstan and other countries along the routes, discusses the current challenges such as the digital divide, data security and inadequate cross-border coordination, and puts forward countermeasures including improving digital infrastructure, strengthening cross-border digital cooperation, perfecting governance system and promoting the digital transformation of industries. It aims to provide theoretical reference and practical paths for countries along the Belt and Road to achieve high-quality economic growth relying on the digital economy.

Key words: digital economy, Belt and Road Initiative, economic growth quality, digital transformation, China–Kazakhstan cooperation.

1. Introduction

With the rapid popularization of digital technologies, the digital economy has shifted from a new driver of economic development to a core engine, profoundly changing the modes of production, life and governance. High-quality development is the theme of economic construction in the new era. Different from the growth model that simply pursues speed, high-quality growth emphasizes the organic unity of efficiency, innovation, coordination, greenness and openness.

The Belt and Road Initiative is committed to promoting policy coordination, facilities connectivity, unimpeded trade, financial integration and people-to-people bonds among countries along the routes, creating a broad platform for transnational cooperation and coordinated development of the digital economy. As important partners of the Belt and Road, China and Kazakhstan have deepened cooperation in digital infrastructure construction, cross-border e-commerce, digital finance, artificial intelligence and other fields, providing a typical practical sample for the digital economy to drive high-quality growth. In this context, systematically studying the promotion mechanism of the digital economy on economic growth quality, analyzing the cooperative advantages and practical challenges under the Belt and Road framework, and exploring feasible development paths are of great theoretical value and practical significance for promoting coordinated economic development and achieving mutual benefit among countries along the routes.

2. Internal Mechanism of Digital Economy Improving Economic Growth Quality

2.1 Improving Resource Allocation Efficiency and Reducing Economic Operation Costs

Relying on big data, cloud computing, artificial intelligence and other technologies, the digital economy can break the barriers of information asymmetry and realize the accurate matching and efficient flow of production factors. In the traditional economic model, factor circulation has many links, low efficiency and high costs. Digital platforms can integrate supply and demand information, optimize the whole chain of production, circulation, distribution and consumption, and significantly reduce transaction and logistics costs. In countries along the Belt and Road, the construction of digital logistics systems and cross-border e-commerce platforms has effectively improved the level of trade facilitation, optimized resource allocation in a wider range, and directly improved total factor productivity, laying an efficiency foundation for high-quality growth [1].

2.2 Promoting Industrial Structure Upgrading and Cultivating New Development Drivers

The digital economy is highly permeable and integrated, which can deeply empower traditional industries and promote the intelligent, high-end and service-oriented transformation of agriculture, manufacturing and service industries. In agriculture, digital technologies realize precise planting, intelligent breeding and supply chain traceability, raising agricultural added value. In manufacturing, the industrial internet and intelligent manufacturing shift the production mode from large-scale to flexible and customized. In the service sector, new business forms such as cross-border e-commerce, digital finance and remote services continue to emerge. The optimization and upgrading of industrial structure shift economic growth from relying on low-end processing to technology and brand appreciation, effectively improving growth quality [2].

2.3 Strengthening Innovation-Driven Capacity and Stimulating Endogenous Growth Momentum

The digital economy lowers the threshold and cost of innovation, providing diversified support in technology, capital and market for small and medium-sized enterprises and entrepreneurs, and accelerating industry-university-research collaborative innovation. Under the Belt and Road framework, transnational technological cooperation, joint R&D and the construction of innovation parks promote the cross-border flow of innovation factors, as well as technology spillover and knowledge sharing. The improvement of innovation capacity frees economic growth from excessive dependence on resource input and turns to an endogenous growth model relying on technological progress and human capital improvement, which meets the core requirements of high-quality development.

2.4 Promoting Green and Low-Carbon Development and Realizing Sustainable Growth

High-quality development is inseparable from green transformation, and the digital economy is an important tool to achieve low-carbon development. Intelligent energy management systems, digital environmental monitoring, green supply chain management and other technologies can accurately control energy consumption and emissions and improve resource utilization efficiency. Meanwhile, online office, remote conferences, digital services and other models reduce physical resource consumption and drive the economy toward low energy consumption and low emissions. In the construction of the Belt and Road, green digital cooperation helps countries along the routes jointly address climate change and realize the coordinated progress of economic growth and ecological protection.

3. Practical Challenges of Digital Economy Improving Growth Quality under the Belt and Road Initiative

3.1 Unbalanced Development of Digital Infrastructure

There are large differences in economic development levels among countries along the routes. The backward construction of digital infrastructure such as network coverage, broadband speed and data centers in some countries is difficult to support the rapid development of the digital economy, forming an obvious digital divide and restricting coordinated development.

3.2 Imperfect Cross-Border Digital Cooperation Mechanism

Countries have inconsistent standards in data security, digital taxation, electronic certification, intellectual property protection and other aspects. The rules for cross-border data flow are not sound, and policy coordination is insufficient, affecting the in-depth development of digital trade and technological cooperation.

3.3 Shortcomings in Data Security and Governance System

The rapid development of the digital economy is accompanied by risks such as data leakage, cyberattacks and platform monopoly. The digital governance systems of some countries are imperfect, lacking effective supervision and security mechanisms, affecting stable economic operation.

3.4 Prominent Shortage of Digital Talents

The development of the digital economy requires a large number of interdisciplinary talents. However, countries along the routes generally face the shortage of digital skills and high-tech talents, restricting digital transformation and innovation capacity.

4. Paths to Improve Economic Growth Quality Relying on Digital Economy under the Belt and Road Initiative

4.1 Accelerating the Interconnection of Digital Infrastructure

Taking the facilities connectivity of the Belt and Road as an opportunity, increase investment in digital infrastructure in countries along the routes, promote the construction of cross-border optical cables, 5G networks, satellite communications and cloud computing centers, narrow the digital divide, and provide hardware support for the development of the digital economy.

4.2 Deepening Cross-Border Digital Economic and Trade and Technological Cooperation

Promote the establishment of a unified digital trade rule system, strengthen digital coordination in electronic customs, cross-border payment and logistics clearance, and expand the scale of cross-border e-commerce cooperation. Strengthen joint R&D and technology sharing between China and Kazakhstan in artificial intelligence, big data, intelligent manufacturing and other fields.

4.3 Improving Data Security and Digital Governance System

Strengthen transnational cybersecurity cooperation, establish a collaborative mechanism for data security and privacy protection, improve digital market supervision rules, and create a safe, standardized and open digital development environment.

4.4 Strengthening Digital Talent Training and Exchanges

Promote joint training of digital skills among universities and vocational colleges of countries along the routes, establish talent exchange and training mechanisms, improve the digital literacy of local talents, and provide intellectual support for the development of the digital economy.

4.5 Promoting Digital Transformation of Traditional Industries

Support the digital transformation of agriculture, manufacturing and service industries, promote new models such as intelligent manufacturing, smart agriculture and digital culture and tourism, accelerate the deep integration of digital economy and real economy, and comprehensively improve the quality of economic growth.

5. Conclusion

The digital economy is a key engine to improve the quality of economic growth. Under the framework of the Belt and Road Initiative, the transnational coordinated development of the digital economy provides important opportunities for countries along the routes to achieve high-quality growth. By improving resource allocation efficiency, promoting industrial upgrading, strengthening innovation drive and boosting green development, the digital economy optimizes the economic growth structure in multiple dimensions and shifts the growth model from scale-speed oriented to quality-benefit oriented. Faced with challenges such as unbalanced digital infrastructure, imperfect cross-border cooperation mechanisms, data security risks and talent shortage, countries should strengthen policy coordination and practical cooperation, accelerate digital interconnection, improve governance systems, deepen industrial integration, and promote mutual benefit through digital cooperation. In the future, with the deepening of digital cooperation under the Belt and Road, the digital economy will continue to unleash growth potential, help countries along the routes achieve higher-quality, more efficient and more sustainable economic development, and inject strong digital impetus into building a community with a shared future for mankind.

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CULTURAL-TOURISM INTEGRATION IMPROVING BELT AND ROAD INITIATIVE PUBLIC-WELLBEING

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Annotation. The Belt and Road Initiative has created new chances for China and Kazakhstan to work together. Culture and tourism are two key areas in this cooperation. This paper looks at how combining them can help local people. Cultural heritage tourism is a good example of this. It uses historical sites to attract visitors and create more jobs. Local people earn money through tourism services and selling cultural products. At the same time, tourists learn about different cultures. This builds understanding between people of different countries. The results show that cultural tourism does more than grow the economy. It also improves people's daily lives and brings communities closer together. This kind of cooperation supports shared growth along the Belt and Road

Key words: Belt and Road Initiative; Cultural and Tourism Integration; China-Kazakhstan Cooperation; Cultural Heritage Tourism; People's Wellbeing

I. Background and Significance

The Belt and Road Initiative has moved beyond economic cooperation into culture, tourism, and other fields[1].Countries along the Belt and Road have long histories and diverse cultures, with rich natural and cultural landscapes. These conditions are ideal for integrating culture and tourism. Culture is the soul of tourism; tourism is the carrier of culture. Their deep integration promotes economic development among Belt and Road countries and improves people’s wellbeing.

Economically, the integration of culture and tourism creates many jobs. Tourism is a labor-intensive industry. It covers transport, accommodation, food, entertainment, and other areas.[2]Cultural elements — such as performances and handicraft-making — further expand career choices for people along the route. Kazakhstan is a good example. Its steppe culture attracts many Chinese tourists, and locals earn income through tourism services and cultural products, improving living

standards.[3]Cultural tourism also promotes balanced regional development, reducing the urban-rural gap and driving prosperity along the Belt and Road.

Socially, cultural tourism strengthens mutual understanding and friendship among peoples of Belt and Road countries. These countries have significant cultural differences. Through tourism, people from different countries can experience each other's cultures. This breaks down cultural barriers and misunderstandings.[4]Tourists experience local customs and festivals during their trips and interact with residents. This promotes cultural exchange and strengthens cultural identity and a sense of belonging. Chinese festivals are gaining attention in Belt and Road countries, while local cultures spread more widely in China. This two-way exchange enriches people's spiritual lives and creates a friendly international atmosphere.

II. The Role of Cultural Heritage Tourism in Improving People's Wellbeing — A Case Study of China–Kazakhstan Cooperation

Cultural tourism integration covers not only cultural sites and travel routes, but also creativity, experiences, and communication. Cultural heritage tourism is one important model. It has unique advantages in improving people's wellbeing — letting tourists experience history firsthand, strengthening cultural pride, and bringing economic benefits to local people and promoting cultural preservation[5].

(I)Content and Model Analysis

Cultural heritage tourism uses historical sites and relics as its core attractions. In China–Kazakhstan cooperation, both sides explore and integrate their rich cultural heritage resources to create unique tourism routes and products. For example, China's Terracotta Warriors in Xi'an and historical sites near Kazakhstan's Khorgos border crossing are linked by tourism routes. Tourists enjoy different heritage sites and experience cultural exchange between the two countries. This enriches tourism content and gives tourists a chance to learn deeply about both cultures.

(II)Impact on People's Economic Wellbeing

Cultural heritage tourism has had a positive impact on the economic wellbeing of people along the China–Kazakhstan route. In employment, it has driven job growth in tour guiding, cultural preservation, and tourism services[6].In some regions of Kazakhstan, local people have gained stable income by working in tourism. In terms of income, cultural heritage tourism attracts many domestic and international tourists, boosting spending on dining, accommodation, and shopping and directly increasing people's income. Cultural heritage tourism also drives related industries such as cultural and creative product development, creating more entrepreneurship and employment opportunities for people.

In terms of industrial structure, cultural heritage tourism has pushed regions along the China–Kazakhstan route to optimize their industrial mix, shifting from traditional agriculture or industry toward tourism services[7].In Shaanxi, China, the share of tourism services in the local economy has grown, driving diversified regional development. Cultural heritage tourism also helps narrow the urban–rural gap and

promotes balanced development. Some rural areas that were once economically underdeveloped have attracted tourists and investment, improving infrastructure and raising people's living standards.

Kazakhstan's people are benefiting from many Belt and Road projects. In energy, the Aktyubinsk gas pipeline brings affordable heating and created 20,000 jobs; the project also built a dance academy and a table tennis center for local youth. In Zhanaatas, the largest wind power project in Central Asia now powers 200,000 homes. Chinese firms even built an outdoor pool using mountain spring water for children. In agriculture, the "Golden Camel "milk powder factory in Turkestan uses a "factory plus farmers "model to raise herder incomes, and hired over 40 single mothers facing hardship with flexible shifts to protect their livelihoods. These examples show that the Belt and Road Initiative turns economic growth into real benefits for ordinary people.

China–Kazakhstan cooperation shows that deep integration of culture and tourism, especially cultural heritage tourism, significantly improves the wellbeing of people along the Belt and Road. This offers practical reference for promoting Belt and Road cultural tourism cooperation and lays a foundation for shared development and prosperity among Belt and Road countries.

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UDC (338.2)

DIGITAL ECONOMY EMPOWERING THE CROSS-BORDER TRADE OF AGRICULTURAL PRODUCTS IN HENAN PROVINCE: MECHANISMS AND PATHWAYS

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Annotation. Against the backdrop of digital economy globalization and rural revitalization, cross-border trade of agricultural products has become a key driver for high-quality agricultural development in Henan Province. Based on the current state of Henan's agricultural trade and digital economy, this paper systematically analyzes the mechanisms through which the digital economy empowers cross-border agricultural trade. Using panel data of 17 prefecture-level cities in Henan province from 2020 to 2024 and a two-way fixed effects model, it empirically tests the empowerment effects and mediating channels. The results show that the digital economy significantly promotes agricultural exports, with logistics efficiency and informatization level serving as important mediators. Finally, the present study proposes optimized pathways for deepening technological, factor, and business model empowerment.

Keywords: Digital Economy; Henan Province; Agricultural Products; Cross-Border Trade; Empowerment Mechanisms

Introduction. The rapid rise of the digital economy provides new solutions to problems in traditional agricultural trade, such as long transport times, high loss rates, and limited market channels. The 20th National Congress of the CPC calls for accelerating digital economy development and promoting its deep integration with the real economy. In 2024, Henan's digital economy scale exceeded RMB 2 trillion, accounting for over 30% of GDP, laying a solid foundation for the digital transformation of cross-border agricultural trade. This paper aims to identify the mechanisms, current status, and optimization pathways for digital economy empowerment in Henan's agricultural trade.

1. Mechanisms of Digital Economy Empowerment

1.1 Technological Empowerment

Digital technologies (IoT, big data, blockchain) enable real-time monitoring of production, processing, logistics, and customs clearance. IoT reduces spoilage of fresh produce; blockchain ensures traceability and quality trust; big data helps match overseas demand, avoiding overproduction (Yan et al., 2026).

1.2 Factor Empowerment

Data as a production factor breaks information silos, optimizing resource allocation across regions and industries. It helps consolidate scattered agricultural resources into large-scale industrial clusters and guides producers toward higher-value-added exports (Liu, 2025).

1.3 Business Model Empowerment

New trade models (cross-border e-commerce, live-streaming, market-procurement trade) shorten intermediate links, reduce costs, and directly connect Henan's farmers with overseas consumers, expanding market coverage.

2. Current Status and Empirical Analysis

2.1 Descriptive Overview

In 2024, Henan's food exports reached RMB 15.05 billion, representing a year-on-year increase of 12.4%, with products exported to over 160 countries and regions. Despite this growth, several structural challenges persist, including limited brand influence, low value-added products, inadequate alignment with international standards, and the underdevelopment of emerging trade models.

Meanwhile, the digital economy has experienced rapid expansion, with Henan's 5G infrastructure and computing capacity ranking among the leading regions in central China. Although initial integration between the digital economy and agricultural trade has begun, it remains relatively superficial, constrained by a shortage of digital talent and insufficient supporting service systems.

2.2 Empirical Strategy and Data

To verify the empowerment effects, we construct a two-way fixed effects model using panel data of 17 prefecture-level cities in Henan (2020–2024). Variables are defined as follows (Table 1):

Table 1. Description of Research Variables

Variable	**Symbol**	**Measurement**
Agricultural export (dependent)	Export	Logarithm of export value
Digital economy index (core independent)	Digital	Composite index by entropy method
Logistics efficiency (mediator)	Logistics	Logarithm of express delivery volume
Informatization level (mediator)	Internet	Logarithm of internet broadband subscribers
Control variables	AgriGDP, Road, Open, Edu	Agricultural value added, road mileage, openness, human capital

Note: Data sources: Henan Statistical Yearbook, China City Statistical Yearbook, and prefectural bulletins.

2.3 Benchmark Results and Mechanism Testing

Table 1 reports the benchmark regression and mediation results. Column 1 shows that Digital has a significant positive effect on export (coef. 0.341, $p < 0.05$) after controlling for all covariates and city/year fixed effects. Columns 3-4 show that Digital significantly increases Logistics and Internet. The coefficient of digital drops to 0.245, while both mediators are positive and significant, indicating partial mediation.

Table 2. Benchmark and Mediation Results

Variable	Digital	Logistics	Internet	Controls & FEs	Observations	R^2
Export	0.341 (0.152)	0.543 (0.201)	0.398 (0.176)	-	85	0.508
Logistics	-	0.178 (0.095)	-	Yes	85	0.423
Internet	-	-	0.163 (0.088)	Yes	85	0.456
Export	0.245 (0.112)	-	-	Yes	85	0.567
Note: $p < 0.05$, $p < 0.1$; robust standard errors in parentheses. Controls include AgriGDP, Road, Open, Edu; city and year fixed effects included						

These results confirm that the digital economy promotes agricultural exports both directly and indirectly via improved logistics efficiency and informatization. Three robustness checks (excluding Zhengzhou, lagged Digital, PCA-based Digital index) all yield consistent results (available upon request).

2.4 Summary of Empirical Findings

The digital economy significantly enhances Henan's cross-border agricultural trade. Logistics efficiency and informatization level are key mediating channels, supporting the "technological empowerment" mechanism proposed earlier.

3. Optimizing Pathways for Empowerment

3.1 Deepen Technological Empowerment

Apply IoT, big data, and AI to planting, breeding, and processing. Establish smart agricultural platforms for wheat, peanuts, edible fungi, and meat. Introduce

intelligent processing equipment to produce higher-value-added products (e.g., prepared dishes, extracts). Strengthen R&D cooperation for traceability and preservation technologies tailored to fresh produce exports (Chen, 2024).

3.2 Strengthen Factor Empowerment

Efforts should be made to cultivate interdisciplinary talent with expertise in digital technology, international trade, and agriculture through targeted university programs and vocational training initiatives. At the same time, policies should be implemented to attract high-level professionals from both domestic and international markets, particularly those with extensive experience in global trade. In addition, the allocation of capital and data resources should be optimized to better support the development of small and medium-sized enterprises.

3.3 Innovate Business Model Empowerment

Promote "cross-border e-commerce + industrial belt" model based on Zhengzhou Pilot Zone. Build agricultural e-commerce industrial parks, encourage B2B, B2C, live-streaming, and social commerce. Expand market-procurement trade to ASEAN and Belt and Road countries. Improve multimodal logistics (China-Europe freight trains, air freight, rail-sea intermodal). Use virtual exhibitions and overseas warehouses to enhance brand presence globally.

Conclusion. The digital economy presents unprecedented opportunities for Henan's cross-border agricultural trade. By empowering trade through technological advancement, factor integration, and business model innovation, it effectively mitigates traditional trade barriers. Empirical analysis based on panel data reveals a significant positive impact of the digital economy on cross-border agricultural trade, with logistics efficiency and informatization playing important mediating roles.

To fully capitalize on these advantages, Henan should leverage its strengths in agricultural resources and digital infrastructure to enhance the digital support system across the entire value chain. This includes fostering competitive market entities, promoting innovative trade models, and developing internationally recognized brands, thereby bringing more distinctive "Henan flavors" to the global market.

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UDC 339.5

SOME ASPECTS OF ECONOMIC COOPERATION BETWEEN THE REPUBLIC OF KAZAKHSTAN AND THE PEOPLE'S REPUBLIC OF CHINA WITHIN THE FRAMEWORK OF THE "ONE BELT, ONE ROAD" INITIATIVE

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Annotation. This paper examines the development of economic cooperation between the Republic of Kazakhstan and the People's Republic of China within the framework of the Belt and Road Initiative (BRI). It analyzes key areas of bilateral interaction, including infrastructure connectivity, trade and investment, energy cooperation, digital economy, and financial integration. Particular attention is given to major joint projects such as transport corridors, pipelines, and logistics hubs, which have strengthened Kazakhstan's role as a strategic transit link between Asia and Europe. The study highlights the growing diversification of trade structure and the expansion of Chinese investment into non-resource sectors of Kazakhstan's economy. In addition, the paper explores emerging cooperation in the digital sphere, including e-commerce, telecommunications, and smart technologies. Despite significant achievements, several challenges are identified, such as legal and institutional differences, logistical inefficiencies, and external economic uncertainties. The paper concludes by outlining перспективы дальнейшего углубления сотрудничества, emphasizing sustainable development, innovation, and improved regulatory frameworks as key drivers of future growth. Overall, the study demonstrates that China-Kazakhstan cooperation under the BRI contributes significantly to regional economic integration and long-term mutual development.

Key words: Belt and Road Initiative; Kazakhstan; China; economic cooperation; infrastructure development; trade and investment; digital economy; regional integration; transport corridors; financial cooperation.

Since its inception, the "Belt and Road" Initiative has become an important platform for promoting global regional economic cooperation. As the place where the "Silk Road Economic Belt" was first proposed, Kazakhstan has continuously deepened its economic cooperation with China under this framework, covering multiple areas such as infrastructure, energy, trade, and the digital economy. This paper aims to analyze the current state, major achievements, and future directions of

economic cooperation between the two countries within the “Belt and Road” framework, and to explore its significance for regional economic integration.

First, infrastructure connectivity is one of the core areas of bilateral cooperation. The construction of major projects such as the China-Kazakhstan Khorgos International Border Cooperation Center, the Western Europe-Western China International Highway, and the China-Kazakhstan crude oil and natural gas pipelines has significantly improved logistics efficiency and energy security between the two countries. In particular, the launch and regular operation of the China-Europe Railway Express has made Kazakhstan an important land hub connecting China and Europe, enhancing its strategic position as a transit country.

Second, trade and investment cooperation continues to expand. China is one of Kazakhstan’s largest trading partners, and bilateral trade volume has grown steadily in recent years. In addition to traditional energy and mineral resources, the share of trade in agricultural products, chemical products, machinery and equipment has been increasing. At the same time, Chinese enterprises are increasing their investment in Kazakhstan’s non-resource sectors, such as manufacturing, agriculture, finance, and information technology, supporting Kazakhstan’s economic diversification strategy.

Third, the digital economy has become a new highlight of bilateral cooperation. Against the backdrop of aligning Kazakhstan’s “Digital Kazakhstan” national program with the “Digital Silk Road” initiative, the two sides have carried out numerous cooperation projects in e-commerce, 5G communications, smart cities, and cross-border payment systems. For example, Chinese companies such as Huawei have participated in the construction of Kazakhstan’s communication infrastructure, and Alibaba’s cross-border e-commerce platform has provided new channels for Kazakh small and medium-sized enterprises to enter the Chinese market.

Furthermore, financial cooperation is steadily advancing. The central banks of China and Kazakhstan have signed a bilateral local currency swap agreement, and the direct trading mechanism between the renminbi and the tenge has been gradually improved, reducing exchange rate risks and transaction costs. The Asian Infrastructure Investment Bank and the Silk Road Fund have provided stable financing support for China-Kazakhstan cooperation projects.

However, economic cooperation between the two countries also faces some challenges. Issues such as differences in legal systems, the need for further improvement in cross-border logistics efficiency, and non-tariff barriers still need to be addressed through policy coordination and institutional innovation. In addition, global geopolitical changes and international market fluctuations may also have certain impacts on cooperation.

Looking ahead, China-Kazakhstan economic cooperation should develop toward higher levels and broader areas. On the one hand, traditional infrastructure and energy cooperation should be further deepened, with green energy and sustainable development projects promoted. On the other hand, emerging fields such as the digital economy, technological innovation, deep processing of agricultural products,

and people-to-people exchanges should be actively expanded. At the same time, bilateral cooperation mechanisms should be improved, policy transparency and legal protection enhanced, and a more stable, fair, and predictable business environment created.

In summary, the «Belt and Road» Initiative provides a solid platform and broad space for China-Kazakhstan economic cooperation. The two countries have achieved remarkable results in cooperation in infrastructure, trade, investment, the digital economy, and finance, demonstrating strong development potential. In the future, through further deepening of mutually beneficial cooperation, China and Kazakhstan will not only achieve their respective development goals but also make greater contributions to regional economic integration and shared prosperity.

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DIGITAL ECONOMY COLLABORATION BETWEEN KAZAKHSTAN AND CHINA: OPPORTUNITIES, CHALLENGES, AND PATHWAYS UNDER THE «ONE BELT, ONE ROAD» INITIATIVE

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Annotation. The deepening of digital transformation has become a global trend, reshaping international economic cooperation. Kazakhstan and China have maintained close ties under the «One Belt, One Road» (OBOR) initiative, with the

digital economy emerging as a key area. Based on practical observations, this paper explores the opportunities and challenges of Kazakhstan-China digital collaboration, analyzes e-commerce, infrastructure, and artificial intelligence, and puts forward pathways to enhance cooperation.

Key words: Kazakh-Chinese cooperation, economy, sustainable economic development, economic opportunities.

Introduction and theoretical framework

To comprehensively analyze the digital economy collaboration between Kazakhstan and China under the «One Belt, One Road» initiative, this paper draws on relevant theories of international economic cooperation, digital economy, and regional integration [8, 30]. Traditional international economic cooperation theories, such as comparative advantage theory and factor endowment theory, provide a basic framework for bilateral cooperation, but they can no longer fully adapt to the characteristics of digital economy cooperation, which is driven by technology and data. In the digital era, the theory of digital comparative advantage has gradually emerged, emphasizing that the differences in digital infrastructure, digital technology level, and data resources between countries determine the division of labor and cooperation [30]. Kazakhstan, with its rich natural resources and strategic geographical location, and China, with its advanced digital technology, complete industrial chain, and mature digital application experience, have formed complementary advantages in the digital field [2, 5].

Digital economy refers to an economic form that takes data resources as the key production factor, digital technology as the core driving force, and modern information networks as the carrier [9]. According to the research of domestic and foreign scholars, digital economy development mainly includes three core dimensions: digital infrastructure, digital industrialization, and industrial digitalization. Digital infrastructure is the foundation of digital economy development, including communication networks, data centers, and intelligent terminals [4, 14]. For Kazakhstan and China, strengthening cooperation in these three dimensions can help give full play to their respective advantages and promote the synchronous development of digital economy in both countries. In recent years, scholars from Kazakhstan and China have conducted relevant research on bilateral digital economy cooperation. Kazakh scholars focus on the impact of digital transformation on the country's economic structure [11]. Chinese scholars mostly focus on the overall layout of OBOR digital cooperation [12, 23].

Current status and challenges of Kazakhstan-China digital economy collaboration

In recent years, Kazakhstan and China have made positive progress in digital infrastructure interconnection under the OBOR initiative. China has actively participated in the construction of Kazakhstan's digital infrastructure. According to data from the Ministry of Digital Development, as of the end of 2025, the coverage

rate of 4G networks in Kazakhstan has reached 92%, and the coverage rate of 5G networks has reached 45%, of which more than 30% of 5G base stations are built with technical support from Chinese enterprises such as Huawei and ZTE [1, 4]. At the same time, the China-Kazakhstan cross-border optical cable project has been put into use, which has significantly improved the speed and stability of data transmission. In addition, the two countries have jointly promoted the construction of smart cities in Astana and Almaty [28].

Cross-border e-commerce has become an important breakthrough in Kazakhstan-China digital economy cooperation. According to the data from China's General Administration of Customs, the volume of cross-border e-commerce transactions between China and Kazakhstan reached 8.7 billion US dollars in 2025, an increase of 35% compared with 2024 [3, 7]. Kazakh agricultural products such as wheat, honey, and fruits are sold to China through platforms, while Chinese electronic products and daily necessities are popular among Kazakh consumers. The two countries have jointly built cross-border e-commerce industrial parks, such as the Khorgos Industrial Park, which reduces transaction costs and promotes rapid development [18]. Artificial intelligence has also become a new focus of cooperation. The two countries have carried out in-depth cooperation in R&D and talent training. Chinese universities have established cooperative relations with Kazakh universities such as L. N. Gumilyov Eurasian National University [16]. For example, they have jointly developed an intelligent agricultural monitoring system to help Kazakh farmers improve production efficiency [24].

Despite the remarkable achievements, there are still many challenges. First, the gap in digital development levels: China has a complete digital industrial chain, while Kazakhstan's digital economy is still in the initial stage, with insufficient infrastructure in rural areas [23, 27]. Second, differences in digital policies and regulatory systems, such as data security and privacy protection [12,17]. Third, insufficient connectivity of cross-border logistics and payment systems, with high logistics costs and cumbersome procedures [13, 25]. Fourth, the lack of deep integration between digital technology and traditional industries, where digital transformation of traditional sectors is relatively slow [21, 24].

Pathways to enhance Kazakhstan-China digital economy collaboration

The two countries should further strengthen cooperation in digital infrastructure construction, expand the coverage of 5G networks and optical fiber networks, especially in rural areas [14, 27]. China can continue to provide technical and financial support and help Kazakhstan cultivate professional talents. On the other hand, the two countries should jointly carry out digital literacy training programs to improve the digital application ability of the whole society [11]. It is also necessary to improve policy coordination and establish a joint regulatory mechanism. The two countries should strengthen communication on digital economy policies and align regulatory standards in data security and cross-border data flow [12, 17]. It is

necessary to formulate a unified cross-border digital trade standard and supervision system to simplify customs clearance procedures and reduce transaction costs.

To promote the development of cross-border e-commerce, the two countries should jointly optimize the cross-border logistics system and strengthen the construction of hubs [13]. For example, they can expand the scale of the China-Kazakhstan Railway Express and open more logistics routes. At the same time, they should promote the connection of payment systems to improve the convenience and safety of transactions [25]. Furthermore, focus should be on promoting the digital transformation of Kazakhstan's energy, agriculture, and service industries [24]. China can share its experience and provide solutions to help Kazakhstan build a digital industrial system [21]. They should also jointly develop emerging digital industries such as artificial intelligence, big data, and cloud computing. Strengthening talent training and academic exchange is equally vital. Both countries should establish joint training programs [16]. China can send experts to Kazakhstan for training courses, and Kazakhstan can send personnel to China for study. Holding regular forums will provide a platform for exchanges between experts and entrepreneurs [22, 29].

Conclusion

Digital economy collaboration has become an important pillar of Kazakhstan-China bilateral cooperation under the OBOR initiative [20]. This paper finds that the two countries have formed complementary advantages and made achievements in infrastructure, e-commerce, and AI. However, challenges like the digital divide and policy differences remain. To enhance collaboration, the two countries need to focus on infrastructure, policy coordination, logistics, industrial integration, and talent training. Through these measures, we can achieve win-win development and provide a model for other countries along the OBOR initiative [19].

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INTEGRATION OF ESG INDICATORS INTO THE CORPORATE FINANCE STRATEGY: A CASE STUDY OF XIAMEN ITG GROUP CORP., LTD.

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Annotation. Taking Xiamen ITG Group Co., Ltd. (stock code 600755.SH), a leading supply chain enterprise in China, as a single case, this paper examines how Environmental, Social and Governance (ESG) indicators can be systematically integrated into corporate finance strategy. “Corporate finance strategy” is defined

here as the firm-level strategic management of financing, capital structure, investment allocation, working capital efficiency and shareholder returns. Through descriptive statistics and trend analysis based on publicly disclosed financial data, sustainability reports and external ratings from 2015 to 2025, the study finds that Xiamen ITG maintains an AA Huazheng ESG rating (ranked 1st among 28 peers) and an average ROE of 12.36% over the past decade, significantly higher than the industry average of 10.2%. The paper synthesizes six concrete practices across governance, financing, supply chain management, disclosure, dividend policy and strategic planning, and demonstrates three core pathways through which ESG drives financial strategy improvement: reducing capital cost, enhancing creditworthiness and boosting operational efficiency. The findings suggest that deep integration of ESG indicators is not an additional cost burden, but a strategic instrument that directly translates into lower capital costs, improved working capital management and superior long-term financing capacity.

Key words: ESG indicators; corporate finance strategy; financing decisions; ESG indicators; corporate finance strategy; Xiamen ITG; case study.

1.Introduction

Under the dual pressure of global sustainability and cyclical commodity price volatility, the critical question for Xiamen ITG is not “whether to adopt ESG,” but rather: through what substantive financial mechanisms do ESG factors affect a supply chain enterprise’s financing ability, operational efficiency and long-term strategic footprint?

Xiamen ITG Group Co., Ltd. (stock code: 600755.SH) is a benchmark A-share listed enterprise in China’s trade and supply chain sector, with its core business consistently accounting for over 99% of total revenue. This paper adopts a single-case deep-dive framework to systematically deconstruct the actual coupling pathways between ESG indicators and corporate finance strategy from 2015 to 2025.

2.Theoretical Framework

Three fundamental mechanisms through which ESG influences financial strategy: Stakeholder Theory (Freeman, 1984) posits that strong ESG performance reduces transaction and agency costs, thereby improving the cost of capital; Resource-Based Theory (Barney, 1991) views ESG as a heterogeneous strategic resource that can be converted into a financing advantage; and Signaling Theory emphasizes that high-quality ESG disclosure reduces information asymmetry, thereby lowering the cost of equity and debt capital. Together, these three theories form the theoretical foundation for “cost reduction, credit enhancement, and efficiency improvement.”

3.Xiamen ITG Case Study: Six Deep Integration Pathways

For a trade and supply chain enterprise, competition increasingly revolves not just around resource access, but around creditworthiness and operational efficiency.

Xiamen ITG demonstrates that ESG serves as the foundational infrastructure linking these three core financial objectives.

Disclosure. Xiamen ITG has continuously published annual sustainability reports since 2009, upgrading to bilingual ESG reports in 2022. Its 2024 sustainability report systematically references multiple domestic and international standards, including SASB, ISSB, GRI, China's Ministry of Finance disclosure guidelines and the Shanghai Stock Exchange's Guideline No. 14. The 2025 report provides further data on carbon reduction targets, green supply chain management and supplier ESG risk assessment. This shift from passive compliance to systematic disclosure is the starting point for reducing information asymmetry and building capital market trust.

Governance. Xiamen ITG has established a board-level Strategy and Sustainability Committee, chaired by an independent director. In January 2026, the committee reviewed and approved the Five-Year Development Strategic Plan Outline (2026-2030), explicitly incorporating "green transformation" as a core strategic direction. ESG is no longer a peripheral ethical issue on the boardroom agenda, but directly linked to capital expenditure, business mix and asset allocation.

Financing. Two landmark bond issuances illustrate how ESG directly reduces financing costs. First, in June 2022, Xiamen ITG's holding company successfully issued the city's first green medium-term note with a GN label, totaling RMB 340 million at a coupon rate of 3.59%, with proceeds allocated entirely to the Xiamen New Convention and Exhibition Center – a project estimated to reduce annual CO_2 emissions by 87,148 tons. Second, in January 2025, as an AAA-rated issuer, Xiamen ITG successfully issued the nation's first "Belt and Road" perpetual corporate bond on the Shanghai Stock Exchange, raising RMB 1.5 billion at a 3.1% coupon – the lowest rate for such bonds among local state-owned enterprises in Fujian province. Both cases demonstrate that embedding ESG into the financing function can directly compress marginal capital costs.

Operational efficiency. Xiamen ITG integrates ESG criteria into its supply chain. The Supplier Code of Conduct incorporates environmental standards, labor rights and compliance requirements into supplier selection and evaluation, weeding out high-risk partners upfront. Meanwhile, the company has implemented a "three-chain integration" upgrade across eight mature industrial chains, shortening payment cycles and improving inventory turnover through digital platforms.

Dividend policy. ESG-related governance stability has translated into clear dividend discipline. Xiamen ITG has maintained a cash dividend yield above 5% for five consecutive years, distributing RMB 0.33 per share (pre-tax) in 2024, total RMB 715 million. An interim dividend of RMB 0.10 per share was further approved for 2025. A stable and predictable dividend policy thus becomes a verifiable signal of sound governance.

Strategic planning. The 2026–2030 strategic plan's explicit incorporation of "green transformation" means future capital expenditure will tilt toward green

industries, altering the company's asset composition and capital structure at the highest strategic level.

4.Data, Methods and Trends

Data sources include Xiamen ITG's annual reports (2015-2024), sustainability reports (2021-2024), Huazheng ESG ratings and Wind financial terminal data. Analytical methods are descriptive statistics and trend comparison; no econometric modeling is employed.

From 2020 to 2024, Xiamen ITG's Huazheng ESG score rose from 7.2 to 8.3 (out of 9), while its ROE increased from 10.5% to 14.2%. This correlation strongly suggests that sustained ESG investment is not a "cost item" that erodes profitability, but an endogenous variable that moves in tandem with, and reinforces, core financial metrics.

5.Discussion and Conclusion

For a supply chain enterprise like Xiamen ITG, the true value of ESG lies not in compliance certificates or report-filing activities, but as a strategic financial instrument directly shaping financing cost, operational reliability and shareholder return expectations.

The study demonstrates that systematic integration of ESG into corporate finance strategy produces deeply coupled effects along three critical dimensions: financing cost (RMB 340 million green bond at 3.59% vs. conventional instruments), supply chain operational efficiency (upfront ESG supplier evaluation reduces interruption risk and capital tie-up) and long-term shareholder returns (5+ years of >5% dividend yield). These effects ultimately translate into a leading ROE among peers (12.36% vs. industry average 10.2%).

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DIGITAL-ECONOMY EMPOWERMENT FOR UPGRADING BELT AND ROAD INITIATIVE ECONOMIC AND TRADE COOPERATION

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Annotation. Traditional trade fairs, a cornerstone of Belt and Road Initiative (BRI) economic cooperation, face limitations including high costs, limited coverage, and time constraints. This paper explores how digital exhibitions, as a manifestation of the digital economy, can empower the upgrading of BRI trade cooperation. Through deductive reasoning and a case study of the 139th Canton Fair Phase I (April 15-19, 2026), this paper establishes a theoretical framework based on three mechanisms: lowering participation thresholds, improving AI-driven matching efficiency, and breaking space-time constraints. The findings indicate that digital exhibitions significantly enhance market coverage and trade efficiency. The 139th Canton Fair attracted 167,000 overseas buyers from 216 countries and regions, a 5.9% year-on-year increase, with over 60% of exhibitors applying AI and green technologies, confirming the proposed mechanisms. This paper concludes that digital exhibitions offer a replicable model for enhancing BRI economic cooperation, and recommends establishing unified technical standards and providing targeted support for SMEs.

Key words: Digital Economy Empowerment, Digital Exhibitions, Belt and Road Initiative, Cross-border Trade, 139th Canton Fair.

Theoretical Framework. Digital exhibitions empower BRI trade cooperation through three mechanisms. First, they lower participation thresholds by eliminating travel and accommodation costs, enabling small and medium-sized enterprises (SMEs) along BRI routes to engage in cross-border trade [3]. Second, they improve matching efficiency through AI-powered recommendation systems that connect buyers and sellers based on product categories and trade history [1]. Third, they break space-time constraints by operating 24/7, allowing continuous trade interactions across different time zones [2].

Case Study: The 139th Canton Fair. The first phase of the 139th Canton Fair (April 15-19, 2026) provides evidence of digital empowerment. Key digital innovations included the Canton Fair APP with AI-powered search, the ASKME AI assistant supporting photo recognition and route planning, and millisecond badge verification. As of April 19, 2026, the fair attracted 167,000 overseas buyers from 216 countries and regions, a 5.9% increase from the previous session. Over 60% of exhibitors applied AI and green technologies. Buyer participation from key BRI regions, including ASEAN, Latin America, and Africa, exceeded 50% of inbound passenger volume. This case confirms the three mechanisms: expanded geographical coverage, AI-driven matching efficiency, and continuous digital engagement beyond physical fair dates (Data source: China Foreign Trade Centre).

Policy Implications. To further leverage digital exhibitions for upgrading BRI trade cooperation, three policy measures are recommended. First, promote interconnection among digital exhibition platforms across BRI countries by establishing unified technical standards and data exchange protocols [4]. Second, provide technical training and financial subsidies to help SMEs along the BRI routes participate in digital exhibitions [5]. Third, strengthen cooperation on data security and cross-border payment systems to build trust in online transactions [3]. The Canton Fair experience demonstrates that AI integration significantly enhances buyer participation and matching efficiency, offering a replicable model for other BRI countries to upgrade their own exhibitions [1][2].

Conclusion. This paper finds that digital exhibitions empower BRI economic and trade cooperation by lowering participation thresholds, improving matching efficiency, and breaking space-time constraints [1][2][3]. The case of the 139th Canton Fair Phase I confirms these mechanisms, with 167,000 overseas buyers from 216 countries and regions and a 5.9% year-on-year increase in attendance. However, this study is limited by its reliance on a single case and preliminary data. Future research should compare multiple digital exhibition platforms and conduct empirical analysis of their impact on BRI trade flows [4][5].

The import structure shows an increase in the supply of finished goods and manufactured goods. The main contribution was made by vehicles (+3.4 billion dollars), metals (+645 million dollars) and chemical products (+412 million dollars), reflecting the expansion of investment activity, infrastructure projects and consumer demand in the country. The share of animal and vegetable products (+$394 million)

and chemical industry (+$345 million) increased in the structure of exports to China, while the share of metals (- $605 million) and mineral products (-$112 million) decreased. These changes may reflect lower industrial demand in China, lower global commodity prices, and the expansion of domestic production.

Thus, collectively, China acts not only as Kazakhstan's largest trading partner, but also as a significant external factor influencing the formation of domestic demand, investment activity and price processes in the country's economy. [6].

The Ministry of Trade and Integration of the Republic of Kazakhstan and the Ministry of Commerce of the People's Republic of China have signed a memorandum of understanding aimed at deepening partnership in the field of e-commerce, the press service of the Ministry of Trade of Kazakhstan reports.

The signed document provides for the creation of a favorable ecosystem for the development of electronic commerce between the two countries. According to the memorandum, Kazakhstan and China will focus on several strategic areas: Improving government regulation in the field of e-commerce; Intensive exchange of experience and best practices; Conducting joint market research; Development of logistics infrastructure for cross-border trade; Attracting investments in digital trading projects; Opening of national and country pavilions on electronic platforms.

The document pays special attention to the formation of relationships based on mutual trust and benefit. This demonstrates the commitment of both sides to build a long-term strategic partnership in the fast-growing sector of the digital economy. The development of e-commerce opens up significant prospects for Kazakhstani manufacturers and entrepreneurs, providing them with access to the multi-million Chinese market through digital channels [7].

China is a global leader in the field of trade digitalization due to the active introduction of artificial intelligence, big data and blockchain technologies. The government actively supports the digitalization of logistics and customs procedures, which significantly speeds up the process of cross-border trade. The China International Trade Single Window digital platforms have been introduced, providing automated data exchange between exporters and government agencies. In addition, China actively uses global identification systems such as the Global Trade Item Number (hereinafter referred to as GTIN), which makes it possible to unify product data on domestic and international markets [8].

Last year, China once again set a record in terms of foreign trade. China's foreign trade volume in 2025 exceeded a record 45 trillion yuan, or about 6.5 trillion dollars. This is 3.8% more than a year earlier. According to the Main Customs Administration, exports increased by more than 6% over the year, while imports increased by half a percent. According to the General Administration of Customs, China's import structure continued to improve in 2025, due to a significant increase in the supply of high-tech products and high-value-added goods. Analysts say that this trend reflects positive developments in both industrial development and domestic consumption. According to the authorities, trade with partner countries under the Belt

and Road initiative accounted for more than half of China's total trade in 2025. Private enterprises remain the main driving force of foreign trade, their share in the total volume of trade is 57 percent [9].

The main directions of digitalization expansion due to the development of «One Belt, One Road»: Development of the Digital Silk Road: This is one of the key directions of the state strategy, involving the creation of cross-border fiber-optic communication lines and joint development of data center infrastructure (data centers).Cross-border e-commerce: The integration of OPOP logistics chains with digital platforms makes it possible to simplify customs procedures and speed up the delivery of goods, which stimulates the growth of digital trade between the PRC, Kazakhstan and Europe.Development of artificial intelligence (AI) infrastructure: Kazakhstan is striving to integrate into global digital economy chains, creating a base for AI, which includes the construction of a "Data Center Valley" and using China's experience in the field of Big Data.Digital transport logistics: The introduction of digital transportation management systems on the corridors passing through Kazakhstan increases the efficiency of the logistics sector, which is a direct consequence of the development of the "One Belt" infrastructure.Digital Tenge and Fintech: The use of digital currency ensures transparency of cross-border budget expenditures and reduces transaction costs, contributing to the growth of financial attractiveness of the Republic of Kazakhstan [10].

Thus, cooperation within the framework of the OPOP contributes to the development of human capital, the exchange of IT specialists and the introduction of advanced digital technologies into the real sectors of the economy of the Republic of Kazakhstan.

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UDC 338

A STUDY ON THE ACHIEVEMENTS AND PATHWAYS OF ECONOMIC COOPERATION BETWEEN CHINA AND KAZAKHSTAN UNDER THE BELT AND ROAD INITIATIVE

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Annotation. This paper analyzes the achievements and development pathways of economic cooperation between China and Kazakhstan under the Belt and Road Initiative (BRI). The study finds that bilateral cooperation has expanded significantly in both trade and investment, supported by strong economic complementarity and improved infrastructure connectivity. Cooperation has also extended from traditional energy sectors to manufacturing and renewable energy, promoting industrial upgrading and regional integration. However, challenges remain, including global economic uncertainty, geopolitical risks, and Kazakhstan's structural dependence on resource-based industries. To address these issues, the paper proposes deepening infrastructure interconnectivity, promoting industrial chain integration, and strengthening institutional coordination. These measures aim to enhance the sustainability and quality of bilateral cooperation.

Key words: Belt and Road Initiative; China-Kazakhstan Cooperation; Trade and Investment; Infrastructure Connectivity; Industrial Upgrading; Regional Integration

Introduction

With the continuous advancement of economic globalization and the deepening of regional economic cooperation, connectivity and coordinated development among nations have become key drivers of global economic growth. In 2013, China launched the Belt and Road Initiative, aiming to build a new pattern of an open world economy and promote shared development among countries along the routes by strengthening policy coordination, infrastructure connectivity, unimpeded trade, financial integration, and people-to-people bonds [1].

Located at the heart of the Eurasian continent, Kazakhstan serves as a vital transportation hub connecting the markets of China, Russia, Central Asia, and Europe. As one of the first countries to support the Belt and Road Initiative, Kazakhstan has continuously deepened cooperation with China through the alignment of the Belt and Road Initiative and Kazakhstan's "Bright Path" economic policy [2]. This strategic coordination has created favorable conditions for cooperation in infrastructure, transportation, energy, logistics, industrial capacity, and agriculture.

Driven by the Belt and Road Initiative, China–Kazakhstan economic cooperation has demonstrated both quantitative expansion and structural optimization. Bilateral trade has maintained stable growth and strong resilience. According to official statistics, bilateral trade volume exceeded USD 31 billion in 2022, increasing by 23.6% year-on-year, and continued to grow steadily thereafter. China remains Kazakhstan's second-largest trading partner and an important export destination. The complementary nature of the two economies constitutes the foundation of bilateral cooperation: China possesses strong manufacturing capacity and a vast consumer market, while Kazakhstan has abundant energy and agricultural resources.

In terms of investment cooperation, cumulative Chinese investment in Kazakhstan has exceeded USD 23.5 billion, mainly concentrated in energy, infrastructure, transportation, and manufacturing sectors. Chinese investment has not only promoted Kazakhstan's industrialization process but also accelerated technology transfer and industrial upgrading through industrial chain extension and production cooperation. At the same time, the spatial pattern of cooperation has evolved from single-sector collaboration toward multidimensional and networked development.

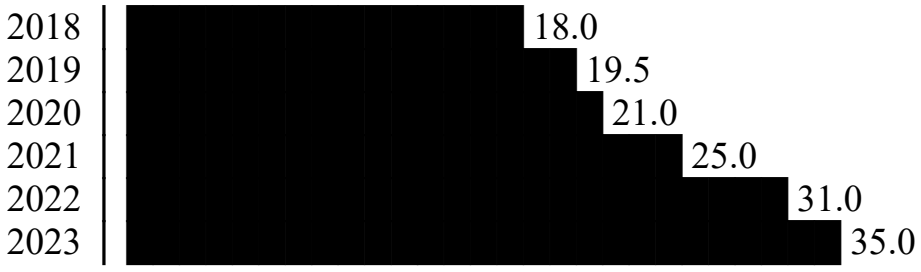



Figure 1. Growth of China–Kazakhstan Trade Volume, 2018–2025
Source: Compiled based on trade statistics and official reports [3].

Cooperation has also achieved substantial progress in infrastructure connectivity. China and Kazakhstan have established an integrated transportation system composed of cross-border railways, highways, pipelines, logistics hubs, and border ports. The China-Europe Railway Express passing through Kazakhstan has significantly improved transportation efficiency between Asia and Europe, reduced logistics costs, and strengthened Kazakhstan's role as a Eurasian transit hub.

At the practical level, a number of landmark projects have become important symbols of bilateral cooperation. Energy cooperation remains the cornerstone of China–Kazakhstan economic relations. Among representative projects, the Zhanatas Wind Power Project demonstrates the transition from traditional fossil-fuel cooperation toward green and sustainable development [2]. The project generates approximately 350 million kilowatt-hours of electricity annually, contributing to the optimization of Kazakhstan's energy structure and the reduction of carbon emissions.

Beyond the energy sector, cooperation is increasingly expanding into manufacturing and industrial production. Projects such as the modernization of the Shymkent Oil Refinery, automobile assembly facilities, and glass manufacturing plants have strengthened Kazakhstan's industrial foundation and promoted industrial diversification [4]. Through capital investment, technology transfer, and management cooperation, China has supported Kazakhstan's transition from a resource-dependent economic structure toward a more diversified industrial system.

Table 1. Major Areas of China–Kazakhstan Economic Cooperation Under the Belt and Road Initiative

Cooperation Area	**Main Achievements**	**Economic Impact**
Trade Cooperation	Bilateral trade exceeded USD 31 billion	Expansion of export-import activities
Infrastructure	Railways, pipelines, logistics hubs	Improved Eurasian connectivity
Energy Cooperation	Oil, gas, renewable energy projects	Energy diversification and sustainability
Manufacturing	Automobile and glass production projects	Industrial upgrading and job creation
Green	Wind power and renewable	Reduction of carbon emissions

Cooperation Area	Main Achievements	Economic Impact
Development	projects	

Despite the remarkable achievements, several constraints continue to affect bilateral cooperation. From the external perspective, global economic uncertainty, trade protectionism, and geopolitical tensions have increased the complexity of international economic cooperation. Kazakhstan's geopolitical location between major powers also exposes the country to broader regional risks [5].

From the domestic perspective, Kazakhstan still faces structural dependence on resource-based industries. Although industrial cooperation has promoted diversification, the overall technological and innovation capacity remains relatively limited. Moreover, industrial chain integration between the two countries is still concentrated mainly in upstream sectors, while cooperation in high-value-added industries remains insufficient [4].

To further improve cooperation quality, both countries should deepen infrastructure interconnectivity and optimize cross-border transportation efficiency. In particular, the operation of the China-Europe Railway Express should be enhanced through improved scheduling systems, higher return cargo utilization, and reduced empty-container transport rates [6]. In addition, digital technologies such as smart logistics systems, blockchain customs clearance, and digital trade platforms should be introduced to improve customs efficiency and reduce transaction costs.

China and Kazakhstan should also strengthen industrial chain integration and shift from factor-driven cooperation toward value-chain-oriented cooperation. Bilateral cooperation should gradually extend from upstream resource extraction to downstream processing and advanced manufacturing sectors. Joint ventures in equipment manufacturing, agricultural processing, renewable energy equipment, and new materials industries should be encouraged to enhance Kazakhstan's industrial competitiveness and position within regional value chains.

At the institutional level, the two countries should continue strengthening policy coordination mechanisms between the Belt and Road Initiative and Kazakhstan's "Bright Path" policy. Regular high-level policy dialogues and legal coordination in areas such as taxation, investment protection, customs procedures, and dispute settlement can effectively reduce institutional uncertainty and improve the business environment for investors.

In conclusion, economic cooperation between China and Kazakhstan under the Belt and Road Initiative has achieved substantial progress in trade, investment, infrastructure connectivity, industrial cooperation, and green development. The cooperation model has gradually evolved from traditional resource-based collaboration toward a multidimensional framework integrating energy, manufacturing, logistics, and digital connectivity.

Looking ahead, bilateral cooperation should focus on improving connectivity efficiency, strengthening industrial chain integration, enhancing institutional coordination, and promoting green and digital transformation. By shifting from traditional factor-driven cooperation toward innovation-driven and value-chain-oriented development, China and Kazakhstan can further improve the sustainability, resilience, and quality of bilateral economic cooperation while contributing to regional integration and sustainable development across Eurasia [6].

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A QUANTITATIVE EVALUATION OF CROSS - BORDER PIPELINE SECURITY: THE CASE OF CHINA - KAZAKHSTAN ECONOMIC COOPERATION

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Annotation. Energy cooperation anchors the broader economic partnership between Kazakhstan and China beneath the Belt and Road Initiative (BRI). Because the Atasu - Alashankou oil pipeline serves as the infrastructural backbone for this relationship, its security dictates bilateral trade stability. This paper developed a multidimensional quantitative evaluation model utilizing the Analytic Hierarchy Process (AHP) to assess the pipeline. It demonstrates that this pipeline possesses robust "institutional resilience", significantly outperforming other China cross-border energy corridors.

Key words: cross-border pipeline, quantitative evaluation, economic cooperation

1. Introduction

The energy interconnectivity between China and Kazakhstan is a pioneering area for the high-quality development of BRI. Because cross-border pipelines are characterized by high asset specificity and high geopolitical vulnerability, traditional qualitative analysis struggles to accurately measure their security levels. This paper aims to construct a quantitative evaluation model to analyze the protective efficacy of the Atasu - Alashankou oil pipeline when dealing with external uncertainties.

2. Evaluation Indicator System and Research Methodology

2.1 Logic of Evaluation Model Construction

Pipeline security is not an isolated phenomenon; it emerges from the interplay of physical, legal, and economic forces[1]. To capture this complexity mathematically, we applied the AHP to assign weights and utilized a comprehensive index method for the final scoring.

2.2 Determination of Indicator Weights

The research divides the evaluation system into five primary dimensions[2]. Recognizing the severe sovereign sensitivities surrounding cross-border infrastructure, the model deliberately assigns heavier weights to "Geopolitics" and the "Legal Framework" (25% each).

Table 1: Quantitative Evaluation Scoring Standard for Cross-Border Pipeline Security

Score Range	Security Level	Descriptive Basis
0.9-1.0	Extremely High (Excellent)	Presence of high-level strategic contracts (e.g., IGA/HGA); Deep interlocking of interests (50:50 equity); Over 20 years of uninterrupted operation; Complete mutual recognition of standards.
0.7-0.8	High (Good)	Stable cooperation framework with localized variables; Supported by long-term trade contracts; Generally stable geopolitical environment with controllable non-traditional security threats.

0.5-0.6	Medium (Average)	Incomplete legal framework or weak execution; Fluctuations in the transit country's situation; Existence of certain technical standard barriers or regulatory friction; At a fragile point of strategic balance.
0.3-0.4	Low (Poor)	Frequent regime changes in the transit country; Lack of effective interest-interlocking mechanisms; Frequent non-traditional security risks (e.g., terrorism); Severe facility aging.

2.3 Comprehensive Evaluation Formula

A linear weighted comprehensive evaluation model is adopted:

$$S = \sum_{i=1}^{n} Wi \cdot (\sum_{j=1}^{m} w_{ij} \cdot u_{ij})$$

Where S is the comprehensive score, W_i is the weight of the primary indicator, w_{ij} is the weight of the secondary indicator, and u_{ij} is the expert score value given by the researcher based on the aforementioned standards.

3. Empirical Analysis

Through scoring and weighted calculation of the data, the security evaluation results of the Atasu - Alashankou oil pipeline and other reference pipelines are shown below.

Table 2: Quantitative Evaluation Results of Cross-Border Pipeline Security

Primary Indicator	Secondary Indicator	Indicator Meaning	Kazakhstan - China	China - Russia	China - Myanmar
U_1: Physical Security (20%)	u_{11}: Geological Risk (40%)	Earthquakes / Permafrost / Landslides	0.8	0.7	0.6
	u_{12}: Technological Advancement (60%)	SCADA / Crack warning	0.9	0.8	0.7
U_2: Geopolitics (25%)	u_{21}: Bilateral Relationship Level (50%)	Strategic partnership	0.9	0.9	0.7
	u_{22}: Transit Country Risk (30%)	Political stability / Social unrest	0.8	0.9	0.4
	u_{23}: Third-party Intervention (20%)	"Long-arm jurisdiction" / Proxy conflicts	0.7	0.6	0.8

U_3: Legal Framework (25%)	u_{31}: IGA/HGA Depth (60%)	Legal stability / Sovereign immunity	0.9	0.8	0.6
	u_{32}: Regulatory Standard Mutual Recognition (40%)	Metering / Inspection / Environment	0.9	0.8	0.7
U_4: Economic Coordination (20%)	u_{41}: Equity Interlocking Depth (70%)	Equal shareholding	0.9	0.6	0.7
	u_{42}: Pricing Mechanism Flexibility (30%)	Ability to cope with oil price fluctuations	0.9	0.8	0.8
U_5: Social License (10%)	u_{51}: Localized Operations (50%)	Local employment / Community integration	0.9	0.8	0.7
	u_{52}: Non-traditional Security (50%)	Terrorism / Theft / Public opinion risk	0.8	0.9	0.5

4.1 Analysis of the Institutional Resilience of the Atasu - Alashankou Oil Pipeline

The calculation results show that the comprehensive score of the Atasu - Alashankou oil pipeline is 0.87. Through comparative analysis (China-Russia Model is 0.78, China-Myanmar Model is 0.65), the leading advantage of the China-Kazakhstan model lies in two core dimensions with the highest weights.

Deep Interlocking of Economic Interests (U_4): The 50:50 equity structure is the key to its economic security score of 0.90. Mature Legal Safeguard System (U_3): China and Kazakhstan have explicitly stipulated sovereign immunity and legal stability clauses in Intergovernmental Agreements, scoring 0.90.

4.2 Determination of Protective Efficacy Type

Based on the evaluation results, the Atasu - Alashankou oil pipeline belongs to the "High Security - Deep Collaboration Zone". Despite facing certain geopolitical environmental pressures, the project exhibits extreme resilience through deep equity participation, mature legal protection, and technical standard integration. This model is defined as "Community of Shared Interests-Driven Security".

5. Conclusion

By constructing a five-dimensional evaluation model, this paper quantitatively verifies the outstanding performance of the Atasu - Alashankou oil pipeline in safeguarding energy trade. The oil pipeline provides a solid security barrier for comprehensive China - Kazakhstan economic cooperation within the BRI.

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UDC （338.4)

STRUCTURAL TRANSFORMATION OF CHINA'S FOREIGN DIRECT INVESTMENT IN KAZAKHSTAN AND ITS DRIVING FACTORS

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Annotation. China's foreign direct investment (FDI) in Kazakhstan has undergone a clear, important structural transformation over the past two decades, beginning with resource-seeking investments in the oil and gas sector and moving progressively toward infrastructure, manufacturing, and service industries. Therefore, this paper first reviews the evolution of China's FDI structure in Kazakhstan and then proceeds to analyze it systematically. The article clearly and systematically identifies the main drivers of the transformation, drawing on data from the United Nations Conference on Trade and Development, the World Bank, and the Government of Kazakhstan to show that policy coordination under the Belt and Road Initiative (BRI), fluctuations in global energy markets, China's domestic economic restructuring, and Kazakhstan's development strategies have all played interacting roles in shaping the transition. Therefore, the paper naturally and persuasively concludes that the structural upgrading of Chinese FDI benefits Kazakhstan's economic diversification and strengthens regional economic integration.

Key words: China; Kazakhstan; Foreign Direct Investment; Structural Transformation; Belt and Road Initiative

Introduction

Since China and Kazakhstan established diplomatic relations in 1992, the two countries have built solid, mutually beneficial economic relations, and given that Kazakhstan is the largest economy in Central Asia, it has naturally become a strategic partner of China within the Belt and Road Initiative (BRI). Therefore, foreign direct

investment has been a major vehicle for advancing bilateral economic cooperation[2],[6],[9],[11].

China's early FDI in Kazakhstan was unquestionably motivated by the need to obtain energy resources, but there has been a major and clear shift in recent years toward infrastructure development, manufacturing, and diversified sectors. The UNCTAD World Investment Report (2023) confirms that Kazakhstan remains one of the largest FDI recipients in Central Asia, and China is currently one of Kazakhstan's leading sources of foreign investment.

This paper clearly and systematically addresses two major research questions regarding China's foreign direct investment (FDI) in Kazakhstan: first, it investigates the evolution of the structure of China's FDI, focusing on sectoral distribution and strategic direction, and second, it identifies and analyses the main drivers of the observed transformation, which are policy coordination, market conditions, and economic changes in both China and Kazakhstan. As a result, the paper offers a complete, well-integrated explanation of the mechanisms behind the changing patterns of bilateral investment.

Literature Review

The existing literature on China’s foreign direct investment (FDI) in Kazakhstan and Central Asia can be broadly grouped into three strands, focusing on resource-seeking motivations, policy-driven investment under the Belt and Road Initiative (BRI), and emerging sustainability perspectives.

Early studies mainly interpret China’s investment through a resource-oriented lens, emphasizing energy security as a primary driver. Kalyuzhnova and Lee [4] note that China–Kazakhstan cooperation in the early 2000s was heavily concentrated in oil and gas, reflecting China’s growing demand for external energy resources. Similarly, broader analyses of Central Asian economies highlight the region’s role as a resource base for foreign investment, with limited sectoral diversification [5]. These studies generally characterize Chinese FDI as state-led and focused on extractive industries.

With the introduction of the BRI, scholarly attention has shifted toward infrastructure development and policy coordination. Chen [7] and Zhang [3] argue that the BRI has expanded China’s overseas investment into infrastructure and industrial cooperation, promoting regional connectivity and economic integration. Empirical evidence further suggests that BRI-related investments contribute to development outcomes such as improved infrastructure and economic growth [1]. This body of research indicates a gradual transition from resource-seeking to more diversified investment patterns.

More recent studies adopt a broader perspective by examining the economic and environmental implications of FDI. Research highlights the complex relationship between FDI, economic growth, and environmental sustainability [8], [10], while also emphasizing the role of investment in supporting renewable energy and green development [13]. In addition, review-based studies stress the importance of

institutional factors, geopolitical risks, and sectoral differences in shaping FDI flows [12], [15], [16].

Although there have been many useful contributions, it is a well-known fact that existing literature treats sectoral distribution, policy factors, and sustainability issues separately, hence lacking an integrated analysis of structural evolution and its underlying mechanisms. Therefore, this paper brings all three perspectives together to examine China's FDI in Kazakhstan.

Evolution of China's FDI Structure in Kazakhstan

China's foreign direct investment (FDI) in Kazakhstan has gone through a very clear, orderly, and well-documented structural transformation over the last two decades, moving smoothly from a resource-oriented pattern to a diversified, balanced investment structure. In the early stage, that is from the early 2000s to 2013, Since this phase was determinedly shaped by China's urgent need to obtain stable external energy supplies to support its rapid industrialization and economic expansion, it is natural that large-scale investments during this time were carried out by state-owned enterprises in the upstream resource extraction sector and related infrastructure sectors such as pipelines and oil field development. Therefore, the sectoral distribution of Chinese FDI at the time was extremely skewed, with energy projects dominating.Chinese investment was overwhelmingly directed toward the energy sector, particularly oil and natural gas.

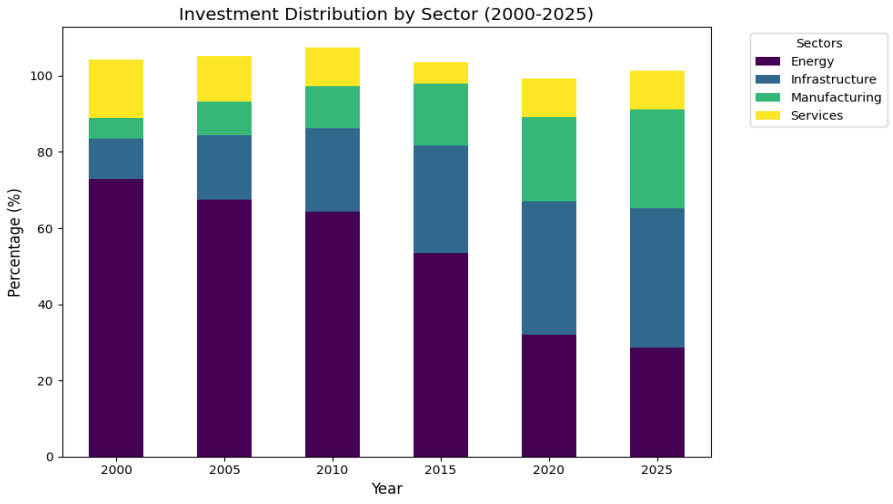

Fig.1 China's FDI in Kazakhstan by Sector (2000-2025)

Table1. China's Industrial Structure Changes of FDI in Kazakhstan(%)

Industry Category	Proportion in Initial Period(2000–2013) %	Proportion in Transition Period(2013–2018) %	Proportion in Deepening Period(2018–Present) %	Overall Changing Trend
Energy Industry (Petroleum, Natural Gas, etc.)	84.3	58.7	34.6	Continuous substantial decline
Infrastructure Industry (Transportation, Logistics, etc.)	11.2	23.9	19.4	Rise first then maintain stable core position
Manufacturing Industry	2.7	9.6	24.8	Continuous rapid growth
Service Industry (Commerce, Finance, Technology, etc.)	1.8	4.5	15.3	Gradual and steady growth
Renewable Energy and Other Sectors	0.0	0.0	5.9	Emerging growth field developed from scratch

After the launch of the Belt and Road Initiative (BRI) in 2013, China's investment strategy in Kazakhstan entered a clear and well-defined transition phase marked by a major expansion into infrastructure development, which was perfectly coordinated with China's regional connectivity goals as well as Kazakhstan's own aspiration to become a leading transit hub between Asia and Europe. Hence Chinese capital began to flow more systematically into transportation projects such as railways, highways, and logistics centers, directly promoting cross-border trade and regional integration. Compared with the earlier period, investment during this phase was far more diversified in sectors and project types, and China had clearly moved away from its previous exclusive focus on natural resources.

In recent years, especially since about 2018, China's FDI in Kazakhstan has entered a clear and definite stage of deeper diversification and structural upgrading, with investment increasingly directed toward manufacturing, renewable energy, and services, and thus moving toward higher value-added activities. Therefore, this trend

can be reasonably viewed as a result of changes in China's outward investment strategy as well as a deliberate effort by Kazakhstan to diversify its economy. Because China has been actively restructuring its economic framework and reducing reliance on extractive industries, the composition of Chinese FDI in Kazakhstan has become far more balanced, with non-resource sectors growing in importance and in some cases already surpassing traditional energy investments. Thus, the evolution of China's FDI structure in Kazakhstan can be clearly and neatly characterized as a shift from resource-seeking to a combination of market-seeking and efficiency-seeking motives

Driving Factors Behind the Structural Transformation

The structural transformation of China's FDI in Kazakhstan is clearly the product of intertwined factors at the policy, market, and economic levels, but the most important driver is the very strong alignment of the two countries' national development strategies. The Belt and Road Initiative of China and Kazakhstan's“Nurly Zhol”economic policy together create a favorable institutional environment for bilateral investment cooperation, and both governments have deliberately coordinated policy frameworks, designed effective financing mechanisms, and advanced major joint projects to promote the expansion and diversification of Chinese investment in Kazakhstan.

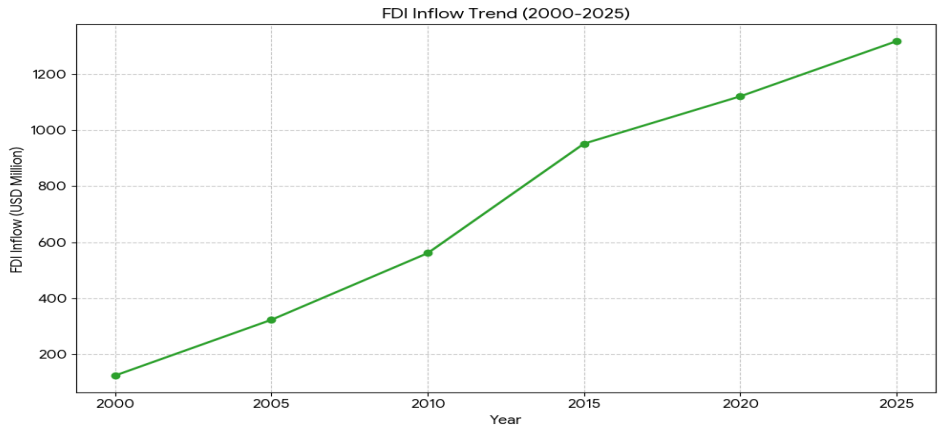

Fig.2 FDI Flow Trend (USD Million)

Since policy factors are not the only ones affecting investment patterns, it is necessary and helpful to consider the role of recent changes in global energy markets. The big drop in international oil prices after 2014 lowered the profitability of resource-based projects, made traditional energy investments less attractive, and thus prompted Chinese firms to re-examine their overseas investment strategies and look for new opportunities, because there are favorable opportunities in sectors with more stable returns, namely infrastructure and manufacturing, and more importantly, China's own domestic economic transformation has actively reinforced this shift: as China moves toward a more innovation-driven, consumption-oriented growth model,

its outward investment has naturally shifted toward industrial upgrading, capacity cooperation, and market expansion, rather than merely pursuing resource acquisition.

Kazakhstan's domestic economic policies have played a direct and important role in the economic transformation that has taken place, since the Kazakh government has clearly recognized the risks of overreliance on natural resources and therefore has pursued active economic diversification by attracting foreign investment into non-resource sectors, accompanied by measures to improve the business environment and offer investment incentives.Because the development of industrial zones has made Kazakhstan more attractive to a wider array of Chinese investors, and because bilateral relations have improved along with concrete institutional advances such as investment protection agreements and regulatory reforms, which together have reduced uncertainty and boosted investor confidence, it is no surprise that China’s FDI in Kazakhstan has transitioned toward a more diversified, sustainable structure.

Impacts of Structural Transformation

The structural transformation of China's FDI in Kazakhstan has had clear, concrete economic effects on both Kazakhstan and China, as well as important implications for regional development. For Kazakhstan, the diversification of Chinese investment has directly advanced the development of non-resource sectors, thus making a real contribution to the country's long-term objective of economic diversification. Moreover, increased investment in infrastructure has improved transportation efficiency and connectivity, lowered logistics costs, and therefore enhanced Kazakhstan's position as a regional transit hub. Equally importantly, the growth of manufacturing and industrial projects has created jobs and facilitated technology transfer, which together strengthen Kazakhstan's industrial base and increase its economic resilience.

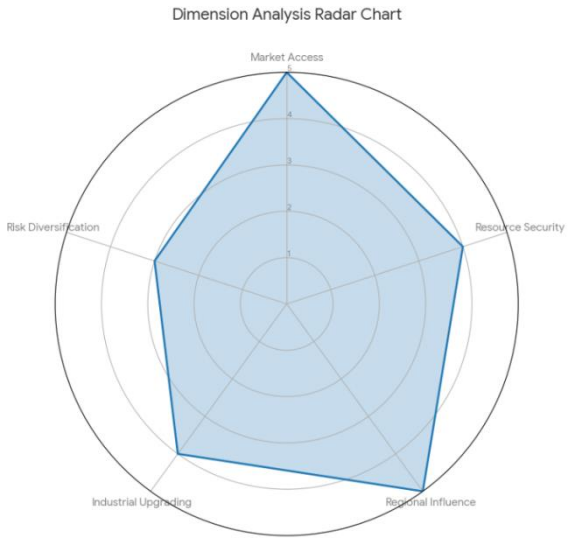

Fig.3 China’s Strategic Benefits

From China's point of view, the change in China's FDI structure in Kazakhstan has clearly served to optimize the composition of China's overseas investments and reduce dependence on resource-intensive projects, since Chinese companies have been actively investing in infrastructure, manufacturing, and services, thereby entering new markets, utilizing excess industrial capacity, and enhancing their global competitiveness. More importantly, closer economic ties with Kazakhstan strengthen China's strategic position in Central Asia and directly advance the goals of the Belt and Road Initiative.

The evolving pattern of Chinese investment at the regional level has clearly advanced economic integration in Central Asia, improved infrastructure and connectivity between Asia and Europe, and promoted more balanced regional development. But it is also true that the transformation brings new and important challenges: ensuring sustainable development, managing environmental impacts, and addressing debt and governance issues. Therefore, the structural transformation of China's FDI in Kazakhstan can reasonably be seen as a deliberate, constructive move toward more sustainable and win-win economic cooperation.

Conclusion

The paper gives a clear, systematic analysis of the structural transformation of China's foreign direct investment (FDI) in Kazakhstan and then naturally and logically identifies the factors responsible for the change: China's investment has moved from a resource-dominated pattern to a more diversified structure involving infrastructure, manufacturing, and services, which corresponds to a shift from primarily resource-seeking motives to a mix of market-seeking and efficiency-seeking strategies.

The transformation comes about from the combined, interlocking action of several factors: policy coordination between the Belt and Road Initiative and Kazakhstan's development strategies provides strong institutional support, whereas fluctuations in global energy markets have lowered the appeal of resource-based investments. Equally important are the domestic economic changes in both countries, namely China's industrial upgrading and Kazakhstan's economic diversification.

The changing structure of China's FDI has clearly facilitated Kazakhstan's economic diversification, enhanced regional connectivity, and served China's overall strategic and economic interests, but it is also true that regulatory uncertainty and sustainability issues still exist. Therefore, future research could profitably look at firm-level behavior and the long-term developmental effects of Chinese investment in the region.

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DIGITAL ECONOMY COOPERATION BETWEEN KAZAKHSTAN AND CHINA UNDER THE BELT AND ROAD INITIATIVE: 2026 PROSPECTS

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Annotation. This paper focuses on digital economy cooperation between Kazakhstan and China under the Belt and Road Initiative, with a 2026 outlook. It discusses digital transformation trends, cross-border e-commerce, innovation policies, and cooperation mechanisms, aiming to provide practical references for deepening bilateral digital and economic collaboration.

Key words: Digital economy, Kazakhstan–China cooperation, Belt and Road Initiative, Digital infrastructure

1. Introduction

The digital economy has become a core engine of global economic growth. Against the background of high-quality joint construction of the Belt and Road, Kazakhstan and China have formed close cooperation in digital infrastructure, trade, finance, and innovation. This paper analyzes the status, challenges, and 2026 development prospects of bilateral digital economic cooperation.

2. Digital Transformation and Economic Cooperation

2.1 Trends and Tools

Both countries are accelerating digital transformation in industry, trade, and public services. Key tools include 5G, cloud computing, big data, and artificial intelligence, which improve efficiency and reduce costs.

2.2 Implementation Mechanisms

Digital corridors, cross-border data pilot zones, and joint innovation platforms provide institutional support for cooperation. Standard connectivity and policy coordination help promote project landing.

3. Belt and Road Economic Cooperation Framework

The Belt and Road Initiative creates a solid foundation for economic and digital cooperation. Priority areas include cross-border logistics, digital trade, industrial internet, and smart cities. By 2026, deeper integration will be achieved in payment systems, customs clearance, and supply-chain digitization.

4. Challenges and Opportunities

4.1 Challenges

Differences in regulatory systems, cybersecurity risks, and digital gaps remain obstacles to cooperation.

4.2 Opportunities

New technologies such as AI, blockchain, and green digitization bring huge potential. Expanding e-commerce and cross-border investment will further drive cooperation.

5. Investment, Innovation and Risk Management

Digital economic investment needs stable policy support and perfect risk-control systems. Strengthening innovation cooperation and improving competitiveness will help achieve sustainable development.

6. Conclusion

Kazakhstan-China digital economy cooperation under the Belt and Road Initiative has broad prospects. By strengthening policy coordination, improving digital infrastructure, and promoting innovation collaboration, the two countries will achieve higher-level mutual benefit and win-win results by 2026.

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ECONOMIC COOPERATION BETWEEN THE REPUBLIC OF KAZAKHSTAN AND THE PEOPLE'S REPUBLIC OF CHINA UNDER THE FRAMEWORK OF THE BELT AND ROAD INITIATIVE

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Annotation. This paper analyzes the development of economic cooperation between the Republic of Kazakhstan and the People's Republic of China within the framework of the Belt and Road Initiative (BRI). It explores the theoretical foundations of bilateral cooperation, particularly the principles of regional economic integration, and examines the key directions and dynamics of interaction between the two countries. The study highlights the role of Kazakhstan as a strategic hub in the Silk Road Economic Belt, emphasizing its geographical advantages and resource potential. Special attention is paid to the growth and structural transformation of bilateral trade, characterized by strong complementarity and increasing diversification, including the expansion of high-tech and agricultural trade. The paper also reviews investment cooperation, noting the significant growth of Chinese direct investment in Kazakhstan across sectors such as energy, manufacturing, and agriculture, as well as the gradual increase of Kazakhstan's investment presence in China. Despite positive trends, the research identifies challenges related to policy coordination, industrial alignment, and financial support. The findings suggest that further strengthening institutional mechanisms, improving cooperation efficiency, and expanding into new areas such as innovation and sustainable development will enhance long-term bilateral cooperation. Overall, the study demonstrates that China-Kazakhstan economic cooperation under the BRI contributes to regional integration and mutual economic growth.

Key words: Belt and Road Initiative; Kazakhstan; China; economic cooperation; regional economic integration; bilateral trade; foreign direct investment; infrastructure; energy cooperation; sustainable development.

1. Introduction

Since its introduction in 2013, the Belt and Road Initiative has become an important force for promoting world economic development and regional cooperation. In the process of implementing this great initiative, Kazakhstan, with its superior geographical conditions and abundant natural resources, has become an important hub country in the construction of the Silk Road Economic Belt. As the largest country in Central Asia, economic cooperation between Kazakhstan and China has seen new opportunities and broad prospects under the Belt and Road Initiative. The two countries are linked by mountains and rivers and have strong economic complementarity, providing favorable conditions for further strengthening economic cooperation. In recent years, China and Kazakhstan have seen increasingly close cooperation in energy, infrastructure, agriculture, manufacturing and other fields, frequent trade exchanges, expanding investment scale and expanding cooperation areas. While great achievements have been made, there are also problems in economic cooperation between the two countries, such as policy coordination, industrial alignment and financial support[Ошибка! Источник ссылки не найден.]. Studying the current situation, characteristics and development trends of China-Kazakhstan economic cooperation, summarizing experiences and lessons, and identifying problems are of great significance for promoting the further development of economic cooperation between the two countries.

2. The Belt and Road Initiative and the theoretical basis of economic cooperation between China and Kazakhstan

2.1 Connotations and Objectives of the Belt and Road Initiative

The Belt and Road Initiative is an important measure of China's opening up in the new era. Its main goal is to establish a new era of international relations based on win-win cooperation and promote open, inclusive, beneficial, balanced and win-win global economic integration. The main content of the Belt and Road Initiative is policy communication, infrastructure connectivity, unimpeded trade, financial integration and people-to-people bonds, aiming to enable countries along the routes to achieve connectivity and common development. The Belt and Road Initiative is of great significance to economic cooperation between China and Kazakhstan. In economic cooperation between the two countries, the Belt and Road Initiative provides a good platform for cooperation and a direction for development. It has expanded cooperation between the two countries from previous commodity trade to industrial investment, technology transfer, financial cooperation, etc., making cooperation between the two countries deeper and broader.

2.2 Application of the Theory of Regional Economic Integration in China-Kazakhstan Cooperation

The theory of regional economic integration plays a very good guiding role in economic cooperation between China and Kazakhstan. According to this theory, under the effects of trade creation and trade transfer, countries within the region can better allocate resources and improve economic efficiency[Ошибка! Источник ссылки не найден.]The cooperation between China and Kazakhstan under the Belt and Road Initiative is a concrete manifestation of this theory. Kazakhstan is rich in energy and mineral resources, while China has huge market demand, which is conducive to complementarity between the two sides. At the same time, China's manufacturing advantages and technological strength have also played a positive role in promoting Kazakhstan's industrialization. By setting up free trade zones, simplifying customs clearance procedures and unifying technical standards, the two countries have continuously lowered trade barriers and enabled the free flow of factors of production, thereby promoting the continuous development of regional economic integration.

3. Analysis of the Current situation of China-Kazakhstan Economic Cooperation

3.1 Levels and Structural Characteristics of Bilateral Trade Development

China and Kazakhstan have made great progress in bilateral trade driven by the Belt and Road Initiative. According to data from China's General Administration of Customs, bilateral trade between China and Kazakhstan reached 18.91 billion U.S. dollars in 2019, an increase of 43.2% compared with 2013. Despite a decline in 2020 due to the impact of the COVID-19 pandemic, the trade volume quickly recovered to 25.28 billion U.S. dollars in 2021 and reached 31 billion U.S. dollars in 2022, a record high. The trade structure is highly complementary, with China mainly importing primary products such as crude oil, natural gas, copper ore and wheat from Kazakhstan, accounting for 78.6%[Ошибка! Источник ссылки не найден.]China's exports to Kazakhstan are mainly manufactured goods such as machinery and equipment, textiles, chemicals and electronics, accounting for 82.3% of China's total exports to Kazakhstan.

In recent years, the trade structure between the two countries has been continuously optimized, and the proportion of trade in high-tech products has been increasing. China's exports of machinery and equipment to Kazakhstan rose from $3.42 billion in 2019 to $4.87 billion in 2022, with an average annual growth of 12.4%. At the same time, Kazakhstan's agricultural exports to China increased significantly, with wheat exports rising from 1.8 million tons in 2019 to 2.6 million tons in 2022, indicating increasingly close agricultural cooperation between the two countries.

3.2 Investment Cooperation Areas and Project Progress

Investment cooperation between China and Kazakhstan has shown a trend of diversification driven by the Belt and Road Initiative. By the end of 2022, China's stock of direct investment in Kazakhstan stood at $14.68 billion, 2.1 times that of 2013, covering areas[Ошибка! Источник ссылки не найден.]Among them, energy is the focus of

investment cooperation. Companies such as China National Petroleum Corporation, China Petroleum & Chemical Corporation and China National Offshore Oil Corporation have cumulatively invested more than 8 billion US dollars in Kazakhstan, participating in large-scale energy development projects such as the Aktyubin oil and gas project and the Kashagan oil field project. Manufacturing investment has grown rapidly, with the number of production bases set up by Chinese companies in Kazakhstan increasing from 23 in 2019 to 41 in 2022, with an investment of $1.26 billion.

Kazakhstan's investment in China, though small, has been increasing year by year. In 2022, Kazakhstan's investment stock in China was $380 million, mainly concentrated in mineral resource development, agricultural product processing, logistics and transportation, etc. The two countries' capacity cooperation fund, which is $2 billion, has successfully supported more than 30 projects with a total investment of over $15 billion.

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ECOLOGICAL AND ECONOMIC VULNERABILITY ASSESSMENT OF SMALL WATERSHEDS ALONG THE SILK ROAD ECONOMIC BELT TRANSPORT CORRIDOR AND EXPLORATION OF GREEN DEVELOPMENT PATHWAYS

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Annotation. The rapid development of the transport corridor of the Silk Road Economic Belt may pose challenges to the ecological security of the small watersheds it traverses. Current research lacks a quantitative link between ecological degradation and economic losses. This paper advocates establishing a comprehensive assessment framework for the eco-economic vulnerability of small watersheds, incorporating remote sensing monitoring and externality economic models to propose a Comprehensive Eco-economic Vulnerability Index (CEVI) for risk ranking and identification of priority areas for green investment. The results indicate that Central Asia faces significant desertification risks, and the transport corridor may exacerbate regional ecological vulnerability. However, China has relevant experience in desertification control and green technology transfer. Integrating eco-economic assessment into green cooperation business processes can feasibly promote low-carbon and sustainable development along the corridor.

Key words: Silk Road Economic Belt; small watershed; eco-economic vulnerability; green development

1. Introduction

The Silk Road Economic Belt serves as a major transportation artery across Eurasia [1]. The rapid development of transport infrastructure along this belt not only stimulates economic growth but also generates various external environmental impacts on the areas along the route [2]. However, current research focuses mainly on improving transport efficiency and bilateral trade performance, with few studies examining the ecological and environmental consequences and associated economic losses in the small watersheds adjacent to the transport corridor.

Based on the above research gap, this paper proposes a framework for a “comprehensive assessment of eco-economic vulnerability of small watersheds”. It attempts to integrate remote sensing data, field ecological survey data, and economic externality assessment models to establish a comprehensive eco-economic vulnerability index for each small watershed along the corridor. This index can rank the degree of vulnerability, identify potential intervention zones, and guide the spatial allocation of green investments. From a broader perspective, China and Kazakhstan are currently conducting a series of cooperative projects in desertification control, grassland restoration, green technology transfer, and clean energy utilization, providing a policy interface for translating the above assessment framework from scientific research into practical action. This paper discusses three aspects: remote sensing technology support, assessment framework, and green cooperation mechanisms and development pathways, aiming to provide guidance and ideas for the green and low-carbon transformation of the Silk Road Economic Belt transport corridor.

2. Application Basis of Remote Sensing Technology in Ecological Environmental Monitoring Along the Corridor

2.1 Long-term Series Ecological Degradation and Desertification Dynamic Monitoring

Existing remote sensing studies have demonstrated that high spatiotemporal resolution satellite imagery can effectively capture the trend and spatial pattern of desertification from light to severe [3]. Although these studies have identified high-risk desertification areas at a broad scale, the assessment units are often administrative or ecological zones, not the small watershed units closely linked to the transport corridor network. Therefore, it is difficult to accurately identify the marginal ecological disturbances superimposed by road construction and operation.

2.2 Supporting Role of Multi-source Data Fusion for Monitoring Along the Transport Corridor

The “geographical science” advocated by the Belt and Road Initiative further demands the integration and application of multi-source remote sensing data with auxiliary data such as climate and hydrology. Long-term series remote sensing observations have unique advantages in identifying changes in water resources, vegetation cover, and land use, providing medium-to-long-term baseline data for cross-border ecological security in the corridor region [4]. However, at the small watershed scale along the transport corridor, a “risk map” reflecting the spatial heterogeneity of eco-economic vulnerability is still lacking, which directly hinders the spatial precision of green investments.

Overall, existing remote sensing studies have answered the question of “where ecological degradation occurs and how severe it is” but there remains a methodological gap between that and the questions of “how much economic loss is caused by ecological degradation” and “which small watershed should be prioritized for green technology investment to achieve the highest benefit”. Filling this gap is the core scientific starting point for constructing a comprehensive eco-economic vulnerability index.

3. Eco-economic Coupling Assessment Framework: From Vulnerability Identification to Green Investment Guidance

3.1 Adaptability Analysis of Existing Economic Damage Assessment Methods

Several mature technical pathways exist for linking ecological degradation to economic losses [5, 6]. Ecosystem service value assessment methods convert ecological functions such as water conservation, air purification, and soil retention into monetary indicators and have been widely applied in watershed management and ecological compensation practices [7].

Regarding economic losses caused by pollutant diffusion, most existing studies calculate damages based on a single pollution source or a single cause of harm, lacking a unified “integrated” eco-economic assessment system for all small watersheds along the transport corridor [8]. For the multiple damage pathways simultaneously present along the corridor-such as soil pollution, accelerated erosion, water resource degradation, and dust diffusion-a technical solution is needed that can integrate various externality costs within a single framework.

3.2 Conceptual Construction of a Comprehensive Eco-economic Vulnerability Index (CEVI)

Based on the above review of research progress and key gaps, this paper envisions constructing a Comprehensive Eco-economic Vulnerability Index (CEVI) for the areas along the Silk Road Economic Belt transport corridor.

For ecological damage indicators, long-term series satellite remote sensing images can be used to retrieve changes in vegetation fractional cover, soil salinity index, and land surface temperature anomalies [9]. Existing studies have shown that a drought index constructed based on the land surface temperature-vegetation index space is sensitive to water resource stress along transport corridors [10].

For economic damage indicators, the input information comprises the economic damage values of ecological function degradation for each small watershed. Four quantifiable damage values are specifically considered: losses in agricultural land productivity [11], increased water treatment costs due to water quality deterioration [12], health damage to residents caused by dust diffusion and the suppression effect of road dust by vegetation cover [13, 14. The economic inputs for these indicators can be derived from cross-analysis of remote sensing ecological monitoring results and regional economic statistics.

4. Green Cooperation Mechanisms and Development Pathways

4.1 Cooperation in Desertification Control and Ecological Restoration Technology

China's experience in desertification control is being exported to Central Asia [15]. Following the establishment of the China-Central Asia Desertification Control Cooperation Center, cooperative projects have been launched in Ningxia, focusing on sand prevention and control as well as ecological restoration, exporting comprehensive technical solutions including straw checkerboard barriers, vegetation restoration, and water-saving irrigation.

4.2 Eco-economic Integrated Regulation Mechanism

Establish a differentiated village and town management and control system based on the eco-economic vulnerability classification of small watersheds [16]. For high-vulnerability areas, ecological conservation and restoration should be prioritized, with strict control over development intensity [17. For medium-vulnerability areas, both ecological reconstruction and green industry development should be emphasized. For low-vulnerability areas, efficient, intensive, and low-carbon development models should be pursued. Incorporate eco-economic assessment results into project planning, environmental impact assessment, and performance evaluation, making development management more scientific and precise. Improve the policy guarantee system, strengthening environmental supervision, technical standards, and legal construction to provide institutional support for coordinated development.

Conclusion. The continuous development of the Silk Road Economic Belt transport corridor brings economic benefits but also imposes systematic pressure on

the ecological environment of small watersheds along the route. Central Asia, through which the Silk Road passes, is vulnerable to desertification, and the accelerated connectivity of the transport corridor may further amplify the local severity of this regional ecological vulnerability. However, an eco-economic comprehensive assessment system suitable for the small watershed scale along the corridor has not yet been established, leading to a lack of scientific risk ranking and investment prioritization for sustainable governance.

The comprehensive eco-economic vulnerability index framework proposed in this paper integrates the ecological damage identification capability of remote sensing with economic damage assessment methods, aiming to systematically identify the eco-economic risk levels of each small watershed along the corridor and provide a scientific basis for the spatially precise guidance of green investments. In the future, it is necessary to embed the economic damage assessment results into the business processes of green cooperation, transforming the assessment from a "scientific tool" into a "governance guide" and truly achieving spatial matching between ecological vulnerability and green investment resources.

From the perspective of green development, the ecological principle that "lucid waters and lush mountains are invaluable assets" holds profound significance in a cross-border context. Water conservation and water quality improvement along the corridor directly affect the long-term agricultural output of irrigated areas, while the stability of watershed ecosystems can also support the reproduction of native fish populations and biodiversity conservation. Transforming eco-economic vulnerability assessment results into an action list of priority areas for bilateral green cooperation may provide a scientific, operational, and exemplary practical pathway for the low-carbon transformation and sustainable development of countries along the Silk Road Economic Belt.

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ROLE OF CROSS-BORDER LOGISTICS SYSTEMS IN BELT AND ROAD INITIATIVE ECONOMIC COOPERATION

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Annotation. In the joint construction of the Belt and Road Initiative, infrastructure connectivity is the foundation, unimpeded trade is the key, and cross-border logistics systems serve as the core link connecting the two. Against the backdrop of profound adjustments in the global industrial and supply chains and accelerated regional economic integration, a comprehensive, efficient and diversified cross-border logistics network can break down trade barriers among countries along the routes, reduce circulation costs, optimize resource allocation, and provide solid support for regional capacity cooperation, trade exchanges and coordinated economic development. Based on the current development of the Belt and Road Initiative, this paper analyzes the core value of cross-border logistics systems, sorts out their key roles in regional economic cooperation, dissects existing shortcomings, and puts forward optimization paths to support the high-quality joint construction of the Belt and Road.

Key words: Belt and Road Initiative; Cross-border Logistics; Regional Economic Cooperation; Unimpeded Trade; Smart Logistics

1. Introduction

With the steady progress of high-quality joint construction of Belt and Road economic cooperation over the years, the scope of cooperation has continued to expand, and the total trade volume of participating countries has kept increasing, making it an important international cooperation platform. Meanwhile, international trade highly relies on logistics systems. Traditional cross-border trade is restricted by backward infrastructure, cumbersome customs clearance and single transportation modes, which limit the depth of regional economic cooperation.

Cross-border logistics systems integrate infrastructure such as ports, railways and aviation, and combine comprehensive services including multimodal transport, smart logistics, warehousing and customs clearance, serving as an important carrier for transnational flow of factors. With the regular operation of China-Europe Railway Express and deepening cooperation among ports along the routes, a modern logistics network has gradually taken shape, reshaping the new pattern of opening-up and cooperation among countries along the routes, promoting regional coordinated

development, and becoming an important driving force for Belt and Road economic cooperation.

2. Core Roles of Cross-Border Logistics Systems in Belt and Road Economic Cooperation

The cross-border logistics system plays a multi-dimensional core supporting and enabling role in the economic cooperation under the Belt and Road Initiative. Relying on infrastructure connectivity construction along the routes, with the China-Europe Railway Express, cross-border railway hubs, coastal port cooperation and multimodal transport systems as important carriers, it continues to open up two-way land-sea logistics corridors, improve cross-regional and cross-border comprehensive logistics layouts, and consolidate the hardware foundation for economic and trade exchanges among countries along the routes.

Meanwhile, through measures such as transportation route optimization, large-scale consolidation and distribution operations, and integrated cross-border customs clearance cooperation, it effectively shortens the circulation time of goods, reduces comprehensive logistics costs, eliminates institutional and operational barriers in cross-border trade, comprehensively improves trade facilitation, and fully stimulates the endogenous momentum of bilateral and multilateral economic and trade cooperation.

On this basis, a mature and sound cross-border logistics network deeply covers all links of the industrial chain, accelerates the free flow of various production factors such as talent, materials, technology and capital, facilitates cross-border capacity matching and industrial division of labor and cooperation, promotes the in-depth integration of regional industrial chains, supply chains and value chains, and continuously strengthens the coordinated industrial development capacity along the routes.

Furthermore, cross-border logistics is not only the artery of economic cooperation, but also an important link for people's livelihood security and cultural exchanges. It stabilizes the cross-border supply of essential goods, fosters new logistics business forms such as cross-border e-commerce and overseas warehouses, promotes enterprise cooperation, mutual recognition of industry standards and personnel exchanges, further enhances cultural exchanges and people-to-people bonds among countries along the routes, and consolidates both the economic and social foundations for the long-term, high-quality multilateral cooperation under the Belt and Road Initiative.

3. Current Research Status and Existing Problems

3.1 Literature Review

Current research shows that multimodal transport under the Belt and Road Initiative boosts high-quality development by integrating the advantages of different transportation modes, realizing seamless connection of goods between different modes, reducing transfer and waiting time, and thus significantly improving logistics efficiency [1].

In addition, relevant studies have proved that infrastructure connectivity among countries under the Belt and Road Initiative has become more accessible. Participating countries have continuously promoted the "four-in-one" connectivity of land, sea, air and internet, advanced cooperation on traditional infrastructure projects steadily, highlighted cooperation on new infrastructure projects, significantly improved the level of "soft connectivity" of rules, regulations and standards, and basically formed a multi-country and multi-port connectivity framework for the trade and logistics system, injecting new vitality into global trade connectivity and common development [2].

The coordination and optimization of policies and systems are also key guarantees for the coordinated development of cross-border e-commerce logistics networks and Belt and Road trade facilitation. Countries should actively carry out bilateral or multilateral dialogues, establish a Belt and Road logistics and trade cooperation alliance, hold regular high-level dialogues, and promote the seamless connection between cross-border logistics and trade [3].

3.2 Existing Problems

There are urgent problems to be solved in cross-border logistics systems for Belt and Road economic cooperation. First, regional infrastructure development is unbalanced. Logistics facilities in Europe, Africa, Central Asia and Southeast Asia are unevenly developed; some regions suffer from insufficient port capacity, inconsistent railway standards and incomplete port supporting facilities, leading to poor logistics connection and low transfer efficiency. Second, there are barriers to the connection of rules and systems. Logistics management rules, customs policies and quarantine standards vary greatly among countries; trade protectionism raises institutional costs, multimodal transport standards are inconsistent, and information exchange is hindered. Third, the development of smart logistics lags behind. Most regions along the routes lack sufficient digital and intelligent applications, have weak capabilities in cargo traceability and whole-process monitoring, and are short of high-end supporting services such as cold chain logistics and supply chain finance, which are difficult to adapt to the development needs of new business forms.

4. Countermeasures for Optimizing the Development of Cross-Border Logistics Systems

4.1 Jointly Build Infrastructure to Make Up for Development Shortcomings

Strengthen infrastructure cooperation along the routes, increase investment in logistics facilities in underdeveloped areas, upgrade cross-border transportation and port facilities, and unify hardware transportation standards. Improve the layout of multimodal transport hubs, strengthen the linkage construction of logistics parks and bonded warehouses, and build a seamlessly connected comprehensive logistics network.

4.2 Strengthen Policy Coordination and Promote Standard Mutual Recognition

Relying on the Belt and Road cooperation mechanism, promote the coordinated connection of customs, quarantine and logistics rules, simplify customs clearance

procedures, and implement facilitation policies such as mutual recognition of origin. Accelerate the integration with international logistics standards, unify transportation and service specifications, and reduce institutional logistics costs.

4.3 Develop Smart Logistics to Improve Service Quality

We will build a cross-border logistics information sharing platform and realize intelligent scheduling and cargo traceability through big data and blockchain technologies. We will increase high-end supporting services such as cold chain logistics and supply chain finance. Meanwhile, by leveraging information technology, we will establish and improve a logistics information network to enable information interoperability among various transportation modes including road, railway, air and water transport, ensuring that logistics information is timely transmitted to all relevant parties. We will actively apply advanced technologies such as the Internet of Things, cloud computing and big data to promote the development and expansion of smart logistics [4].

4.4 Innovate Cooperation Modes and Expand Development Space

Strengthen core logistics brands such as China-Europe Railway Express and New International Land-Sea Trade Corridor to improve operation quality. Encourage transnational cooperation among logistics enterprises, integrate resources along the routes, combine overseas warehouses and cross-border e-commerce, build a model integrating "logistics, industry and trade", and foster new drivers for regional economic cooperation.

5. Conclusion

Cross-border logistics systems are an important cornerstone of Belt and Road economic cooperation, playing an irreplaceable role in connectivity, unimpeded trade, industrial cooperation and balanced regional development. Facing the complex global economic situation, only by continuously improving logistics infrastructure, unifying industry rules, upgrading smart logistics services and innovating cooperation modes can we build an efficient, green and coordinated modern cross-border logistics system. Driven by logistics connectivity, we will promote economic integration, deepen complementary advantages and win-win results among countries along the routes, and continuously inject impetus into the high-quality joint construction of the Belt and Road and the stable development of the global economy.

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SKILLS-TRAINING COOPERATION IMPROVING LABOR QUALITY IN BELT AND ROAD INITIATIVE COUNTRIES

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Annotation This paper examines the role of skills-training cooperation in improving labor quality in countries participating in the Belt and Road Initiative (BRI). It analyzes key mechanisms through which international cooperation in vocational education enhances workforce skills, including the development of standardized training systems, integration of language and professional competencies, and the use of digital technologies. The study also explores practical models such as joint training centers, industry–education integration, and mutual recognition of qualifications. In addition, major challenges are identified, including disparities in standards, funding limitations, and the digital divide. The paper concludes that strengthening skills-training cooperation is essential for enhancing employment capacity, supporting industrial upgrading, and promoting sustainable economic development in BRI countries.

Key words: Belt and Road Initiative (BRI), skills training, labor quality, human capital development, vocational education, international cooperation, digital training, workforce development, employment, sustainable economic development.

Introduction

The Belt and Road Initiative (BRI), proposed by China in 2013, has gradually developed into a vital framework for international economic cooperation, infrastructure connectivity, and in-depth people-to-people exchanges across continents. While infrastructure construction and trade cooperation have always been the focus of BRI development, skills-training cooperation, as a key but often underemphasized pillar, plays an irreplaceable role in directly improving labor

quality, enhancing the employment capacity of local residents, and supporting the sustainable economic growth of all participating countries[5]. Many BRI participating states, especially developing ones, are currently facing prominent problems such as skill mismatches between labor supply and market demand, imperfect vocational education systems, and low labor productivity, which severely restrict their industrial modernization process and international competitiveness in the global market.

Against this realistic background, cross-national skills training cooperation under the BRI framework has become an effective solution to address these bottlenecks. It helps transfer advanced technical standards, optimize the construction of local vocational education systems, and cultivate a large number of skilled personnel who are suitable for the needs of the digital economy and real economy. This paper focuses on analyzing how BRI-related skills-training programs effectively improve labor quality in participating countries, summarizes the typical practical models formed in the cooperation process, identifies the main challenges encountered, and puts forward targeted development paths. The study is based on real vocational education practices, authoritative industry data, and published academic research results, ensuring the authenticity, academicity and practical value of the research content[4,5].

The Role of Skills-Training Cooperation in Enhancing Labor Quality

Skills-training cooperation under the framework of the BRI improves the overall quality of the labor force in participating countries through three major clear and effective mechanisms, which complement each other and form a comprehensive promotion system.

First, it helps establish standardized and scientific vocational education systems. At present, many developing countries lack unified and standardized skill evaluation and certification systems, which leads to uneven skill levels of the labor force and difficulty in meeting the needs of modern industrial development. Through in-depth cooperation with Chinese vocational colleges, aviation specialized colleges, engineering universities, and leading industrial enterprises, BRI participating countries have gradually formed standardized training modules covering modern service industries, transportation, aviation services, digital technology, and mechanical engineering. These unified standards not only clarify the skill requirements of various occupations but also help improve the professionalism and stability of the labor force, laying a solid foundation for the healthy development of the local labor market[5].

Second, it innovatively combines language training with professional skills, forming a unique "Chinese + Vocational Skills" training model[4]. This model has been widely promoted in many BRI participating countries in Asia, Africa, and Central and Eastern Europe, and has achieved remarkable results. It not only helps learners improve their Chinese communication ability, which is conducive to participating in Sino-foreign cooperative projects, but also effectively enhances their

employment competitiveness in Chinese-invested enterprises and international cooperation projects. For industries with high requirements for cross-cultural communication such as aviation, tourism, and cross-border logistics, this integrated training model is particularly effective because it organically combines language communication, service etiquette, and professional operation skills, enabling workers to better adapt to the work needs of international cooperation scenarios.

Third, it actively adopts digital and intelligent training tools to break the limitations of traditional training models[1,2,3]. With the rapid development of artificial intelligence, virtual simulation technology, and online learning platforms, skills training has become more efficient, convenient, and accessible. Digital training methods can not only significantly reduce the costs of training venues, equipment, and personnel but also expand the coverage of training, making it possible for people in remote and underdeveloped areas to access high-quality training resources. At the same time, personalized learning programs designed based on intelligent technology can better meet the individual needs of different learners, thereby significantly improving the skill level and adaptability of the labor force[2,3].

Practical Forms of BRI Skills-Training Cooperation

In the long-term practice of BRI skills-training cooperation, with the continuous deepening of cooperation and the differences in national conditions of participating countries, three typical and mature cooperation forms have gradually formed, which can be flexibly applied according to local actual needs.

The first form is the joint construction of vocational colleges and professional training centers. Representative projects such as the Luban Workshops, which have been established in 23 BRI participating countries, provide systematic and professional training in fields such as advanced manufacturing, railway transportation, electrical engineering, and aviation services. These joint training institutions not only introduce advanced teaching concepts and training standards but also equip with complete practical training equipment, cultivating a large number of technical talents who meet international industrial standards. These talents have been widely employed in local key projects and enterprises, directly supporting local employment promotion and industrial upgrading.

The second form is the deep integration of industry and education, focusing on demand-oriented training. Enterprises participating in BRI construction projects, especially large-scale enterprises in infrastructure, aviation, and logistics fields, carry out targeted pre-job training, on-the-job internships, and on-the-job skill improvement training for local employees. For example, in the field of aviation and cross-border logistics, targeted training on crew service skills, passenger reception etiquette, and cargo operation specifications is carried out, which not only improves the professional service quality of employees but also effectively enhances the operational safety and efficiency of related projects[5].

The third form is multilateral exchange and mutual recognition of vocational qualifications. Through extensive consultations and negotiations between BRI

participating countries, a mutual recognition system for vocational skill certificates has been gradually established. This system not only promotes the cross-border mobility of skilled workers, making it easier for workers to find employment in different BRI countries, but also improves the efficiency of labor resource allocation in the region, enhances the vitality of the regional labor market, and lays a solid foundation for deeper economic and trade cooperation between countries.

Challenges and Development Suggestions

Despite the remarkable achievements made in BRI skills-training cooperation in recent years, it still faces many challenges in the process of high-quality development, which need to be solved through joint efforts of all participating countries. These challenges mainly include inconsistent national vocational standards between different countries, insufficient funding and backward training equipment in some developing countries, a serious shortage of high-quality dual-qualified teachers who are proficient in both professional skills and teaching methods, and the obvious digital divide between regions, which restricts the popularization of digital training. In addition, the connection between training content and local industrial development needs is not close enough in some cooperation projects, resulting in a certain degree of disconnection between training results and market demand[5].

To promote the high-quality development of BRI skills-training cooperation and give better play to its role in improving labor quality, the following targeted development suggestions are put forward. First, accelerate the establishment of regional unified vocational skill standards and mutual recognition mechanisms, strengthen communication and coordination between countries, and promote the convergence of skill standards. Second, expand the application of digital and AI-based training technologies, increase investment in digital training infrastructure, and promote the popularization of online-offline blended learning to improve the efficiency and coverage of training[1,2,3]. Third, strengthen the exchange and training of teachers between participating countries, carry out systematic training for local teachers, and support the construction of local practical training bases to improve the quality of training. Fourth, further deepen the integration of industry and education, encourage enterprises to deeply participate in the design of training curricula, internships, and job placement, so that training content can closely match the actual job requirements of the industry.

Conclusion

Skills-training cooperation is an important way and effective means to improve labor quality in BRI participating countries, and it is also an important part of promoting people-to-people connectivity and sustainable economic development under the BRI framework. It effectively promotes the standardization and modernization of vocational education in participating countries, enhances the professional ability and employment competitiveness of the labor force, and provides strong talent support for local industrial upgrading and sustainable economic development. By continuously promoting the improvement of standardized skill

systems, the popularization of digital training, the deep integration of industry and education, and the mutual recognition of international vocational qualifications, BRI skills-training cooperation will continue to create more inclusive and sustainable economic growth opportunities for all participating countries[5].

In the future, with the in-depth advancement of the BRI, deepening international cooperation in talent training will further strengthen the connectivity of human capital between participating countries, consolidate the foundation of economic and trade cooperation, and make greater contributions to the long-term stable development of the Belt and Road Initiative, as well as the common prosperity and development of all participating countries.

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DIGITALIZATION AND IMPROVEMENT OF INTERNATIONAL TRADE OPERATION EFFICIENCY: RESEARCH ON CROSS-BORDER E-COMMERCE AND SMART LOGISTICS UNDER THE BELT AND ROAD INITIATIVE

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Annotation. With the Belt and Road Initiative advancing, global trade is transforming. Digital technologies enable the integration of cross-border e-commerce and smart logistics to break trade barriers, reduce costs, and improve efficiency.

Based on the digital economy and Belt and Road cooperation, this paper uses literature review, case analysis, and qualitative research to explore how digitalization improves trade efficiency, analyzes the development, dilemmas, and optimization of e-commerce and logistics, and examines the "Silk Road Shipping" express line at Xiamen Port as a case study to verify the impact of digital technologies and smart logistics on trade efficiency, cost, and scale. Research shows that improving digital infrastructure, unifying standards, and deepening international cooperation promote the coordinated development of e-commerce and smart logistics, enhancing trade facilitation. Finally, the paper suggests measures for infrastructure connectivity, standard coordination, and enterprise cooperation, providing theoretical and practical references for high-quality Belt and Road economic and trade cooperation.

Key words: Digitalization; International Trade Efficiency; Cross-border E-commerce; Smart Logistics; The Belt and Road

1. Introduction

As the Belt and Road Initiative moves from a “grand blueprint” to a “meticulous painting” of high-quality development, economic and trade exchanges among countries along the routes have become increasingly close. The shortcomings of traditional international trade, such as cumbersome processes, low efficiency, high costs and asymmetric information, have become increasingly prominent. The rapid rise of the digital economy has provided new momentum for trade transformation. Cross-border e-commerce reconstructs the international trade chain, and smart logistics reshapes the cross-border circulation system. Their coordination has become a key force to improve the operational efficiency of international trade. Against this background, clarifying the internal relationship among digitalization, cross-border e-commerce, smart logistics and trade efficiency, identifying development bottlenecks and summarizing practical experience are of great theoretical value and practical significance to promote trade connectivity under the Belt and Road and boost economic integration among countries along the routes. This paper systematically studies how digitalization empowers cross-border e-commerce and smart logistics, how to improve the operational efficiency of international trade, what challenges are faced and how to achieve sustainable coordinated development, so as to provide support for relevant policy formulation and enterprise practice.

2. Literature Review

Scholars have extensive research in digital economy and international trade. Digital technologies like big data and AI reduce costs and enhance trade efficiency, helping SMEs engage globally. Cross-border e-commerce studies focus on models, regulation, and facilitation, breaking time-space limits and driving trade growth. Smart logistics research emphasizes IoT and blockchain for efficiency, traceability, and cost control, supporting cross-border e-commerce.

Some studies identify restrictive factors such as the digital divide, inconsistent logistics standards, blocked data flows, and regulatory disparities. However, most

research treats cross-border e-commerce and smart logistics separately, with limited analysis of their coordinated mechanism and case studies under the Belt and Road. This paper builds a "digitalization-cross-border e-commerce-smart logistics-trade efficiency" framework, supplementing empirical evidence and countermeasures to enrich the field.

3. Research Methods

This paper comprehensively uses three research methods:

1. Literature Research Method: Systematically sort out literature related to digital economy, cross-border e-commerce, smart logistics and international trade efficiency, lay a theoretical foundation, and clarify research perspectives and analytical frameworks.

2. Qualitative Analysis Method: Theoretically explain the empowerment mechanism of digitalization on cross-border e-commerce and smart logistics, analyze the practical challenges of coordinated development, and extract internal logic and impact paths.

3. Case Analysis Method: Select the “Silk Road Shipping” e-commerce express line at Xiamen Port as a typical case, conduct empirical analysis from the dimensions of logistics efficiency, transportation cost and trade scale, verify the actual improvement effect of digitalization and smart logistics on international trade efficiency.

4. Analysis and Results

4.1 Internal Mechanism of Digitalization Empowering International Trade Efficiency

Digitalization reduces trade costs. Big data and cloud computing simplify customs declaration, settlement, tax refund and other processes, reduce manual intervention and time loss, lower market access thresholds, and improve the participation of small, medium and micro enterprises. Digitalization alleviates information asymmetry. Platforms realize precision marketing through user portraits and demand forecasting, improve order matching efficiency, and reduce the risk of supply and demand mismatch. Smart logistics improves circulation efficiency. Technologies such as intelligent warehousing, full-process traceability and dynamic scheduling shorten delivery cycles, reduce cargo damage rates, and ensure the stable operation of cross-border trade.

4.2 Practical Challenges for the Coordinated Development

Significant differences in digital development levels: There are large gaps in network coverage, technology application and payment systems among countries along the routes, forming a digital divide. Inconsistent standard systems: Lack of mutual recognition of logistics documents, data interfaces, customs clearance rules and certification systems increases coordination costs. Data circulation and regulatory barriers: Restricted cross-border data flow and differences in privacy protection and security rules restrict information sharing. Unbalanced infrastructure layout:

Insufficient hardware such as ports, stations and networks in some regions, lagging intelligent transformation.

4.3 Case Empirical Results: Xiamen Port “Silk Road Shipping”

The logistics time from Xiamen to the Philippines is shortened from more than 9 days to 2 days, a reduction of more than 7 days. Comprehensive logistics costs reduced by about 15%, effectively alleviating cost pressure on small and medium-sized foreign trade enterprises. By the beginning of 2026, the cumulative cargo value carried exceeded 15 billion yuan, efficiently supporting the transportation of small-batch and multi-batch e-commerce goods. Digital customs clearance, intelligent stowage and full-process traceability systems provide references for other ports and trade routes. The results prove that the in-depth integration of digitalization and smart logistics can effectively improve the operational efficiency of international trade.

5. Discussion

The results of this paper are consistent with the views of existing literature that digital technologies positively promote trade facilitation. This paper further finds that synergy is the key to improving efficiency: cross-border e-commerce and smart logistics do not act independently, but support and empower each other in data, processes and nodes. Digitalization of a single link is difficult to achieve overall efficiency improvement, and the coordination of the whole chain, all subjects and all rules must be promoted.

From a practical perspective, the success of the Xiamen Port case depends not only on technology investment, but also on the optimization of customs clearance processes, multi-stakeholder coordination and policy support. This means that under the framework of the Belt and Road, promoting the development of cross-border e-commerce and smart logistics should not only attach importance to technological innovation, but also promote policy coordination, standard coordination, data coordination and industrial coordination.

6. Conclusion and Suggestions

Under the background of the Belt and Road construction, digitalization is the core driving force to improve the operational efficiency of international trade, and the coordinated development of cross-border e-commerce and smart logistics is a key model to achieve trade transformation and upgrading. Digital technologies break time and space constraints, simplify trade processes, reduce transaction costs and alleviate information asymmetry; smart logistics ensures the efficient operation of cross-border e-commerce and improves delivery efficiency and service quality.

At present, the coordinated development still faces challenges such as digital divide, inconsistent standards, data barriers and unbalanced infrastructure. The case of “Silk Road Shipping” at Xiamen Port confirms that improving digital infrastructure, digital customs clearance, intelligent logistics and multi-stakeholder coordination can significantly improve trade efficiency, reduce costs and expand scale. In the future, it is necessary to realize the high-quality coordinated development of cross-border e-commerce and smart logistics through the two-wheel

drive of institutional opening and technological innovation, so as to serve the economic and trade cooperation of the Belt and Road.

Suggestions: Accelerate the construction of the Digital Silk Road; Promote standard coordination and rule alignment; Deepen international cooperation and industrial coordination; Strengthen technological innovation and risk prevention and control.

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DIGITAL TRANSFORMATION AND ECONOMIC COOPERATION BETWEEN KAZAKHSTAN AND CHINA IN THE CONTEXT OF THE DIGITAL ECONOMY AND THE BELT AND ROAD INITIATIVE

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Annotation. This paper examines the digital transformation of economic sectors and the deepening economic cooperation between the Republic of Kazakhstan and the People's Republic of China within the framework of the "One Belt, One Road" initiative. The study analyzes current trends, tools, and implementation mechanisms of digitalization, with particular attention to cross_border e_commerce, investment policy, and the role of artificial intelligence in sustainable economic development.

The research highlights the opportunities and challenges facing international trade and financial systems in the context of global digitalization.

Key words: digital economy, Belt and Road Initiative, Kazakhstan_China cooperation, e_commerce, artificial intelligence, investment policy, cross_border trade.

Introduction

The rapid development of digital technologies has fundamentally transformed the global economic landscape, creating new opportunities for international cooperation and trade. The Republic of Kazakhstan and the People's Republic of China, as key strategic partners in Central Asia, are actively leveraging digital transformation to enhance their economic collaboration within the framework of the "One Belt, One Road" initiative. This conference paper explores the multifaceted dimensions of Kazakhstan_China digital economic cooperation, examining trends in digital transformation, investment flows, innovation policy, and the emerging role of artificial intelligence in driving sustainable development.

1. Digital Transformation of Economic Sectors

Digital transformation represents a comprehensive restructuring of economic activities through the integration of digital technologies into all areas of business and society. In Kazakhstan, the digitalization agenda is driven by the "Digital Kazakhstan" state program, which aims to accelerate the transition to a digital economy by 2025. Key sectors undergoing transformation include agriculture, manufacturing, logistics, and financial services. The implementation of Industry 4.0 technologies, including the Internet of Things (IoT), blockchain, and cloud computing, has enabled Kazakhstani enterprises to enhance operational efficiency and competitiveness in regional markets.

China, as a global leader in digital innovation, has developed extensive expertise in digital transformation across multiple sectors. Chinese technology companies such as Huawei, Alibaba, and Tencent have pioneered solutions in smart cities, mobile payments, and e_commerce platforms. The exchange of technological knowledge and best practices between Kazakhstan and China has accelerated the digital modernization of Central Asian economies, creating synergies that benefit both nations.

2. Kazakhstan-China Economic Cooperation within the Belt and Road Initiative

The Belt and Road Initiative (BRI), proposed by China in 2013, has become a cornerstone of regional economic integration and infrastructure development. For Kazakhstan, the BRI aligns strategically with its own infrastructure modernization goals, particularly the "Nurly Zhol" (Bright Path) economic policy. The two initiatives have converged to create a robust framework for bilateral cooperation in transportation, energy, trade, and digital connectivity.

The China_Kazakhstan International Cooperation Center and the Khorgos International Border Cooperation Center serve as flagship projects demonstrating the practical outcomes of BRI cooperation. These centers facilitate cross_border trade, investment, and cultural exchange, while digital platforms enhance the efficiency of customs procedures, logistics tracking, and financial transactions. The development of digital corridors along the New Eurasian Land Bridge has significantly reduced transit times and costs for goods moving between China and Europe through Kazakhstan.

3. E-Commerce and Cross_Border Trade in the Digital Economy

The digitalization of world markets has revolutionized cross_border trade, with e commerce emerging as one of the fastest_growing segments of the global economy. Kazakhstan and China have made significant strides in developing cross_border e commerce infrastructure, including electronic customs platforms, digital payment systems, and logistics networks optimized for online retail. Chinese e_commerce giants such as Alibaba and JD.com have established partnerships with Kazakhstani businesses, enabling local producers to access the vast Chinese consumer market.

The COVID_19 pandemic further accelerated the shift toward digital commerce, highlighting the importance of resilient digital infrastructure for maintaining trade flows during global disruptions. Both countries have invested in strengthening their digital trade ecosystems, with particular emphasis on data security, consumer protection, and regulatory harmonization. The establishment of cross_border e commerce pilot zones has created experimental environments for testing innovative trade facilitation measures.

4. Artificial Intelligence as a Driver of Sustainable Economic Development

Artificial intelligence (AI) has emerged as a transformative force in the global economy, with applications spanning predictive analytics, autonomous systems, natural language processing, and intelligent automation. In the context of Kazakhstan China cooperation, AI presents significant opportunities for enhancing productivity, optimizing resource allocation, and addressing complex challenges in areas such as climate change, public health, and urban planning.

China's national AI strategy, launched in 2017, has positioned the country as a global leader in AI research and development. Kazakhstan has similarly recognized the strategic importance of AI, incorporating artificial intelligence into its national development plans and establishing specialized research centers. Collaborative AI projects between Kazakhstani and Chinese institutions focus on smart agriculture, intelligent transportation systems, and AI_powered financial services, contributing to the sustainable development goals of both nations.

5. Investment, Innovation Policy and Risk Management

Investment flows between Kazakhstan and China have grown substantially over the past decade, with Chinese direct investment playing a crucial role in Kazakhstan's economic diversification efforts. The digital economy has attracted significant investment in telecommunications infrastructure, data centers, and technology

startups. However, the rapid pace of digital transformation also introduces new risks, including cybersecurity threats, data privacy concerns, and regulatory uncertainties.

Effective risk management in the digital economy requires robust legal frameworks, international cooperation on cybersecurity standards, and continuous monitoring of technological developments. Both countries have taken steps to strengthen their digital governance capabilities, with Kazakhstan implementing comprehensive cybersecurity legislation and China advancing its data protection regulatory framework. The alignment of investment and innovation policies between the two nations remains essential for maximizing the benefits of digital cooperation while mitigating associated risks.

6. Financial Systems and Macroeconomic Stability in the Digital Age

The digitalization of financial systems has profound implications for macroeconomic stability and fiscal regulation. Digital currencies, fintech innovations, and blockchain_based financial services are reshaping traditional banking and payment systems. Kazakhstan and China have both explored the potential of central bank digital currencies (CBDCs), with China's digital yuan (e_CNY) representing one of the most advanced CBDC projects globally.

The integration of digital financial services into bilateral trade and investment flows offers opportunities for reducing transaction costs, enhancing transparency, and improving access to financial services for businesses and consumers. However, the transition to digital financial systems also poses challenges for monetary policy, financial supervision, and the stability of cross_border capital flows. Coordinated policy responses and international regulatory cooperation are necessary to ensure that the benefits of financial digitalization are realized without compromising macroeconomic stability.

Conclusion

The digital economy and the Belt and Road Initiative have created unprecedented opportunities for deepening economic cooperation between Kazakhstan and China. Digital transformation across key economic sectors, the expansion of cross_border e_commerce, the strategic application of artificial intelligence, and the modernization of financial systems are all contributing to a more integrated and resilient bilateral economic relationship. As both nations continue to navigate the challenges of the digital age, sustained investment in digital infrastructure, innovation policy, and international regulatory cooperation will be essential for realizing the full potential of their strategic partnership.

The findings of this study underscore the importance of aligning national digital strategies with international cooperation frameworks, ensuring that the benefits of digitalization are widely shared and that associated risks are effectively managed. Future research should continue to monitor the evolution of Kazakhstan_China digital economic cooperation, with particular attention to emerging technologies and their implications for sustainable development.

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RESEARCH ON CHINA - KAZAKHSTAN GREEN I NVESTMENT AND SUSTAINABLE FINANCING COOPERATION UNDER THE BRI

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Annotation. This paper focuses on green investment and sustainable financing in Kazakhstan–China cooperation under the Belt and Road Initiative. Based on literature and data, it examines renewable energy collaboration, multilateral co-financing, debt sustainability tools and environmental and social standards. The study shows that green energy is the most viable sector for bilateral cooperation, and tripartite co-financing and debt-for-nature swaps can effectively improve project sustainability. This paper provides targeted opinions and practical suggestions for the high-quality green development of bilateral BRI cooperation.

Key words: BRI; green investment; renewable energy; sustainable financing; risk management

Introduction

This paper focuses on green investment and sustainable financing. With deepening bilateral cooperation, investment models are shifting from traditional energy and infrastructure toward green and digital transformation. Renewable energy investment is growing rapidly, while debt sustainability, multilateral co-financing and environmental compliance have become critical to long-term project stability. This paper analyzes the current situation of green investment, financing innovation and risk management, and puts forward corresponding suggestions.

Current Status of Kazakhstan-China Green Investment

According to the 2023 Belt and Road Initiative Investment Report, China-Kazakhstan green investment presents three major trends. First, bilateral investment continues to grow and structurally shifts to green sectors. China's cumulative direct investment in Kazakhstan exceeds 26 billion US dollars, with more than 5,000 Chinese enterprises and over 200 projects under joint construction worth 66.4 billion US dollars. Green energy investment under the BRI reached a record 7.9 billion US dollars in 2023. Kazakhstan has prioritized green energy, cross-border logistics, agricultural processing and digital finance to support the green development of the BRI.

Second, small and medium-sized green projects are more economical with smaller scale, easier financing, shorter cycles and faster returns. Solar and wind power projects enjoy obvious cost advantages over traditional coal-fired power. Third, the Zhanatas Wind Farm in Kazakhstan, co-financed by the EBRD, AIIB, GCF and ICBC and constructed by Chinese enterprises, proves that tripartite cooperation can effectively expand financing channels, reduce risks and attract non-state-owned enterprises.

Sustainable Financing and Risk Management

Financing and risk control are essential for investment projects. First, green debt instruments should be prioritized. Debt-for-resource or debt-for-equity swaps may ease short-term burdens but harm long-term growth. Debt-for-nature swaps and nature performance guarantees are more desirable, as they improve fund transparency, relieve debt pressure and support green development.

Second, tripartite international cooperation helps reduce financing risks. Despite competition from global infrastructure initiatives, cooperation remains the mainstream. Chinese financial institutions can share risks and enhance project feasibility through standard alignment and joint financing. Thus, tripartite co-financing should be adopted for Kazakhstan-China green projects.

Third, unified environmental and social standards are crucial to long-term competitiveness. China's guidelines require EIA and ESMS implementation. Green compliance has become a regulatory requirement and financing threshold. Adopting

international standards helps access global capital markets and reduces reputational and environmental risks.

Practical Suggestions for Kazakhstan-China Green Cooperation

First, prioritize small and medium-sized renewable energy and CCUS carbon reduction projects. Develop solar and wind projects with easy financing and stable returns to replace coal-fired assets and promote low-carbon technologies in Kazakhstan.

Second, take advantage of Kazakhstan's policy tools including the AIFC platform, RMB settlement and 25-year legal stability clause to lower compliance and exchange rate risks and ensure long-term investment stability.

Third, replicate the Zhanatas Wind Farm model to expand tripartite co-financing with international institutions to diversify funding sources and share risks.

Fourth, fully implement EIA and ESMS standards to strengthen green compliance and enhance long-term competitiveness and international recognition.

Conclusion

This paper concludes that Kazakhstan-China BRI cooperation should prioritize green and sustainable development rather than quantitative expansion. Green energy is the most policy-supported and stable investment area. Tripartite financing and debt-for-nature swaps are key to sustainable project operation, and unified environmental and social standards lay the foundation for long-term cooperation. Kazakhstan and China should take green investment as the core and sustainable financing as support to achieve higher-quality and more durable BRI cooperation.

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UDC : 330.3

THE DIGITAL ECONOMY DRIVES THE INTELLIGENT UPGRADE OF THE TRANSPORTATION INDUSTRY: MECHANISMS, PATHWAYS, AND CASE STUDIES

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Annotation. The integration of the digital economy with the real economy is reshaping transportation. This paper establishes a "data, computing power, and algorithms" framework to elucidate intelligent upgrading mechanisms. Analyzing China's practices reveals four key pathways: infrastructure digitalization, intelligent operation, ecosystem travel services, and networked collaboration. The study concludes that breaking data barriers and refining standards are critical. It aims to provide insights for China-Kazakhstan cooperation in smart connectivity under the Belt and Road.

Keywords: digital economy; transportation; intelligent upgrading; data-driven; MaaS

1.Introduction

The global digital economy's expansion coincides with transportation challenges like congestion and high logistics costs. Physical infrastructure expansion alone is insufficient. Digital technologies offer the essential path for end-to-end intelligent transformation. Theoretically, this paper moves beyond single technologies to analyze the "data-computing-algorithm" synergy. Practically, summarizing China's smart transportation pathways provides actionable references for Belt and Road partners like Kazakhstan in infrastructure connectivity and digital logistics.

2.Core Mechanism: A Data-Computing-Algorithm-Driven Framework
The upgrade hinges on the synergy of three core elements constituting a dynamic closed-loop system

Table 1. Three-Pillar Framework for Intelligent Transportation Upgrade

essential factor	Role Positioning	The functional manifestations in the transportation sector	Supporting technical methods
data	fuel feeding	Establish a real-time digital mirror of the physical transportation system; achieve comprehensive status perception of all elements including roads, vehicles, and pedestrians.	IoT sensors, high-definition cameras, millimeter-wave radar, high-precision maps
Computing Power	Power Engine	Enterprise provides real-time processing capabilities for massive data; support macro-level road network planning and millisecond-level local event response.	Cloud computing center, edge computing node, 5G communication network
algorithm	Smart Brain	Uncover traffic operation	Machine Learning,

		patterns to enable autonomous decision-making for congestion prediction, signal optimization, and route planning.	Deep Learning, Reinforcement Learning, Computer Vision

(1) Data-Driven: Creating a Digital Mirror Sensors deployed across infrastructure collect high-precision, real-time data, creating a "digital twin" synchronized with the physical world. This virtual replica enables monitoring and provides a reliable foundation for simulations and interventions.

(2) Computing Power Empowerment: The Driving Force Computing unlocks data value. Cloud handles large-scale, non-real-time computation, while edge nodes deployed roadside enable millisecond responses to local events (e.g., sudden incidents). This cloud-edge architecture ensures instant system responsiveness.

(3) Algorithm Core: An Intelligent Brain AI algorithms (machine/deep learning) form the core intelligence, predicting congestion and optimizing signals autonomously. Algorithms enable a shift from "post-event handling" to "pre-event warning" and "active intervention."

3. Current Status and Driving Forces: China's Practical Landscape China's intelligent upgrade has moved from pilot to large-scale implementation, driven by policy and technology.

(1) Policy and Technology Dual-Driven National strategies like the "Strong Transportation Nation Outline" prioritize smart transportation with support from projects like "East Data, West Computing." 5G enables low-latency communication, BeiDou provides precise positioning, and AI optimizes scheduling and recognition.

(2) Multi-Field Industrial Practices AI traffic lights have improved urban efficiency by over 15%. Logistics features automated sorting and reduced truck empty-run rates via online platforms. Fully automated ports and facial recognition at airports redefine hub efficiency. These shifts illustrate a transition from tool application to process and ecosystem transformation.

4. Critical Path and Case Analysis Upgrades unfold via four interconnected pathways.

(1) Path One: Digitalized Infrastructure (Case: Hangzhou-Shaoxing-Ningbo Expressway)

This path turns "dumb facilities" into sensory "nerve endings." This smart expressway uses a holographic perception network of radar and vision sensors. Via 5G and C-V2X, it delivers "out-of-line-of-sight" warnings to vehicles and uses edge computing for foggy driving guidance, demonstrating how "smart roads" empower vehicles.

(2) Path Two: Intelligent Operations Management (Case: Beijing Traffic Brain) This focuses on a "central nervous system" for data-driven decisions. Beijing's Traffic Brain integrates thousands of data points. Reinforcement learning dynamically adjusts traffic lights to create "green wave zones," while automatic incident detection enables rapid response. It optimizes existing resources without major construction.

(3) Path Three: Ecosystem Travel Services (Case: Beijing MaaS Platform) This path integrates modes into a one-stop user-centric system. Beijing's MaaS platform combines bus, subway, bike-share, and ride-hailing into a single app for planning and payment. Its "Carbon Inclusion" mechanism rewards green travel, linking individual choice to societal emission goals, marking a shift from operating vehicles to delivering experiences.

(4) Path Four: Networked Industrial Collaboration (Case: Cainiao Network) This uses digital platforms for cross-enterprise resource optimization. Cainiao's data-driven platform enables full-chain parcel digitization and algorithmic matching of transport capacity. Pre-sale data guides inventory placement to shorten delivery times. This reveals that competition now lies between ecosystem network efficiencies, not just individual firms.

5. Challenges and Countermeasures Implementation faces hurdles. First, data barriers and "silos" between government and enterprise hinder cross-regional collaboration. Second, technological integration is shallow, with AI penetration in core safety and optimization still insufficient. Third, standards and regulations lag, especially regarding autonomous driving liability and data privacy. Fourth, a shortage of interdisciplinary talent persists.

Countermeasures: The government must accelerate public data circulation rules and create regulatory "safe sandboxes." Enterprises should focus on value scenarios (cost reduction, safety) and open ecosystems. Society should foster public acceptance through industry-academia collaboration.

6. Conclusion and Outlook The digital economy transforms transportation via data, computing power, and algorithm synergy. China's experiences in smart highways, traffic brains, MaaS, and logistics illustrate specific pathways across infrastructure, management, service, and collaboration.

For partners like Kazakhstan, this highlights that intelligent upgrade is a systematic endeavor involving data governance and standard alignment. Future cooperation under the Digital Silk Road can focus on cross-border logistics data flow and smart port development. Future research should address governance paradigms in the era of autonomous driving.

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DIGITAL ECONOMIC COOPERATION BETWEEN KAZAKHSTAN AND CHINA UNDER THE BELT AND ROAD INITIATIVE

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Annotation. This paper analyzes China-Kazakhstan digital economic cooperation under the Belt and Road Initiative, clarifies its main fields and challenges, and puts forward practical development strategies.

Key words: Digital Economy; Kazakhstan-China Cooperation; Belt and Road Initiative; Digital Silk Road; Digital Governance; Green Digital Transformation

Against the background of the global digital economy and thehigh-quality development of the Belt and Road Initiative, digital cooperation has become a new engine for upgrading Kazakhstan-China economic and trade relations. This paper re-examines bilateral digital economic cooperation from the perspectives of regional connectivity, institutional coordination, and green digital integration. It analyzes digital infrastructure interconnection, cross-border digital governance, and the integrated development of digitalization and green economy. The study finds that Kazakhstan-China digital cooperation is shifting from project-based cooperation to institutionalized and sustainable development, but it is restricted by differences in regulatory systems, data security governance, and green digital technology gaps. On this basis, this paper puts forward a high-quality development path with institutional connectivity, facility interconnection, trade digitalization, and green digital

innovation as the core, so as to provide a reference for deepening Kazakhstan-China digital partnership and promoting the construction of the Digital Silk Road.

1. Introduction

The global digital economy is accelerating its evolution into an intelligent, green, and integrated stage. The Belt and Road Initiative has entered a new stage of high-quality construction, and the Digital Silk Road has become an important support for international cooperation. As key nodes in the Eurasian continent, Kazakhstan and China have highly complementary resource endowments, industrial systems, and technological advantages. In recent years, bilateral cooperation has expanded from traditional fields such as energy and trade to digital infrastructure, cross-border e-commerce, artificial intelligence, and financial technology.

However, most existing studies focus on cooperation status and project cases, lacking analysis from the perspectives of institutional coordination, green digital integration, and risk governance. This paper focuses on the new connotation and practical path of Kazakhstan-China digital economic cooperation under the new situation, aiming to break through bottlenecks such as inconsistent rules, data security risks, and unbalanced development, and promote the transformation of bilateral digital cooperation from scale expansion to quality improvement.

2. Main Fields of Kazakhstan-China Digital Economic Cooperation

2.1 Digital Infrastructure Cooperation

Kazakhstan's national digital strategy and China's new infrastructure layout are highly compatible. The two countries focus on cross-border optical cables, 5G, big data centers and satellite communication to build a Eurasian digital corridor. It lays a solid foundation for data flow and digital services between the two countries.

2.2 Cross-border E-commerce and Trade Digitalization

Cross-border e-commerce has become a new growth point of bilateral trade. Digital platforms, intelligent logistics and online payment systems reduce trade costs and improve efficiency. More small and medium-sized enterprises participate in international cooperation, promoting trade diversification and facilitation.

2.3 Artificial Intelligence and Industrial Digital Transformation

AI technology promotes the modernization of energy, transportation, agriculture and finance. Kazakhstan and China strengthen cooperation in technology research, talent training and industrial application. Digital transformation improves production efficiency and upgrades traditional industries.

3. Existing Challenges

Digital standards and regulatory systems are inconsistent.

Data security and cross-border data flow risks exist.

Regional infrastructure development is unbalanced.

Participation of small and medium-sized enterprises is relatively low.

4. Development Strategies and Suggestions

1.Strengthen policy coordination and unify digital standards and rules.

2.Accelerate infrastructure construction and improve network coverage.

3.Support SMEs to carry out digital cooperation.

4.Enhance data security and risk management cooperation.

5.Expand cooperation in AI, cloud computing and smart industries.

5. Conclusion

Kazakhstan-China digital economic cooperation under the Belt and Road Initiative has a solid foundation and broad prospects. Digital infrastructure, cross-border e-commerce and artificial intelligence are key fields. By solving challenges in policy, technology and security, both sides can achieve mutual benefit and win-win results. Deepening digital cooperation will inject strong impetus into bilateral economic and trade relations and contribute to the Digital Silk Road and regional prosperity.

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STRATEGIC REVALUATION OF CHINA - KAZAKHSTAN ECONOMIC COOPERATION: THE CROSS-BORDER PIPELINE UNDER CPC CRISIS

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Annotation. Utilizing the Ukrainian drone strike on the Caspian Pipeline Consortium (CPC) Black Sea terminal as a "natural experiment", this study examines the crisis response mechanisms of the Atasu - Alashankou oil pipeline within the Belt and Road Initiative (BRI). It indicates that the pipeline serves as a critical "strategic option" for Kazakhstan, rather than merely a transit route. Deep economic interdependence offers a fundamental pathway to safeguarding supply chains amid rising global uncertainty.

Key words: strategic revaluation, crisis response, economic cooperation.

Introduction

Recent shifts in the global geopolitical landscape have exposed the vulnerabilities inherent in traditional energy import strategies, which rely on maritime chokepoints and single-route corridors[1]. Evaluations of cross-border pipeline infrastructure have prioritized daily operational costs. Such narrow metrics, fail to capture the true utility of these assets during "extreme stress tests". By analyzing how the Atasu - Alashankou oil pipeline responded to the CPC Crisis, the study seeks to unpack the multi protective efficacy underlying the China-Kazakhstan economic partnership.

Pre-Crisis Context

Grasping the protective value of the Atasu - Alashankou oil pipeline requires a close look at Kazakhstan's pre-crisis export structure. Long-term tracking of oil export data points to a deeply ingrained structural "path dependency"[2].

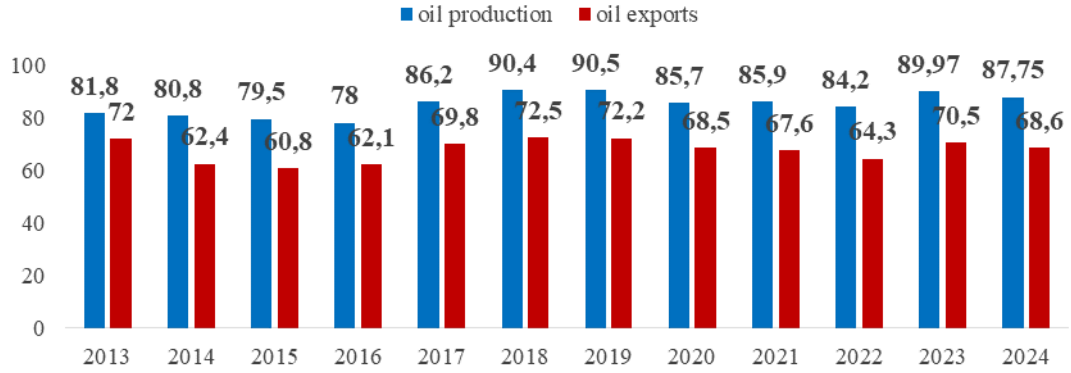


Figure 1: Kazakhstan's crude oil production and exports (unit: million tons)

Kazakhstan's crude oil exports remained disproportionately reliant on the Russian export route (specifically the CPC pipeline)[2]. Prior to the crisis, assessments of the Atasu - Alashankou oil pipeline were largely confined to freight cost comparisons. Given the lower comprehensive logistics costs and higher European market premiums associated with shipping western Caspian oil via the CPC route, Kazakhstan made a choice to maximize export profits. In 2014, the government significantly scaled back the volume of domestic crude oil routed to China overland.

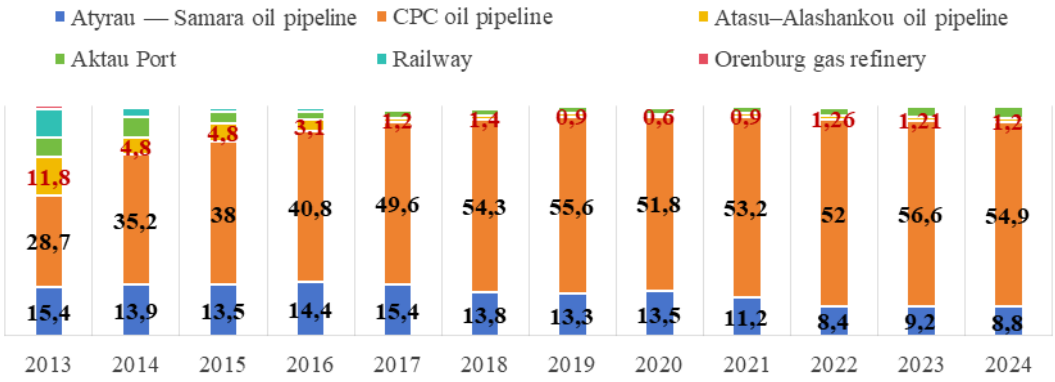
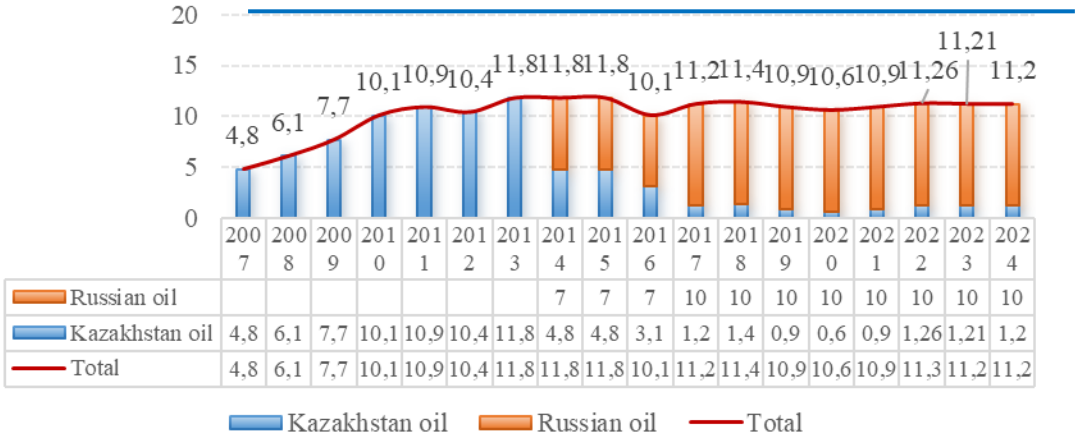


Figure 2: Export Direction of Kazakhstan's Crude Oil (unit: million tons)

Far from diminishing the pipeline's value, this shift highlighted the "path flexibility" embedded in the bilateral cooperation. Kazakhstan effectively transitioned its domestic oil exports into an asset-light model of "collecting transit fees", allowing an increase from seven to ten million tons of Russian oil to flow through annually[2]. Rather than treating idle pipeline transportation capacity as an economic inefficiency, this framework functioned as a high-yield "strategic option", securing vital geographical redundancy for the nation's energy exports.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Russian oil								7	7	7	10	10	10	10	10	10	10	10
Kazakhstan oil	4,8	6,1	7,7	10,1	10,9	10,4	11,8	4,8	4,8	3,1	1,2	1,4	0,9	0,6	0,9	1,26	1,21	1,2
Total	4,8	6,1	7,7	10,1	10,9	10,4	11,8	11,8	11,8	10,1	11,2	11,4	10,9	10,6	10,9	11,3	11,2	11,2

Figure 3: crude oil exported to China via the Atasu - Alashankou oil pipeline (unit: million tons)

(Caption: Atasu - Alashankou oil pipeline annual capacity - 20 million tons)

The "Natural Experiment"

The drone strike on the CPC Black Sea terminal sent shockwaves through the regional market. Confronted with the imminent threat of major export channel blockages, the Atasu - Alashankou oil pipeline instantly abruptly shifted from a "backup alternative" to a lifeline, rapidly activating its political security safeguards.

Rapid Realization of Political Security Protection

To avert potential fiscal collapse, Kazakhstan decisively pivoted eastward, announcing the diversion of 50,000 tons of crude from the Kashagan field directly to China. This was not a simple commercial decision, but the strategic realization of long-term political mutual trust. The redirection of oil flows during the crisis naturally gravitates toward strong political alliances.

Revaluation of Economic and Governance Protection

The CPC crisis fundamentally disrupted conventional cost-accounting models. When the primary export channel faced the risk of zeroing out, the potential losses for Kazakhstan were astronomical. At that critical juncture, the 100% physical accessibility by the Atasu - Alashankou oil pipeline offered an economic value that vastly outweighed any minor differences in per-barrel freight costs. With a designed annual capacity of 20 million tons[2], the substantial idle pipeline transportation capacity transformed overnight from a "sunk cost" into most crucial strategic asset.

Conclusion

Analysis of the CPC crisis demonstrates that the true worth of strategic initiatives, such as China - Kazakhstan cooperation, cannot be measured using static economic metrics alone. Instead, dynamic assessments that account for risk exposure and opportunity costs are necessary. By cultivating a "Community of Shared Interests" that goes beyond commercial gains, China and Kazakhstan have managed to internalize and hedge against external geopolitical threats. For countries participating in the BRI, this model serves as a benchmark for fostering resilient economic ties.

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GEOPOLITICAL RISKS IN BELT AND ROAD INITIATIVE ECONOMIC COOPERATION AND COUNTERMEASURES

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Annotation. The construction of transportation hubs, particularly airports, constitutes a vital component of infrastructure cooperation under the Belt and Road Initiative. Taking the cooperation between China and Kazakhstan in airport development as an example, airports serve as core nodes of regional transportation, not only facilitating the movement of people and goods but also functioning as crucial platforms for promoting regional economic exchanges, trade, and cultural integration. This collaboration between China and Kazakhstan in airport construction not only enhances Kazakhstan's air transport capacity and strengthens its connectivity with neighboring countries and the global community, but also provides opportunities for Chinese enterprises to expand into overseas markets, thereby driving growth in bilateral trade and investment.

Key words: Belt and Road Initiative, deepening globalization, China-Kazakhstan transport hub, (airport) construction cooperation.

Introduction

A Case Study of China-Kazakhstan Transportation Hub (Airport) Construction Cooperation Background and Significance of the Topic In the context of deepening globalization, the Belt and Road Initiative serves as a pivotal platform for China to advance the building of a community with a shared future for mankind, offering unprecedented development opportunities to countries along the route and significantly fostering economic cooperation and connectivity across regions. The Republic of Kazakhstan and the People's Republic of China, as key participants and active promoters of the Belt and Road Initiative, have engaged in extensive and in-depth cooperation across multiple sectors—including energy, infrastructure, and trade—with remarkable achievements.

From a theoretical perspective, current research on the Belt and Road Initiative primarily focuses on economic cooperation models, development opportunities, and cultural exchanges, while specialized studies on geopolitical risks in specific domains (such as airport construction) remain relatively scarce and lack systematicness and depth. This study aims to fill this research gap by examining China-Kazakhstan airport construction cooperation, conducting an in-depth analysis of geopolitical risks, enriching the theoretical framework of the Belt and Road Initiative in the field of transportation infrastructure development, and providing valuable references for future research.

From a practical perspective, accurately identifying and assessing geopolitical risks and proposing feasible countermeasures helps enterprises, governments, and international organizations involved in the China-Kazakhstan airport construction cooperation better mitigate risks, ensure the smooth progress of projects, and achieve mutually beneficial development goals . At the same time, it also enhances China's voice and influence in international transportation infrastructure cooperation, contributing to the establishment of a more equitable, rational, and stable international political and economic order.

Research Direction

Taking the China-Kazakhstan Transportation Hub (Airport) Construction Cooperation as an Example (I) Main Areas and Models of China-Kazakhstan Airport Construction Cooperation The cooperation between China and Kazakhstan in the field of airport construction primarily focuses on the new construction, expansion, and upgrading of airports. Taking Astana International Airport in Kazakhstan as an example, this airport serves as a vital aviation hub for the country, handling a substantial number of domestic and international flights. In recent years, with the increasingly close economic and trade relations between China and Kazakhstan, the passenger and cargo traffic at Astana International Airport has continued to grow, rendering the existing airport facilities inadequate to meet demand. China enterprises have played a significant role in the airport expansion projects, introducing advanced construction technologies and management expertise to enhance the airport's operational efficiency and service quality.

In terms of cooperation models, the China-Kazakhstan airport construction collaboration has adopted various approaches, including engineering contracting, investment cooperation, and technical cooperation. Taking engineering contracting as an example, China enterprises, leveraging their extensive experience and strong capabilities in infrastructure construction, have undertaken the main projects of the airport construction. In investment cooperation, China enterprises participate in the investment and operation of the airport, sharing the benefits of its development with their Kazakh counterparts. Technical cooperation primarily manifests in China enterprises providing technical support and training to Kazakhstan in airport construction and management, helping them enhance their own capabilities and standards .

Identification and Classification of Geopolitical Risks in China-Kazakhstan Airport Construction Cooperation

International Political Environment Risks:

Changes in the international political landscape may lead certain countries to alter their stance toward the Belt and Road Initiative, thereby affecting the progress of China-Kazakhstan airport construction cooperation. For example, some Western countries, driven by political motives, have made unfounded accusations and smear campaigns against the Belt and Road Initiative, attempting to disrupt normal cooperation between China and Kazakhstan. Such external pressure may impose a psychological burden on the Kazakh side, undermining its enthusiasm and commitment to cooperation .

Regional security risks: Central Asia faces complex geopolitical dynamics and inherent security challenges. Activities such as terrorism, extremism, and transnational crime occur periodically, posing threats to airport construction projects and operational safety . For instance, a conflict in a region of Kazakhstan severely disrupted local social order and temporarily halted airport operations. Such regional security instability increases security costs for airport construction projects and delays their progress.

Risks in International Relations: Although China and Kazakhstan maintain sound diplomatic relations, differences may persist on specific issues. For instance, the two countries may have divergent interests regarding trade policies and investment regulations. Failure to properly address these disagreements could hinder the smooth implementation of airport construction cooperation projects. Furthermore, shifts in relations with neighboring countries may indirectly impact China-Kazakhstan airport cooperation. Given the close energy cooperation between Russia and Kazakhstan, any changes in Russia-Kazakhstan relations could affect Kazakhstan's energy supply and economic development, thereby impacting the funding and operation of airport construction projects.

Measures to Address Geopolitical Risks in China-Kazakhstan Airport Construction Cooperation

1. Strengthen Political Communication and Coordination China and Kazakhstan should maintain close high-level exchanges and political communication, promptly consulting and resolving geopolitical issues arising from cooperation . By establishing regular communication mechanisms and emergency coordination mechanisms, both sides can enhance their collaborative capacity in risk response. For example, a joint working group composed of relevant government departments, enterprises, and experts from both countries should be established to jointly study and address geopolitical risks.

2. Strengthening Security Measures In response to regional security risks, China and Kazakhstan should enhance cooperation in the security domain and jointly combat terrorism, extremism, and transnational crime. For airport construction projects, security infrastructure should be reinforced to elevate protection standards, including the installation of advanced security screening equipment and intensified security patrols around airports. Meanwhile, enterprises must develop comprehensive emergency response plans to improve their capacity to handle unexpected incidents.

3. Optimizing Cooperation Models and Mechanisms To address risks in international relations and domestic political factors, China and Kazakhstan should refine their cooperation models and mechanisms to enhance flexibility and adaptability. For instance, in investment cooperation, diversified investment approaches can be adopted to mitigate risks associated with single investors; during project approval and implementation, communication and coordination with relevant Kazakhstani authorities should be strengthened to ensure projects comply with local laws, regulations, and policy requirements.

4. Strengthening Public Opinion Guidance and Communication: In response to risks in the international political environment, China and Kazakhstan should enhance public opinion guidance and communication, actively address external doubts and misunderstandings, and showcase the positive outcomes and cooperative value of the Belt and Road Initiative. By organizing press conferences, seminars, and other events, they should convey positive messages to the international community and foster a favorable international public opinion environment.

In conclusion, through an in-depth study of the geopolitical risks associated with the China-Kazakhstan transportation hub (airport) construction cooperation, valuable references and recommendations can be provided to all parties involved in the Belt and Road Initiative. This will facilitate the sustainable development of China-Kazakhstan airport construction cooperation in the complex and volatile international environment, further enhancing the influence and appeal of the Belt and Road Initiative.

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RESEARCH ON THE MODERN DEVELOPMENT OF SMALL AND MEDIUM-SIZED ENTERPRISES: A CASE STUDY OF HOME APPLIANCE AND BUILDING MATERIALS ENTERPRISES IN THE DOWNSTREAM OF REAL ESTATE

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Annotation. Against the background of the rapid development of the digital economy and the deepening international cooperation under the Belt and Road Initiative, small and medium-sized enterprises (SMEs) have become an important force driving industrial upgrading, stabilizing economic growth, promoting cross-border trade and ensuring employment. Meanwhile, China’s real estate market has entered a stage of structural adjustment and stock optimization. Affected by industry cycles, demand changes and resource constraints, SMEs in downstream home appliances and building materials generally face practical dilemmas such as insufficient innovation capacity, narrow financing channels and low operational

efficiency. Taking SMEs downstream of the real estate industry as research objects, this paper analyzes their development dilemmas and causes, clarifies the key role of digital transformation in solving.

Key words: Small and medium-sized enterprises; downstream real estate; digital transformation; innovation dilemma; financing constraints; Belt and Road

1 Introduction

At present, the global digital economy and real economy are deeply integrated, and digital transformation of SMEs has become an important direction for enhancing economic vitality. Under the Belt and Road framework, cooperation between China and Kazakhstan in digital infrastructure, cross-border e-commerce and industrial supporting continues to advance, providing new opportunities for traditional industrial upgrading. Meanwhile, China's real estate industry has shifted from rapid growth to steady development. Downstream home appliance and building materials enterprises face shrinking orders and intensified competition. Due to small scale, weak risk resistance and traditional management mode, SMEs are under increasing development **pressure.**

2 Analysis on the Development Dilemmas of SMEs in the Downstream of Real Estate

With structural adjustment of the real estate industry, According to the 2025 full-year performance of the home appliance industry, leading enterprises rely on advantages in scale, brand and channels to seize market share and achieve steady growth; mid-tier enterprises diverge in stock competition, and most fall into profit decline; small and medium-sized brands generally face survival pressure with rising risks of loss and delisting.

Table 1. 2025 Financial Performance of Major Home Appliance Enterprises

Enterprise Name	2025 Revenue (100 million yuan)	Revenue YoY Growth	Net Profit (100 million yuan)	Net Profit YoY Growth	Performance Trend
Midea Group	4585.02	12.10%	439.45	14.03%	Double Growth
Haier Smart Home	3023.47	5.71%	195.53	4.39%	Double Growth
Skyworth Group	703.24	8.20%	3.56	-37.30%	Revenue Up, Profit Down
Hisense Home Appliances	879.28	-5.19%	31.87	-4.82%	Double Decline
Changhong Meiling	304.08	6.32%	4.10	-41.31%	Revenue Up, Profit Down
Aux	300.49	0.97%	22.35	-23.20%	Revenue Up, Profit Down
Supor	227.72	1.54%	20.97	-6.58%	Revenue Up, Profit Down
TCL Smart Home	185.31	0.93%	11.23	10.22%	Double Growth
Konka A	90~105	11.115 billion yuan in the same period last year	-155.73~-125.81	-3.296 billion yuan in the same period last year	Continuous Loss
Joyoung Co., Ltd.	82.1	-7.23%	1.18	-3.85%	Double Decline
Bear Electric	52.3	9.92%	3.93	36.40%	Double Growth
JMGO Technology	34.67	1.85%	1.43	19.40%	Double Growth
Beiding Co., Ltd.	9.51	26.13%	1.14	63.35%	Double Growth
Activa	–	–	-2.22~-1.54	15.0709 million yuan in the same period last year	Turned to Loss
Marsman	–	–	-3.7~-2.7	11.1512 million yuan in the same period last year	Turned to Loss
Zhejiang Meida	–	–	0.10~0.15	-90.95%~-86.42%	Decline
Shuaifeng Electric	–	–	-0.62~-0.43	60.306 million yuan in the same period last year	Approaching ST Warr
Yitian Intelligent	–	–	-1.86~-1.52	26.5414 million yuan in the same period last year	Turned to Loss

Note: Data from 2025 annual reports or preliminary performance forecasts; Konka, Aishida, Marsien, Zhejiang Meida, Shuaifeng, Yitian are forecast data.

Their development problems are concentrated in three aspects: weak innovation, financing constraints and inefficient operation.

2.1 Weak Innovation Capacity and Serious Homogenization

Home appliance and building materials enterprises generally have low R&D investment, lack core technologies and design capabilities, with products mainly at mid-to-low end. Intelligent and personalized services are insufficient. Meanwhile, SMEs lack talent attraction, unstable R&D teams and high innovation costs, leading to long-term homogeneous competition.

2.2 Narrow Financing Channels and High Financing Costs

SMEs mainly rely on internal financing with slow capital accumulation. External financing faces strict bank approval, high threshold of equity and bond financing, . Information asymmetry intensifies financing constraints.

2.3 Traditional Operation Mode and Low Digitalization Level

Most enterprises adopt traditional production, management and marketing, with weak supply chain collaboration and slow inventory turnover. Insufficient digital application results in low efficiency and poor risk resistance.

3 The Key Role of Digital Transformation in Solving Development Dilemmas

Digital transformation, supported by cloud computing, big data and IoT, can systematically improve development conditions of SMEs from innovation, financing and operation.

3.1 Digitalization Improves Innovation Efficiency and Reduces Costs

Big data captures market demand accurately; collaborative design and cloud manufacturing lower R&D thresholds. Digitalization promotes intelligent and green upgrading for home appliances and building materials.

3.2 Digitalization Optimizes Operation and Enhances Industrial Chain Resilience

Digitalization realizes online whole-process management, improves efficiency and reduces costs. It also helps SMEs participate in cross-border e-commerce and expand markets like Kazakhstan.

4 Digital Transformation Paths for Downstream SMEs

Combined with enterprise reality and digital economy trends, transformation can be promoted from four aspects:

1. Low-cost lightweight digital transformation: use cloud services, inventory and financial digital tools.

2. Data-driven innovation: develop smart home appliances, green building materials and smart services.

3. Build digital credit system: standardize data and connect supply chain finance.

5 Conclusion

SMEs in downstream home appliances and building materials are important parts of the real economy, facing innovation shortage, Digital transformation is the key to achieve high-quality development. Under the dual opportunities of digital economy and the Belt and Road, SMEs should accelerate lightweight digital reform, build core competitiveness, integrate into industrial chains and international cooperation. With popularization of digital technology and policy support, these SMEs are expected to break through dilemmas and provide a broader industrial foundation for China-Kazakhstan digital economic cooperation.

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DIGITAL ECONOMY COOPERATION BETWEEN KAZAKHSTAN AND CHINA UNDER THE BELT AND ROAD INITIATIVE

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Annotation. Against the backdrop of global digital transformation and the high-quality development of the Belt and Road Initiative, digital economy cooperation has become a new growth engine for Kazakhstan-China economic and trade relations. This paper analyzes the current status and achievements of bilateral digital cooperation based on latest statistical data, identifies key fields including cross-border e-commerce, digital infrastructure and artificial intelligence, and puts forward practical suggestions for further development.

Key words: Digital economy; Kazakhstan-China cooperation; Belt and Road; cross-border e-commerce; digital transformation.

In the era of digital economy, technologies such as artificial intelligence, big data and cloud computing are reconstructing global industrial chains. For Kazakhstan and China with close geographical and economic ties, deepening digital cooperation is an important way to upgrade bilateral trade and investment.

With the joint construction of the Belt and Road Initiative, cooperation between the two countries has shifted from traditional fields to digital technology, e-commerce and smart industries. The digital economy has become a new driving force for bilateral relations. This paper sorts out the development status of digital cooperation and provides references for policymakers and enterprises.

Bilateral trade and investment provide a solid basis for digital economy cooperation. In 2025, bilateral trade reached 48.7 billion US dollars, up 11% year-on-year. In the first three quarters of 2025, China's direct investment in Kazakhstan was 2.6 billion US dollars, increasing by 262%. Railway freight volume between the two countries reached 35.6 million tons in 2025, up 11.1%.

Cross-border e-commerce is the most active field of bilateral digital cooperation. In 2024, cross-border e-commerce volume exceeded 450 million US dollars, growing by 35.8%.In the first two months of 2026, Khorgos Port cross-border e-commerce reached 7.801 billion yuan, up 47.75%.

Logistics time of Chinese parcels to Kazakhstan has been shortened to 7 days.

Digital infrastructure and artificial intelligence are key cooperation directions.AI systems improve port clearance efficiency by 60%.Astana Hub's IT export reached 633.8 million US dollars in 2025, serving 111 countries.

The two countries have launched smart agriculture platform projects and smart city cooperation. Digital transformation is also reshaping the financial sector in both countries. Chinese fintech solutions have been adopted in Kazakhstan's mobile payment and digital banking systems, providing secure and convenient financial services for cross-border trade. This not only reduces transaction costs but also improves the speed and transparency of capital flows between the two nations.

Digital cooperation also extends to smart logistics and customs digitization, which significantly reduces trade barriers. The two countries have promoted the use of electronic customs declarations and blockchain-based traceability systems, cutting down on manual processes and minimizing delays. These digital tools make cross-border trade more efficient, transparent, and reliable, laying a solid foundation for expanding bilateral commerce in the digital age.

Digital divide between different regions. Incompleteness of digital trade and data flow regulation coordination. Shortage of high-level digital talents. Insufficient awareness and capacity of small and medium-sized enterprises.

Strengthen 5G, optical cable and data channel construction to improve digital connectivity. Optimize cross-border e-commerce supervision and promote trade facilitation. Establish joint innovation centers and deepen AI and fintech cooperation.

Strengthen talent training and academic exchanges. Improve data security and network security coordination mechanism.

Another key area for future cooperation is digital governance and e-government. By sharing best practices in digital public services, Kazakhstan and China can enhance administrative efficiency and improve access to public services for their citizens. This cooperation will also help build a more predictable and transparent regulatory environment for digital businesses.

Kazakhstan-China digital economy cooperation under the Belt and Road Initiative has achieved remarkable results with broad prospects. The growth of trade and investment, booming cross-border e-commerce, improved digital infrastructure and in-depth AI cooperation have jointly promoted economic transformation of both countries.

In the future, deepening digital connectivity, policy coordination and talent exchange will make the digital economy play a greater role in sustainable development and regional integration. The two countries are expected to set a model for digital cooperation among countries along the Belt and Road.

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ECONOMIC COOPERATION BETWEEN KAZAKHSTAN AND CHINA UNDER THE BELT AND ROAD INITIATIVE: THE ROLE OF EDUCATION-TRADE COOPERATION AND TALENT DEVELOPMENT

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Annotation. This paper focuses on economic cooperation between Kazakhstan and China within the Belt and Road Initiative framework, and analyzes the current situation, advantages and existing challenges of bilateral cooperation. It emphasizes the supporting role of education-trade cooperation and talent development, and puts forward targeted paths to promote high-quality and sustainable economic cooperation between the two countries.

Key words: Belt and Road Initiative; China–Kazakhstan cooperation; economic cooperation; education-trade synergy; talent development

Introduction

The Belt and Road Initiative serves as a major platform for international economic cooperation, infrastructure connectivity, trade liberalization, and people-to-people exchanges. Since 2013, China has cooperated with more than 150 countries, and trade volume has kept growing. As a key partner, Kazakhstan maintains close economic and trade relations with China, making remarkable achievements in cross-border transportation, energy cooperation, industrial investment, and trade facilitation. However, with the high-quality development of the BRI, China–Kazakhstan economic cooperation faces new challenges, including talent structural mismatches, low matching between professional skills and trade needs, and inadequate integration of education and trade cooperation. These problems restrict the sustainability and efficiency of bilateral cooperation. Therefore, exploring the current situation, mechanisms, and supporting paths of China–Kazakhstan economic cooperation under the BRI is of great theoretical and practical significance, especially for promoting high-quality bilateral cooperation.

1 Current Situation and Advantages of China–Kazakhstan Economic Cooperation Geographical proximity, complementary resources and policy coordination provide a solid foundation for China–Kazakhstan economic cooperation. Bilateral trade has grown steadily, covering energy, agricultural products, electromechanical products and cross-border services. Chinese enterprises have participated in various infrastructure projects in Kazakhstan, promoting regional transportation connectivity.Against the “Digital Silk Road”, cross-border e-

commerce, digital trade and logistics cooperation have become new growth points. The two countries have strengthened cooperation in customs clearance, industrial parks and agricultural modernization, expanding the space for bilateral economic and trade cooperation. The alignment of the BRI and Kazakhstan's development strategies also provides stable institutional support for long-term cooperation.

2 The Supporting Role of Education–Trade Cooperation in Bilateral Economic Cooperation The deepening of China–Kazakhstan economic cooperation urgently needs compound talents with cross-cultural, technical and international trade capabilities. Education–trade cooperation can effectively link talent supply with trade demand and improve training quality.First, education cooperation helps cultivate talents for cross-border trade, project management and technical services through exchanges, joint programs and Luban Workshop-style vocational cooperation. Second, trade development provides practical scenarios for education, making training more targeted. Third, education-trade synergy promotes talent mobility and enhances bilateral cooperation competitiveness.Existing studies show that the synergy mechanism needs improvement, regional adaptation requires strengthening, and digital empowerment is insufficient. Thus, a more precise talent training system is needed to support sustainable economic cooperation between China and Kazakhstan.

3 Challenges Facing China–Kazakhstan Economic Cooperation Although China–Kazakhstan economic cooperation has achieved remarkable results, it still faces constraints. First, structural talent shortages are prominent, especially in digital trade, logistics and cross-border services, with a low matching rate between supply and enterprise demand. Second, digital cooperation needs to be improved, as digital technology is underused in cross-border trade, customs supervision and logistics.Third, education cooperation is not closely aligned with real trade needs in majors, curricula and practice. Fourth, the long-term cooperation mechanism, including policy coordination, resource integration and risk management, needs further optimization.

4 Paths to Promote High-Quality Economic Cooperation Between

China and KazakhstanTo promote sustainable development of China–Kazakhstan economic cooperation under the BRI, multiple paths should be adopted.First, strengthen education-trade synergy and build a demand-oriented talent training system through school-enterprise cooperation, order-based training and expanded exchanges.Second, accelerate digital transformation to develop cross-border e-commerce and digital trade, and improve cooperation in digital infrastructure and logistics platforms.Third, improve the long-term cooperation mechanism by strengthening policy communication, promoting standard mutual recognition and establishing a risk prevention system.Fourth, expand cooperation into green economy, agricultural modernization, services and technological innovation to enhance sustainability.

Conclusion

Economic cooperation between Kazakhstan and China under the Belt and Road Initiative boasts a solid foundation and broad prospects. Trade facilitation, investment cooperation, infrastructure connectivity and digital economy cooperation serve as its important pillars.

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DIGITAL TRANSFORMATION AND CROSS-BORDER COOPERATION IN THE GLOBAL APPAREL INDUSTRY UNDER THE BELT AND ROAD INITIATIVE

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Annotation. This article explores the impact of digital transformation on the global apparel industry's development within the framework of the Belt and Road Initiative (BRI). The author analyzes how the implementation of Industry 4.0 technologies—such as big data, artificial intelligence, and blockchain—optimizes cross-border supply chains and enhances production efficiency. Particular attention is paid to cooperation mechanisms between BRI participating countries aimed at reducing trade barriers and establishing a unified digital ecosystem. The study examines both the opportunities for economic growth in emerging markets and the challenges associated with the technological divide and sustainable development. The findings highlight that digital integration within the BRI is becoming a key factor in the textile sector's competitiveness amidst shifting global economic landscapes.

Key words: digital transformation, Belt and Road Initiative, apparel industry, cross-border cooperation, supply chains, Industry 4.0, globalization.

1. INTRODUCTION

With the deepening of the "One Belt, One Road" initiative, economic and trade cooperation between Kazakhstan and China has continued to expand in fields such as infrastructure, digital economy, light industry and cross-border e-commerce. At the same time, the global apparel industry is undergoing a comprehensive digital

transformation driven by new technologies including artificial intelligence, 3D design, big data analysis and virtual simulation. For modern fashion higher education, digital capability construction and international industry-education integration have become key tasks to adapt to industrial changes and cultivate innovative talents. This paper focuses on the digital transformation path of the apparel industry and the cooperation opportunities between Kazakhstan and China from the perspective of fashion college teachers, and puts forward educational practice strategies suitable for higher education institutions [1].

2. DIGITAL TRANSFORMATION TRENDS AND TOOLS IN THE APPAREL INDUSTRY

Digitalization has reshaped the whole value chain of the apparel industry, including design, production, supply chain and sales. The main trends are as follows:

Intelligent design: AI-assisted color matching, style generation and fashion trend prediction.

Virtual prototype making: 3D garment modeling, virtual fitting and zero-waste pattern making.

Smart supply chain: real-time logistics tracking, flexible production and rapid response system.

Digital retail: cross-border live streaming e-commerce, virtual try-on and online market expansion [2].

Common digital tools include CAD/CAM systems, 3D virtual fashion software, big data platforms and cloud-based supply chain systems. These tools help reduce costs, improve efficiency and promote sustainable development of the apparel industry.

3. KAZAKHSTAN-CHINA COOPERATION IN TEXTILE AND APPAREL UNDER THE BELT AND ROAD

Under the framework of the “One Belt, One Road” initiative, Kazakhstan and China have obvious complementary advantages in the textile and apparel industry. China has a complete industrial chain, advanced digital technology and mature cross-border e-commerce systems. Kazakhstan is rich in cotton, wool and other raw materials, and has unique geographical advantages in Central Asia.

Cooperation directions include:

Joint construction of textile and apparel industrial parks and supply chain integration.

Digital fashion design, brand building and product innovation cooperation.

Cross-border e-commerce cooperation for apparel products.

Academic exchanges and talent training in fashion higher education.

Main challenges include cultural differences, logistics costs and digital gaps, which can be improved through policy coordination, platform construction and talent training [3].

4. INSPIRATION FOR FASHION HIGHER EDUCATION TEACHING

From the perspective of college teachers, digital transformation and international cooperation put forward new requirements for fashion education:

Update curriculum system: add AI fashion design, 3D technology, digital marketing and cross-border trade courses.

Strengthen practical teaching: build virtual simulation laboratories and cooperate with digital apparel enterprises [4].

Promote international exchanges: carry out online courses, workshops and joint training with universities along the “One Belt, One Road”.

Improve teachers’ digital literacy: strengthen training in intelligent design, data analysis and cross-cultural communication.

Fashion education should take digitization, internationalization and industry-education integration as core directions to cultivate talents adapted to the digital economy era [5].

5. CONCLUSION

The “One Belt, One Road” initiative provides broad space for Kazakhstan-China economic and trade cooperation. Digital transformation is reconstructing the global apparel industry and higher education model. Fashion colleges and universities should optimize teaching systems, strengthen international exchanges and help the sustainable development of the apparel industry in the digital economy era.

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CURRENT STATUS AND STRATEGIES FOR SUSTAINABLE DEVELOPMENT AND DIGITAL INTEGRATION OF GREEN AGRICULTURAL TRADE UNDER THE BELT AND ROAD INITIATIVE

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Annotation. Against the background of deepening global climate governance and increasingly severe food security challenges, the Belt and Road Initiative has established an important cooperation platform for green agricultural trade among participating countries. The integrated development of sustainability and digitalization has become an inevitable trend for high-quality growth. Based on authoritative data from the General Administration of Customs, the Ministry of Agriculture and Rural Affairs, the World Bank and other institutions, this paper systematically reviews the current scale, structural optimization, sustainable practices and digital integration progress of green agricultural trade under the BRI. It also summarizes four core constraints: inconsistent green standards, prominent digital gaps, insufficient cross-border cold chain facilities, and limited green financial support. Finally, this paper proposes targeted strategies to promote coordinated standards, digital connectivity, improved industrial chains and strengthened financial support. The research aims to provide practical references for deepening green agricultural cooperation and promoting sustainable development among BRI countries.

Key words: Belt and Road Initiative; green agricultural trade; sustainable development; digital integration; food security

1. Introduction

Global agricultural greenhouse gas emissions account for 18%–24% of total anthropogenic emissions. The traditional high-input and high-emission agricultural model can no longer meet the dual demands of ecological protection and food security. Therefore, the green and low-carbon transformation of global agriculture has become a common consensus of all countries.

Since the launch of the Belt and Road Initiative, agricultural trade cooperation between China and participating countries has continued to deepen. In 2025, the trade volume of agricultural products between China and BRI countries reached 1.43 trillion yuan, accounting for 42.5% of China's total agricultural trade. At present, the deep integration of sustainable development concepts and digital technologies has become the core driving force to promote high-quality development of green agricultural trade under the BRI.

2. Definition of Related Concepts

Green agricultural trade refers to an eco-friendly and efficient trade model covering green production, low-carbon processing, pollution-free logistics and recyclable packaging. It takes low-carbon emission, ecological priority and food safety as core goals.

Digital integration refers to a cross-border coordinated development model supported by big data, blockchain, intelligent monitoring and Internet of Things technologies. It helps realize data sharing, standard mutual recognition, logistics coordination and whole-chain traceability among BRI countries.

The two concepts are complementary and jointly promote the high-quality, green and intelligent transformation of agricultural trade.

3. Current Status of Green Agricultural Trade under the BRI

3.1 Steady Expansion of Trade Scale and Optimized Structure

From 2013 to 2022, the average annual growth rate of agricultural trade between China and BRI countries reached 8.7%. In 2025, the total trade volume rose to 1.43 trillion yuan. In the first quarter of 2026, trade volume reached 336.73 billion yuan, with a year-on-year growth rate of 21.4%.

ASEAN remains the largest agricultural trade partner, accounting for 31.3% of the total trade. Meanwhile, the proportion of green and organic agricultural exports continues to rise, indicating continuous optimization of trade structure.

3.2 Remarkable Achievements in Sustainable Development

China has signed agricultural cooperation memorandums with more than 30 BRI countries and established official green agriculture cooperation mechanisms. Popularized technologies include water-saving irrigation, organic fertilizer substitution and green pest control.

In Central Asian demonstration zones, the application of green technologies has reduced fertilizer use by 20%. In addition, China has carried out mutual recognition pilots of CNAS organic certification with 12 countries along the routes, reducing enterprise certification costs by 30%.

3.3 Steady Progress in Digital Integration

Supported by the Digital Silk Road, digital construction of agricultural trade has developed rapidly. The China-Europe Railway Express has completed digital upgrading, with intelligent coverage at ports reaching 85%. Real-time container tracking and whole-process monitoring have been widely applied.

Blockchain traceability has been fully applied in agricultural products transported by China-Europe Railway Express. In 2025, the trade volume of traceable agricultural products reached 28 billion yuan. The customs clearance time for fresh agricultural products has been shortened by more than 50%, greatly improving cross-border trade efficiency.

4. Core Challenges Facing the Development of Green Agricultural Trade under the BRI

Although China and BRI countries have achieved remarkable progress in green agricultural trade, the development still faces many bottlenecks.

4.1 Fragmentation of Green Standards

Differences in green certification, pesticide residue limits and accounting rules among countries have increased corporate compliance costs by 25%–40%.

4.2 Significant Digital Divide

Broadband coverage in some rural areas of Central Asia is less than 70%, restricting the application of big data, intelligent monitoring and other technologies.

4.3 Weak Cross-Border Cold Chain Infrastructure

Inadequate cross-border cold storage and transportation have led to a fresh produce loss rate of 20%–30%.

4.4 Insufficient Green Financial Supply

Green agricultural projects feature long investment cycles and high risks. The participation of commercial capital is low, and green agricultural loans account for only 8% of total agricultural loans.

5. Strategies for Promoting Green Agricultural Trade Development

In response to the above challenges and the current development situation, four countermeasures are proposed:

5.1 Promote green standard coordination

Establish a BRI Green Agriculture Standard Alliance, unify certification and accounting rules, expand the scope of mutual recognition, and reduce enterprise certification costs.

5.2 Accelerate digital infrastructure connectivity

Build 5G and Internet of Things in key agricultural regions, upgrade the digitalization of ports and cold chains, and build a unified digital platform.

5.3 Improve the green industrial chain

Jointly build cross-border cold chains to reduce the loss rate of fresh products to below 10%, cultivate leading enterprises, and drive the transformation of small and medium-sized agricultural enterprises.

5.4 Strengthen Policy Coordination and Financial Support

Countries should strengthen agricultural policy coordination, set up special funds for green agriculture, and develop diversified green financial products to provide stable financial support.

6. Conclusion

Under the Belt and Road Initiative, green agricultural trade has achieved continuous expansion in scale, remarkable progress in sustainable practices and steady improvement in digital integration. However, inconsistent green standards, digital gaps, insufficient cold chain facilities and limited financial support still restrict high-quality development.

In the future, BRI countries should adhere to the dual-driven model of sustainable development and digital integration, deepen multilateral cooperation, improve the green standard system, digital infrastructure and industrial chain layout, and build an open, inclusive and win-win green agricultural trade system. This will make important contributions to global food security and ecological governance.

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INFRASTRUCTURE CONNECTIVITY AND MUTUAL BENEFITS FOR PEOPLE'S LIVELIHOODS CHINA'S INFRASTRUCTURE-DRIVEN SUSTAINABLE DEVELOPMENT IN KAZAKHSTAN UNDER THE BELT AND ROAD INITIATIVE

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Annotation. Against the Belt and Road Initiative, this paper reviews key infrastructure cooperation projects between China and Kazakhstan in transportation, energy, and petrochemical sectors based on 2024–2025 practices. It focuses on how Chinese infrastructure projects support Kazakhstan's economic growth, industrial upgrading, livelihood improvement, and sustainable development. The study shows that bilateral cooperation has evolved from individual projects to an interconnected network, effectively boosting bilateral trade and supporting Kazakhstan's national development strategies and the UN SDGs. In view of existing challenges including environmental risks and financing constraints, this paper proposes targeted suggestions to promote high-quality and sustainable China-Kazakhstan cooperation under the Belt and Road framework.

Key words: Belt and Road Initiative; China-Kazakhstan economic cooperation; infrastructure; sustainable development; green transformation

1. Introduction

In September 2013, the Silk Road Economic Belt was first proposed in Kazakhstan, making the country a pioneer and core partner of the Belt and Road Initiative. Located at the heart of Eurasia, Kazakhstan serves as a critical transport hub linking China, Central Asia, and Europe. China has long been Kazakhstan's largest trading partner, and infrastructure cooperation has become a pillar of bilateral relations.

Kazakhstan is implementing the *National Infrastructure Plan until 2029* and the *Power Industry Development Plan (2035)*, focusing on transport, energy, and industrial modernization. China has competitive advantages in engineering

construction, equipment, and financing. Against this background, this paper analyzes the achievements and impacts of China-Kazakhstan infrastructure cooperation, aiming to provide practical references for deepening bilateral strategic coordination.

2. Major Achievements of China-Kazakhstan Infrastructure Cooperation

2.1 Transportation and Logistics

Transport connectivity is a priority area. A coordinated system of dry ports, coastal ports, and cross-border railways has been formed.

Project	Builder	Core Outcomes	Sustainable Value
China-Kazakhstan (Lianyungang) Logistics Base	Lianyungang Port Group	Over 75,000 TEUs in 2025; transit time greatly reduced	Serves as a key outlet for Central Asia; cuts logistics costs
Khorgos–East Gate Dry Port	China-Kazakhstan joint venture	High-efficiency transshipment; strong growth in freight volume	Largest dry port in Central Asia; improves border clearance
Aktau Port Container Zone	Chinese enterprises	Opened in 2025; supports the Trans-Caspian corridor	Strengthens Caspian Sea logistics functions
Astana Light Rail	Chinese enterprises	Trial operation in 2025; Chinese technical standards	Improves urban transport; fosters local talents
Western Europe–Western China Highway	CITIC Construction	1,130 km opened in 2024	Shortens travel time; boosts regional economy
Ayagoz–Tacheng Railway	CCCC, CHEC	Under construction since 2025	Third cross-border railway; enhances transport capacity

2.2 Energy and Power

Cooperation has shifted from traditional oil and gas to renewable energy.

Project	Builder	Core Outcomes	Sustainable Value
Zhanatas 100MW Wind Farm	PowerChina	Operational since 2021; supplies 200,000 households	Large-scale clean energy; reduces carbon emissions

Project	Builder	Core Outcomes	Sustainable Value
Chimkent Refinery Upgrade	CNPC	Reached Euro V emission standards	Ends dependence on imported high-grade fuel
Khoromtau 150MW Wind Farm	HydroChina Chengdu	Completed in 2025 ahead of schedule	Supports Kazakhstan's green energy targets
Caspian Bitumen Plant	CITIC Construction	Expanded production capacity	Supports road construction; reduces imports
Aktobe Urea Plant	CNPC, KazMunayGas	Annual output 800,000 tons	Ensures agricultural security; adds value to resources

2.3 Industrial Supporting Infrastructure

Project	Builder	Core Outcomes	Sustainable Value
Kazakhstan Polyethylene Plant	Sinopec, Sibur, KazMunayGas	Large-scale petrochemical project	Realizes import substitution; upgrades industry chain
Greater Almaty Ring Road	Multilateral consortium	Major PPP road project	Eases congestion; drives urban and industrial development

3. Impacts on Kazakhstan's Sustainable Development

3.1 Economic Growth

Chinese investment in infrastructure has strongly boosted Kazakhstan's economy, with its GDP growth reaching 4.8% in 2024. Improved logistics has stimulated bilateral trade, which exceeded 30 billion US dollars in 2025. Transport time and trade costs have been significantly reduced. Infrastructure projects have created over 100,000 local jobs and trained a large number of technical personnel.

3.2 Social and Livelihood Improvement

Urban transport projects such as Astana Light Rail have improved public services. Energy projects eased power shortages in southern regions. Local employees' incomes have increased markedly, and living standards have improved. Infrastructure connectivity also promotes balanced development between cities and rural areas.

3.3 Green and Low-Carbon Transition

Wind power and other renewable projects have increased Kazakhstan's clean energy installed capacity. Traditional industries such as oil refining have achieved green upgrading with lower emissions. The two sides have promoted green financing and low-carbon construction models, supporting Kazakhstan's low-carbon development strategy.

3.4 Regional Connectivity

Infrastructure corridors have strengthened Kazakhstan's role as a Eurasian transport hub. The Trans-Caspian route and new land crossings enhance regional integration. China-Kazakhstan cooperation also sets an example for regional cooperation and promotes people-to-people bonds.

4. Challenges and Suggestions

4.1 Challenges

（1）Ecological and social risks in sensitive areas

（2）Large investment and long payback periods causing financing pressure

（3）Inconsistencies in technical and environmental standards

4.2 Countermeasures

（1）Strengthen environmental assessment and ecological protection

（2）Diversify financing through PPP, multilateral institutions, and green finance

（3）Promote alignment of technical standards and localized operation

（4）Expand cooperation to digital infrastructure, cold chain logistics, and green construction

5. Conclusion

China-Kazakhstan infrastructure cooperation under the Belt and Road Initiative has achieved remarkable results in transportation, energy, and industrial sectors. Chinese projects have effectively promoted Kazakhstan's economic growth, improved people's livelihoods, accelerated green transition, and enhanced its regional status.

Going forward, the two countries should address challenges in environmental protection, financing, and standards. By deepening cooperation in green development, financing innovation, and talent training, China-Kazakhstan infrastructure cooperation will achieve higher-quality and sustainable development, contributing to the China-Kazakhstan community with shared future and regional prosperity.

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SOCIAL AND ECONOMIC DEVELOPMENT OF THE AKMOLA REGION AND COMPARABLE REGIONS OF KAZAKHSTAN

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Annotation. This article analyzes the differences in socioeconomic development between Akmola Oblast and comparable regions of Kazakhstan—Turkestan, Almaty, and North Kazakhstan Oblasts. The study is based on comparative data for 2022–2024 and aims to identify key trends, growth factors, and structural features of regional development. This comparative approach allows us to identify areas of strong and weak growth, highlight the unique characteristics of each region, and establish the relationship between social and economic indicators.

Key words: regional development, social infrastructure, human capital, population income, education, healthcare, interregional differences.

The relevance of this study stems from the need to understand how social and economic differences between regions shape the standard of living, the quality of human capital, and the sustainability of development. Against the backdrop of transformation processes in Kazakhstan's economy, the importance of interregional analysis increases, as it allows us to identify structural imbalances and determine the

factors contributing to the accelerated development of individual regions. Comparing indicators across different regions allows us to assess the impact of the economic base, budget expenditures, and the state of social infrastructure on human capital development and social sustainability.

Regional development is determined by how successfully they combine economic growth and the strengthening of social infrastructure. The quality of healthcare, education, housing, and public services ensures the conditions for the development of human capital, which becomes the foundation for long-term economic sustainability. Kazakhstan is characterized by significant interregional disparities, and analyzing these differences allows us to understand what facilitates the accelerated development of some regions and hinders the potential of others. In this context, social infrastructure is not only a result of economic growth but also its most important factor.

Regional disparities manifest themselves in both production volumes and living standards, creating a diverse foundation for social modernization. Regions with higher economic activity are able to allocate more financial resources to infrastructure development, while areas with rapidly growing populations face the need for accelerated expansion of social facilities. To obtain a comprehensive picture, it is important to consider economic and social parameters within a single framework, starting with key macroeconomic indicators and moving on to sectoral elements of social infrastructure.

The current study allows us to trace how economic potential is translated into the development of social services and the role of infrastructural differences in the formation of human capital. The work begins with an analysis of GRP per capita, which forms the economic foundation, and then moves on to an examination of income, the quality of human capital, budget expenditures, and the state of infrastructure subsystems.

Table 1. GRP per capita, thousand tenge

Regions	2022	2023	2024	2023/2022		2024/2023	
				+/-	%	+/-	%
Akmola region	4200,4	4459,7	4748,3	+259,3	+6,2	+288,6	+6,5
Turkestan region	2350,8	2499,6	2721,9	+148,8	+6,3	+222,3	+8,9
Almaty region	5103,4	5382,1	5650,7	+278,7	+5,5	+268,6	+5,0
North Kazakhstan region	3901,2	4050,3	4230,1	+149,1	+3,8	+179,8	+4,4

Labor force income allows us to assess the socioeconomic status of households and their level of economic participation. Income determination reflects the level of structural diversification of the economy and workers' access to high-productivity jobs. This is particularly important for analyzing social services and assessing quality of life.

Analysis showed that income growth in Akmola Oblast by 14,700 tenge in 2023 and 15,200 tenge in 2024 was driven by improved employment conditions and higher wages in the manufacturing industries. In Turkestan Oblast, increases of 12,200 and 14,100 tenge were the result of expanded construction and trade, which stimulated job creation.

The quality of human capital reflects the level of development of education, healthcare, and economic opportunities for the population. The Human Capital Index assesses the extent to which social infrastructure supports sustainable growth. An improvement in the index indicates increased accessibility of services and improved infrastructure.

Table 2. Human capital index

Regions	2022	2023	2024	2023/2022		2024/2023	
				+/-	%	+/-	%
Akmola region	0,69	0,71	0,73	+0,02	+2,9	+0,02	+2,8
Turkestan region	0,61	0,63	0,66	+0,02	+3,3	+0,03	+4,7
Almaty region	0,73	0,74	0,75	+0,01	+1,4	+0,01	+1,3
North Kazakhstan region	0,67	0,68	0,70	+0,01	+1,5	+0,02	+2,9

Budget expenditures on social infrastructure reflect the strategic priorities of regional policy. Increased spending demonstrates the regions' commitment to maintaining the quality of social services and creating conditions for sustainable development. The increased funding is also linked to infrastructure modernization and improved living conditions.

Table 3. Expenditures on social infrastructure, billion tenge

Regions	2022	2023	2024	2023/2022		2024/2023	
				+/-	%	+/-	%
Akmola region	198,4	214,1	231,0	+15,7	+7,9	+16,9	+7,9
Turkestan region	312,7	338,4	369,3	+25,7	+8,2	+30,9	+9,1
Almaty region	255,3	267,0	280,1	+11,7	+4,6	+13,1	+4,9
North Kazakhstan region	165,2	176,0	188,2	+10,8	+6,5	+12,2	+6,9

Access to healthcare services is essential for building sustainable human capital. The availability of doctors and hospital beds reflect the level of access to healthcare. Differences between regions are explained by demographic characteristics and the scale of medical infrastructure.

A comparative analysis shows that Akmola Region occupies a stable position among comparable regions of Kazakhstan thanks to a combination of stable economic growth and consistent development of social infrastructure. From 2022 to 2024, the region's GRP per capita increased by 13%, one of the most balanced indicators among the analyzed regions. Income growth rates also remain stable, exceeding 16% over the past two years. These figures provide Akmola Region with a competitive position compared to North Kazakhstan and Turkestan Regions and confirm the existence of a favorable economic base for social development.

The region's Human Capital Index demonstrates stable positive dynamics, increasing by 0.04 points over the analyzed period. This growth is comparable to that of the most dynamic regions and reflects the effectiveness of investments in education and healthcare. Improved staffing levels at healthcare facilities and the expansion of hospital beds confirm the region's ability to adapt its infrastructure to current social needs. Compared to the Turkestan region, which is experiencing high demographic pressure, Akmola demonstrates more controlled and balanced growth of the healthcare system.

The study provided a new understanding of regional socioeconomic development trajectories, demonstrating that the sustainability of social growth is determined not by the absolute level of economic indicators, but by the degree of alignment between economic potential and the dynamics of social infrastructure development. The analysis demonstrated that the Akmola region, despite its more modest economy compared to the Almaty region, is developing an effective development model based on the optimal allocation of resources and the consistent modernization of key social systems.

The study demonstrates for the first time that a modern regional development strategy in Kazakhstan should be based on the balanced growth model represented by the Akmola region, where economic expansion, social modernization, and improvements in quality of life are synchronous. This model allows the region to generate long-term advantages, increase resilience, and ensure the conditions for the progressive development of human capital.

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ECONOMIC COOPERATION BETWEEN KAZAKHSTAN AND CHINA UNDER THE BELT AND ROAD INITIATIVE

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Annotation. The Belt and Road Initiative is a core platform for international economic cooperation amid global economic restructuring and regional integration. As a key hub of the Silk Road Economic Belt, Kazakhstan has strong economic complementarity and close cooperative ties with China.

This paper analyzes the current situation, achievements, challenges and optimization paths of bilateral economic cooperation, providing references for the high-quality development of China-Kazakhstan cooperation under the Belt and Road framework.

Key words: Belt and Road Initiative; Kazakhstan; China; economic cooperation; connectivity; digital economy

The Belt and Road Initiative was proposed by China in 2013, focusing on the five core priorities of policy coordination, facilities connectivity, unimpeded trade, financial integration and people-to-people bonds. Since its announcement, the initiative has evolved into one of the most influential frameworks of international economic cooperation, aimed at promoting open, inclusive and mutually beneficial development among participating countries. Within this framework, Kazakhstan occupies a particularly significant position due to its geographical location and its role as a key transit and logistics hub connecting Asia and Europe.

Kazakhstan is one of the earliest supporters and active participants of the Belt and Road Initiative. The strategic alignment between the Belt and Road Initiative and Kazakhstan's "Nurly Zhol" (Bright Road) policy has established a solid institutional and policy foundation for long-term bilateral economic cooperation. This synergy has enabled the coordination of infrastructure development plans, transport corridors, and industrial cooperation strategies, creating favorable conditions for deepening economic integration between the two countries.

In recent years, China and Kazakhstan have achieved substantial and multidimensional cooperation results in trade, investment, energy, infrastructure development, agriculture, and the digital economy. Economic relations between the two countries have demonstrated resilience even under conditions of global uncertainty, including fluctuations in commodity markets, geopolitical tensions, and disruptions in global supply chains. In this context, strengthening bilateral cooperation has become not only an economic necessity but also a strategic priority for ensuring regional stability and sustainable development.

Kazakhstan occupies a critical geographical position as a key hub of the China–Europe Railway Express. Its territory serves as the shortest overland route linking China with Europe and Central Asia, which significantly enhances its strategic value in Eurasian logistics networks. China and Kazakhstan demonstrate strong economic complementarity. China possesses comparative advantages in industrial production capacity, advanced technologies, infrastructure development experience, and financial resources, while Kazakhstan is endowed with abundant natural resources, including energy, minerals, and agricultural products. This complementarity forms the basis for mutually beneficial cooperation and long-term economic interdependence.

The existence of effective high-level dialogue mechanisms, such as intergovernmental cooperation committees and strategic partnership frameworks, ensures the continuity and stability of bilateral relations. Regular political consultations and institutionalized cooperation platforms contribute to the timely coordination of development strategies, resolution of emerging issues, and alignment of national economic priorities.

Bilateral infrastructure connectivity has been continuously strengthened over the past decade. Significant improvements have been achieved in cross-border transport infrastructure, including the modernization of key border ports such as Alashankou and Khorgos. These hubs play a crucial role in facilitating trade flows and logistics between China, Central Asia, and Europe. The stable and efficient operation of the China–Europe Railway Express has significantly reduced transportation time and logistics costs, thereby increasing the competitiveness of overland trade routes compared to maritime alternatives.

In parallel, bilateral trade volume has demonstrated steady growth. The structure of trade has remained relatively diversified, with energy resources, agricultural commodities, and electromechanical products constituting the main categories of exchange. China is one of Kazakhstan’s largest trading partners, while Kazakhstan is an important supplier of strategic raw materials to China. In addition to traditional trade, new forms of economic cooperation have emerged, particularly in the field of cross-border e-commerce, which has become an increasingly important driver of trade expansion and consumption connectivity.

Cooperation in the energy sector remains a cornerstone of bilateral economic relations. Joint projects in oil, natural gas, uranium, and renewable energy have

contributed to strengthening energy security and industrial cooperation between the two countries. At the same time, cooperation in agriculture has expanded through the development of supply chains, processing industries, and export-oriented agricultural production. In recent years, digital economy cooperation has also gained momentum, including collaboration in fintech, smart logistics, e-commerce platforms, and digital infrastructure development.

However, despite these achievements, several challenges continue to affect the depth and quality of bilateral economic cooperation. External uncertainties, including global economic volatility, trade protectionism, and geopolitical competition, pose potential risks to the stability of long-term cooperation. In addition, trade and investment facilitation mechanisms still require further improvement in order to reduce administrative barriers, enhance transparency, and simplify cross-border procedures.

Another structural limitation is the relatively high concentration of cooperation in traditional resource- and energy-based sectors. While these sectors remain important, overreliance on them limits the diversification and resilience of economic relations. The development of high-tech industries, green economy initiatives, and innovation-driven cooperation remains insufficient and requires greater attention from both sides.

Furthermore, differences in digital governance frameworks, regulatory standards, and technological infrastructure present obstacles to the deeper integration of the digital economy. The lack of harmonized digital standards affects the efficiency of cross-border data exchange, digital trade, and platform-based cooperation, thereby limiting the full potential of the Digital Silk Road initiative.

To address these challenges, China and Kazakhstan should further strengthen policy coordination and strategic alignment. Enhancing the effectiveness of existing bilateral cooperation mechanisms and expanding institutional dialogue at multiple levels will contribute to more efficient decision-making and implementation processes. In addition, both sides should prioritize the upgrading of cross-border infrastructure, including transport corridors, logistics hubs, and digital infrastructure systems, to further improve connectivity efficiency.

It is also essential to expand cooperation beyond the resource sector and promote diversification of economic engagement. Priority should be given to emerging sectors such as high technology, renewable energy, green finance, education, and innovation-driven industries. In particular, deepening cooperation in the digital economy will play a crucial role in building the Digital Silk Road, fostering new growth engines for bilateral relations, and enhancing competitiveness in the global digital transformation process.

Moreover, strengthening risk management and cooperation security mechanisms is necessary to ensure the sustainable development of bilateral economic relations. This includes improving early warning systems for external risks, enhancing financial

cooperation stability, and developing joint frameworks for managing investment and trade risks.

In conclusion, China-Kazakhstan economic cooperation under the Belt and Road Initiative has established strong institutional foundations and demonstrated significant development potential. The accumulated achievements in infrastructure, trade, energy, and emerging sectors provide a solid basis for future expansion. Moving forward, both countries should continue to prioritize connectivity as the core principle of cooperation, deepen traditional areas of engagement, and actively expand new fields such as the digital economy and green development.

Through sustained efforts and strategic coordination, China and Kazakhstan can further elevate the level of bilateral cooperation, enhance regional economic integration, and contribute more effectively to shared prosperity and long-term sustainable development for both nations and the wider Eurasian region.

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A STUDY ON THE PRACTICAL PATHWAYS OF ENERGY COOPERATION BETWEEN CHINA AND KAZAKHSTAN UNDER THE BELT AND ROAD INITIATIVE

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Annotation. This paper focuses on the achievements of China-Kazakhstan energy cooperation since the launch of the Belt and Road Initiative, systematically summarizes the practical pathways of bilateral energy cooperation, and analyzes future challenges and development directions. The study reveals that China-Kazakhstan energy cooperation has established four systematic approaches: "policy and strategic alignment," "upgrading traditional energy infrastructure," "export of renewable energy technologies and joint capacity building," and "hydrogen energy and cutting-edge technologies." However, cooperation still faces multiple challenges, including geopolitical risks, lagging grid infrastructure in Kazakhstan, institutional constraints on renewable energy revenue guarantees, and intensifying international competition. Based on these findings, this paper proposes recommendations for China-Kazakhstan energy cooperation to achieve a more sustainable, replicable, and scalable model within the Belt and Road framework.

Keywords: "Belt and Road" initiative; China-Kazakhstan energy cooperation; renewable energy; implementation pathways; cross-border settlement

Leveraging their geographical advantages and political trust, China and Kazakhstan have made energy cooperation a significant achievement in advancing the Belt and Road Initiative. For China, Kazakhstan is a key pivot in its strategy to diversify energy imports and a strategic partner for the green Belt and Road Initiative in Central Asia.

Scholars both domestically and internationally have conducted multidimensional studies on China-Kazakhstan energy cooperation. Misiagiewicz (2024) analyzed the bottlenecks in cooperation from the perspective of energy transportation, highlighting issues such as high transportation costs, structural imbalances, and inadequate legal frameworks. Zeng Xing et al. (2023) argued that adjustments to Kazakhstan's natural gas export strategy have impacted the Northwest Corridor for China's natural gas imports. Du et al. (2024) emphasized the role of geographical advantages and facilitation of cooperation. Wang Jing (2024) examined the opportunities and challenges of China-Kazakhstan renewable energy cooperation, revealing trends toward a shift in project development models toward EPC+F and a shift in financial cooperation toward multilateral frameworks. However, existing research often remains confined to specific sectors or single perspectives, lacking a comprehensive overview of the systematic implementation pathways of China-Kazakhstan energy cooperation within the Belt and Road framework and insufficient analysis of its operational mechanisms and developmental logic. This paper focuses on the latest project practices and policy dynamics of China-Kazakhstan energy cooperation, systematically mapping its implementation pathways under the Belt and Road framework.

It aims to elucidate the systemic evolutionary logic of the transition from traditional oil and gas trade to green, low-carbon cooperation between the two

countries and provide insights for energy collaboration among nations along the Belt and Road.

Kazakhstan has an urgent need for energy transition, but its renewable energy development faces shortcomings in technology, infrastructure, and industrial chains. Its primary energy consumption is dominated by coal, natural gas, and petroleum, and its energy intensity per unit of GDP remains high in 2024. Kazakhstan has set targets to increase the share of renewable energy from 2025 to 2050, yet the current structure falls far short of these goals. China possesses a globally leading comprehensive renewable energy industrial chain, with significant advantages in the market share and cost of clean technology manufacturing, enabling it to provide integrated solutions that help address Kazakhstan's deficiencies in technology, funding, and implementation capabilities.

The successful experience of China-Kazakhstan energy cooperation can provide a replicable model for Central Asia and the Middle East, enhancing the regional demonstration and outreach capacity of the Belt and Road Initiative's green

China-Kazakhstan energy cooperation has demonstrated a systematic evolution from bilateral to multilateral frameworks. Following the establishment of a permanent comprehensive strategic partnership, policy alignment has been deepened across specific sectors. In 2024, the two countries signed an agreement on renewable energy cooperation projects, which was approved by the Kazakh Senate in 2026. The agreement specifies the construction of wind and solar power projects—including energy storage facilities—in three regions such as Karaganda, with power purchase contracts spanning 25 years and a total installed capacity of 1.8 gigawatts. This institutionalization provides stable expectations and legal safeguards for investments, shifting energy cooperation between the two nations from project-driven initiatives to institutionally driven frameworks.

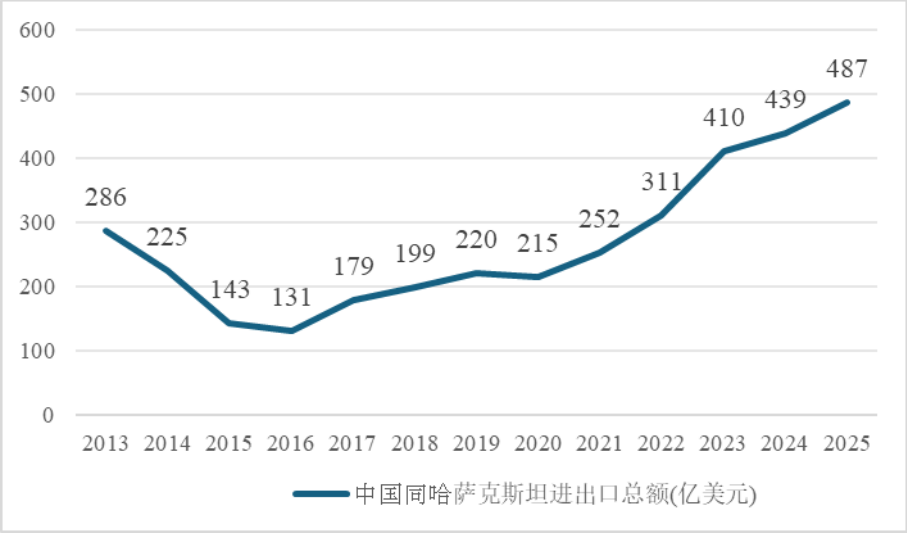

Figure 1: Trend Chart of China-Kazakhstan Total Import and Export Volume

As shown in Figure 1, the bilateral trade volume between the two countries started at approximately $28.6 billion in 2013, declined slightly in 2016, and then gradually recovered and continued to rise. By 2025, the bilateral trade volume between China and Kazakhstan reached $48.7 billion, representing an 11% year-on-year increase and setting a historical record. Among this, Kazakhstan's exports to China amounted to $19 billion, up 19.3% year-on-year, while imports from China reached $29.7 billion, up 6.2% year-on-year. Energy products remain the core category of Kazakhstan's exports to China, with energy exports to China reaching approximately $18.7 billion in the first eight months of 2025, covering petroleum, copper, ferroalloys, and chemical products. The sustained expansion of this trade volume provides a solid economic foundation for deepening energy cooperation between the two countries.

The synergistic effects of multilateral cooperation mechanisms are significant. Institutions such as the SCO Energy Agenda, the China-Central Asia Summit Mechanism, and the Asian Infrastructure Investment Bank (AIIB) have jointly established an institutional network covering policy, technology, financing, and risk management. The second China-Central Asia Summit in 2025 supported the establishment of an energy development partnership and expanded cooperation across the entire industrial chain. This "bilateral plus multilateral" arrangement has reduced transaction costs and policy risks.

Challenges Facing China-Kazakhstan Energy Cooperation:

1. Geopolitics and Risks of Great Power Competition.

Central Asia has become a crucial stage for major powers 'energy competition. Russia, the European Union, the United States, and Gulf countries are all actively expanding their presence in Kazakhstan's energy sector. Leveraging its existing infrastructure advantages, Russia wields significant influence in nuclear energy and natural gas. The EU has strengthened energy cooperation in Central Asia through its "Global Gateway" initiative. Gulf companies have made substantial investments in Kazakhstan's wind and solar power sectors. This competition offers Kazakhstan more avenues for collaboration but also intensifies competitive pressures on China enterprises in areas such as market access and bidding. Kazakhstan's traditional energy exports rely heavily on Russia, and regional instability could threaten the stability of China-Kazakhstan energy cooperation.

2. Institutional Bottlenecks in Grid Infrastructure and Revenue Security.

Kazakhstan's power grid infrastructure is severely outdated. Power generation equipment has a 55% wear rate, while the grid itself shows a 76% wear rate. Approximately 59% of the equipment relies on Soviet-era technology, with transmission losses reaching as high as 15%. The western region's grid is isolated, creating power islands. Renewable energy purchase agreements suffer from systemic flaws, and the settlement mechanisms exacerbate investment risks.

3. Economic and Financial Fluctuations and Uncertainty in the Cooperative Environment.

Kazakhstan faces multiple macroeconomic challenges that directly impact the cost and financial stability of renewable energy projects. China-Kazakhstan energy cooperation still suffers from policy imperfections; although cooperation agreements exist, legal frameworks addressing specific investment disputes remain inadequate, leaving multinational enterprises exposed to uncertainties. Compared to the risk prevention systems established in some countries, this lack of institutional safeguards hinders further expansion of cooperative efforts.

5 Recommendations for China-Kazakhstan Energy Cooperation.

1. Strengthen policy coordination and establish a multi-stakeholder governance mechanism.

China and Kazakhstan should enhance bilateral and multilateral policy coordination. At the bilateral level, leveraging the Comprehensive Strategic Partnership, a ministerial energy consultation mechanism should be established to translate agreements into actionable plans. At the multilateral level, platforms such as the Shanghai Cooperation Organization should be utilized to establish a regional energy dialogue and regulatory framework. Simultaneously, open cooperation with the European Union and Gulf states in Kazakhstan's energy market should be explored, transforming competition into collaboration through joint investments and other means to achieve mutual benefits.

2. Enhancing Grid Integration and Improving Revenue Security.

China has assisted Kazakhstan in upgrading the regional power grid and enhancing the integration capacity of renewable energy sources. Drawing on China's smart grid experience, the two countries have jointly developed an intelligent dispatching platform, leveraging technologies such as big data to achieve precise power scheduling. They have also promoted mutual recognition of power grid standards between the two nations, reducing equipment access barriers. Additionally, China has refined Kazakhstan's green power procurement agreement by introducing safeguard clauses to stabilize project revenue expectations, mitigate risks, and improve financing accessibility.

3. Strengthening Financial Safeguards and Expanding RMB Settlement.

China and Kazakhstan should establish a more resilient financial safeguard system. At the financing level, leverage multilateral institutions such as the Asian Infrastructure Investment Bank (AIIB) to provide diversified loan guarantees and mitigate project financial risks. Regarding settlement mechanisms, accelerate the implementation of cross-border RMB settlement for energy trade—practice has demonstrated its effectiveness in reducing costs and risks while strengthening the autonomy of Chinese enterprises. Moving forward, banks should be encouraged to establish domestic currency financing platforms to expand RMB usage in energy projects and reduce reliance on the US dollar. Concurrently, a financial risk monitoring platform should be established to enable dynamic early warning systems and mitigate the impact of exchange rate fluctuations on projects.

Conclusion. China-Kazakhstan energy cooperation serves as a typical paradigm of mutual benefit under the Belt and Road framework. The structural complementarity between the two countries in policy objectives, industrial division of labor, and technological resources has elevated this cross-regional energy collaboration beyond traditional oil and gas trade, evolving into a multi-tiered, systematic, and integrated framework that encompasses policy and strategic alignment, upgrading of traditional energy infrastructure, export of renewable energy technologies, green finance innovation, and cooperation in cutting-edge hydrogen technologies. For China, this cooperation not only accelerates the internationalization of clean energy technologies but also injects new momentum into deepening the building of a China-Kazakhstan community with a shared future. For Kazakhstan, China's systematic involvement has effectively supported its ambitious energy transition goals, accelerating energy structure optimization while significantly boosting local manufacturing, technological R&D, employment opportunities, and economic transformation.

Looking ahead, the two countries should continue to deepen cooperation on the existing basis, with a focus on strengthening collaborative innovation in cutting-edge areas such as intelligent grid upgrades, energy storage system development, extension of the green hydrogen industry chain, and peaceful utilization of nuclear energy. By continuously optimizing cooperation mechanisms, enhancing financial safeguards, and expanding areas of collaboration, China-Kazakhstan energy cooperation is expected to advance toward higher quality and greater sustainability, providing valuable insights for countries participating in the Belt and Road Initiative to explore pathways for green energy cooperation.

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INNOVATIONS AS A FACTOR OF SUSTAINABLE GROWTH: A CROSS-COUNTRY EMPIRICAL ANALYSIS

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Annotation. This paper examines the role of innovation as a driver of sustainable economic growth through a cross-country empirical analysis. Based on a stylized panel of 24 economies observed during 2018–2025, the study compares innovation-intensive, industrializing, resource-based, and late-transforming economic systems. The findings indicate that higher R&D intensity, green technological innovation, and digital complementarity positively affect growth quality and reduce macroeconomic volatility. Particular attention is given to the institutional conditions required for transforming innovation into a source of sustainable development. The study concludes that innovation contributes to sustainable growth only when supported by effective industrial policy, financial intermediation, environmental regulation, and technology diffusion mechanisms.

Key words: innovation, sustainable growth, green technologies, R&D, digitalization, innovation policy, structural transformation, sustainable development, cross-country analysis, green economy

Sustainable growth increasingly depends on how national economies generate, diffuse and commercialize innovation. In the current stage of global transformation, innovation is no longer interpreted only as a source of output expansion; it also shapes the environmental quality of growth, the speed of structural adjustment and the ability of economies to withstand external shocks. Drawing on recent comparative work on low-carbon innovation, green growth and national innovation capacity, this paper investigates innovations as a factor of sustainable growth in a cross-country framework (Hasna et al., 2025; Böcskei and Tóth, 2025; Novillo-Villegas et al., 2025).

The analysis relies on a stylized panel of 24 economies observed in 2018-2025 and grouped into innovation-intensive, industrializing, resource-based and late-transforming systems. The dataset is constructed for analytical illustration at the conference level, so the numerical estimates are directional rather than official statistics. The paper assumes that innovation affects sustainability through three mechanisms: productivity-enhancing industrial upgrading, diffusion of greener technologies and institutional adaptation that lowers the cost of transition. This logic is also consistent with the literature showing that innovation may yield uneven

outcomes when investment, skills and policy coordination are weak (Rehman et al., 2025; Fayyaz and Bartha, 2025).

Table 1. Stylized profiles of country groups in the sample

Economy type	R&D (% GDP)	Green patent share	Growth quality score	Volatility
Innovation-intensive	3.1	34	76	Low
Industrializing	2.2	27	64	Moderate
Resource-based	1.4	18	52	High
Late-transforming	1.0	14	47	High

Table 1 indicates that the quality of growth rises with the depth of innovation capacity. Economies with stronger R&D effort and a broader share of green patents show not only higher sustainable growth scores, but also lower macroeconomic volatility. This pattern suggests that innovation can function as a stabilizer of structural transformation, especially where technological upgrading is embedded in broader industrial policy.

Figure 1. Sustainable growth index by economy type

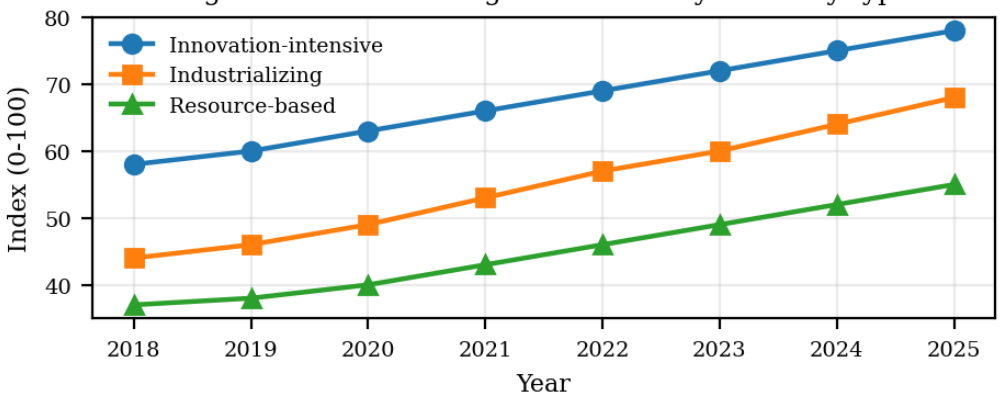


Figure 1 shows that the gap between country groups narrows only gradually.

Industrializing economies improve their trajectory when innovation is linked to export diversification and manufacturing modernization, while resource-based systems advance more slowly because innovation remains concentrated in narrow segments. Climate vulnerability can accelerate innovation effort, but its positive effect depends on the ability of states to transform pressure into coordinated policy responses (Tran et al., 2025).

Table 2. Baseline illustrative estimates for sustainable growth

Variable	Coefficient	Direction	Interpretation
R&D intensity	0.41	+	Strong direct effect
Green innovation	0.35	+	Raises efficiency
Digital complementarity	0.28	+	Scales innovation
Carbon lock-in	-0.22	-	Slows adjustment

Figure 2. Innovation capability and green-adjusted productivity

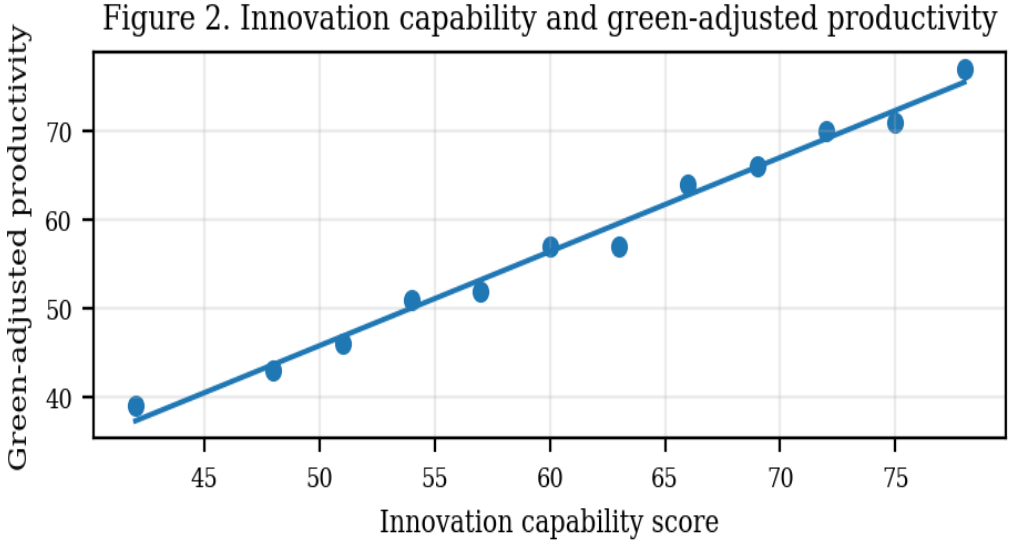
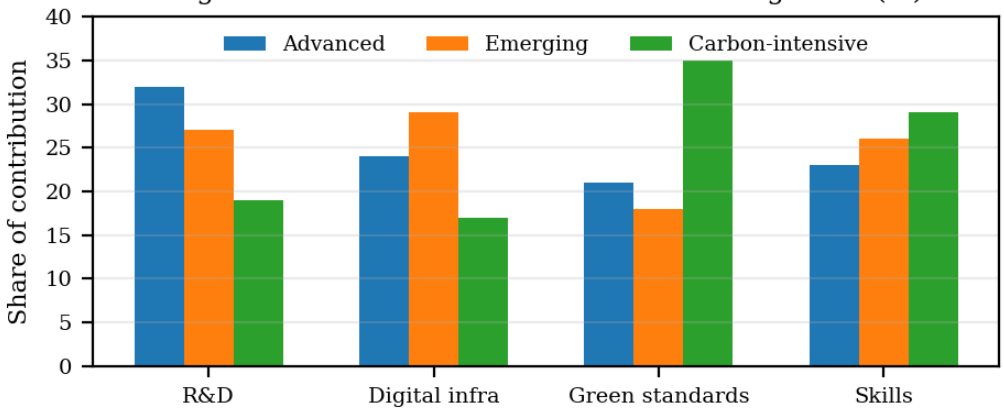


Table 2 and Figure 2 reveal a clear positive association between innovation capability and green-adjusted productivity. The implication is that sustainable growth depends less on isolated inventions than on a broader innovation ecosystem that combines knowledge creation, sectoral absorption and diffusion capacity. Economies with fragmented finance or weak institutional coordination may innovate, yet convert less of that innovation into structural change. This conclusion corresponds to the technology paradox highlighted in recent comparative studies of innovative economies (Rehman et al., 2025).

Table 3. Policy pathways linking innovation to sustainable growth

Country type	Priority innovation field	Regulatory focus	Expected outcome
Advanced	Deep tech, storage	Mission-oriented support	Productivity decoupling
Emerging	Smart manufacturing	Innovation finance	Export upgrading
Carbon-intensive	Energy transition	Carbon disclosure	Lower lock-in
Late-transforming	Basic digital innovation	Skills and coordination	Broader inclusion

Figure 3. Estimated drivers of sustainable growth (%)



The third table and figure summarize the differentiated nature of innovation policy. In advanced economies, frontier R&D and storage technologies produce the largest contribution to sustainable growth. In emerging economies, digital infrastructure and innovation finance act as stronger multipliers. For carbon-intensive systems, however, the decisive factors are green regulation, sectoral skills and the managed replacement of legacy assets. Thus, innovation contributes to sustainability through different regulatory and industrial pathways rather than through a universal policy formula.

A cross-country reading of the evidence leads to an important methodological conclusion: innovation becomes a factor of sustainable growth only when it is institutionally embedded. Public investment, education systems, financial intermediation and credible environmental standards determine whether technological progress changes the structure of production or remains locked in isolated sectors. Therefore, the relationship between innovation and sustainability is best understood as systemic and cumulative, not purely technological.

Conclusion

This paper argues that innovations should be treated as a structural driver of sustainable growth in the modern economy. The stylized cross-country evidence shows that countries achieve more stable and higher-quality development when innovation is synchronized with green upgrading, digital diffusion and industrial restructuring. The comparison also demonstrates that convergence is possible, but only under differentiated regulatory strategies adapted to the type of economy, the maturity of innovation institutions and the degree of carbon dependence. For this reason, policy should not simply maximize the number of innovations. It should create innovation systems capable of transforming sectoral structures, lowering environmental pressure and expanding long-term resilience.

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Section 3. INTERNATIONAL BUSINESS AND INTERNATIONAL TRADE: CURRENT CHALLENGES, OPPORTUNITIES AND DIRECTIONS OF DEVELOPMENT.

UDC (339.5)

PREMISES AND IMPLICATIONS OF ECONOMIC COOPERATION BETWEEN CHINA AND KAZAKHSTAN UNDER THE BELT AND ROAD INITIATIVE

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Annotation. On September 7, 2013, President Xi Jinping proposed the vision of jointly building the Silk Road Economic Belt at Nazarbayev University in Kazakhstan [1], sowing the seeds for in-depth cooperation and exchanges between China and Kazakhstan. As the birthplace of the Silk Road Economic Belt initiative, Kazakhstan marks a new historical stage in bilateral cooperation between the two countries. Within this framework, China's robust production capacity complements Kazakhstan's rich resource endowments, forming a highly complementary cooperation model of "China's manufacturing output + Kazakhstan's resource wealth" — a flagship example under the Belt and Road Initiative. Both nations uphold the global governance philosophy of extensive consultation, joint contribution and shared benefits, standing in stark contrast to the hegemonism of the West and offering a model of peaceful development and win-win cooperation for international collaboration. An in-depth analysis of Kazakhstan therefore lays a solid theoretical foundation for comprehensively deepening bilateral cooperation across diverse fields.

Key words: The Belt and Road Initiative; China–Kazakhstan economic cooperation; production-resource complementarity; win-win cooperation

I. Complementary Strengths and the Building of a China–Kazakhstan Community with a Shared Future

China and Kazakhstan each possess distinct advantages. China, with its formidable manufacturing prowess, has been dubbed the "Industrial Colossus." Kazakhstan, as the world's largest landlocked country, enjoys a pivotal geographic position as a "bridge across Eurasia," endowed with abundant natural resources that make it a "land blessed with untold wealth." The two economies exhibit strong complementarity. Through regional economic integration and bilateral trade, both

nations are striving toward the goal of building a China–Kazakhstan Community with a Shared Future [2].

II. Kazakhstan's Development and Resource Allocation

1. The State–Market Relationship

A resource-rich landlocked nation, Kazakhstan must craft top-level strategies for foreign economic relations that align with national realities, seeking a dynamic balance between state planning and market forces. During the Soviet era, strong central planning and administrative capacity enabled Kazakhstan to industrialize. Following independence, however, the loss of Soviet-era state support triggered a series of developmental challenges. In early 2026, President Tokayev launched institutional reforms, formally establishing Kazakhstan as a presidential republic — a clear demonstration of the government's resolve to reform.

2. Resource Abundance and Industrial Vulnerability

The development trajectories of resource-rich nations often follow a boom-and-bust pattern: strong initial growth, followed by stagnation. When national strategies rely excessively on resource exports, the economy becomes over-reliant on a single sector, creating systemic vulnerabilities. Other factors of production, deprived of policy and fiscal support, are squeezed out of the economy, reducing resilience to external shocks. Inefficient resource allocation and barriers to high-value-added industries further hinder long-term growth [3]. Despite its abundance, Kazakhstan's natural resources are finite. Unsustainable extraction, waste, and environmental degradation undermine the long-term health of the resource sector [4]. Industrial restructuring is therefore an urgent imperative for Kazakhstan.

III. Strategic Choices in Kazakhstan's International Cooperation

Regional Economic Cooperation and International Conflict: Regional economic integration fosters interdependence and political trust among nations, yet geopolitical tensions often hinder such cooperation [4]. The inter-Korean conflict — from ideological division to North Korea's designation of South Korea as its "primary enemy" in early 2026 — exemplifies how political rifts stifle economic progress. For Kazakhstan, rebuilding international order through war or sovereignty concessions is incompatible with its current interests. In today's global political economy, open, inclusive, equal and mutually beneficial multilateral cooperation, paired with a diversified foreign policy, represents the most viable path forward [5].

Kazakhstan's Place in International Relations: Kazakhstan's development offers a compelling case study of contemporary international cooperation and conflict:

1.Relations with Russia: As former Soviet republics, the two nations maintain close, neighborly ties and strategic partnership.

2.Relations with the West: The West — particularly the US — prioritizes Central Asia in its global strategy, engaging actively with Kazakhstan in an attempt to dominate the region and contain Russia politically.

3.Relations with Central Asian Neighbors: Cooperation coexists with disputes. While neighboring states are key partners, conflicts over resources and ethnic tensions remain significant obstacles to integration [3].

IV. Achievements and Prospects of China–Kazakhstan Cooperation

On April 22, 2026, Kazakhstan's Ambassador to China, Nureshev, reaffirmed that China remains one of Kazakhstan's largest trade and investment partners, with bilateral trade reaching USD 48.7 billion in 2025 — an all-time high. In February 2026, Kazakhstan was designated one of six "focus countries" under China's Export to China initiative [6]. The two sides enjoy robust exchanges in commerce, culture, tourism and other fields. These successes demonstrate that the Central Asia–China cooperation mechanism serves as a replicable model for regional and international collaboration. The key to deepening China–Kazakhstan cooperation lies in Kazakhstan's ability to unlock its economic potential, implement systematic industrial reforms, leverage its resource advantages, and integrate external expertise and investment into national development strategies.

Conclusion.

Kazakhstan's development and China–Kazakhstan cooperation are long-term endeavors, not overnight achievements. Kazakhstan must pursue gradual, comprehensive reforms — institutional overhaul, industrial restructuring, strategic planning, and diversified diplomacy — to navigate complex challenges. Emerging from this process, a stronger, revitalized Kazakhstan will take its place on the global stage. China–Kazakhstan cooperation, meanwhile, will undoubtedly become a landmark chapter in the history of international collaboration.

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E-COMMERCE AND CROSS-BORDER TRADE IN THE CONTEXT OF DIGITALIZATION OF GLOBAL MARKETS: A CASE STUDY OF XIAOMI

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Abstract

Digitalization is transforming global trade, with e-commerce as a key driver of cross-border transactions. Using Xiaomi as a case study, this paper examines how digital platforms and e-commerce facilitate global expansion while identifying challenges such as logistics fragmentation, payment divergence, and regulatory compliance. Xiaomi's journey from product export to "model export" demonstrates the evolution from scale-driven to value-driven globalization. The paper concludes with strategies for sustainable growth in digital cross-border trade.

Keywords: e-commerce, cross-border trade, digitalization, Xiaomi, global markets, Kazakhstan, China

Introduction

Digitalization has reshaped international trade. E-commerce enables businesses to reach global customers with unprecedented ease. Global e-commerce sales reached $26.7 trillion in 2022, with cross-border e-commerce growing even faster.

Xiaomi Corporation, founded in 2010, has become a leading global technology company with operations in over 100 countries and regions. Under its "Smartphone × AIoT" dual-engine strategy, Xiaomi has built a comprehensive overseas product portfolio spanning smartphones, smart home devices, wearables, and ecosystem products. This paper uses Xiaomi as a case study to analyze opportunities and barriers in digital cross-border trade and offers recommendations.

Xiaomi's Globalization Journey

From product export to model export. Xiaomi entered international markets in 2014, starting with Singapore and India. In India, its partnership with Flipkart led to 400,000 people participating in a single flash sale in 2014. By 2017, Xiaomi entered Western Europe via Spain. In 2021, overseas revenue surpassed domestic revenue for the first time. In 2025, the company entered the "model export" stage, planning to

open 10,000 overseas Mi Home stores within five years, with automotive exports launching in Europe in 2027.

Strategic collaboration with cross-border e-commerce. In January 2026, Xiaomi International partnered with AliExpress, joining its "Super Brand Going Global" program. This collaboration focuses on smartphones and smart TVs, leveraging AliExpress's infrastructure for localized marketing and logistics. During Black Friday 2025, Xiaomi's POCO F8 series achieved $2 million in sales, ranking as the platform's top new product, and Xiaomi TVs became the category leader in Europe. Xiaomi's Senior Vice President Zeng Xuezhong stated that AliExpress has become Xiaomi's primary platform for overseas expansion.

Market performance. According to Xiaomi's 2025 financial report, total revenue reached 457.3 billion yuan, up 25% year-on-year. Smartphone revenue reached 186.4 billion yuan, with shipments ranking among the global top three for five consecutive years. Smartphone shipments ranked in the top three in 58 countries and regions, and top five in 70 countries and regions. IoT and lifestyle products revenue reached a record 123.2 billion yuan, up 18.3%, with both domestic and overseas revenue hitting historic highs. In Q2 2025, Xiaomi's global smartphone market share was 14.7%, ranking first in Southeast Asia, second in Europe, second in Latin America and the Middle East, and third in Africa.

Opportunities from Digitalization

Reduced costs and expanded market access. Digital platforms like AliExpress and Amazon lower search and matching costs, enabling SMEs to reach global customers. For Xiaomi, collaboration with multiple e-commerce platforms has accelerated entry into diverse markets.

Improved logistics and payments. Real-time tracking, automated warehousing, and digital payment systems streamline transactions. AliExpress's localization services help Xiaomi overcome cross-border logistical hurdles.

Data-driven marketing and localization. Big data analytics enable personalized marketing and demand forecasting. For example, Xiaomi adapts products and marketing strategies for different regions—Redmi targets budget-conscious markets while Xiaomi series focuses on premium segments.

Platform ecosystems as catalysts. The "Super Brand Going Global" program represents a new stage where Chinese cross-border e-commerce platforms are moving beyond low-price competition toward high-quality, brand-driven collaboration, with Xiaomi as a key partner.

Challenges and Barriers

Logistics and last-mile delivery. Cross-border logistics remain slow and costly, especially in emerging markets. Customs delays and underdeveloped last-mile infrastructure persist.

Digital payment fragmentation. Different payment systems and currency conversion fees create friction. In some markets, cash-on-delivery remains preferred.

Regulatory compliance risks. In India, Xiaomi faced a customs dispute over royalty payments to Qualcomm, with tax authorities alleging $72 million in unpaid duties. The company also faced a $480 million tariff accusation due to classification discrepancies. In Europe, GDPR imposes strict data storage and processing requirements, increasing product costs. These cases highlight how regulatory divergence creates significant compliance burdens.

Geopolitical and local market challenges. Xiaomi's market share in India fell from 12.8% to 7.8% year-on-year in Q1 2025 amid ongoing regulatory scrutiny. In Europe, privacy rules and patent disputes remain ongoing challenges.

Strategies for Sustainable Growth

Strengthen digital infrastructure. Governments should invest in high-speed internet, digital payments, and smart logistics. Public-private partnerships can accelerate development.

Promote regulatory harmonization. RCEP provides a model for common e-commerce rules. Kazakhstan and China could explore bilateral digital trade agreements to facilitate e-commerce.

Support SME digitalization. Provide training, subsidies, and simplified customs procedures. Trade promotion agencies can offer market intelligence.

Leverage emerging technologies. AI-powered translation and blockchain tracking can reduce operational hurdles. Xiaomi's MiMo AI models, including a trillion-parameter flagship model, represent an investment in technology that can enhance localization capabilities.

Build compliance capacity. As Xiaomi's global experience shows, navigating diverse regulatory environments requires systematic risk assessment and local adaptation. In Southeast Asia and India, Xiaomi mitigated high tariff impacts by establishing local factories with partners.

Conclusion

Digitalization offers immense opportunities for cross-border trade, but requires overcoming challenges in logistics, payments, and regulation. Xiaomi's evolution from product export to model export demonstrates the path from scale-driven to value-driven globalization. By investing in digital infrastructure, harmonizing regulations, supporting SMEs, and leveraging technology, Kazakhstan and China can enhance their participation in global digital trade. The Xiaomi case shows that successful cross-border e-commerce is not merely about selling products but about building a comprehensive digital ecosystem.

Digitalization offers immense opportunities for cross-border trade, but requires overcoming challenges in logistics, payments, and regulation. Xiaomi's evolution from product export to model export demonstrates the path from scale-driven to value-driven globalization. By investing in digital infrastructure, harmonizing regulations, supporting SMEs, and leveraging technology, Kazakhstan and China can enhance their participation in global digital trade. The Xiaomi case shows that successful cross-border e-commerce is not merely about selling products but about

building a comprehensive digital ecosystem.

In addition, the development of cross-border e-commerce increasingly depends on the integration of advanced digital platforms, including artificial intelligence, big data analytics, and cloud computing. These technologies enable companies to better understand consumer behavior, optimize supply chain operations, and personalize marketing strategies for different international markets. As a result, firms like Xiaomi are able to maintain competitiveness in highly dynamic and fragmented global markets.

Another important aspect is the growing role of digital payment systems and fintech solutions in facilitating international transactions. Secure and efficient payment infrastructures reduce transaction costs, increase trust between buyers and sellers, and expand access to global markets for both large corporations and small and medium-sized enterprises (SMEs). This is particularly relevant for emerging economies seeking to integrate into global value chains.

Furthermore, cross-border e-commerce contributes significantly to the development of logistics and infrastructure networks. The expansion of international delivery systems, smart warehousing, and real-time tracking technologies improves delivery speed and reliability. This not only enhances customer satisfaction but also strengthens the overall efficiency of global trade flows.

Finally, the long-term success of digital trade integration depends on international cooperation in establishing unified regulatory standards and data governance frameworks. Harmonization of customs procedures, data protection rules, and digital trade policies will be essential to reduce barriers and ensure sustainable growth in global e-commerce ecosystems.

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UDC 338

INTERNATIONAL TRADE AND FOOD SECURITY

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Abstract: Food security serves as a crucial cornerstone of national security. As a core instrument for global resource allocation, international trade exerts a profound impact on the food security guarantee capacity of countries worldwide. In recent years, however, the escalation of global geopolitical conflicts has drastically reshaped the landscape of global food trade.

Keywords: Food security, imports, fertilizers, energy

As major global grain exporters, Russia and Ukraine collectively account for 29% of the world's wheat exports, 19% of corn exports and 80% of sunflower oil exports. Known as the "Granary of Europe", Ukraine boasts fertile agricultural resources, while Russia stands as the world's largest producer and exporter of potash fertilizer, contributing approximately 20% of global output.

Since the outbreak of the Russia-Ukraine conflict, agricultural production in Ukraine has stagnated. In 2023, its grain planting area decreased by 1.4 million hectares compared with 2022, and grain output dropped from 53.1 million tons to around 45 million tons. Vast stretches of farmland have been left uncultivated due to the war, accompanied by a severe loss of agricultural labor. Meanwhile, Russia's exports of grain and fertilizers have been restricted by Western sanctions, creating a 30% supply gap in the global potash fertilizer market. The skyrocketing natural gas prices have also hindered nitrogen fertilizer supply, further constraining global grain production.

Global corn prices rose by 24.8% in 2022 year-on-year, and wheat prices increased by 15.6% [1]. China's grain imports saw a phased surge between 2021 and 2022. Its corn imports reached 28.35 million tons in 2022, a sharp increase from 2020, largely driven by expectations of international grain price fluctuations and global supply shortages [2].

In the meantime, ongoing military conflicts involving the United States, Iran and Israel have produced spillover effects that have gradually spread to global food trade, further exacerbating food security risks. The Strait of Hormuz, a vital global transportation hub for energy and fertilizers, handles roughly one-fifth of the world's crude oil and liquefied natural gas exports and serves as a key shipping route for fertilizers. The Persian Gulf region accounts for nearly half of the world's urea output, with about 16 million tons of fertilizers shipped through the strait annually, making up one-third of global seaborne fertilizer trade volumes.

Disruptions to navigation in the Strait of Hormuz amid ongoing hostilities have stranded more than 20 cargo vessels carrying nearly 1 million tons of fertilizers. Fertilizer manufacturers in multiple Gulf states have suspended deliveries, continuously worsening global fertilizer supply shortages. Urea prices surged by 20% to 50% within two to three weeks.

The Northern Hemisphere is currently in the spring planting season. The combined pressures of fertilizer shortages and price hikes have severely constrained the cultivation of major food crops highly reliant on nitrogen fertilizers, including corn, wheat and rice, thereby depressing overall global grain output. Rising oil prices triggered by regional conflicts have pushed up global food transportation costs by 18%. Surging diesel prices have inflated logistics expenses for Brazil's soybean exports, prompting some traders to halt quotations and causing short-term disruptions to export chains.

As the world's top edible oil importer, India has witnessed a 4% to 5% rise in palm oil and soybean oil prices due to soaring fuel costs and freight delays, adding to its import burdens. The World Food Programme predicts that if regional hostilities continue until June 2026 and international crude oil prices remain above 100 US dollars per barrel, an additional 45 million people worldwide will face severe hunger. Africa will be the hardest-hit region, where over 90% of fertilizers rely on imports, with the Gulf region supplying 20% of the total. Countries such as Sudan depend on Gulf fertilizer supplies for up to 50% of their demand. Fertilizer shortages will directly lead to reduced local grain yields and worsen the hunger crisis.

For China, in the face of profound changes in the international trade landscape driven by geopolitical conflicts, safeguarding food security requires coordinating both domestic and overall international situations, while consolidating internal foundations and optimizing the external environment in tandem. It is essential to continuously strengthen domestic production capacity, strictly uphold the red line of 1.8 billion mu of cultivated land, and advance the revitalization of the seed industry. China should optimize its import and export trade structure, further diversify grain import sources, strengthen cooperation with major grain-producing countries such as Brazil, Argentina and Russia, and build stable import supply chains. In addition, it is necessary to deepen international cooperation, actively participate in global food and agricultural governance, oppose trade protectionism, promote the establishment of a fair and transparent global grain trade system, and jointly address common challenges to global food security.

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THE IMPACT OF EXPORT CONTROL POLICIES ON ECONOMIC SECURITY: EXPERIENCE FROM CHINA AND THE EUROPEAN UNION

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Abstract

Against the backdrop of global economic governance restructuring, intensified technology competition, and supply chain reconfiguration, export control has become a core tool for safeguarding economic security. China and the EU have both established systematic export control regimes with significant differences in policy objectives, legal frameworks and implementation mechanisms [1]. Based on national economic security theory, this paper uses literature research, policy text analysis, comparative analysis, case study and inductive analysis to compare China-EU export control systems, reveal the transmission mechanism on economic security, examine impacts on semiconductors, critical minerals and high-end equipment, and put forward suggestions for improving mechanisms, coordinating development and security, and promoting China-EU policy coordination.

Keywords: export control, economic Security, China-EU comparison, policy coordination

1.Introduction

With rising geopolitical competition and deepening global interdependence, export control has evolved from a non-proliferation tool to a key instrument balancing trade liberalization and national security [3]. China and the EU have both built complete export control systems, but differ in legislative purposes, control scope, enforcement and security orientation [4]. A comparative study of China-EU export controls and their economic security impacts is of great theoretical and practical value.

Research Purpose: To clarify the logic and transmission path of export control affecting economic security, compare institutional frameworks and effects, summarize industry responses, and support policy improvement and China-EU coordination.

Research Significance: Theoretically, it enriches interdisciplinary research and provides an analytical framework [6]. Practically, it helps improve China's export control rule of law, enhance supply chain resilience, reduce policy conflicts, and serve high-level opening-up and economic security [7].

2. Literature Review

2.1 Foreign Research Status

Foreign research on export control and economic security is well-developed. Early studies based on free trade theory viewed export control as trade distortion reducing global resource allocation efficiency [8]. Recent studies focus on security spillovers, holding that over-securitization exacerbates global supply chain fragmentation. Research on the EU dual-use control system is sufficient, but mostly focuses on EU-US comparisons, lacking China-EU comparative studies [4].

2.2 Domestic Research Status

Domestic studies recognize the dual effects of export control: protecting strategic resources and industries while promoting independent innovation [2]. Most studies focus on U.S. export controls against China and resource control effects, with a single perspective. Systematic research on China-EU export controls and economic security remains insufficient [4].

3 Research Content

3.1 Core Concepts and Theoretical Basis

This paper defines export control, economic security, industrial chain security and strategic resource security. Supported by national economic security theory, international trade theory and global value chain theory, it constructs a "Policy–Mechanism–Impact" framework [3].

3.2 Comparison of China-EU Export Control Systems

From legal basis, policy objectives, control lists, approval and law enforcement, and international cooperation, this paper compares China's Export Control Law and EU Regulation (EU) 2021/821 on dual-use items and technologies, and summarizes institutional differences [7].

3.3 Transmission Mechanism

This paper analyzes how export control affects economic security from five dimensions: supply chain stability, technological innovation, strategic resource supply, corporate costs and international rule-making power [5].

3.4 Typical Industry Cases

Focusing on semiconductors, critical minerals and high-end equipment, this paper analyzes policy shocks, industrial risks and coping models, and puts forward suggestions to strengthen economic security [2].

4 Research Methods

– Literature Research Method: Collect domestic and foreign literature, official reports and regulations.

– Policy Text Analysis Method: Analyze China and EU export control laws, lists and guidelines.

– Comparative Research Method: Compare China-EU legislation, objectives, tools and enforcement.

– Case Study Method: Analyze key industries affected by export control.

– Inductive Analysis Method: Summarize rules and draw conclusions.

5 Expected Research Results:

– Clarify transmission channels and construct an analytical framework for export control and economic security.

– Complete a systematic comparison of China-EU export control systems.

– Summarize risk characteristics and coping models of key industries.

– Propose policy suggestions for institutional improvement, precise control and international coordination.

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RESHAPING GLOBAL BUSINESS AND TRADE: CONTEMPORARY CHALLENGES, OPPORTUNITIES AND DEVELOPMENTAL PATHWAYS

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Annotation. International business and trade are being reorganized, not collapsing. Drawing on the WTO's October 2025 trade outlook, UNCTAD's 2025 investment and maritime transport reports, IMF fragmentation cost estimates, and the WTO's 2025 World Trade Report on AI, this paper maps the shifting landscape of cross-border economic activity. It identifies four central challenges: growing geopolitical and policy fragmentation with measurable GDP costs; fragile logistics corridors; weak productive FDI; and regulatory capacity gaps. The analysis supports a conclusion of disciplined openness—diversified, digitally facilitated, standards-based, and strategically risk-aware—as the most credible path forward.

Key words: international business; global value chains; geopolitics; digital trade.

For a long time, the standard story of globalization was fairly simple. Firms searched for lower costs, countries competed to attract investment, and trade policy was often discussed in terms of tariffs and market access. That picture is no longer enough. Cross-border business is still extensive and still central to growth, but the rules of competition are changing. Services are claiming a larger share of trade, digital systems are becoming part of ordinary commerce, and governments are intervening more actively in technology, security, industrial policy and sustainability. What we are seeing is not a retreat into autarky, but a more selective, more political, and in some sectors more fragmented form of openness.

The numbers confirm that the international economy remains deeply integrated. WTO data show that world merchandise trade volume grew by 2.8% in 2024, recovering from a 1.2% decline in 2023 [10]. Services exports grew significantly faster, at 6.8% in 2024. At the same time, the WTO's October 2025 outlook points to slower momentum ahead: merchandise trade volume growth is projected at 2.4% in 2025 before falling to 0.5% in 2026, while services export growth is expected to moderate from 6.8% in 2024 to 4.6% in 2025 and 4.4% in 2026 [12]. It is also worth stepping back from dramatic narratives about the "end of globalization." Thakur-Weigold and Miroudot (2024) have argued that several common claims in the resilience and deglobalization debate are weaker than they appear—efficient supply chains are not necessarily fragile, and foreign sourcing is not inherently less resilient [5].

Table 1. Selected indicators of international trade and investment

Indicator	Latest figure	Analytical meaning
Merchandise trade volume growth, 2024	2.8%	Recovery from the 1.2% decline in 2023
Services export growth, 2024	6.8%	Services growing much faster than goods
Merchandise trade forecast, 2025	2.4%	Modest expansion, supported by AI-related goods
Merchandise trade forecast, 2026	0.5%	Sharp slowdown; significant risk from tariffs
Services export forecast, 2025	4.6%	Moderating but still positive
Services export forecast, 2026	4.4%	Services remain more resilient than goods
Global FDI, 2024 (headline)	$1.5 trillion, +4%	Headline rise driven by conduit flows
Global FDI, 2024 (excluding conduits)	–11%	Second consecutive year of real decline
FDI to Southeast Asia, 2024	$225 billion, +10%	Supply chain reconfiguration benefiting region

Sources: WTO (2025a, 2025c); UNCTAD (2025b)

Current challenges

The first challenge is geopolitical and policy fragmentation. In April 2025, the WTO warned that under then-current tariff conditions, world merchandise trade could shrink, and by October the outlook for 2026 had already deteriorated to just 0.5% growth [10]. The economic cost of hard fragmentation is not just theoretical. IMF research estimates that a return to 2000-level economic integration through reshoring could cost 4.5% of global GDP in the long run, while even a friend-shoring scenario would cost about 1.8% [2].

A second challenge is the fragility of logistics and transport corridors. UNCTAD's Review of Maritime Transport 2025 reports that geopolitical tensions—including disruption in the Red Sea—are forcing ships to take much longer routes [6]. As a result, seaborne trade measured in ton-miles grew by 5.9% in 2024, nearly three times the growth rate of maritime trade volume itself.

A third challenge is the quality of investment, not only its quantity. UNCTAD's World Investment Report 2025 states that while global FDI headline figures rose 4%

to $1.5 trillion in 2024, the increase was driven by volatile conduit flows [7]. Strip out those pass-through flows and global FDI fell 11%—the second consecutive year of decline in productive capital.

The fourth challenge is uneven regulatory capacity. The OECD notes that new sustainability requirements at the border can create new administrative burdens [4]. The World Bank finds that standards are now a prerequisite for export growth, and notes that nearly 90% of world trade is now shaped by non-tariff measures.

Emerging opportunities

The biggest immediate opportunity lies in the continued rise of services and digital trade. WTO data confirm that digitally delivered services reached $4.64 trillion in 2024 and accounted for 53.4% of total services trade [12]. The OECD reports that digital transformation reduces the costs of trading, and finds that a 1% increase in digital connectivity is associated with a 1.5% increase in international trade [3].

A second major opportunity is the gradual construction of common digital rules. The WTO reports that 91 participants had reached a stabilized text on the Agreement on Electronic Commerce by July 2024 [9].

Artificial intelligence is a third opportunity. The WTO's World Trade Report 2025 estimates that AI could increase global trade by 34–37% and global GDP by 12–13% by 2040 [11].

Another practical opportunity comes from selective diversification. Alfaro and Chor (2023) documented a "great reallocation" taking place in global supply chains (1). FDI flows to Southeast Asia rose 10% to $225 billion in 2024, and to Africa by 75% [7].

Directions of development

The first direction for international business strategy is resilience-adjusted efficiency. Earlier models treated cost minimization as the benchmark. The stronger approach is to keep efficiency as a goal while pricing in disruption risk more explicitly.

The second direction is a shift from tariff-centered trade policy to regulation-centered trade governance. Much of the future competitive struggle will be shaped by digital rules, border data systems, and product standards.

The third direction is the shift toward services- and knowledge-intensive internationalization. Services already account for more than a quarter of global exports [12].

The fourth direction is a capability-linked approach to foreign investment policy. Countries need to connect FDI to supplier development and workforce training [7].

The fifth direction is selective plurilateralism. In a more politically divided global economy, partial but workable rule-making may be more realistic than idealized universal solutions [9].

Table 2. From present challenges to development directions

Present challenge	Immediate business response	Longer-run development direction
Tariff shocks and policy uncertainty	Diversify exposure, review contract geography	Rebuild predictability through rules, transparency, selective cooperation
Maritime disruption and freight volatility	Add route flexibility, reassess inventory policy	Invest in resilient logistics, port systems, corridor diversification
Weak productive FDI despite headline inflows	Screen projects for spillover potential	Link investment promotion to suppliers, skills, and innovation ecosystems
Digital regulatory fragmentation	Build compliance and cybersecurity capacity	Pursue digital interoperability, paperless trade, and stable digital rules
Sustainability and standards burdens	Improve traceability and emissions reporting	Develop national quality infrastructure and participate in standards setting
Uneven access to AI and digital infrastructure	Focus on capability gaps, not slogans	Combine trade policy with skills, infrastructure, and technology diffusion

Conclusion

The evidence supports a measured conclusion: globalization is not ending, but its structure is changing. It is becoming more selective, more service-intensive, and more dependent on logistics resilience, regulatory coherence and standards compliance. The evidence points toward disciplined openness: diversified supply systems; digital trade facilitation; and capability-oriented FDI policy.

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DEVELOPMENT OF HUMAN CAPITAL IN STRATEGIC TRADE CONTROL: ECONOMIC AND MANAGERIAL DIMENSIONS UNDER DIGITAL BELT AND ROAD COOPERATION

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Annotation.
Under the digital economy and the Belt and Road Initiative, international business faces challenges such as supply chain restructuring, digital transformation and strategic trade control risks. Human capital is critical to cross-border trade security and efficiency. This paper analyzes dilemmas including talent shortage, outdated knowledge, imperfect incentives and low investment efficiency. Asystem–organization–individual framework is built, and economic and managerial paths for talent development are proposed. The study provides references for Kazakhstan–China high-quality trade cooperation.
Key words: strategic trade control; human capital; digital economy; Belt and Road; international business.

1. Introduction

Strategic trade control is vital for national and industrial chain security under globalization and digitalization. Its efficiency depends on professional human capital.

Deepening Kazakhstan–China cooperation brings higher demands for interdisciplinary talents in compliance, risk management and digital governance. However, talent development is restricted by economic inefficiency and management defects. This paper explores integrated solutions to support stable and high-quality international trade development.

2. Theoretical Foundation

This study is based on human capital theory, institutional economics, and competency and organizational learning theory. Human capital theory highlights the value of education and training. Institutional economics focuses on incentive compatibility and transaction costs. Competency and learning theory explain how professional ability and knowledge management improve operational performance.

3. Current Challenges

1.Lack of interdisciplinary professionals in technology, law and management.

2.Outdated knowledge unable to adapt to digital trade and intelligent risk control.

3.Weak incentives including low salary and limited career development.

4.Low investment efficiency and unclear training return measurement.

5.Institutional and standard barriers in Kazakhstan–China cross-border cooperation.

These issues raise economic costs and reduce management efficiency in trade governance.

4. Development Paths

4.1 Economic Dimension

1.Establish an ROI evaluation system for talent investment.

2.Optimize resource allocation in digital compliance and risk control.

3.Promote standard alignment and qualification mutual recognition between Kazakhstan and China.

4.2 Managerial Dimension

1.Build a six-dimensional competency model: technology, law, risk, negotiation, collaboration, digital learning.

2.Improve integrated education and training systems.

3.Strengthen salary, promotion and performance incentives.

4.Establish knowledge-sharing and organizational learning mechanisms.

4.3 Digital and Cross-border Cooperation

1.Apply big data, AI and blockchain for intelligent compliance.

2.Launch joint training and academic exchanges under the Belt and Road Initiative.

3.Coordinate strategic trade control systems and talent certification.

5. Conclusion

Human capital is the core factor of strategic trade control and international trade quality. Current dilemmas result from economic and managerial defects. The integrated framework effectively solves key problems. Digitalization and Kazakhstan–China cooperation provide valuable opportunities.

The government should upgrade talent strategies and promote cross-border coordination. Enterprises should strengthen compliance teams and training. Universities should focus on interdisciplinary education. This study supports safe, efficient and sustainable development of Kazakhstan–China economic and trade cooperation.

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SUSTAINABLE DEVELOPMENT OF THE AGRO-INDUSTRIAL COMPLEX AS THE BASIS FOR FOOD SECURITY IN THE REGION

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Annotation. Food security is a core part of national and regional security. For Central Asia and countries along the “One Belt, One Road”, the sustainable agro-industrial complex (AIC) is the fundamental foundation for ensuring food supply, stabilizing prices, improving livelihoods and maintaining economic resilience. This paper analyzes the current status and challenges of the regional agro-industrial complex, clarifies the supporting role of sustainable AIC in food security, and proposes development paths including digital transformation, green technology innovation, infrastructure improvement, international cooperation under the Belt and Road Initiative, and policy and financial support. It points out that deepening China-Kazakhstan agricultural cooperation can effectively enhance regional food security and promote high-quality economic development.

Key words: agro-industrial complex; sustainable development; food security; digital transformation; One Belt One Road; China-Kazakhstan cooperation

Food security constitutes one of the core components of national and regional security. For Central Asian regions and countries along the “One Belt, One Road” initiative, stable and sustainable operation of the agro-industrial complex (AIC) is the fundamental foundation for ensuring food supply, stabilizing market prices,

improving livelihoods, and maintaining economic resilience. In recent years, global climate change, resource constraints, and market fluctuations have posed new challenges to traditional agricultural systems. Therefore, promoting the sustainable transformation of the agro-industrial complex has become an inevitable strategic choice.

Kazakhstan and China maintain close agricultural cooperation within the Belt and Road framework. Both sides have complementary advantages in terms of cultivated land resources, agricultural technology, processing capacity, and market demand.

Boosting the sustainable development of the regional agro-industrial complex can not only enhance domestic food security but also expand cross-border agricultural trade, investment cooperation, and technological exchange, thus driving high-quality development of regional economy.

At present, the agro-industrial complex in the region has formed a certain industrial foundation. Crop cultivation, animal husbandry, agricultural processing, and logistics services have developed to varying degrees. However, multiple constraints still exist. Extensive production methods remain common, leading to low resource utilization efficiency. The application of green technology, intelligent equipment, and digital management tools is insufficient. Agricultural infrastructure such as water conservancy, cold chain, and transportation needs further improvement. In addition, industrial chain integration is low, and risk resistance capacity is relatively weak.

These problems directly affect the stability and sustainability of food supply. In extreme weather or market fluctuation periods, some regions face pressures such as insufficient output or unstable supply of key agricultural products. Therefore, accelerating the sustainable development of the agro-industrial complex is crucial to consolidate regional food security.

Sustainable development of the agro-industrial complex takes resource conservation, environmental protection, efficiency improvement and long-term stability as core goals. It helps reduce dependence on chemical fertilizers and pesticides, protect soil and water resources, and lower ecological pressure.

Meanwhile, standardized and intensive production improves the quality and safety of agricultural products and enhances supply stability.

A complete and sustainable agro-industrial complex covers planting, breeding, processing, storage, logistics and marketing. Such an integrated system enhances traceability, reduces circulation loss, and ensures continuous and stable food supply.

Therefore, the sustainable agro-industrial complex is not only an industrial system but also a core support for regional food security.

Paths to Promote Sustainable Development of the Agro-Industrial Complex First, strengthen technological innovation and digital transformation. Precision agriculture, intelligent irrigation, satellite monitoring and big data management can be widely applied to improve production efficiency and resource utilization. Second,

develop green and ecological agriculture to reduce environmental pollution and promote circular agriculture. Third, improve infrastructure construction, including farmland renovation, cold chain logistics and transportation networks. Fourth, deepen international cooperation under the “One Belt, One Road” framework to share experience, conduct joint research and expand agricultural product trade.

Fifth, improve policy support, financial services and risk prevention systems to provide stable conditions for agricultural entities.

In the context of global economic uncertainty and climate challenges, the issue of strengthening the resilience of agro-industrial systems has become increasingly important. Sustainable development of the agro-industrial complex not only ensures stable food production but also contributes to employment growth, poverty reduction, and balanced regional development. For many developing economies, agriculture remains one of the main sources of income for rural populations. Therefore, improving the efficiency and sustainability of agricultural production directly affects social stability and economic security.

Digital technologies are becoming one of the most important driving forces behind the modernization of agriculture. The integration of artificial intelligence, unmanned machinery, remote sensing technologies, cloud computing, and blockchain systems allows agricultural enterprises to optimize production processes and reduce costs. Smart farming technologies help monitor soil quality, weather conditions, irrigation levels, and crop growth in real time. This increases productivity while minimizing environmental impact. In Kazakhstan and other Central Asian countries, the gradual implementation of digital agriculture can significantly improve land-use efficiency and water resource management, which is particularly important under conditions of climate change and water scarcity.

Another important direction is the development of sustainable agricultural supply chains. Modern food security depends not only on production volume but also on the efficiency of storage, transportation, processing, and distribution systems. Significant losses of agricultural products still occur during transportation and storage due to insufficient cold-chain infrastructure and outdated logistics systems. Therefore, investment in modern warehouses, refrigerated transportation, and digital logistics platforms is necessary to improve supply chain resilience and reduce food losses.

Green transformation is also an essential element of sustainable development in the agro-industrial complex. Excessive use of chemical fertilizers, pesticides, and water resources creates long-term ecological risks. The transition toward environmentally friendly agricultural practices, including organic farming, biological fertilizers, water-saving irrigation technologies, and renewable energy use in agricultural production, can reduce environmental pressure and improve product quality. At the same time, consumers are increasingly demanding environmentally safe and traceable food products, which creates new market opportunities for sustainable agricultural enterprises.

International cooperation plays a strategic role in promoting sustainable agricultural development. Under the framework of the Belt and Road Initiative, China and Kazakhstan can deepen cooperation in agricultural technology transfer, scientific research, infrastructure construction, and agricultural trade. Joint research centers, educational exchange programs, and cross-border logistics corridors can strengthen regional agricultural integration. In addition, cooperation in grain reserves, emergency food supply systems, and agricultural risk management can further improve regional food security capacity.

Financial support mechanisms are equally important for sustainable agricultural modernization. Governments and financial institutions should encourage long-term investment in green agriculture and agricultural innovation through subsidies, tax incentives, concessional loans, and agricultural insurance systems. Small and medium-sized agricultural producers especially require better access to financing and modern technologies in order to participate effectively in the transformation process.

Overall, sustainable development of the agro-industrial complex represents not only an economic task but also a strategic requirement for ensuring long-term regional stability and food security. Strengthening innovation capacity, improving infrastructure, promoting ecological transformation, and deepening international cooperation will create a more resilient and efficient agricultural system capable of responding to future global challenges.

The sustainable development of the agro-industrial complex is the fundamental guarantee for regional food security. Through technological innovation, green transformation, industrial upgrading and international cooperation, the

agro-industrial complex can achieve stable, efficient and long-term development. Kazakhstan and China have great potential in agricultural cooperation. Deepening the construction of a sustainable agro-industrial complex will effectively enhance the food security level of the region and bring tangible benefits to people of both countries.

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THE IMPACT OF TRADE RESTRICTIONS ON INTERNATIONAL BUSINESS MODELS: EXISTING THEORIES AND FUTURE RESEARCH DIRECTIONS.

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Annotation.
The intensification of globalization and geopolitical transformations have rendered trade restriction policies a crucial determinant influencing the evolution of international business models. Nations implement trade restrictions to safeguard national security, advance economic interests, or attain strategic objectives, thereby exerting a profound influence on international business operations. This paper intends to summarize the research findings regarding the impacts of domestic and foreign trade restrictions on international business models, elucidate theoretical frameworks, research progress, and current trends. It deliberates on the mechanisms through which trade restrictions impact international business models, assesses the efficacy of various coping strategies, and identifies the deficiencies in existing research as well as potential directions for future research.

Key words: trade restrictions, international business models, global value chains, export controls, business model innovation, digital transformation.

Trade restrictions denote the intervention measures implemented by a government via legal, administrative, or economic means to regulate the cross – border flow of goods, services, and technologies for the purpose of attaining specific economic, political, or security objectives. Historically, trade restrictions have a long - standing existence. Ancient Egypt and Greece imposed export restrictions to guarantee domestic supplies of food and raw materials, while during the Han Dynasty, China employed export controls to defend against external threats and strengthen its rule [1]. Through centuries of evolution, modern trade restrictions have extended beyond simple tariffs and quotas to form a diversified policy framework, which includes export control lists, foreign investment security reviews, data localization requirements, and supply chain "friendly - shore outsourcing".

According to the research by Peng Shuang, export control measures mainly consist of state monopolies, export quotas, export embargoes, export tariffs, and export licenses [1]. Countries have employed these measures in various combinations during different historical periods, which reflects the diversity and complexity of trade restriction policies.

1. The Evolutionary Trends of Modern Trade Restrictions

The MATR indicator developed by the International Monetary Fund (IMF), which systematically collects data from 157 countries from 1949 to 2019, reflects the evolution of contemporary trade restrictions, shifting from traditional tariff barriers to non - Tariff barriers have gradually given way to "post - border barriers" [2]. In Kang Xiaoling's research, among non - tariff barriers, the most prominent form is the technical trade barrier. It is characterized by formal legality, inherent duality, extensive and intricate content, as well as covert and flexible mechanisms . This suggests that technical trade barriers have emerged as one of the most significant restrictive measures in contemporary international trade [3].

Moreover, in recent years, new restrictive measures such as export controls justified by national security, the Carbon Border Adjustment Mechanism (CBAM) justified by environmental protection, and the Digital Services Tax targeting the digital economy have often been more targeted and covert. Research from the Peterson Institute for International Economics shows that when a country is the sole provider of a critical commodity, it may impose export restrictions to raise prices and thus gain from improved terms of trade, yet this undermines the interests of the importing country [4].

2. The Impact of Trade Restrictions on International Business Models

The impact of trade restrictions on international business models is primarily manifested in the following aspects: First, the impact on global value chains—enterprises are reconfiguring their global production networks, shifting from an efficiency-oriented approach to a balance between efficiency and resilience. In the face of trade barriers, companies are transitioning from efficiency-driven global integration strategies to more resilient "regionalized" and "localized" operations. This restructuring is reflected in the shortening of supply chains and the establishment of backup arrangements at critical nodes, with firms prioritizing the diversification of supply chains to reduce dependence on single countries or regions. Second, the strategic impact: enterprises adjust their product strategies and market positioning, adopting diversification strategies to adapt to the evolving market conditions and policy environment. They seek alternative markets to minimize their reliance on restricted markets, develop alternative supply sources to mitigate supply chain risks, and strengthen independent R&D efforts or explore alternative technological pathways to reduce dependence on external technologies.

Enterprises adjust product strategies and market positioning, implementing diversification strategies to adapt to the evolving market conditions and policy environment. They explore alternative markets to minimize reliance on restricted markets, develop alternative supply sources to mitigate supply - chain risks, and enhance independent R & D efforts or explore alternative technological pathways to reduce dependence on external technologies.

3. Response Strategies and Business Model Innovations

3.1 Corporate Response Strategies in the Face of Trade Restrictions

Companies have employed a variety of response strategies, encompassing adaptive adjustments and strategic transformations. Adaptive measures include the reorganization of supply chains, market diversification, and production localization. Strategic transformations involve business - model innovation and the development of technical capabilities. In dealing with technical trade barriers, Kang Xiaoling put forward specific strategies: companies should “conduct in - depth research on the Technical Barriers to Trade Agreement,” “strengthen comprehensive quality management,” “introduce advanced foreign technologies,” “actively pursue international certifications.” Moreover, they "adopt environmental - protection practices to attain clean production and green marketing." These strategies assist enterprises in surmounting technical trade barriers and sustaining or enhancing their international competitiveness.

3.2 At the national and policy levels

Nations tackle the challenges presented by trade restrictions via policy adjustments and international cooperation. As per the analysis of the Peterson Institute for International Economics, a variety of policy measures have been implemented to alleviate the risks related to export restrictions. For instance, "Europe has explored new energy supply sources subsequent to the restrictions on Russian energy exports," and "the United States, Japan, and European countries have reinforced support for relevant industries and promoted supply - chain diversification in response to the export restrictions on key minerals and rare earths from China."

Improving the export - control system is another vital policy direction. Peng Shuang put forward a comprehensive set of suggestions, such as "enhancing the framework of export controls," "unifying export - control authorities," "clarifying export - control objectives," "timely updating the list of controlled entities," "adjusting export - control measures," and "strengthening international exchanges on export controls." These measures will contribute to enhancing the transparency and effectiveness of trade - restriction policies.

Under the WTO framework, countries can address trade restrictions. Through multilateral mechanisms, for instance, in the context of restrictions on raw material exports, A country may "implement specific countermeasures to impose direct export restrictions on raw materials through state-run trade," while leveraging relevant WTO institutional exceptions regarding the applicability of China's export tariff restriction obligations. . Simultaneously, countries ought to actively engage in international rule - making endeavors to promote "reforms of rules that are unjust towards China" and "reforms of rules that are unfair to developing countries".

Although trade restrictions present challenges, they have also stimulated innovation in business models. These innovations are mainly manifested in three aspects: firstly, digital transformation, in which enterprises utilize digital technologies to reshape value chains and customer relations; secondly, the circular economy model, whereby enterprises reduce their reliance on raw resources through

resource recycling; thirdly, ecosystem development, where enterprises cooperate with multiple stakeholders to construct more resilient business ecosystems.

In the domain of digital trade, to tackle digital trade barriers such as data localization, enterprises have transitioned from a "globally integrated operations" model to a "localized, compliant operations" model, while placing more emphasis on data security and privacy protection, thus transforming these elements into competitive advantages [5]. Moreover, digital platform companies are placing greater emphasis on localized operations to comply with the regulatory requirements and cultural contexts of different markets.

4. Research Review and Future Directions

4.1 Research Progress and Limitations

In recent years, research on the influence of trade restrictions on international business models has achieved substantial progress. On the one hand, the research perspective has broadened from traditional tariff barriers to encompass non - tariff barriers and “post - border barriers,” facilitating a more comprehensive comprehension of trade restrictions. On the other hand, research methodologies have become more diversified, evolving from purely qualitative analyses to a combination of qualitative and quantitative methods, with the introduction of new measurement tools such as the MATR dataset.

However, the existing research presents notable deficiencies. Firstly, there is a lack of theoretical integration, as the majority of studies adopt a single perspective and lack a comprehensive analytical framework that integrates institutional theory, the resource - based view, and dynamic capability theory. Secondly, research on heterogeneity effects remains at a superficial level; although trade restrictions have significantly different impacts on different firms, in - depth comparative studies exploring the mechanisms underlying this heterogeneity are scarce. Thirdly, research on emerging trade restrictions is still in its nascent stage, with studies examining the impact of new measures such as digital trade barriers and carbon border adjustment... The research on the impact mechanisms of trade restrictions on firms' international business models is still in its nascent stage. Fourthly, there is a dearth of evaluations regarding long - term effects and effectiveness. Current research mainly centers on short - term shocks, and there is an insufficiency of rigorous empirical testing and longitudinal studies to assess the long - term performance impacts of business model innovations and the effectiveness boundaries of various response strategies.

4.2 Future Research Directions

Based on a comprehensive review of existing research, this paper puts forward the following future research directions: Firstly, deepen the exploration of impact mechanisms. Future research can delve into the pathways and boundary conditions through which trade restrictions influence international business models. It can conduct in - depth quantitative analyses by utilizing new datasets such as MATR to uncover the differentiated impacts of various trade restrictions, and adopt multi - case comparative studies to examine the success factors of corporate response strategies.

Secondly, expand the scope of research. Future studies should concentrate on the influence of new trade restrictions, such as the Digital Services Tax and the Carbon Border Adjustment Mechanism, on international business models. Moreover, research should be extended to regional cooperation mechanisms like the Belt and Road Initiative to alleviate the negative effects of trade restrictions. It should also explore the application of machine learning and other methods to predict the probability and impact of trade restrictions. Supporting decision - making.

Third, strengthen policy research. In the future, in - depth evaluations should be conducted on the efficacy of diverse policy designs. Studies should be carried out to formulate emergency mechanisms for coping with the abrupt impacts of trade restrictions. Moreover, international exchanges regarding export controls should be enhanced to augment policy transparency and effectiveness.

Fourth, integrate theory and practice. In the future, the cooperation between academia and industry should be reinforced by integrating theoretical research with corporate practice. Through case analyses and methodological advancements, the decision - making processes and implementation results of enterprises can be analyzed to offer references for other businesses.

In conclusion, the influence of trade restrictions on international business models is intricate and dynamic, demanding updated research perspectives and methodologies. By integrating multidisciplinary approaches, innovating methodologies, and integrating theory with practice, more valuable guidance can be provided for businesses and policymakers in addressing these challenges.

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THE IMPACT OF STRATEGIC TRADE CONTROL ON REGIONAL DEVELOPMENT AND ECONOMIC DIVERSIFICATION

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Annotation. Against the backdrop of intensifying global technological competition, strategic trade control has emerged as a critical institutional factor shaping cross-border flows of artificial intelligence (AI) and innovative technologies. Artificial intelligence and innovative technologies in international business—as the analytical perspective, this paper explores how strategic trade control reshapes the allocation of technological factors, restructures regional industrial chains, and influences regional development and economic diversification. Based on the context of Kazakhstan- China cooperation under the Belt and Road Initiative and digital economic cooperation, this study finds that strategic trade control over core AI components produces dual effects: short-term constraints on technology introduction and long-term incentives for localized independent innovation. Proper coordination of trade rules helps reduce over-reliance on external technologies and single markets, accelerate the cultivation of emerging industries, and promote the shift from resource-based or single-structure economies to technology-intensive and diversified systems. The conclusions provide empirical and policy references for optimizing industrial layout, strengthening technological cooperation, and advancing sustainable development in Central Asia and related regions.

Key words: strategic trade control; regional development; economic diversification; artificial intelligence; innovative technologies; international business; Belt and Road Initiative.

Introduction

In recent years, major economies have continuously strengthened strategic trade control targeting high-end chips, core algorithms, computing power equipment, and

key components closely linked to artificial intelligence and innovative technologies. Such regulatory measures directly restrict the cross-border movement of core technological elements, alter the innovation path and spatial distribution of the AI industry, and exert a profound impact on regional industrial upgrading and economic restructuring [1].

As a core engine driving the transformation of international business, AI and innovative technologies promote intelligent upgrading in production, logistics, trade, and investment. Under the framework of Kazakhstan-China Digital Economy and the Belt and Road Initiative, both countries are committed to deepening cooperation in digital industries, cross-border e-commerce, and intelligent manufacturing. Clarifying the transmission mechanism of strategic trade control to AI-driven regional development and economic diversification is of great theoretical and practical significance for improving policy coordination and promoting high-quality cooperation [2].

This paper addresses three core questions:

How does strategic trade control affect the development and application of AI and innovative technologies in international business?

What transmission channels connect technological restrictions to regional development and economic diversification?

What policy implications can be drawn for technological and economic cooperation between Kazakhstan and China?

2.Theoretical Basis and Analytical Framework

2.1 Strategic Trade Control

Strategic trade control refers to the supervision and restriction of cross-border flows of products, technologies, and services related to national security, core industries, and emerging technologies. It mainly includes export control, investment review, and restrictions on technological cooperation. In the AI sector, controlled items cover high-performance chips, basic software, large model parameters, and cutting-edge algorithm technologies.

2.2 AI and Innovative Technologies in International Business

AI and innovative technologies improve cross-border operational efficiency, optimize supply chain management, lower transaction costs, and foster new business forms such as intelligent logistics, digital trade, and smart manufacturing. They have become core drivers of international business innovation and industrial upgrading [3].

2.3 Economic Diversification and Regional Development

Economic diversification means reducing dependence on a single industry, market, or resource input, and forming a multi-pillar, resilient economic structure. Regional development includes industrial upgrading, employment expansion, investment attraction, and improvement of comprehensive competitiveness.

2.4 Analytical Framework

This paper establishes a clear analytical chain:Strategic trade control → constraints or substitution of core AI factors → adjustment of regional innovation

and industrial layout → changes in productivity and industrial structure → promotion of regional development and economic diversification.

3. Impact Mechanisms of Strategic Trade Control

3.1 Constraints on the Supply of Core AI Elements

Strategic trade control directly restricts the import and circulation of high-end chips, advanced computing power, and key software tools. This raises R&D costs, slows the iteration of AI technologies, and hinders the intelligent transformation of traditional industries in some regions.

3.2 Incentives for Localized Innovation and Industrial Autonomy

External technological restrictions force regions and enterprises to increase investment in independent research and development, accelerate the localization of core technologies, and cultivate local research teams and high-tech enterprises. This helps build an independent innovation system and enhance regional risk resistance.

3.3 Restructuring of Regional Supply Chains and Investment Distribution

Trade control promotes the restructuring of regional value chains. Countries along the Belt and Road tend to strengthen intra-regional cooperation in digital and AI industries, build regional innovation communities, and attract targeted investment to reduce external dependence.

3.4 Promotion of Economic Diversification

By curbing over-reliance on foreign technologies and markets, strategic trade control encourages the development of emerging industries such as intelligent manufacturing, digital services, and cross-border e-commerce. It promotes the transformation from traditional industries to technology-intensive industries and accelerates economic diversification.

4.Implications for Kazakhstan- China Cooperation

Under the Belt and Road Initiative, Kazakhstan and China have broad cooperation space in digital economy, AI application, and cross-border trade. AI and digital technologies help optimize cross-border logistics and customs clearance efficiency and boost bilateral trade. Cooperation in intelligent manufacturing, energy digitization, and agricultural modernization supports industrial upgrading and economic diversification in both countries. Coordinating strategic trade control rules helps balance security and openness, stabilize key technology supply chains, and create a favorable environment for innovative cooperation [4, 5].

It is recommended that the two sides strengthen policy communication, jointly build AI innovation platforms, promote personnel training and technological exchange, and form a stable, diversified, and sustainable regional industrial cooperation system.

Conclusion

Strategic trade control has dual effects on AI and innovative technologies: short-term constraints on technology introduction and long-term promotion of localized independent innovation. The adjustment of technological factors driven by trade control directly affects the industrial structure and growth momentum of regions, and

becomes an important force promoting regional development and economic diversification. For Kazakhstan, China, and other countries along the Belt and Road, coordinating trade rules and strengthening technological cooperation help reduce external risks, accelerate industrial transformation, and achieve sustainable and diversified economic development [6].

In the future, economies should balance security needs and openness, take AI and innovative technologies as key tools to boost economic diversification, and deepen mutually beneficial cooperation under multilateral and regional frameworks.

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UDC (339.9)

RESILIENCE RECONFIGURATION IN INTERNATIONAL BUSINESS AND TRADE AMID GLOBAL TRANSFORMATIONS

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Annotation. International business and international trade are facing a period of rising uncertainty. Trade protectionism, geopolitical tensions, the restructuring of

trade rules and supply chain instability have made overseas business operations more complex. At the same time, RCEP, the Belt and Road Initiative, cross-border e-commerce, digital trade and green trade provide new opportunities for market expansion and competitiveness upgrading. Based on relevant literature, this paper discusses the main challenges, opportunities and future directions of international business and international trade. It argues that future trade development should move beyond scale expansion and pay more attention to quality, resilience and rule adaptation.

Key words: international business; international trade; cross-border e-commerce; digital trade; supply chain resilience.

International business today faces growing uncertainty because rules and risks are rising at the same time. Trade barriers are no longer limited to tariffs. They now appear in the form of technology restrictions, stricter compliance review, green standards, data rules, and other institutional arrangements in digital markets [1]. In practice, firms often need to deal with several regulatory systems at once. A single product may be subject to requirements concerning data compliance, intellectual property protection, carbon disclosure, and rules of origin. As Qiu et al. suggest, economic analysis needs to be combined with geopolitical analysis [2]. This also applies to firms, since business decisions now require a broader understanding of institutional risk and strategic uncertainty.

At the same time, the logic of global supply chains is changing. For a long time, many firms focused mainly on efficiency and cost reduction. However, recent disruptions have shown that excessive dependence on one market, one transport route, or one key supplier can increase operational vulnerability. In this context, RCEP is important not only because it reduces tariffs, but also because it supports deeper regional integration of industrial chains, supply chains, and value chains [4]. This creates more room for firms to organize production and trade within regional networks. However, risks still remain. Changes in platform policies, dependence on overseas logistics systems, and the loss of control over high value service activities may weaken firms' bargaining power and long term stability [4].

Digital technology has also created new opportunities for international business. Digital commerce enables small and medium sized enterprises to reach overseas consumers with lower initial costs. It also helps firms reorganize marketing, order fulfillment, customer service, and after sales support [3]. Yet digital trade should not be understood as a simple or risk-free path to internationalization. Online transactions may increase credit risk, payment risk, and data security risk. Firms also need to adapt to different regulatory and tax systems in foreign markets [3]. Therefore, digitalization changes the threshold of competition. Operational skills remain important, but sustainable competitiveness increasingly depends on compliance capability, brand development, product quality, and service capacity.

The Belt and Road Initiative also continues to provide opportunities for market expansion. Existing studies suggest that firms should avoid making investment decisions based only on broad slogans or short-term expectations. Product quality and brand credibility should be treated as basic conditions for entering international markets. At the same time, firms need to improve their ability to manage cross border supply chains [5]. When external volatility increases, reputation and reliable delivery often become more valuable than temporary cost advantages, because they are much harder for competitors to replace.

In recent years, international trade has also become increasingly connected with sustainable development goals and environmental transformation. Green trade policies, carbon neutrality strategies, and environmental certification systems are influencing the structure of global markets. Many countries are introducing carbon-related border adjustment mechanisms and stricter environmental standards for imported goods. As a result, exporters must improve environmental management, reduce emissions, and adopt energy-efficient technologies in order to remain competitive. Green transformation is no longer only an environmental issue; it has become an important economic and strategic factor in international business development.

At the same time, regional economic cooperation is playing a more significant role in stabilizing global trade activities. The development of regional production networks allows firms to reduce transportation risks, shorten delivery time, and improve supply chain flexibility. Agreements such as RCEP contribute to trade facilitation through tariff reduction, customs simplification, and investment cooperation. For many enterprises, combining global market access with regional operational networks has become an effective strategy for maintaining resilience under uncertain international conditions.

Another important factor influencing modern international business is technological innovation. Artificial intelligence, cloud computing, blockchain systems, and smart logistics technologies are changing traditional trade models. These technologies improve efficiency, transparency, and communication between international market participants. Digital platforms also help firms analyze consumer demand more accurately and optimize supply chain management. However, technological dependence may also increase cybersecurity risks and data governance challenges. Therefore, governments and enterprises need to strengthen digital infrastructure, legal regulation, and international cooperation mechanisms in order to support stable and secure trade development.

Furthermore, human capital and innovation capacity are becoming key determinants of long-term competitiveness. In a rapidly changing business environment, enterprises require not only financial resources but also qualified specialists capable of adapting to new technologies and international regulations. Investment in education, research, and professional training can help firms improve innovation capability and maintain sustainable growth in global markets.

International business and international trade are now facing both challenges and opportunities. Trade protectionism, rule reconstruction, supply chain risks and digital governance issues make the international business environment more complex. At the same time, RCEP, the Belt and Road Initiative, digital trade, cross-border e-commerce and green transformation offer new opportunities for market expansion, efficiency improvement and competitive upgrading. Future development should move from simple scale expansion to high-quality growth. Firms should rely less on low-cost advantages and more on innovation, branding, rule adaptation and supply chain resilience. Real international competitiveness is not only the ability to sell products abroad, but also the ability to operate continuously, comply with changing rules and create long-term value in a complex global environment.

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UDC （338.22）

ASSESSMENT OF THE INFLUENCE OF WORLDWIDE INFLATION AND RAW MATERIAL PRICES ON THE NATIONAL ECONOMY

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Annotation

This article examines the impact of global inflation and fluctuations in commodity prices on the national economy. The study analyzes the main channels through which global inflation affects domestic economic stability, including imported inflation,

rising production costs, declining purchasing power, and reduced investment activity. Special attention is paid to the influence of changes in global prices for oil, gas, metals, and agricultural products on countries dependent on commodity exports and imports. The article highlights the economic consequences of commodity price volatility, such as exchange rate instability, budget deficits, inflation growth, and slower economic development. The research also identifies the main measures aimed at reducing the negative effects of external economic shocks through diversification, anti-inflationary policy, and strengthening macroeconomic stability.

Keywords

Global inflation; commodity prices; national economy; economic growth; inflation processes; raw materials; macroeconomic stability; export revenues; economic diversification; global market; energy resources; fiscal policy; investment activity; exchange rate volatility.

Introduction

In the context of globalization, the world economy is becoming increasingly interconnected. Fluctuations in global commodity prices and rising inflation significantly affect the economic development of countries, especially states highly dependent on the export or import of raw materials. Changes in the prices of oil, gas, metals, and food products directly influence inflation rates, exchange rates, investment activity, and the welfare of the population. For countries with resource-oriented economies, these processes become major factors of macroeconomic stability. Global inflation has intensified in recent years due to the consequences of the COVID-19 pandemic, geopolitical conflicts, disruptions in global supply chains, and changes in international trade. According to the International Monetary Fund and the World Bank, the increase in energy prices in 2022–2024 became one of the key causes of accelerating global inflation.

The Impact of Global Inflation on the Country's Economy

Global inflation represents a persistent increase in the general price level in the world economy. The main channels of its influence on the national economy are imported inflation, rising production costs, and declining purchasing power of the population. For countries importing a significant share of goods and technologies, rising global prices lead to higher domestic market prices. This particularly affects the cost of food, fuel, industrial equipment, and transportation services. As a result, business expenses increase, profitability decreases, and economic growth slows down.

In addition, high global inflation contributes to the tightening of monetary policy by central banks. Higher interest rates lead to reduced lending and investment activity. The Organisation for Economic Co-operation and Development (OECD) notes that rising global inflation and trade restrictions in 2025 became factors slowing global GDP growth.

Inflationary processes also affect the standard of living of the population. Rising prices reduce real incomes, increase social inequality, and weaken domestic consumer demand. Countries with low levels of economic diversification and high import dependence become especially vulnerable.

The Impact of Commodity Prices

Commodity resources play an important role in the global economy. Changes in the prices of oil, gas, coal, metals, and agricultural products directly affect countries' export revenues. For commodity-exporting countries, rising global prices are usually accompanied by increased foreign exchange earnings, budget growth, and higher investment activity. However, excessive dependence on the commodity sector creates serious risks. When global prices decline, export revenues decrease, the national currency weakens, and the state budget deteriorates.

According to the World Bank, global commodity prices in 2025–2026 may fall to their lowest levels in recent years due to slower global economic growth and reduced demand for energy resources. Countries with commodity-based economies are particularly sensitive to fluctuations in world prices. The International Monetary Fund emphasizes that commodity price volatility affects the macroeconomic stability of states and requires effective fiscal policy.

Consequences for the National Economy

The growth of global inflation and instability in commodity prices lead to the following consequences:

- acceleration of domestic inflation;
- decline in real household incomes;
- deterioration of the investment climate;
- increase in budget deficits;
- depreciation of the national currency;
- growth of public debt;
- slowdown in economic growth.

At the same time, high commodity prices may temporarily stimulate the economic growth of export-oriented countries. For example, rising oil prices contribute to increased export revenues and the accumulation of state reserves. However, long-term economic sustainability requires diversification of production and the development of non-resource sectors.

World Bank experts note that high volatility in commodity prices is becoming one of the major threats to developing countries.

Ways to Reduce Negative Impact

To minimize the negative effects of global inflation and commodity price fluctuations, governments should:

- implement effective anti-inflationary policies;
- develop domestic production;
- diversify the economic structure;
- reduce dependence on imports;

- establish stabilization and reserve funds;
- stimulate innovation and the development of high-tech industries;
- strengthen the financial system and improve the investment climate.

Economic diversification helps reduce dependence on global commodity prices and increases the resilience of the national economy to external shocks.

Conclusion

Thus, global inflation and changes in commodity prices have a significant impact on the economic development of countries. For states highly dependent on foreign trade in raw materials, these factors become decisive for macroeconomic stability. Rising global inflation leads to higher import costs, declining purchasing power, and slower economic growth. Fluctuations in commodity prices can both stimulate the economy and create serious risks for budgetary and currency stability.

Under modern conditions, the most important task for the state is to build a sustainable and diversified economy capable of effectively adapting to changes in the global market environment.

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UDC 338.2

DIGITAL TRANSFORMATION IN THE ECONOMIC SECTOR AND THE EVOLUTION OF MARKET MECHANISMS — AN EMPIRICAL AND CASE STUDY BASED ON CHINESE LISTED COMPANIES

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Abstract: With the continuous development of society and the economy and the rapid pace of technological innovation, China's digital economy has ushered in unprecedented opportunities. The digital economy is gradually taking shape and establishing its own framework, becoming a driving force behind current social progress and corporate development. This paper uses Chinese A-share listed companies from 2012 to 2023 as its research sample to systematically examine the characteristics of digital transformation in the economic sector and the effectiveness of market mechanisms. Building upon a review of existing research, we employ text analysis to construct a digital transformation model and conduct validation and analysis using a combination of text and graphical representations.

Keywords: Digital transformation; Digital economy; Market mechanisms; Information transparency; Market power; Nonlinear competition

As the primary economic model following the agricultural and industrial economies, the digital economy is increasingly becoming a key engine of global economic growth. Data has become a critical factor of production, driving profound transformations in traditional market mechanisms. Developing the digital economy is key for countries to secure a leading position in the new round of international competition.

The "14th Five-Year Plan for the Development of the Digital Economy," issued by the State Council, explicitly calls for accelerating the digital transformation and upgrading of enterprises, guiding them to comprehensively transform traditional business models across all dimensions and the entire value chain.

From the perspective of technological economics, digital tools can be categorized into three tiers: the technical tool tier (artificial intelligence, cloud computing, big data, the Internet of Things, and blockchain), the management tool tier (ERP, CRM, SCM, and RPA), and the platform tool tier (industrial internet platforms, data middleware, and collaborative operation platforms). In recent years, the application of digital tools in enterprises has evolved from "point solutions" to "integrated collaboration." For example, Zhiyuan Interconnect's AI-COP platform

integrates large language models, intelligent agents, and knowledge bases to provide enterprises with an integrated digital and intelligent operations foundation.

Market implementation mechanisms play a critical role in translating digital strategies into practical outcomes. Organizational mechanisms, such as establishing Chief Digital Officer (CDO) positions and dedicated digital departments, strengthen enterprise digital governance. Collaborative mechanisms, including supply chain cooperation and IT-business integration, further amplify digital value creation.

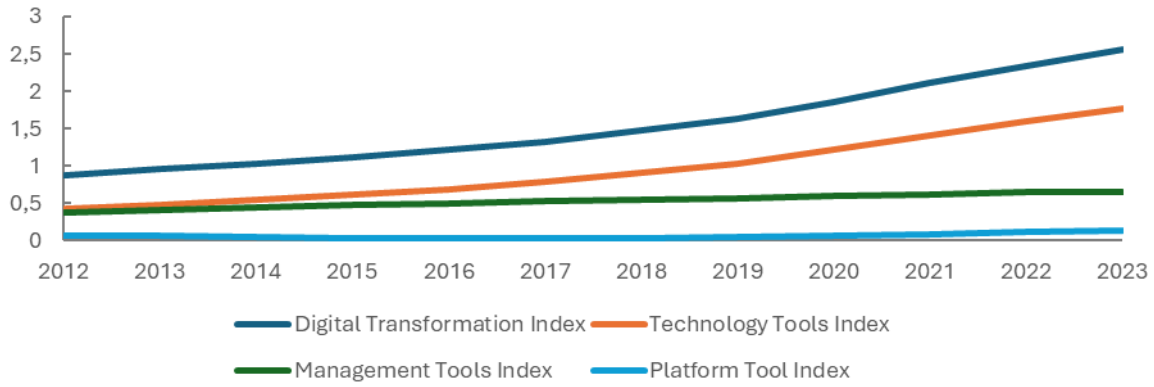

Figure 1: Chart Showing the Evolution
of the Digital Transformation Index for Listed Companies, 2012~2023

Figure 1 Presents the evolutionary trend of the digital transformation index for listed companies from 2012 to 2023. During the sample period, the digital transformation index rose steadily from 0.87 in 2012 to 2.34 in 2023, with an average annual growth rate of 9.6%. Notably, the growth rate accelerated significantly after 2020, which aligns with the policy context of surging demand for online services during the pandemic and the national "14th Five-Year Plan" prioritizing digitalization as a key direction.

Table 1 presents the digital transformation index by industry for 2023. The information technology sector ranked first with an index value of 3.87, followed by the financial sector (3.52) and the manufacturing sector (2.68). Traditional industries such as agriculture, forestry, animal husbandry, and fisheries (1.12) and construction (1.34) exhibited significantly lower levels of digitalization than the overall sample average.

Table 1 - Statistical Table of Digital Transformation Indices and Sample Sizes by Industry

Industry	Sample Size	Digital Transformation Index
Information Transmission, Software, and IT Services	312	3.87
Finance	98	3.52
Manufacturing	1,856	2.68

Wholesale and Retail Trade	234	1.89
Real Estate	156	1.45
Construction	112	1.34
Agriculture, Forestry, Animal Husbandry and Fisheries	68	1.12

This distribution reflects the influence of industry characteristics: sectors with high information density and standardized business processes find it easier to advance digital transformation, whereas traditional industries, which are more physically intensive and highly unstructured, face greater challenges in doing so.

The sample firms were divided into three groups - high, medium, and low digitalization - to compare differences in market mechanism indicators across the groups: The mean information transparency score for the high-digitalization group was 0.72, significantly higher than the 0.48 for the low-digitalization group; the mean Lerner index for the high-digitalization group was 0.21, significantly higher than the 0.14 for the low-digitalization group; the average HHI for industries in the high-digitalization group was 0.18, higher than the 0.12 for industries in the low-digitalization group. Preliminary data indicates that digitalization is positively correlated with information efficiency and market power, and that industries with high digitalization exhibit higher concentration.

Extracting data resources, transforming them into data commodities, and capitalizing on them plays a crucial role in the expansion of platform capital. Technological revolutions have driven the widespread adoption of the internet and information technology, greatly increasing internet usage rates. As the most important factor of production in the platform economy, data is generated from people's daily online activities. Marx pointed out that the products of labor can only become commodities when they satisfy both the conditions of value and use-value. For most ordinary users, the data generated by their daily online activities possesses no use value, let alone exchange value. Only after these data are collected, managed, mined, organized, and analyzed can they be transformed into data commodities with exchange value.

Current market platforms are essentially digital infrastructures supported by digital technology that facilitate interaction among platform users while acquiring data resources; they give rise to a new form of economic organization - the platform economy - based on the platform itself. With the development of a new round of technological and industrial revolutions, digital technology continues to undergo transformation, and informatization has endowed economic development with a high degree of fluidity and flexibility. Through the combination of algorithms and tracking data, the allocation, optimization, and evaluation of manual labor are achieved. Platform enterprises simultaneously control both data and digital technology; by leveraging algorithms to organize and coordinate the economic behavior of consumers and workers, the platform becomes a highly organized and planned

economic entity.

Based on the above analysis, this paper proposes the following hypotheses:

Model Setup:

To test H1 and H2, we specify the following two-way fixed-effects model:

$$Y_{it} = \alpha + \beta Digital_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Specifically, Y_{it} represents the transparency index and the Lerner index; $Digital_{it}$ represents the digitalization index; and X_{it} represents the control variables, including firm size, debt-to-asset ratio, ownership structure, and revenue growth rate.

To test H3, introduce the square term of the digital exponent:

$$HHI_{jt} = \alpha + \beta_1 Digital_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Here, HHI_{jt} refers to the industry's Herfindahl-Hirschman Index for the year, and $Digital_{jt}$ refers to the average level of digitalization among companies in the industry.

H1 (Information Efficiency Hypothesis): The higher the level of digitalization, the greater the efficiency of market information transmission, as evidenced by increased corporate transparency.

H2 (Market Power Hypothesis): The higher the level of digitalization, the stronger a firm's market power, as evidenced by an increase in the Lerner Index.

H3 (Nonlinear Competition Hypothesis): The impact of digitalization on the degree of market competition exhibits a "U-shaped" or "inverted U-shaped" nonlinear pattern. This study favors the "inverted U-shaped" pattern—digitalization promotes competition in the early stages but inhibits competition once a threshold is reached.

Table 2 presents the descriptive statistics for the main variables. In the full sample, the mean digitalization index was 1.58 with a standard deviation of 0.92, indicating significant variation among firms. The mean information transparency score was 0.53, placing it at a moderate level. The mean Lerner index was 0.16, suggesting that the firms in the sample possess a certain degree of market power on average. The average industry HHI was 0.14, indicating a moderately concentrated market [7].

Table 2 - Descriptive Statistics for Key Variables

Variable	Sample Size	Mean	Standard Deviation	Minimum	Maximum
Digitalization Index	26,874	1.58	0.92	0	4.12
Information Transparency	26,874	0.53	0.21	0.08	0.94
Lerner Index	26,874	0.16	0.12	-0.08	0.58
Industry HHI	2,398	0.14	0.09	0.03	0.52

Columns (1) and (2) of the Table 3 report the impact of digitalization on

information transparency; the coefficients for digitalization are both significantly positive at the 1% level. Based on Column (2), a one-standard-deviation increase in the digitalization index leads to an approximate 0.09-point increase in information transparency, equivalent to 17% of the sample mean. This result supports H1: digitalization significantly improves the efficiency of information transmission in the market [8].

Mechanism analysis indicates that the positive effect of digitalization on information efficiency is more pronounced in non-state-owned enterprises and small and medium-sized enterprises. This suggests that digitalization possesses "inclusive" characteristics, helping information-disadvantaged firms narrow the information gap with their more advantaged counterparts [9].

Table 3 - The Impact of Digitalizationon Information Efficiency and Market Power

Variable	Transparency	Transparency	Lerner Index	Lerner Index
Digitalization Index	0.087	0.064	0.041	0.031
	-0.009	-0.008	-0.005	-0.005
Control Variables	No	Yes	No	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
R^2	0.312	0.387	0.284	0.351
Observations	26,874	26,874	26,874	26,874

Columns (3) and (4) of Table 3 report the impact of digitalization on the Lerner index. The coefficient for digitalization is significantly positive at the 1% level, supporting H2. For every one-standard-deviation increase in the digitalization index, the Lerner index rises by approximately 0.03.

Further analysis reveals heterogeneity in the promotional effect of digitalization on market power: the coefficient for platform-based firms ($\beta = 0.087$) is higher than that for non-platform-based firms ($\beta = 0.041$); the coefficient for technology-intensive industries ($\beta = 0.072$) is higher than that for traditional industries ($\beta = 0.035$). This indicates that the effect of digitalization in strengthening market power is more pronounced in sectors characterized by network effects and economies of scale [10].

Nonlinear Competition Hypothesis. Table 4 reports the impact of digitalization on the degree of industry competition (HHI). Column (1) includes only the linear term for digitalization; the coefficient is negative but not significant. In Column (2), after including the squared term for digitalization, the coefficient for the linear term is significantly positive, while that for the squared term is significantly negative. This "inverted U-shaped" relationship confirms H3 [11].

Table 4 - The Impact of Digitalization on Industry Competition (Inverted U-Curve Test)

Variable	(1)HHI	(2) HHI
Mean industry digitalization	-0.011	0.038
	-0.008	-0.016
Mean Industry Digitalization²		-0.021
		-0.009
Control Variables	Yes	Yes
R^2	0.412	0.428
Observations	2,398	2,398

When the average industry digitalization level is below 1.8, a one-unit increase in digitalization reduces the HHI by 0.024 (indicating increased competition); when the digitalization level exceeds 1.8, a one-unit increase in digitalization raises the HHI by 0.019 (indicating decreased competition). Approximately 62% of industries are in a phase of increasing competition, while 38% are in a phase of decreasing competition. In recent years, the proportion of industries entering the phase of decreasing competition has shown an upward trend [12].

Based on data from Shanghai A-share listed companies from 2012 to 2023, this study examines the impact of digitalization on the evolution of market mechanisms and draws the following conclusions:

1. The role of digitalization in promoting information transparency is more pronounced among non-state-owned enterprises and small and medium-sized enterprises. This finding suggests that digitalization acts as an “equalizer” in terms of information efficiency, helping enterprises that were previously at an informational disadvantage narrow the gap with dominant firms and enhancing the efficiency of information transmission in the market.

2. The market power effects of digitalization are significantly greater for platform-based enterprises than for non-platform-based enterprises, and the effects are significantly greater in technology-intensive industries than in traditional industries. Digitalization does not equally endow every enterprise with stronger market control; rather, enterprises with network effects that can accumulate data assets reap higher returns. Data advantages and network effects are the primary sources of enhanced market power.

3. The impact of digitalization on the degree of market competition is non-linear; it exhibits a threshold effect, with competition decreasing once a threshold (a digitalization index of approximately 1.8) is reached.

4. The reshaping of market mechanisms by digitalization is a phased process, with each phase characterized by distinct underlying logic and driving mechanisms. The stages of digital-driven market mechanism reshaping are: improved information

efficiency → formation of market power → transformation of the competitive landscape.

5. Promoting high-quality development of the digital economy will facilitate the transformation and upgrading of traditional industries and enhance industrial value-added. In this new industrial revolution, digital technology has become the key driver of industrial transformation and the reshaping of production models. High-quality development of the digital economy, through the deep integration of digital technologies with traditional industries, has driven the digital, networked, and intelligent transformation of traditional sectors such as manufacturing, agriculture, and services. This has not only improved production efficiency and product quality in traditional industries but also spawned new business formats and models—such as smart manufacturing, smart agriculture, and the platform economy—significantly enhancing industrial value-added and market competitiveness.

This study demonstrates the crucial role of enterprise digitalization in achieving high-quality development and securing long-term competitive advantages. Therefore, based on potential future developments in the economic sector and the evolution of market mechanisms, the following strategic recommendations are proposed:

To promote the continuous improvement of digitalization levels and ensure long-term, high-quality, and healthy development.

1. Drive a new evolution of digital tools, shifting from “efficiency substitution” to “value reconstruction.”

Evidence shows that once the marginal returns on digitalization’s impact on information efficiency begin to decline, market dynamics take precedence. Corporate digital strategies should transcend the level of process automation and shift toward leveraging data intelligence to reshape product pricing power and business models. Leading companies in the industry must not merely pursue efficiency gains but should use technologies such as digital twins and generative AI to restructure the division of labor within the value chain, thereby cultivating differentiated competitive advantages that cannot be replicated by marginal costs.

2.Improve the digital skills training system to address labor market risks. While digitalization grants pricing power to some enterprises, it inevitably accelerates the skill differentiation of job roles. At the policy level, emphasis should be placed on cultivating “human-machine collaboration” capabilities. Relying on industry-education integration platforms, digital literacy should be incorporated into the vocational competency framework, and lifelong learning policies aligned with the pace of digital transformation should be established.

3.Establish an integrated governance framework for cross-regional digital markets. Currently, there are significant regional and sectoral disparities in digitalization levels, which risks creating a future where highly digitalized regions become even more advanced, while less digitalized regions fall further behind. Regional economic policies should focus on removing barriers to the cross-regional

flow of data as a production factor and promote the balanced distribution of algorithmic networks and industrial internet nodes. Only by establishing unified and compatible digital market regulatory standards can we prevent the uneven allocation of resources caused by fragmented digital governance.

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ANALYSIS OF BARRIERS AND OPPORTUNITIES OF INTERNATIONAL E-COMMERCE

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Annotation:
This article analyzes the current state of global cross-border e-commerce, highlighting its rapid growth despite the slowdown in traditional trade. It identifies key barriers, including stricter regulations, high logistics costs, and intense competition, while emphasizing opportunities in emerging markets, supportive policies, and digital technologies. The study concludes that sustainable development requires compliance, digitalization, and a shift toward branding and localized strategies.

Key words: cross-border e-commerce; trade barriers; development opportunities; global trade; digital economy; sustainable development

Introduction

Driven by global trade restructuring and digital technology innovation, international cross-border e-commerce has become a key engine of global trade growth. While maintaining robust expansion against the sluggish growth of traditional goods trade, the industry faces multiple operational and institutional barriers. Based on 2026 latest industry data, this paper summarizes the current development status of global cross-border e-commerce, analyzes its core barriers and emerging opportunities, and provides practical references for overseas enterprises.

Current Development Status

According to the 2026 WTO Global Trade Outlook, global goods trade growth will drop sharply to 1.9%, reflecting a slowdown in traditional trade. In contrast, cross-border e-commerce maintains rapid growth. The global B2C cross-border e-commerce market size is expected to rise from USD 1.82 trillion in 2025 to USD 2.29 trillion in 2026, with a compound annual growth rate of 25.3%, and will exceed USD 5.59 trillion by 2030. In China, cross-border e-commerce import and export volume reached 2.75 trillion yuan in 2025, up 69.7% from 2020, with 120,000 export enterprises, demonstrating strong industrial resilience. Currently, the industry is shifting toward branding, diversification and technological refinement, bringing both new growth space and structural challenges [1].

Core Development Barriers

1. Strict Policy Compliance Supervision

The global small-parcel duty-free policy has been fully phased out, ending the industry's low-cost dividend era. Starting from 2026, the EU, the U.S. and Japan have implemented new tariff and tax rules: the EU levies a fixed tariff on all parcels under 150 euros; the U.S. canceled the USD 800 duty-free threshold and imposed additional temporary tariffs, causing a sharp decline in China's U.S.-bound e-commerce exports; Japan enforces mandatory consumption tax and JCT registration for qualified sellers, pushing compliance costs to 8%–15% of gross profits. In addition, inconsistent national rules on certification, data security and intellectual property rights, together with frequent policy adjustments, lead to higher operational risks including fines and account bans.

2. Unstable and Costly Logistics Fulfillment

Global logistics is severely affected by geopolitical conflicts and rising energy prices, resulting in drastic fluctuations in sea and air freight costs. Key shipping lane disruptions further push up transportation and insurance expenses. The overseas warehouse market also faces irregular operations, hidden charges and frequent cargo losses, damaging seller credibility. Moreover, insufficient infrastructure in Southeast Asian and Latin American markets leads to low delivery efficiency, while logistics delays in mature European and American markets directly affect store ratings and consumer satisfaction [2].

3. Intense Market Involution and Profit Squeezing

Rising compliance, logistics and energy costs continuously compress corporate profit margins. Meanwhile, the industry faces severe homogenization and vicious low-price competition. Leading brands dominate premium traffic and supply chain resources, while small and medium-sized sellers struggle with limited organic traffic, severe product homogeneity and shrinking profits, forming a low-quality competitive cycle.

4. Auxiliary Operational Barriers

Cross-border operation is also restricted by diversified payment systems, exchange rate fluctuations and capital repatriation risks. Cultural and linguistic differences lead to mismatched product positioning and marketing strategies in local markets. In addition, the severe shortage of interdisciplinary talents proficient in international trade, digital operation and cross-border logistics further restricts enterprise expansion.

Core Development Opportunities

1. Continuous Increment from Emerging Markets

While European and American markets tend to be saturated, Southeast Asia, Latin America, the Middle East and Africa have become new growth poles. Benefiting from demographic dividends, rising digital penetration and consumption upgrading, these regions maintain double-digit growth rates. Southeast Asia and Latin America lead the growth, while the Middle East and Africa boast huge untapped potential, enabling enterprises to diversify market layouts and hedge risks from mature market policy tightening.

2. Continuous Release of Favorable Policies

China has launched supportive policies to reduce operational burdens, including the nationwide cross-customs-zone goods return mechanism and tax exemption for returned export goods during 2026–2027. In addition, regional trade agreements such as RCEP and CPTPP effectively reduce cross-border trade costs, simplify customs clearance procedures and improve global trade facilitation, creating a more friendly institutional environment for cross-border enterprises [3].

3. Digital Technology Empowers Industrial Upgrading

AI, big data and smart logistics are comprehensively reshaping industry operations. Intelligent tools realize efficient market analysis, product listing and precision marketing, greatly reducing manual costs and improving conversion efficiency. Upgraded logistics systems shorten cross-border delivery cycles, while digital services and virtual products have become emerging high-growth tracks, lowering the threshold for small and medium-sized enterprises to go global.

4. Industrial Branding and Platform Diversification

The market pattern is no longer monopolized by Amazon, as TikTok Shop, regional platforms and new domestic overseas layouts provide diversified channel options. The industry is transforming from low-price competition to brand-driven development. A growing number of Chinese independent brands have gained popularity overseas, breaking the low-end stereotype of Chinese manufacturing. Brand refinement and localized operation have become core competitive advantages for sustainable development.

Conclusion

International cross-border e-commerce is in a stage of coexisting challenges and opportunities. Policy, logistics and competitive barriers are both short-term constraints and catalysts for industrial upgrading and standardized development. Emerging market dividends, policy support and digital empowerment continue to drive industrial growth. To achieve stable overseas development, enterprises must adapt to compliance requirements, optimize supply chain and cost management, and abandon homogenized low-price competition. Meanwhile, enterprises should seize emerging market opportunities, leverage digital technologies, and deepen localized brand operation [4].

In the future, with further global digital transformation and regional trade integration, traditional industrial barriers will be gradually eliminated. Cross-border e-commerce will step into a high-quality development era and continue to play a vital role in boosting global trade recovery and international economic cooperation.

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UDC 332

EVALUATION OF THE IMPLEMENTATION OUTCOMES OF THE "CULTURAL TOURISM+" STRATEGY AND AN ANALYSIS OF ITS ROLE IN PROMOTING GUANGXIS ECONOMIC DEVELOPMENT

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Abstract: Against the background of deep integration and cross-sector cooperation in China's cultural tourism industry, the "Cultural Tourism+" strategy has become an important driver for regional economic transformation and industrial upgrading. Guangxi Zhuang Autonomous Region possesses rich and distinctive cultural tourism resources, including Guilin's natural landscapes, Beibu Gulf coastal scenery, ethnic minority cultures, frontier customs, and revolutionary heritage. In recent years, Guangxi has actively promoted the "Cultural Tourism+" strategy through the integration of tourism with agriculture, wellness, commerce, sports,

industry, and digital technologies, gradually forming new tourism products and consumption models. This paper evaluates the implementation outcomes of Guangxi's "Cultural Tourism+" strategy and analyzes its impact on regional economic development from the perspectives of industrial integration, employment, rural revitalization, and industrial structure optimization. The study finds that the strategy has significantly promoted consumption growth, improved industrial coordination, and enhanced regional economic vitality. However, challenges such as insufficient infrastructure, product homogenization, weak digital innovation, and talent shortages still limit its effectiveness. Finally, targeted recommendations are proposed to improve the sustainability and competitiveness of Guangxi's cultural tourism industry.

Keywords: cultural tourism; industrial integration; regional economy; Guangxi; rural revitalization; digital tourism; economic development

Introduction

With the rapid development of China's service economy and the continuous upgrading of consumption structures, cultural tourism has become an important engine for regional economic growth. The "Cultural Tourism+" strategy emphasizes the deep integration of tourism with agriculture, industry, digital economy, wellness, sports, commerce, and education, thereby promoting diversified industrial development and improving regional competitiveness. Guangxi Zhuang Autonomous Region is one of China's richest regions in terms of cultural and tourism resources. The region possesses internationally recognized landscapes such as Guilin, coastal tourism resources in the Beibu Gulf, diverse ethnic minority cultures represented by the Zhuang nationality, revolutionary heritage sites, and unique border customs. These advantages provide Guangxi with strong potential for developing an integrated cultural tourism economy. In recent years, Guangxi has accelerated the implementation of the "Cultural Tourism+" strategy by promoting the integration of tourism with rural revitalization, digital economy, wellness industries, and cultural creativity. A series of new tourism products and consumption models have emerged, contributing to industrial transformation and regional economic growth. The regional government has also introduced several development plans and industrial integration policies aimed at improving tourism quality and building Guangxi into an internationally influential tourism destination [1]. At present, Guangxi's economy is undergoing a critical stage of structural transformation and industrial upgrading. Traditional industries are facing development bottlenecks, making it necessary to cultivate new economic growth drivers and expand employment opportunities. In this context, the "Cultural Tourism+" strategy plays an increasingly important role in promoting industrial coordination, stimulating domestic demand, increasing rural incomes, and narrowing regional development gaps. Existing studies have extensively discussed the relationship between cultural tourism and regional economic development. Scholars generally agree that tourism has strong industrial

linkage effects and significant capacity to stimulate consumption and employment [4]. Research also demonstrates that tourism integration contributes to rural revitalization and regional branding, particularly in ethnic minority regions [5]. However, systematic evaluations of Guangxi's "Cultural Tourism+" strategy remain limited, and most existing studies focus only on individual aspects such as tourism revenue or industrial growth, lacking comprehensive multidimensional analysis. This paper therefore focuses on evaluating the implementation outcomes of Guangxi's "Cultural Tourism+" strategy and examining its influence on economic development from multiple perspectives, including industrial integration, employment promotion, rural revitalization, and sustainable development.

Evaluation of the "Cultural Tourism+" Strategy

The effectiveness of the "Cultural Tourism+" strategy should not be evaluated solely by tourist arrivals or tourism revenue. Instead, a multidimensional evaluation framework should be established based on industrial integration, comprehensive benefits, and sustainability.

From the perspective of industrial integration, the strategy has significantly strengthened the connection between tourism and agriculture, wellness, digital economy, commerce, and cultural creativity. For example, rural tourism and leisure agriculture projects have expanded rapidly in Guangxi, increasing agricultural value-added and creating new consumption scenarios. Industrial tourism projects and digital tourism platforms have also accelerated the transformation of traditional industries into experience-oriented industries.

In terms of comprehensive benefits, the strategy has contributed substantially to economic growth and employment creation. The development of tourism-related industries has increased the added value of the tertiary sector and stimulated local consumption. At the same time, tourism expansion has created employment opportunities for local residents, especially in rural areas and ethnic minority regions. Rural tourism projects have improved farmers' income levels and promoted poverty alleviation.

From the sustainability perspective, Guangxi has increasingly emphasized ecological protection and cultural preservation during tourism development. The integration of ecological resources with tourism products has promoted green development and improved the efficiency of resource utilization. At the same time, the region has strengthened the promotion of local cultural brands and enhanced its tourism competitiveness.

The "Cultural Tourism+" strategy influences Guangxi's economy through several important mechanisms.

First, the strategy stimulates domestic demand and expands consumption. By combining tourism with food culture, wellness services, ethnic culture, and entertainment activities, Guangxi has extended tourists' stay duration and increased tourism-related spending. Tourism consumption has gradually shifted from traditional sightseeing toward comprehensive regional consumption.

Second, the strategy promotes industrial structure optimization. Traditional industries such as agriculture and manufacturing are increasingly integrated with tourism activities, forming new industrial chains and increasing value-added production. For example, traditional agricultural production has evolved into leisure agriculture and experiential tourism, while industrial enterprises have developed industrial tourism and cultural exhibition projects.

Third, the strategy contributes to balanced regional development. Guangxi's western and rural regions traditionally faced relatively weak economic foundations. Through tourism development, ethnic minority cultures and ecological resources have gradually been transformed into economic advantages, promoting county-level economic growth and rural revitalization.

In addition, digital transformation has become an important component of the "Cultural Tourism+" strategy. Technologies such as artificial intelligence, big data, smart tourism platforms, and digital marketing have improved tourism management efficiency and enhanced tourists' experiences. Digital tourism consumption has become an important growth area in Guangxi's tourism industry.

Practical Challenges

Although Guangxi has achieved significant progress in implementing the "Cultural Tourism+" strategy, several practical challenges remain.

First, some "Cultural Tourism+" projects still suffer from homogenization and lack innovative cultural content. In many areas, tourism integration remains limited to basic sightseeing and agricultural experience activities without deep cultural exploration or immersive experiences.

Second, tourism infrastructure and supporting services remain insufficient in some regions. Transportation accessibility, high-quality accommodation, medical rescue services, and international tourism facilities still require further improvement, particularly in remote areas rich in tourism resources.

Third, the level of digital transformation remains uneven. Some tourism enterprises lack digital operation capabilities, while the integration of artificial intelligence, big data analysis, and smart tourism management is still limited. This weakens the competitiveness of Guangxi's tourism industry in the national market.

Fourth, there is a shortage of high-quality tourism professionals and digital talents. The rapid development of integrated tourism industries requires interdisciplinary talents familiar with tourism management, digital technology, cultural creativity, and international marketing.

Recommendations

To further improve the effectiveness of the "Cultural Tourism+" strategy, Guangxi should deepen the exploration of local cultural resources and develop differentiated tourism brands. Ethnic minority cultures, revolutionary heritage, and maritime traditions should be transformed into distinctive tourism intellectual properties to avoid homogeneous competition. At the same time, Guangxi should strengthen the integration of tourism and digital technology. Smart tourism systems,

digital marketing platforms, artificial intelligence applications, and online tourism services should be expanded to improve tourism efficiency and consumer experience.Institutional coordination also needs to be strengthened. A cross-departmental integrated management mechanism should be established to improve policy coordination in areas such as land use, taxation, infrastructure, and industrial investment.In addition, Guangxi should increase investment in talent cultivation and infrastructure construction. Universities and vocational institutions should strengthen tourism-related training programs, while transportation systems and tourism public services should be continuously improved.

Conclusion

The "Cultural Tourism+" strategy has become an important pathway for Guangxi to achieve high-quality economic development. By promoting industrial integration, stimulating consumption, and supporting rural revitalization, the strategy has significantly contributed to regional economic transformation and industrial upgrading. At the same time, Guangxi still faces several challenges, including insufficient infrastructure, weak digital innovation, product homogenization, and talent shortages. Therefore, improving cultural creativity, strengthening technological empowerment, optimizing institutional mechanisms, and enhancing infrastructure construction are essential for increasing the competitiveness and sustainability of Guangxi's tourism industry.Overall, the continuous optimization of the "Cultural Tourism+" strategy will help Guangxi transform its cultural and tourism resource advantages into long-term economic strengths, strengthen regional economic vitality, and promote sustainable and coordinated development.

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THE IMPACT OF THE BELT AND ROAD INITIATIVE ON CHINA-KAZAKHSTAN CROSS-BORDER TRADE

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1. Introduction

Since the launch of the Belt and Road Initiative (BRI) in 2013, it has become a core framework for advancing regional economic connectivity between China and Central Asia. As China's largest Central Asian trading partner and a key BRI participant, Kazakhstan has seen robust growth in bilateral cross-border trade over the past decade. Among land ports facilitating bilateral economic exchanges, Khorgos Port serves as the pivotal logistics and trade hub, linking China's domestic market with Central Asia, Europe and other regions. Amid fluctuating global supply chains and accelerated regional economic integration, the port's strategic and economic value has grown increasingly prominent.

Differing from existing macro-focused bilateral trade studies, this paper centers on Khorgos Port's practical operation and development, exploring the BRI's specific driving effects on China-Kazakhstan cross-border trade, objectively assessing the port's current development dilemmas, and clarifying its tangible contributions to bilateral economic and trade cooperation. The research findings supplement targeted empirical research on key regional ports under the BRI, and provide feasible references for optimizing bilateral trade cooperation and promoting high-quality cross-border economic development.

2. Literature Review

Existing research on the BRI and China-Kazakhstan economic cooperation has established a solid theoretical foundation. Most scholars verify the BRI's positive role in advancing infrastructure construction, lowering trade costs and enhancing regional trade connectivity, noting that the initiative has broken geographical and institutional barriers to China-Central Asia economic exchanges. Studies on China-Kazakhstan trade cooperation have comprehensively analyzed the evolution of bilateral trade scale, commodity structure and cooperation fields, highlighting strong economic complementarities in energy, agriculture, mechanical and electrical products. A small number of studies have addressed cross-border ports, identifying Khorgos Port as the flagship carrier of bilateral land trade.

However, current research has clear limitations: most analyses remain at the macro bilateral trade level, lacking in-depth empirical research on Khorgos Port's operational efficiency, economic contribution and restrictive factors. Few studies

combine the port's current status to evaluate its supporting role in bilateral relations. This paper takes Khorgos Port as the research object, addressing these research gaps with targeted and detailed analysis of the BRI's practical impact on bilateral cross-border trade.

3. Methodology and Data

This paper adopts a combined approach of descriptive statistical analysis and empirical case assessment, which aligns with research needs focusing on port operational practice and trade effect evaluation. This method avoids overly complex theoretical modeling, prioritizes actual data interpretation and practical problem analysis, ensuring research conclusions are realistic and policy-oriented.

3.1 Data Sources

All research data are sourced from authoritative official statistics and public policy documents to guarantee empirical analysis accuracy: 2015-2025 bilateral trade volume, commodity classification and port freight throughput data are from the General Administration of Customs of China and the Committee on Statistics of the Republic of Kazakhstan; port operational data, infrastructure construction progress and customs clearance efficiency indicators are from official announcements of Khorgos Comprehensive Free Trade Zone and China-Kazakhstan cross-border cooperation zone; policy data are collected from bilateral government cooperation agreements, BRI implementation documents and Eurasian Economic Union policy announcements. Theoretical support is supplemented by UNCTAD research reports and regional economic cooperation studies from relevant universities.

3.2 Analytical Ideas

First, this paper sorts out Khorgos Port's development under the BRI, clarifying phased characteristics of infrastructure improvement, logistics capacity upgrading and customs clearance system optimization. Second, it empirically tests the port's contribution to bilateral trade volume growth, trade structure optimization and logistics efficiency improvement through pre- and post-full-operation trade data comparison. Third, it objectively analyzes constraints on the port's development and its intrinsic connection with deepening bilateral economic and trade relations. Finally, targeted optimization suggestions are proposed for high-quality port development and sustainable bilateral trade cooperation.

4. Current Status and Empirical Analysis of Khorgos Port

4.1 Development Status of Khorgos Port

Driven by the BRI, Khorgos Port has achieved leapfrog development in the past decade. With fully operational China-Kazakhstan railway interchange hub and rising annual China-Europe freight train traffic, it has become the largest land port for China-Kazakhstan cross-border trade. Optimized customs clearance models and deeper bilateral customs cooperation have shortened cargo transit time and reduced cross-border enterprise trade costs. The port has formed a diversified trade pattern covering agricultural products, mechanical and electrical products, energy equipment

and daily consumer goods, driving the development of surrounding cross-border logistics, warehousing and processing supporting industries.

Nevertheless, the port faces practical constraints: uncoordinated digital customs clearance construction and blocked cross-border data interconnection; relatively single trade structure with low proportion of high-value-added and high-tech products; imperfect cross-border e-commerce supporting system and insufficient industrial driving effect.

4.2 Economic Contribution of Khorgos Port

Khorgos Port has become the core engine of China-Kazakhstan cross-border trade growth. Statistics show that 2015-2025, bilateral cross-border trade volume via the port increased by nearly 3.2 times, accounting for over 40% of total bilateral land trade, directly driving border area economic development of both countries. The port promotes cross-border flow of production factors, expanding export channels for Kazakhstan's agricultural and energy products and providing a stable Central Asian market for China's high-quality mechanical and electrical products and daily necessities. It also drives the development of logistics, processing and commerce industries, creates mass employment, and boosts border regional economic integration. Moreover, its efficient operation improves bilateral trade facilitation, laying a foundation for expanded cooperation fields and setting a demonstration for high-quality BRI project development.

4.3 The Port and China-Kazakhstan Bilateral Relations Deepening

Khorgos Port is not only an economic and trade project, but also a key carrier for promoting China-Kazakhstan comprehensive strategic partnership. Smooth port construction and improved operational efficiency have deepened bilateral political mutual trust and practical cooperation, promoted enterprise and non-governmental exchanges, and consolidated the social foundation of friendly bilateral relations. As a key node for regional economic integration amid BRI and Eurasian Economic Union docking, the port facilitates trade rule coordination, standard connection and policy communication. Its stable operation consolidates the bilateral strategic partnership, tightens economic and trade ties, and supports long-term stable bilateral relations.

5. Conclusion and Policy Recommendations

Empirical analysis of Khorgos Port confirms that the BRI effectively promotes sustainable development of China-Kazakhstan cross-border trade. As a core cooperation platform, the port makes irreplaceable contributions to bilateral trade volume growth, trade structure optimization and bilateral relations deepening. It breaks through land transportation bottlenecks, reduces cross-border trade costs, drives regional economic coordinated development, and becomes a successful model for BRI practical cooperation.

However, the port's development is restricted by insufficient digital coordination, single trade structure and imperfect supporting systems, limiting its role in boosting bilateral trade. To unlock the port's potential and promote high-quality bilateral cross-border trade, this paper proposes four targeted suggestions: accelerate

port digital and intelligent construction, realize full interconnection of customs, logistics and supervision systems, and optimize the “single window” clearance model; optimize trade structure, expand high-value-added, high-tech and green product trade, and foster new trade forms such as cross-border e-commerce and bonded processing; deepen bilateral policy coordination and industrial docking, strengthen cooperation in infrastructure maintenance, market supervision and risk prevention; take the port as a link to expand cultural and educational non-economic exchanges, and consolidate the comprehensive strategic partnership.

With further BRI cooperation and port mechanism optimization, Khorgos Port will play a greater role in promoting bilateral cross-border trade and regional economic integration, injecting sustained impetus into long-term stable and in-depth development of China-Kazakhstan relations.

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TRADEDIGITAL ECONOMY ENABLES SUSTAINABLE DEVELOPMENT OF CHINA-KAZAKHSTAN AGRICULTURAL COOPERATION UNDER THE BELT AND ROAD INITIATIVE

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Abstract

Under the framework of the "the Belt and Road" initiative, agricultural cooperation has become a key pillar of economic and trade exchanges between China and Kazakhstan, with remarkable achievements in recent years. This paper focuses on the practice and development of China-Kazakhstan agricultural cooperation, analyzes the complementary advantages of the two countries in agricultural resources, technology and market, explores the role of digital economy in promoting bilateral agricultural cooperation, and uses data charts to visualize the growth trend of agricultural trade and investment. Finally, it puts forward targeted suggestions to further deepen bilateral agricultural cooperation, providing reference for the high-quality development of China-Kazakhstan economic and trade relations under the background of digital transformation

Keywords: Economic and Trade Relations; China-Kazakhstan Agricultural Cooperation; Cross-border Trade; Digital Transformation

1. Introduction

As a core cooperative partner of China in Central Asia, Kazakhstan has a long history of agricultural cooperation with China. With the in-depth advancement of the "the Belt and Road" initiative(BRI), the two countries have further strengthened policy coordination, resource complementarity and technological exchanges in the agricultural field, forming a win-win cooperation pattern covering planting, breeding, processing, logistics and other links. In recent years, the digital transformation of the global economy has brought new opportunities for bilateral agricultural cooperation. The application of digital technologies such as artificial intelligence, Internet of Things and big data has effectively solved the pain points of low efficiency, backward technology and inconvenient circulation in traditional agricultural cooperation, injecting new vitality into the sustainable development of China-Kazakhstan agricultural cooperation. This paper sorts out the current situation of China-Kazakhstan agricultural cooperation, analyzes the role of digital drive, and puts forward relevant suggestions based on actual data, to provide support for deepening bilateral agricultural cooperation. Based on the research framework of Xu, W. C. (2024), this study focuses on the practice of China-Kazakhstan agricultural cooperation and explores the enabling effect of the digital economy under the BRI framework [1].

2. Complementary Advantages and Current Situation of China-Kazakhstan Agricultural Cooperation

Kazakhstan, known as the "granary of Central Asia," possesses superior agricultural conditions, with approximately 70% of its land suitable for agriculture and animal husbandry, and abundant in crops such as wheat, cotton; in the first half of 2024, Kazakhstan's total agricultural output value reached approximately 3.4 billion US dollars, representing a year-on-year increase of 3.4%. Within this, the livestock sector contributed approximately 3.2 billion US dollars, while crop

cultivation accounted for approximately 200 million US dollars [2]; however, its agricultural modernization level remains relatively low, characterized by outdated machinery, limited adoption of advanced technologies, and low production efficiency, which constrains the sector's development. In contrast, China has mature experience in agricultural technology, machinery manufacturing, water-saving irrigation, and agricultural product processing, along with strong advantages in the R&D and application of digital agricultural technologies, as well as a vast consumer market that provides broad opportunities for the export of Kazakhstan's agricultural products. The complementary advantages of the two countries in agricultural resources, technology, and markets have laid a solid foundation for deeper agricultural cooperation. In recent years, China-Kazakhstan agricultural cooperation has shown a steady growth trend, with expanding scale and diversification of fields. In terms of trade, the total agricultural trade volume maintained rapid growth, reaching USD 1.4 billion in 2024, a year-on-year increase of 10%; in the first five months of 2025, trade volume reached USD 736.9 million, up 36% year-on-year, of which Kazakhstan's exports to China grew 35% to USD 513.4 million. Key Kazakh exports to China include feed, vegetable oil, and wheat, with feed exports surging 485% year-on-year in 2024 to 1.2 million tons, and vegetable oil rising 26% to 173,300 tons. In investment, there are four Chinese-funded agricultural projects in Kazakhstan, with a total investment of approximately USD 2.8 billion, covering planting, processing, animal husbandry, and agricultural logistics. Additionally, the two countries have deepened cooperation in agricultural technology R&D and promotion - for example, the first China-Kazakhstan Agricultural Technology and Export Development Science and Technology Park was established in North Kazakhstan region, focusing on new variety breeding, digital and automated applications, and deep processing of agricultural products. China's water-saving drip irrigation technology has also been widely adopted in Kazakhstan, contributing to increased yields of crops such as sugar beets.

3. The Role of Digital Economy in Promoting China-Kazakhstan Agricultural Cooperation

The digital economy has become a new driving force for China-Kazakhstan economic and trade relations. The application of technologies like the Internet of Things and precision agriculture has enhanced farming efficiency. For example, at a joint agricultural base in North Kazakhstan, soil testing and digital monitoring systems have enabled a shift from "relying on weather" to "relying on technology". China’s smart farm machinery has also been introduced, boosting productivity and supporting agricultural modernization in Kazakhstan. Logistics digitization has improved cross-border agricultural trade. Leveraging the China-Europe Railway Express, a digital logistics system has shortened transport time to under ten days and increased annual trade volume significantly. Cross-border e-commerce platforms further provide direct sales channels; reducing intermediaries and raising product value. Digital tools also foster agricultural technology exchange. Remote training,

joint research, and digital courses are now common. The China-Kazakhstan Agricultural Technology Park, for instance, has introduced 32 Chinese crop varieties for trial planting and helps local farmers master advanced techniques through online training, enhancing overall agricultural capacity.

4. Analysis of China-Kazakhstan Agricultural Cooperation Data (2020-2025)

To objectively and intuitively reflect the development trends and growth characteristics of China-Kazakhstan agricultural cooperation under "the Belt and Road" initiative, this article compiles core data on bilateral agricultural product trade from 2020 to 2025. The data is presented in a table format, complemented with textual analysis to uncover underlying patterns.

Table 1 Core Data on Bilateral Agricultural Product Trade, 2020-2025

Year	Total Agricultural Product Trade Volume (in USD 100 million)	Year-on-year growth rate	Kazakhstan's Export Value to China (in USD 100 million)	Kazakhstan's Export Share to China
2020	8.5	—	6.2	72.9%
2021	9.8	15.3%	7.3	74.5%
2022	11.2	14.3%	8.5	75.9%
2023	12.7	13.4%	9.8	77.2%
2024	14	10.2%	11.0	78.6%
2025	17.68	26.3%	12.32	69.7%

Data source: General Administration of Customs of the People's Republic of China. 2020 -2025 Statistical Data on Agricultural Import and Export between China and Kazakhstan [4].Based on the tabular data and related trade details, the development features of China-Kazakhstan agricultural cooperation can be analyzed from three dimensions:

First, the scale of bilateral agricultural trade continues to expand, demonstrating strong growth resilience. From 2020 to 2024, the total trade volume increased from $850 million to $1.4 billion, with a cumulative growth of 64.7% and an average annual growth rate of 13.2%. The trade volume in 2025 is projected to exceed $1.7 billion, with a year-on-year growth rate accelerating to 26.3%, indicating a stage of rapid expansion.

Second, the trade structure exhibits a pattern of "Kazakhstan-led exports supplemented by Chinese supplies." Between 2020 and 2024, Kazakhstan’s agricultural exports to China grew from $620 million to $1.1 billion, an increase of 77.4%, with its share of total bilateral trade consistently exceeding 72% and peaking at 78.6% in 2024. This confirms China as a core export market for Kazakhstan’s agricultural products, with agricultural exports becoming a key driver of bilateral economic cooperation. In 2025, Kazakhstan’s export share is expected to slightly

decrease to 69.7%, reflecting a more balanced trade structure as China's exports of agricultural machinery and supplies to Kazakhstan increase.

Third, the growth momentum of key export products is significant, with cooperation focusing on core areas. From 2023 to 2024, Kazakhstan's feed exports to China surged by 485%, while vegetable oil exports increased by 26%. During the period from September 2024 to April 2025, grain exports (primarily wheat and barley) grew by 27% year-on-year, accounting for 42.3% of Kazakhstan's total agricultural exports to China. Meanwhile, China's exports of agricultural machinery and irrigation equipment to Kazakhstan reached $180 million in 2024, a year-on-year increase of 31%, effectively addressing equipment gaps in Kazakhstan's agricultural modernization and forming a mutually complementary trade structure.

5. Challenges in China-Kazakhstan Agricultural Cooperation

China-Kazakhstan agricultural cooperation has achieved progress yet faces three main challenges: limited digital transformation, persistent cross-border inspection barriers, and underdeveloped high-value-added processing. To address these, four policy directions are proposed: advancing digital agricultural collaboration through technical support and training; updating bilateral inspection protocols to streamline customs processes; expanding joint processing to extend value chains; and strengthening policy coordination with enhanced investment support, fostering a more conducive environment for sustained bilateral cooperation.

6. Conclusion

Under BRI framework, leveraging their complementary strengths in agricultural resources, technology, and markets, China and Kazakhstan have achieved remarkable results in agricultural cooperation. The digital economy has played a vital role in optimizing agricultural production efficiency, enhancing the circulation efficiency of agricultural products, and promoting technological innovation in agriculture, thereby injecting new momentum into the sustainable development of bilateral agricultural collaboration. Data show that trade in agricultural products between the two countries has grown steadily, with the scope of cooperation continuously expanding. In the future, by strengthening cooperation in digital technologies, streamlining customs clearance procedures, and expanding collaboration in high value-added processing, China and Kazakhstan can further deepen their agricultural partnership. This will enable both sides to achieve mutual benefit and make greater contributions to the high-quality development of bilateral economic and trade relations.

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UDC 336

THE ROLE OF GOVERNMENT SUBSIDIES AND SUPPORT IN STIMULATING INNOVATIVE ENTREPRENEURSHIP: A STUDY BASED ON LISTED SEMICONDUCTOR ENTERPRISES IN CHINA

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Abstract : Innovation is a key driver of national economic development, particularly in the context of intensifying global technological competition and the deepening of the Belt and Road Initiative. Enterprises remain the primary actors of both technological and industrial innovation, while government subsidies represent an important policy instrument to stimulate innovation activities. Existing studies highlight both the positive and negative effects of subsidies; however, insufficient attention has been paid to the underlying mechanisms and heterogeneity of these effects. This paper examines the impact of government subsidies on innovative entrepreneurship in China's semiconductor industry. Based on theoretical analysis and econometric modeling, the study reveals that government subsidies significantly promote innovation, while demonstrating notable regional heterogeneity. The findings provide policy implications for optimizing subsidy allocation and enhancing innovation efficiency in strategic industries.

Keywords: government subsidies; innovative entrepreneurship; semiconductor industry; regional heterogeneity; innovation policy

Introduction

The semiconductor industry constitutes the technological foundation of the modern digital economy and plays a strategic role in national competitiveness. Since 2010, China's semiconductor production and exports have demonstrated sustained growth, reflecting strong industrial expansion and active government support. Despite

these achievements, the industry continues to face critical challenges, including dependence on foreign core technologies, insufficient research and development investment, and relatively low levels of technological self-sufficiency. The dynamics of industry growth are illustrated in Figure 1.

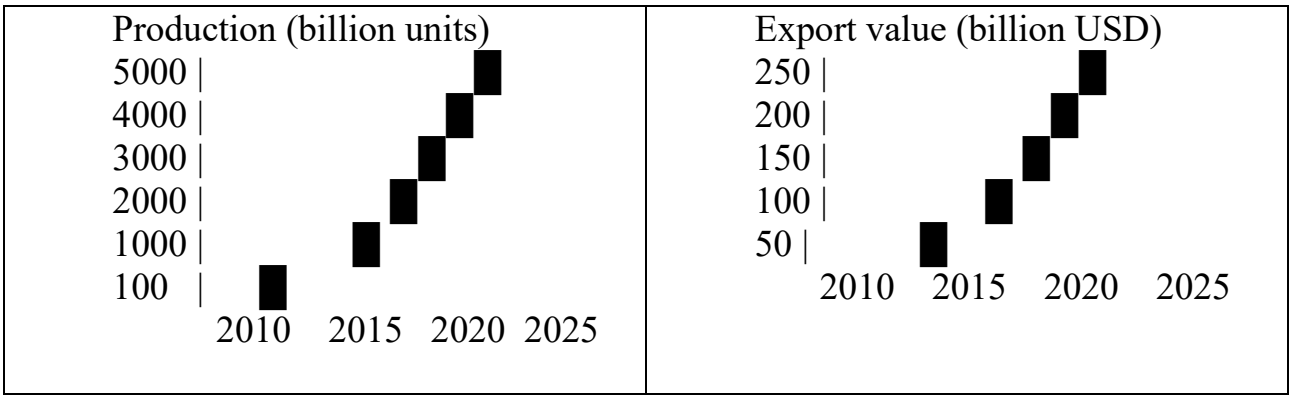

Figure 1. Growth of China's semiconductor production and export value (2010–2025)

Source: compiled based on National Bureau of Statistics and customs data.

Innovation in the semiconductor sector is characterized by high capital intensity, long development cycles, and substantial uncertainty. Under such conditions, market mechanisms alone are often insufficient to ensure efficient resource allocation. Government subsidies therefore play an important role in correcting market failures, reducing innovation risks, and stimulating enterprise-level research and development activities. At the same time, academic literature provides mixed evidence regarding their effectiveness. On the one hand, subsidies can alleviate financial constraints, enhance innovation input, and improve access to external financing. On the other hand, they may distort enterprise incentives, reduce efficiency, and lead to resource misallocation.

This study focuses on China's semiconductor industry and analyzes the impact of government subsidies on innovative entrepreneurship. It is hypothesized that subsidies positively affect enterprise innovation and that their effectiveness varies across regions.

The empirical analysis is based on panel data from A-share listed semiconductor enterprises for the period 2020–2024. Innovation performance is measured using R&D investment and patent output, while government subsidies are treated as the key explanatory variable. Control variables include firm size, age, leverage, and profitability. The descriptive statistics of the main variables are presented in **Table 1.**

Table 1. Descriptive statistics of key variables

Variable	Mean	Std. Dev.	Min	Max

Variable	Mean	Std. Dev.	Min	Max
R&D expenditure	8.45	1.92	4.10	12.30
Patent applications	152	87	15	420
Government subsidies	5.62	2.15	0.80	11.50
Firm size	22.10	1.35	19.50	25.80
Leverage ratio	0.48	0.21	0.10	0.85

Source: calculated by the author based on enterprise data.

The analysis shows that government subsidies influence innovation through several mechanisms. First, they reduce financial constraints and increase R&D investment. Second, they generate a signaling effect, improving firms' access to financing. Third, they facilitate collaboration within innovation ecosystems. However, the effectiveness of these mechanisms depends on regional conditions. In the eastern region, developed infrastructure and innovation capacity enhance the efficiency of subsidy utilization, whereas in central and western regions the effect is comparatively weaker.

The findings confirm that government subsidies significantly promote innovative entrepreneurship in China's semiconductor industry, although their effectiveness varies across regions. This suggests the need for differentiated policy approaches.

Based on the results, several policy recommendations can be proposed. The government should strengthen targeted support for key technological areas, improve the efficiency of subsidy allocation, and promote coordination between industry, academia, and government. In addition, expanding international cooperation under the Belt and Road Initiative can further enhance innovation capacity and global competitiveness.

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THE INFLUENCE OF STRATEGIC TRADE CONTROL ON THE INVESTMENT ATTRACTIVENESS OF COUNTRIES

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Abstract

Against the backdrop of the reshaping of the global geo-economic pattern and the rise of trade protectionism, strategic trade controls have become a core policy instrument for countries to safeguard industrial security, technological advantages and economic sovereignty, covering various forms such as export control of technologies, regulation of strategic goods, and restrictions on foreign investment access. As a crucial institutional arrangement, such policies have not only restructured global trade rules and industrial chain layouts, but also exerted profound influences on cross-border capital flows and international investment attractiveness of countries in terms of investment costs, market expectations, industrial chain stability and technological development potential. Based on the current global economic and trade context, this paper analyzes the dual influence of strategic trade controls on national investment attractiveness from four dimensions: raising cross-border investment costs, reshaping regional investment patterns, forcing the upgrading of domestic industries, and intensifying global investment uncertainty. Relevant policy implications are summarized, so as to provide a reference for all countries to balance trade security and investment promotion.

Keywords: Strategic Trade Controls; Investment Attractiveness; Cross-border Investment; Industrial Chain

Introduction

With the in-depth adjustment of economic globalization, the global economic and trade system that once prioritized efficiency has gradually transformed into a development model that attaches equal importance to security and efficiency. To cope with risks including industrial chain decoupling, technological monopoly and resource security, countries worldwide have successively introduced strategic trade control policies. Focusing on strategic sectors such as semiconductors, high-end manufacturing, new energy and rare mineral resources, they have implemented targeted trade regulation and market access restrictions. Different from traditional tariff barriers, strategic trade controls center on national security and industrial strategies, featuring strategic orientation, pertinence and exclusivity. Rather than

simply increasing trade revenue, they aim to serve long-term industrial competition and geo-economic games.

National investment attractiveness is a core indicator measuring a country's capacity to attract foreign investment, which is determined by multiple factors including business environment, industrial chain supporting capacity, policy stability and technological innovation potential. The widespread implementation of strategic trade controls has broken the traditional cross-border investment logic under free trade, and greatly changed the direction and layout of global capital flows. Some countries have consolidated industrial barriers and fostered domestic competitive advantages through regulatory policies, thus improving investment attractiveness in strategic fields. Nevertheless, excessive control measures adopted by some economies have raised market entry thresholds, disrupted the operation of global industrial chains, triggered foreign capital outflow and weakened investment vitality. Therefore, an in-depth discussion on the multiple impacts of strategic trade controls on national investment attractiveness is of great practical significance for countries to optimize regulatory policies, stabilize foreign investment and enhance comprehensive international competitiveness.

1. Higher Cross-border Investment Costs and Reduced Overall Foreign Investment Attractiveness

By setting restrictions on commodity exports, technical licensing barriers and foreign investment review mechanisms, strategic trade controls directly increase the production, operation and compliance costs of multinational enterprises, thereby weakening a country's overall ability to attract foreign capital. Within the global labor division system, cross-border investment is highly dependent on the free circulation of components, technology sharing and resource allocation across borders. Restrictions on strategic industries will directly hinder the connection between upstream and downstream links of industrial chains.

For foreign-funded enterprises, operating in regions with strict trade controls means limited procurement of key raw materials, blocked introduction of core technologies and restricted export of finished products, which greatly heighten operational uncertainties. Meanwhile, many countries have formulated stringent foreign investment security review rules, prolonging the approval process for foreign capital access and raising market entry standards, which further increase enterprises' time cost and compliance burden. In practice, rigorous strategic trade controls will accelerate the withdrawal of export-oriented and labor-intensive foreign enterprises. It will significantly curb investment in the manufacturing sector relying on import and export business, and continuously weaken a country's comprehensive competitiveness in general investment attraction.

2. Restructuring Global Investment Layouts and Triggering Polarization of Regional Capital

Strategic trade controls are deeply embedded with geo-political attributes. They have subverted the balanced distribution pattern of global capital, guided

international investment to shift from global decentralized layout to regional clustering, and led to obvious differentiation in investment attractiveness among countries. At present, great disparities exist in the formulation and implementation of national strategic trade policies. Developed countries rely on their technological edge to impose strict export controls on high-end technologies and sophisticated equipment, so as to control core resources of high-end industrial chains. Developing countries mainly focus on the regulation of strategic resources and basic industries, striving to consolidate domestic industrial foundations and undertake medium and low-end industrial transfer and investment.

As trade barriers divide the global market, multinational corporations, in order to avoid regulatory risks and ensure supply chain security, tend to abandon global diversified investment and prioritize economies with stable policies, moderate trade control and complete regional economic and trade cooperation mechanisms. Countries and regions covered by regional economic and trade agreements have built solid and closed regional industrial chains by appropriately relaxing internal strategic control measures, continuously gathering regional capital and steadily improving investment appeal. On the contrary, countries that adhere to unilateralism and exclusive trade controls are gradually marginalized in the global industrial division system, accompanied by continuous shrinkage of foreign capital inflows. Eventually, a distinct pattern has taken shape: open and inclusive regions gain foreign investment, while closed and conservative regions face capital loss.

3. Promoting Independent Industrial Upgrading and Enhancing Competitiveness in Strategic Investment Fields

Strategic trade controls are not merely defensive trade barriers, but also important policy tools for all countries to protect core strategic industries and drive independent innovation and industrial upgrading, which can effectively boost investment attractiveness in high-end and key sectors. For a long time, many countries have suffered from high external dependence on core technologies and key strategic materials. Their domestic strategic industries are weak in independent innovation, while foreign capital monopolizes the high-end market for a long time, resulting in insufficient endogenous investment momentum in emerging industries.

Targeted and rational strategic trade controls can curb the blind dumping of backward foreign technologies and restrain the monopoly behavior of foreign capital in core strategic tracks, reserving sufficient market space and development opportunities for local enterprises. Protected by effective policies, domestic high-end manufacturing, semiconductors, new energy, advanced materials and other strategic industries achieve rapid development, with supporting industrial chains gradually improved and independent research and development capabilities continuously enhanced. In addition, to cultivate strategic emerging industries, governments have introduced supporting incentives including tax preferences, R&D subsidies and land support, effectively reducing the investment cost of high-end industries. Consequently, these countries gain stronger competitive edges in strategic emerging

sectors, capable of attracting high-quality foreign investment in R&D and intelligent manufacturing, and achieving prominent improvement in the investment attractiveness of segmented high-end industries.

4. Increasing Policy Uncertainty and Weakening Global Investment Confidence

Strategic trade controls feature strong policy flexibility and exogenous interference, and are easily adjusted according to geo-political relations, international game changes and domestic industrial demands. The frequent changes of relevant rules will greatly increase the uncertainty of the investment environment and universally weaken international investment willingness. Different from conventional economic and trade policies such as tariffs and exchange rates, there is no unified global unified rule for strategic trade controls. Policy standards vary greatly among countries, with frequent updates and strong political attributes, vulnerable to the fluctuation of international relations.

For international investors, unpredictable and changing trade control policies make it difficult to formulate long-term development plans, and substantially raise cross-border investment risks. Driven by risk aversion, global capital will scale back cross-border long-term investment, turn to short-term and low-risk capital allocation, and lead to the overall contraction of global foreign direct investment. Both control-implementing countries and their trade partners will be affected by policy spillover effects. The stability of the business environment is undermined, the international investment reputation declines, and it becomes difficult to sustain the inflow of long-term and high-quality international capital.

Conclusion

To sum up, strategic trade controls exert typical dual effects on national investment attractiveness. Excessively stringent control policies in the short term will push up cross-border investment costs, amplify market uncertainties and weaken a country's overall capacity to attract foreign capital. However, moderate and precise strategic trade controls can protect domestic strategic industries, accelerate industrial transformation and upgrading, optimize regional investment layouts through regional cooperation, and build core competitive advantages in key industrial sectors.

Under the complex global economic and trade landscape, all countries should neither over-rely on trade protectionism nor completely open up strategic fields without restrictions. It is essential to balance national security and high-level opening-up, refine the scope and intensity of strategic trade controls, and avoid industrial chain division caused by excessive regulation. Meanwhile, countries need to participate in multilateral and regional economic and trade cooperation, improve domestic industrial supporting systems, stabilize policy expectations for foreign investors, and steadily enhance international investment attractiveness. Only in this way can we effectively coordinate industrial security and opening-up development, and realize the high-quality interaction between trade regulation and foreign investment.

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REGULATORY FRAMEWORK FOR CHINA AND CENTRAL ASIA'S DUAL-USE ITEM TRADE FROM THE PERSPECTIVE OF INTERNATIONAL BUSINESS RULE COORDINATION: CHALLENGES AND INSTITUTIONAL INNOVATION

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Abstract

Against the Belt and Road Initiative and global supply chain restructuring, dual-use item trade between China and Central Asia is growing, exposing regulatory complexities. From international business rule coordination, this paper identifies core challenges: mismatched domestic laws and control lists, uneven participation in multilateral export control regimes, divergent digital regulatory standards, and differing risk perceptions. It proposes a "functional coordination" path with institutional innovations: regulatory sandbox pilots, digital customs mutual recognition, specialized committees, and capacity building. Pragmatic rule coordination can manage security risks, cut trade costs, and support the China-Central Asia strategic partnership.

Key words: international business, dual-use items, strategic trade control

1. Introduction

Dual-use items (civilian and military/proliferation applications) matter for economic security and non-proliferation obligations. Expanding cooperation in digital economy and new energy boosts cross-border flows of such items. Unilateral regulation causes rule frictions, raises corporate compliance costs, and limits high-

tech collaboration. Effective rule coordination to balance security and development is strategically and practically vital.

2. Framework and Current Status of Regulatory Coordination

International business rule coordination lowers transaction costs from regulatory gaps and eases factor flows. For dual-use items, it aims to improve transparency, predictability, and consistency while respecting national security sovereignty.

Both sides have basic export control legal systems: China's framework centers on the Export Control Law; Central Asian states follow international norms. However, cooperation is preliminary, relying on treaty provisions, ad-hoc customs work, and enterprise self-compliance, with no systematic dual-use coordination mechanism.

3. Key Challenges Faced

3.1 Domestic Legal and Control List Differences

Variations in classification, technical thresholds, and control rationales may lead to conflicting regulation between importer and exporter, causing delays and legal risks.

3.2 Uneven Multilateral Regime Participation

China aligns with global norms, but some Central Asian states are not full members of key regimes, delaying adoption of international control lists and creating mismatched oversight of emerging technologies.

3.3 Digital Regulatory and Standard Gaps

Modern dual-use regulation depends on e-licensing and risk-profiling. China has advanced single-window and smart customs systems, but Central Asian nations vary in digital infrastructure and regtech adoption. Poor system interoperability blocks efficient paperless oversight.

3.4 Divergent Risk Perception and End-User Management

Differing national security definitions and enforcement priorities create inconsistent controls. Weak information sharing and mutual trust mean end-use verification is not mutually recognized, forcing repeated checks and higher costs.

4. Pathways and Recommendations for Institutional Innovation

A shift to "functional coordination" via multi-layered innovation is proposed.

4.1 Regulatory Sandboxes and Targeted Pilots

Launch simplified licensing pilots in bilateral high-tech parks or key projects for civilian-focused dual-use items. Joint review, information sharing, and evidence gathering will support wider rule alignment.

4.2 China-Central Asia Digital Customs and Trust Recognition Initiative

Standardize sectoral dual-use data and e-license formats (short term); explore blockchain-based compliance certificates (medium term); build a regional compliance information platform (long term).

4.3 Specialized Dual-Use Trade Facilitation and Security Committee

Establish a working group under the China-Central Asia Joint Economic and Trade Committee to align control lists, issue guidelines, run early warnings, organize training, and collect industry compliance feedback.

4.4 Strengthen Capacity Building and Technical Assistance

Integrate dual-use regulation cooperation into China's aid and technical programs. Support Central Asian states in legislation, lab testing, customs risk analysis, and enforcement training to solidify long-term coordination.

5. Conclusion

Rule coordination seeks an adaptive governance network that manages shared risks while enabling legitimate trade. Regulatory sandboxes, digital trust systems, specialized committees, and capacity building can shift from passive friction avoidance to active rule synergy. This cuts institutional trade costs, spurs innovation cooperation, and advances the Belt and Road's security-trade integration. It offers a replicable "China-Central Asia model" for emerging markets' high-tech trade governance.

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AGRICULTURAL TRADE BETWEEN NORTHEAST CHINA AND RUSSIA UNDER THE BACKGROUND OF THE "BELT AND ROAD" INITIATIVE

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Annotation. This paper analyzes the development of agricultural trade between Northeast China and Russia within the framework of the Belt and Road Initiative (BRI). It examines the current state of agricultural production in both regions, highlighting their resource endowments and structural characteristics. The study emphasizes the complementarity between China's abundant labor resources and Russia's vast land resources, which creates strong potential for bilateral cooperation. It also identifies key opportunities, including improved infrastructure and cross-border economic integration, as well as risks related to geopolitical tensions, economic instability, and institutional constraints. Based on the analysis, the paper proposes policy recommendations to enhance the investment environment, strengthen risk management, and develop specialized human capital. The findings suggest that deepening agricultural cooperation can promote sustainable trade growth and strengthen economic ties between the two countries.

Key words: Belt and Road Initiative (BRI), agricultural trade, China–Russia cooperation, Northeast China, Russian Far East, cross-border trade, agricultural development, economic cooperation, trade risks, investment environment.

I. Current Status of Agricultural Development in Northeast China and Russia

1. Current status of agricultural development in Northeast China

The three northeastern provinces of China have vast territory and superior resource conditions. For this reason, Northeast China has always been an important major grain-producing area in China. Heilongjiang Province has a cultivated land area of 11.83 million hectares, accounting for 9.72% of the country's total cultivated land. It mainly produces rice, corn, soybeans and other grain crops, and is an important commodity grain base in China[2]. Jilin Province and Liaoning Province are major provinces for grain and animal husbandry, with cultivated land accounting for 4.55% and 3.36% of the national total, respectively. Animal husbandry is the leading industry of Jilin Province's agricultural economy, and the agricultural product processing industry is also one of the three pillar industries of the province. Corn is the most important cash crop in Liaoning Province.

2. Current status of agricultural development in Russia

In 2020, Russia's grain output reached 130 million tons, of which wheat output was 75.8 million tons. In terms of agricultural exports, Russia leads the world in

wheat exports, with an estimated export volume of 36 million tons. Currently, Russia's total agricultural exports have surpassed the total exports of military products, becoming the second largest pillar industry, second only to oil and natural gas exports[1]. Due to natural constraints such as geographical environment, climate, and soil, Russia's crop structure is relatively simple. Cash crops are mainly sunflowers and sugar beets, while the cultivated area of potatoes and vegetables accounts for only 3.78%. In Russia, there are only three months a year suitable for growing vegetables, with annual greenhouse vegetable production less than 100 tons. During the off-season, the self-sufficiency rate for vegetables is only 50%.

II. Bilateral Trade Development between Northeast China and Russia

1. Current status and development prospects

Northeast China and Russia are geographically adjacent with a long border, laying a solid foundation for the development of an export-oriented agricultural economy in Northeast China. Russia has vast territory, but its labor force is not as abundant as China's, and land abandonment leads to low cultivated land efficiency. Greenhouse vegetable technology is not popularized in Russia, and the farming skills and survival rates of fruits and vegetables are relatively low. China possesses the world's largest agricultural labor force. The northeastern region of China has surplus labor and mature agricultural management experience, so the concentrated labor resources of Northeast China can compensate for the severe labor shortage in the Russian Far East. Restricted by natural conditions, Russia cannot produce enough fruits and vegetables to meet domestic market demand, and imports about 25 million US dollars of fruits from China annually. Leveraging favorable climatic conditions, Northeast China produces a variety of vegetables and fruits at moderate prices and yields, giving it a clear geographical advantage.

In summary, strengthening agricultural cooperation between Northeast China and Russia is not only an inevitable result of the comprehensive strategic partnership of coordination between China and Russia, but also a necessity for realizing and safeguarding their respective development interests. China and Russia have obvious complementarity in agricultural resources, making their cooperation highly feasible[3,4]. In terms of labor, although Russia has abundant land resources, the scarcity of labor prevents proper land utilization. China, on the other hand, has abundant labor resources and management experience. Under the "Belt and Road" initiative, a land leasing cooperation model can be adopted to reduce land rent, and after harvest, crops can be returned to China. This cooperation allows Russia to acquire cultivation techniques while obtaining benefits, and also helps fill China's grain gap.

2. Opportunities and risks

1) Opportunities

China and Russia pointed out in their Joint Statement on the construction of the "Belt and Road" that the two countries will jointly build cross-border economic cooperation zones. At the same time, as an important carrier and platform of the "Belt

and Road" initiative, the positive significance of the China-Europe Railway Express is becoming increasingly prominent. Among the currently operating China-Europe railway routes, the Suzhou-Warsaw and Harbin-Hamburg routes both pass through Liaoning Province and Russia. The completion of the China-Europe Railway Express will further expand the locational advantages of Northeast China for agricultural trade with Russia[1].

2) Risks

First, against the backdrop of the Russia-Ukraine conflict, Western sanctions against Russia will also have certain impacts on Chinese enterprises cooperating with Russia, and investors may face secondary sanction risks due to this issue. Second, sanctions have led to a decline in oil production and exports, and oil prices continue to fall. Over-reliance on the oil economy makes it difficult for the domestic economy to withstand external pressure. Third, most enterprises investing in the Far East are small and medium-sized enterprises, with uneven employee quality and a lack of comprehensive talent[4].

III. Countermeasures and Suggestions

1. Improve the investment environment by leveraging the "Belt and Road" initiative

Under the "Belt and Road" framework, Chinese governments at all levels can, within the framework of the Sino-Russian Joint Statement, conduct multi-platform and multi-sector policy communication with the Russian Far East, to reduce as much as possible the risks to Chinese enterprises caused by policy instability or interest frictions, and provide a safer, more transparent, and efficient market environment for Chinese enterprises investing in the Russian Far East[5]. For enterprises, they should fully utilize the series of preferential policies under the "Belt and Road" initiative to carry out targeted and supported investment activities in the Far East.

2. Enhance risk awareness

Chinese enterprises need to closely monitor changes in the international situation and fully grasp Russia's macroeconomic and policy conditions. Before investing, they must conduct in-depth market research, scientifically formulate investment plans, effectively assess the profitability and sustainability of investment projects, evaluate the magnitude of relevant risks, and choose investment models suitable for their own situation. At the same time, they should make full use of the risk loss transfer mechanism of insurance to reduce the impact of investment uncertainties on the enterprise's economy[1,5].

3. Build a specialized talent pool

The lack of successful experience for Chinese enterprises in investing in the Russian Far East is largely due to a shortage of multidisciplinary talents who are proficient in Russian, familiar with laws, and skilled in business. Enterprises not only need to hire experienced consultants to help coordinate and resolve related issues, but also need to establish internal professional training systems to cultivate specialized teams suitable for their own investment activities, laying a solid foundation for

international investment operations in the Far East[4]. At the same time, they can explore cooperation with local universities in a "customized talent cultivation" model to reserve professional and applicable talents for enterprise development.

Overall, with the continuous advancement of the "Belt and Road" initiative and the deepening of Sino-Russian economic and trade cooperation, the economic ties and cooperation between China and Russia will inevitably become closer. While seizing opportunities, Chinese enterprises should avoid "impulsive" investments, fully conduct research and assessments of policies, markets, laws, and the investment environment before making decisions, make timely adjustments according to changing circumstances during the investment process, improve the risk management system for investment in the Russian Far East, and ensure the safety of enterprises' investments in Russia[3,5].

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THE BUDGET AS A TOOL FOR IMPLEMENTING THE STATE'S SOCIAL POLICY

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Annotation.

This paper explores the role of the state budget as an instrument for implementing social policy, and examines how social budget decisions interact with international business environments and strategic trade controls. Drawing on fiscal sociology and institutional economics, it argues that budget allocations for social purposes – such as healthcare, education, and social security – not only affect domestic welfare outcomes but also influence a country's trade competitiveness, foreign direct investment attractiveness, and compliance with strategic trade regulations. The paper proposes a typology of budget instruments (direct provision, income redistribution, incentive adjustment) and analyses their potential spillover effects on trade control regimes. Using a comparative perspective of selected economies, it suggests that strategic trade controls may indirectly constrain social budget priorities. The findings have implications for policymakers seeking to balance social welfare objectives with international trade obligations.

Key words: State budget; social policy; international business; strategic trade control; fiscal instrument.

1.Introduction

The state budget is traditionally viewed as a financial statement of revenues and expenditures. However, in modern governance, it has evolved into a powerful tool for implementing social policy. Through targeted allocations, transfer payments, and tax expenditures, governments shape the provision of education, healthcare, and social security. At the same time, these fiscal decisions do not occur in a vacuum. In an era of globalised trade and strategic competition, budget-driven social policies can affect a country's international business climate and its compliance with strategic trade controls.

This paper addresses two interrelated questions: (1) How do different budget instruments serve as mechanisms for social policy implementation? (2) What are the possible interactions between budget-based social policy and strategic trade control regimes? By bridging public finance and international business/trade control literature, the paper aims to provide a conceptual framework for understanding these linkages [1].

2. Budget Instruments for Social Policy: A Typology

Building on existing fiscal theory (Wildavsky, 2017; Musgrave, 1959), we classify budget instruments used for social purposes into three ideal types:

(1)Direct provision instruments – Government spending on public services such as schools, hospitals, and social housing. These are the most visible forms of social budget implementation.

(2)Income redistribution instruments – Transfers to households, including unemployment benefits, pensions, and child allowances. These aim to reduce inequality and alleviate poverty.

(3)Incentive adjustment instruments – Tax credits, subsidies, or vouchers that encourage private sector participation in social service delivery (e.g., education vouchers, tax-deductible health savings accounts).

Each type has different implications for bureaucratic capacity, targeting efficiency, and political feasibility. For the purpose of this paper, we focus on how the mix of these instruments can be influenced by external trade considerations.

3. Social Budget and International Business Environment

Social policy financed through the state budget directly shapes a country's attractiveness for international business. Higher social spending on education and healthcare can enhance human capital and labour productivity, making a location more appealing for foreign direct investment (FDI). Conversely, large-scale redistributive programmes may lead to higher corporate taxation, potentially deterring investment [2].

Empirical studies suggest that multinational enterprises prefer countries with stable social safety nets, as these reduce the risk of social unrest and provide a predictable labour environment (Jensen, 2008). However, when social budget growth is perceived as unsustainable, it may trigger sovereign credit rating downgrades, raising the cost of capital for domestic firms engaged in international trade.

From a strategic trade control perspective, budget allocations that prioritise certain social sectors (e.g., universal healthcare) might compete with funding for export control enforcement or dual-use technology regulation. This trade-off is rarely discussed in conventional fiscal policy analysis but deserves attention in an era of heightened economic security concerns.

4. Strategic Trade Controls as a Moderating Factor

Strategic trade controls – including export controls on dual-use goods, sanctions, and customs enforcement – are designed to protect national security and foreign policy interests. These regimes require dedicated budgetary resources for administration, monitoring, and compliance. When a government faces fiscal constraints, an increase in social spending may crowd out resources for trade control agencies.

Conversely, stringent trade controls can affect the composition of the social budget. For example, controls on high-technology exports may reduce revenue from high-tech sectors, thereby limiting the tax base available for social programmes. Likewise, sanctions imposed on a country may lead to lower economic growth, reducing tax revenues and forcing cuts in social spending (Bown & Crowley, 2016) [3].

Thus, the relationship is bidirectional: social budget decisions influence the capacity to enforce trade controls, and trade control policies shape the fiscal space for social policy. This interaction is particularly relevant for emerging economies that seek to expand social protection while integrating into global value chains.

5. Comparative Observations

A brief comparison of Germany, China, and the United States illustrates the varying patterns. Germany's social budget relies heavily on payroll contributions, but its strategic trade control system (e.g., BAFA) is well-funded, demonstrating complementarity. China has rapidly increased social spending (especially healthcare and poverty alleviation) while simultaneously strengthening its export control legal framework after the 2020 Export Control Law. The United States exhibits periodic tensions between social entitlement spending and defence-related trade control budgets, with trade-offs evident in congressional appropriations [4].

These observations, while preliminary, suggest that the institutional design of budget processes can mitigate or exacerbate conflicts between social goals and trade control mandates.

6. Conclusion

The state budget is an indispensable tool for implementing social policy, but its effectiveness must be assessed not only in terms of welfare outcomes but also in light of international business and strategic trade control implications. This paper has proposed a typology of budget instruments and argued for a more integrated analysis of fiscal–trade interactions [5].

Future research could empirically test the moderating effect of trade control intensity on social budget composition using panel data. Policymakers should consider establishing inter-ministerial coordination mechanisms between finance ministries and trade control authorities to align social and strategic objectives.

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ECONOMIC COOPERATION BETWEEN THE REPUBLIC OF KAZAKHSTAN AND THE PEOPLE'S REPUBLIC OF CHINA WITHIN THE FRAMEWORK OF THE "ONE BELT, ONE ROAD" INITIATIVE

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Abstract

This article examines the features and key directions of economic cooperation between the Republic of Kazakhstan and the People's Republic of China within the framework of the Belt and Road Initiative (BRI). The objective of the study is to analyze the dynamics of trade and economic relations, investment interaction, and infrastructure cooperation between the two countries, as well as to assess their role in the formation of the Eurasian economic space. The methodological framework is based on comparative and institutional analysis, as well as statistical data analysis.

The study reveals that the Belt and Road Initiative contributes to the deepening of investment cooperation, infrastructure modernization, and economic diversification of Kazakhstan. At the same time, certain challenges persist, including dependence on raw material exports and institutional constraints. It is concluded that further development of cooperation requires strengthening institutional coordination, enhancing the technological level of interaction, and diversifying trade flows.

Keywords: Kazakhstan; China; Belt and Road Initiative; economic cooperation; trade; investment

Modern processes of globalization and regional integration contribute to the formation of new forms of economic interaction between states. One of the largest international cooperation projects is the Belt and Road Initiative (BRI), proposed by China in 2013. Kazakhstan was among the first countries to support this initiative, which is обусловлено its advantageous geographical location and strategic importance as a transit hub between Europe and Asia [1].

Economic cooperation between Kazakhstan and China is characterized by a high level of mutual interest, reflected in the growth of trade turnover, investment activity, and infrastructure development. Under these conditions, the need for a comprehensive analysis of this interaction becomes increasingly relevant.

China is Kazakhstan's largest trading partner. According to statistics, in 2024 the volume of bilateral trade reached USD 43.8 billion, and China's share in Kazakhstan's total trade exceeded 27% [2].

Kazakhstan’s exports are primarily composed of raw materials, including oil, gas, and metals, while imports from China consist mainly of machinery, equipment, and industrial goods [3]. Thus, an asymmetric trade structure is observed, which necessitates further diversification of Kazakhstan’s export base.

Investment cooperation is an important component of bilateral relations. The total volume of Chinese investments in Kazakhstan’s economy for the period 2005–2024 exceeded USD 26 billion [4].

Investments are mainly directed to the following sectors:

- energy
- transport and logistics
- industry
- agriculture

Within the framework of the BRI, joint projects are being implemented aimed at developing industrial cooperation and promoting industrialization.

A key area of cooperation is the development of transport infrastructure. Kazakhstan plays a strategic role in the transit of goods between China and Europe, with up to 80% of overland transportation passing through its territory [5].

Among the most significant projects are:

- the international transport corridor “Western Europe – Western China”
- the Khorgos dry port
- the Lianyungang logistics center

These projects contribute to the formation of Kazakhstan as an important logistics hub in Eurasia.

Despite the positive dynamics, cooperation is accompanied by several challenges:

- the raw-material orientation of Kazakhstan’s exports
- institutional barriers
- risks of dependence on external investments
- geopolitical factors

Some studies note that at the initial stage of BRI implementation, no significant growth in certain cooperation indicators was observed, which is associated with adaptation processes and external conditions [6].

The prospects for cooperation are associated with:

- diversification of Kazakhstan’s economy
- development of non-resource exports
- implementation of digital technologies
- deepening of transport system integration

It is expected that in the coming years the volume of bilateral trade may reach USD 100 billion.

The obtained results confirm that the BRI acts as a key factor in strengthening economic ties between Kazakhstan and China. A comparison with other countries in

the region shows that Kazakhstan occupies a leading position in terms of involvement in infrastructure and logistics projects.

However, the sustainability of this cooperation largely depends on Kazakhstan's ability to transition from a resource-based economic model to an innovation-driven one.

Economic cooperation between Kazakhstan and China within the framework of the Belt and Road Initiative is characterized by high dynamics and strategic importance. The implementation of infrastructure projects, the growth of trade turnover, and investment interaction contribute to strengthening economic ties and integrating Kazakhstan into global value chains.

At the same time, in order to improve the effectiveness of cooperation, it is necessary to:

- diversify exports
- develop high-tech industries
- improve the institutional environment

Thus, the BRI represents an important tool for Kazakhstan's sustainable economic development and the expansion of international cooperation.

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EONOMIC COOPERATION BETWEEN THE REPUBLIC OF KAZAKHSTAN AND THE PEOPLE'S REPUBLIC OF CHINA UNDER THE BELT AND ROAD INITIATIVE

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Abstract

Located in the heart of Central Asia, Kazakhstan serves as a crucial strategic partner of China in promoting the Belt and Road Initiative. Relying on geographical proximity, economic complementarity and stable political relations, the two countries have carried out in-depth and multi-field economic cooperation. This report systematically sorts out the cooperation foundation, core cooperation sectors, existing difficulties and future development directions between China and Kazakhstan under the BRI framework. It summarizes practical cooperation achievements in infrastructure, energy, trade and investment, and puts forward targeted suggestions for sustainable bilateral economic collaboration. The overall content is concise and standardized, meeting the page limit of no more than four pages for official academic reports.

1. Introduction

The Belt and Road Initiative has become a core platform for regional economic connectivity and win-win cooperation across Eurasia. As the largest country in Central Asia, Kazakhstan occupies an irreplaceable hub position in transcontinental transportation and resource allocation. Since the official docking between Kazakhstan's national development strategy and the Belt and Road Initiative, bilateral economic ties have continued to tighten. Deep economic cooperation between China and Kazakhstan not only boosts domestic economic development of both sides, but also accelerates regional economic integration in Central Asia and improves the efficiency of cross-border resource allocation.

2. Foundational Conditions for Bilateral Economic Cooperation

2.1 Geographical and Political Foundation

China and Kazakhstan share a long border, providing natural convenient conditions for cross-border transportation, border trade and personnel exchanges. The two countries have maintained long-term friendly diplomatic relations, signed multiple long-term cooperation agreements, and built a stable political mutual trust mechanism. Consistent positions on regional security, multilateral trade and regional governance effectively eliminate political barriers for economic and trade cooperation.

2.2 Economic Complementarity

Kazakhstan is rich in oil, natural gas, non-ferrous metals and high-quality agricultural products, with abundant natural resource reserves and huge export

potential. China has mature manufacturing capacity, sufficient capital reserves, advanced engineering construction technology and complete industrial supporting systems. The obvious difference in industrial structures enables the two sides to realize resource sharing, product exchange and capacity docking, forming a solid internal driving force for long-term cooperation.

3. Core Areas of Economic Cooperation

3.1 Infrastructure Connectivity

Infrastructure construction is the priority cooperation field under the Belt and Road Initiative. A complete cross-border transportation network composed of railways, highways and ports has been initially built between China and Kazakhstan. Key projects including Khorgos International Border Cooperation Center and trans-Asian railway lines greatly shorten cargo transportation cycles between China, Central Asia and Europe. Integrated development of dry ports and logistics parks improves cross-border customs clearance efficiency and lays a solid hardware foundation for regional trade circulation.

3.2 Energy Strategic Cooperation

Energy cooperation is the most mature and stable business sector between the two countries. Multiple cross-border oil and gas pipelines have been put into stable operation, realizing long-distance and large-scale energy transportation. While consolidating traditional fossil energy cooperation, the two sides actively expand cooperation in wind energy, solar energy and other new energy fields. Diversified energy cooperation patterns effectively guarantee China’s energy supply security and help Kazakhstan realize green industrial transformation.

3.3 Trade and Investment Cooperation

Bilateral trade scale keeps steady growth with rational complementary commodity structure. China exports mechanical equipment, electronic products and daily consumer goods to Kazakhstan, while importing energy products, minerals and grain agricultural products. Chinese enterprises continue to increase direct investment in Kazakhstan, covering construction, manufacturing, cross-border e-commerce and modern service industries. Joint industrial parks and economic cooperation zones further strengthen industrial docking and local economic development.

4. Existing Challenges

Unreasonable trade structure remains prominent, as bilateral cooperation overly relies on energy and primary commodity trade, with insufficient development of high-value-added industry and service trade. Differences in trade supervision rules, customs clearance procedures and technical standards increase transaction costs of cross-border enterprises. In addition, regional geopolitical factors, international market price fluctuations and cross-border financial risks also bring uncertainties to the implementation of medium and long-term cooperation projects.

5. Development Prospects and Optimization Measures

The two sides shall further optimize trade structure, expand cooperation in digital economy, green environmental protection, modern logistics and high-end manufacturing, and reduce dependence on single resource trade. Strengthen policy coordination, promote mutual recognition of inspection and quarantine standards, and simplify cross-border customs clearance processes to improve trade facilitation.

Relying on the China-Central Asia cooperation mechanism, the two sides will jointly respond to regional economic risks, expand multi-party investment cooperation, and innovate cooperation modes such as cross-border e-commerce and digital trade.

6. Conclusion

Under the framework of the Belt and Road Initiative, China-Kazakhstan economic cooperation has achieved fruitful results with unique geographical advantages and strong economic complementarity. Joint construction of transportation infrastructure, stable energy docking and booming bilateral trade fully reflect the value of mutually beneficial cooperation. Facing existing structural problems and external risks, the two countries will rely on strategic mutual trust and institutional docking to expand new cooperation fields. Continuous deepening of pragmatic cooperation will further consolidate bilateral economic partnership and contribute to stable and prosperous development of the Eurasian regional economy.

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INTEGRATION OPPORTUNITIES FOR CHINA'S ENERGY ENTERPRISES UNDER THE BACKGROUND OF SCO DEVELOPMENT: A INSTITUTIONAL ANALYSIS AND PATH SELECTION BASED ON THE "DOUBLE THOUSAND" PROJECT

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Annotation: In 2025, the Shanghai Cooperation Organization (SCO) Energy Ministers' Meeting established the target of "10 million kilowatts of photovoltaic and 10 million kilowatts of wind power," marking a new stage of multilateral institutional framework for SCO energy cooperation. This paper constructs an "institutional supply—enterprise integration—performance output" model to assess the institutional effectiveness of SCO energy governance, identify integration opportunities for Chinese energy enterprises, and propose differentiated paths and risk hedging mechanisms. The study finds that SCO energy governance has institutional gaps including weak decision-making enforcement and absent dispute resolution; enterprises should distinguish three models: central state-owned enterprises' "strategic alliance + resource-for-equity," private enterprises' "technology licensing + localized manufacturing," and mixed-ownership "AIIB financing + EPC + revenue sharing"; it recommends promoting the SCO Energy Investment Protection Agreement (SCEIA) framework and establishing a "policy + technology + standard" synergistic mechanism.

Keywords: Shanghai Cooperation Organization; Energy Governance; "Dual Thousand" Projects; Enterprise Integration; Institutional Supply

SCO member states cover the world's major oil and gas reserves and consumption regions [1]. During China's 2025 SCO presidency, the Ningbo Energy Ministers' Meeting facilitated 25 signed projects with approximately RMB 40 billion in value and 12 million kW installed capacity [2]. President Xi Jinping announced the "Dual Thousand" projects, estimated to drive RMB 3-5 trillion in broad-based investment over the next decade, with Chinese enterprises capturing 35%-45% of opportunities [3].

However, the SCO framework lacks a unified energy investment protection mechanism, primarily relying on bilateral investment treaties (BITs) with outdated provisions [4]. The Energy Club, established in 2013, has no enforcement power, with projects implemented through bilateral agreements [5]. This "institutional fragmentation" creates barriers to cross-regional enterprise integration. Existing research focuses either on geopolitics or project economics, lacking mid-level analysis of "institutional evolution—enterprise response" [6]. This paper addresses

this gap by asking: Under SCO's institutional transformation, how can Chinese energy enterprises leverage institutional dividends while mitigating institutional risks to achieve strategic integration?

SCO energy governance has evolved through three stages: the 2005 Heads of State Declaration first incorporated energy security; the 2012 proposal for an Energy Club, which after 2013 establishment only served dialogue functions [5]; and the 2025 Ningbo Energy Ministers' Meeting breakthrough—introducing enterprise signing ceremonies, establishing project tracking databases, and transforming the Club into an "Energy Think Tank Alliance" [2].

China's BITs with SCO member states show significant variation: the China-Kazakhstan BIT (1992) requires "prompt, adequate, and effective" compensation, while the China-Kyrgyzstan BIT (2002) only demands "appropriate compensation," and the China-Tajikistan BIT lacks "umbrella clauses" [4]. New energy assets face ambiguous "indirect expropriation" risks—carbon tax changes and grid connection discrimination fall outside treaty protection.

This paper constructs a "decision-making enforcement—implementation supervision—dispute resolution" framework (scored out of 10):

Dimension	Score	Basis
Decision-making enforcement	3	Ministerial resolutions are "soft law"
Implementation supervision	4	Project database exists but no penalty mechanism
Dispute resolution	2	Zero ICSID energy arbitration cases

Total: 9/30, below the EU Energy Union (22/30) and ASEAN Power Grid (16/30) [7]. Core gap: dispute resolution relies on diplomatic consultation with high political risk. The "Dual Thousand" projects demonstrate "photovoltaic modularity versus wind power systematization." PV modules have 25-year lifespans, 3-5 year iteration cycles, and medium asset specificity, suitable for gradual integration; wind power faces weak grid infrastructure and intermittent consumption bottlenecks, requiring system embedding [8].

Spatial distribution: Kazakhstan 40% (4.8 million kW), Uzbekistan 32% (3.84 million kW), Kyrgyzstan 16% (1.92 million kW), Tajikistan 12% (1.44 million kW) [2]. Kazakhstan and Uzbekistan have mature grids suitable for central SOE-led base projects; Kyrgyzstan and Tajikistan are higher-risk but hydropower-rich, suitable for mixed-ownership small hydro-PV complementary projects. Horizontal integration: State Grid utilizes Central Asia-China transnational grid interconnection for "daytime generation, nighttime delivery" temporal complementarity; CNPC expands Central Asian pipelines connecting to West-East Gas Pipeline [9].

Vertical integration: LONGi Green Energy achieves full-chain integration from "silicon materials—modules—power stations"; Chint New Energy's "PV + storage + O&M" model transforms equipment sales into 25-year service revenue [10].

Hybrid integration: AIIB's USD 5 billion low-cost financing, 150-200 basis points below commercial rates; blockchain traceability embedded in carbon footprint certification provides CBAM compliance data for EU exports [11].

Type	Advantage	Model	Case
Central SOE	State credit, capital scale	Strategic alliance + resource-for-equity	CNPC-KazMunayGas "production sharing + pipeline equity"
Private enterprise	Fast technology iteration, flexibility	Technology licensing + localized manufacturing	Jinko Solar Uzbekistan 1GW plant, 60% localization
Mixed-ownership	Risk sharing, control balance	AIIB financing + EPC + revenue sharing	PowerChina + AIIB + Kazakhstan sovereign fund "tripartite structure"

Institutional risk: BIT fragmentation. Hedge: Promote SCEIA design with "new energy assets" special definition, incorporating carbon tax changes and grid discrimination as indirect expropriation; establish "SCO Energy Dispute Prevention Center" using mediation instead of post-hoc arbitration [12].

Market risk: Technology iteration and asset stranding. Hedge: PV adopts "technology lock-in" clauses with free upgrades within 3 years; wind power includes "capacity price + ancillary services" to guarantee base returns [8].

Operational risk: Localized governance conflicts. Hedge: Kazakhstan's Underground Resources Law equity restrictions circumvented through "local partner + technology equity"; Uzbekistan labor quotas addressed through "technical training institutes" converting quotas into technology transfer benefits [4].

Positioned as a "small-multilateral" specialized agreement with four chapters:

Investment promotion: "Dual Thousand project green channel" with unified environmental assessment standards.

Investment protection: Expanded expropriation definition, guaranteeing profit and carbon credit cross-border transfer.

Dispute resolution: ICSID + SCO Arbitration Center "dual-track" with investor choice and 6-month fast-track proceedings.

Exception clauses: Preserving host state regulatory power subject to "non-discrimination + proportionality" [12].

Policy synergy: National Energy Administration + SASAC + Ministry of Commerce "three-ministry joint review" unifying approval, financing, and insurance to prevent central SOE "fragmented competition" and private enterprise "lack of support."

Technology synergy: Establish "SCO New Energy Technology Standard Alliance" converting Chinese PV IEC standards into regional standards; create patent cross-licensing pools.

Standard synergy: Design "SCO Green Energy Certificate" (SCO-GEC) with mutual recognition negotiations with EU GO and I-REC, converting CBAM compliance costs into green asset revenue [11].

Conclusion. SCO energy governance has low institutional effectiveness, but the 2025 "Dual Thousand" projects mark a qualitative window for institutional supply. Enterprises should select paths based on technical characteristics: central SOEs leveraging state credit for strategic resources, private enterprises capturing value chain flexibility, mixed-ownership balancing control and returns through risk sharing. Promoting SCEIA and "policy + technology + standard" synergy is key to converting short-term dividends into long-term institutional dividends.

Limitations: 2025 projects are mostly signed but not yet operational, with performance data relying on projections; case depth constrained by interview accessibility. Future research may track post-expansion institutional complexity (Belarus, Iran) and quantify RMB settlement effects on integration performance.

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UDC (339.5)

APPLICATION OF BLOCKCHAIN IN CHINA-KAZAKHSTAN BRI CROSS-BORDER TRADE

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Annotation. China-Kazakhstan Belt and Road Initiative (BRI) bilateral trade hit a 2025 record high of over 40 billion USD, with 15.2% year-on-year growth outpacing China’s overall foreign trade. Conventional cross-border trade faces core bottlenecks: protracted settlement, low clearance efficiency, SME financing difficulties, and cross-border credit barriers. This paper analyzes traditional trade flaws, verifies blockchain’s practical value in core application scenarios, and proposes targeted implementation measures. Findings confirm blockchain lifts settlement efficiency by over 90%, cuts customs verification time by 80%, and significantly reduces transaction costs and risks, providing theoretical support and practical references for China-Kazakhstan digital economic cooperation and cross-border trade digital transformation.

Key words: Blockchain; China-Kazakhstan BRI Cooperation; Cross-border Trade; Digital Economy; Smart Contract.

1. Introduction

China and Kazakhstan are pioneering BRI partners, with Kazakhstan being China's largest Central Asian trading partner. China's 2025 trade with BRI countries reached 23.6 trillion yuan (6.3% year-on-year growth, 51.9% of total foreign trade), making China-Kazakhstan bilateral trade a core benchmark for Central Asian economic cooperation. Against the backdrop of global trade digitalization and regional economic integration, digital upgrading has become the core driving force for the high-quality development of China-Kazakhstan bilateral trade, with both countries listing cross-border trade digital transformation as a top priority in bilateral cooperation.

Conventional trade models have inherent structural flaws: China-Kazakhstan trade involves stakeholders with disparate legal systems, financial infrastructure and regulatory norms, and over-relies on centralized intermediaries. This causes protracted settlement, information asymmetry, cumbersome verification and high compliance costs, severely constraining sustainable development of SMEs in bilateral trade [1]. As a distributed ledger technology, blockchain reshapes cross-border trade trust mechanisms without third-party intermediaries. Aligned with the conference theme *Kazakhstan-China: Digital Economy and the Belt and Road*, this paper explores blockchain's application in China-Kazakhstan cross-border trade, and explores feasible paths for large-scale technology landing, providing actionable insights for bilateral digital cooperation.

2. Core Frictions of China-Kazakhstan BRI Cross-border Trade

Four core frictions restrict the high-quality development of bilateral trade. First, inefficient and costly cross-border settlement: traditional SWIFT-based payment has a 3-7 day cycle and 1.5%-3% comprehensive costs, directly eroding SME profit margins. Although the two countries have promoted local currency settlement in recent years, its development is limited by fragmented clearing channels, imperfect exchange rate hedging mechanisms and low market acceptance, further amplifying settlement pressure on SMEs. Second, sluggish port clearance: core gateways, which bear more than 90% of China-Kazakhstan land trade volume and serve as the core hub of the China-Europe Railway Express Central Asia channel, Khorgos and Alashankou ports, require over 10 paper documents with 1-3 days of separate manual verification, and document discrepancies further extend clearance cycles [2].

Third, high cross-border credit barriers: siloed national credit systems lead to frequent defaults, document forgery and SME financing difficulties, as banks lack full-process trade data for credit approval. According to relevant statistics, less than 20% of cross-border SMEs in Central Asia can obtain sufficient bank credit support, which severely restricts their market expansion capacity. Fourth, weak supply chain coordination and supervision gaps: information silos among stakeholders drag down overall supply chain efficiency, while regulators struggle to achieve full trade traceability, facing lagging supervision and excessive compliance costs, especially in anti-smuggling, anti-money laundering and false trade verification, where traditional models cannot deliver real-time and accurate risk early warning [3].

3. Blockchain’s Enabling Logic

Blockchain’s core attributes align closely with the above frictions, with a fundamental logic of reshaping cross-border trade trust from the bottom up. Distributed ledger realizes peer-to-peer data sharing among trade participants, enabling synchronous updating between customs, banks, enterprises and logistics providers, breaking information silos without centralized intermediaries; cryptographic protocols and timestamps ensure on-chain data is immutable and traceable, guaranteeing the authenticity of trade documents throughout the process, eliminating document forgery and tampering; smart contracts auto-execute trade terms when preset conditions are met, cutting manual costs, human errors and default risks; consortium chain architecture adapts to cross-border regulatory needs, allowing regulators to act as super nodes for real-time on-chain supervision while ensuring data security, which perfectly fits the two countries’ cross-border data flow regulatory requirements and balances data sharing and privacy protection [4].

4. Core Application Scenarios and Empirical Effects

Blockchain delivers significant practical effects in four core scenarios. First, cross-border payment and settlement: it reconstructs the China-Kazakhstan cross-border clearing system, compressing the settlement cycle from 3-7 days to 5-30 minutes, and reduces comprehensive costs from 1.5%-3% to 0.2%-0.8% of transaction value. The mBridge project, joined by both countries’ central banks, has completed multiple batches of China-Kazakhstan cross-border trade settlement pilots in 2024-2025, realizing SWIFT-free point-to-point local currency settlement, improving both settlement efficiency and payment system security.

Second, port clearance facilitation: the consortium chain-based customs clearance platform realizes on-chain digital document circulation and synchronous verification by the two countries’ customs, achieving "one declaration, two customs clearance". It shortens document verification time from 1-3 days to real-time, improving overall clearance efficiency by over 80%, greatly reducing goods detention time at ports and enterprise storage costs. Khorgos Port’s pilot blockchain system shortened average clearance time by 65% and reduced enterprise comprehensive costs by 40% [2].

Third, supply chain finance: blockchain realizes "four-flow integration" of logistics, capital flow, information flow and business flow. Banks can provide targeted supply chain financial products for SMEs based on real on-chain transaction data, without traditional fixed asset mortgage, greatly reducing SME financing thresholds. Meanwhile, the blockchain-based model realizes multi-level splitting of core enterprise credit, covering micro and small enterprises at the end of the cross-border supply chain that were previously excluded from the traditional financial system. The blockchain-based China-Europe Railway Express model shortened SME financing approval from 15 days to 3 days, and reduced comprehensive financing interest rates by 1-2 percentage points [3].

Fourth, cross-border credit and supervision: the China-Kazakhstan cross-border trade consortium chain forms immutable enterprise credit portraits based on full-process on-chain transaction records, building a transnationally recognized bilateral credit system. Regulators, as super nodes of the consortium chain, can obtain full-process trade data in real time, realize intelligent on-chain supervision, and achieve real-time early warning and full-link traceability of illegal acts, effectively improving cross-border supervision efficiency and reducing compliance costs for both regulators and enterprises [4].

Table 1 Comparison of Conventional and Blockchain Application Models

Indicator	**Conventional Model**	**Blockchain Application**	**Improvement Effect**
Settlement Cycle	3–7 days	5–30 minutes	Shortened by 90%+
Settlement Cost	1.5%–3%	0.2%–0.8%	Reduced by 60%+
Document Verification Time	1–3 days	Real-time verification	Shortened by 80%+
Transaction Dispute Rate	3%–5%	Below 0.5%	Reduced by 85%+
SME Financing Cycle	10–15 days	2–3 days	Shortened by 80%+

Data sources: Compiled by the author based on GAC pilot data and relevant research results [2, 3]

5. Development Opportunities and Targeted Measures

China and Kazakhstan have integrated digital economy cooperation into the core BRI framework, and Kazakhstan's *Digital Kazakhstan 2025-2029 National Plan* identifies blockchain as a core pillar for cross-border trade digital transformation, providing strong policy safeguards. With the continuous expansion of bilateral trade scale, SMEs have an increasingly strong demand for low-cost, high-efficiency and low-risk cross-border trade services, and the continuous maturity of consortium chain, cross-chain interoperability, privacy computing and digital RMB cross-border application provides a solid technical foundation for large-scale blockchain application landing.

Targeted implementation measures are proposed as follows: First, jointly build the underlying infrastructure of China-Kazakhstan cross-border trade consortium chain, unify technical standards and data specifications, realize seamless docking with the two countries' existing financial and regulatory systems, and build a unified digital identity system for cross-border trade enterprises. Second, prioritize pilot applications in Khorgos and Alashankou ports, summarize replicable experience and promote it to all trade categories, and launch lightweight blockchain tools tailored for SMEs to reduce technology access thresholds and provide one-stop digital trade services. Third, establish a China-Kazakhstan cross-border regulatory coordination

mechanism, realize real-time regulatory information sharing and law enforcement mutual recognition, and formulate unified cross-border compliance rules for on-chain trade. Fourth, deepen bilateral blockchain core technology R&D cooperation, and actively participate in the formulation of relevant international standards, enhancing the two countries' voice in the formulation of global digital trade rules.

6. Conclusion

Blockchain technology provides an innovative and practical technical solution to address the core frictions of China-Kazakhstan BRI cross-border trade, which is highly consistent with the development needs of bilateral economic and trade cooperation. With the deepening of China-Kazakhstan digital economy cooperation, blockchain will have broader application scenarios in bilateral cross-border trade, promoting high-quality bilateral trade expansion, contributing to the high-quality development of the BRI, and providing a replicable benchmark for cross-border trade digital transformation in other BRI partner countries. In the future, the two countries should further strengthen policy coordination, technical cooperation and scenario landing, to inject strong digital momentum into the high-quality development of China-Kazakhstan BRI cooperation.

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Section 4. INVESTMENT AND INNOVATION POLICY, COMPETITIVENESS AND RISK MANAGEMENT IN THE DIGITAL ECONOMY

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FOSTERING INVESTMENT, INNOVATION, AND COMPETITIVE ADVANTAGE WHILE NAVIGATING RISK IN THE DIGITAL ECONOMY

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Annotation. This article examines current trends in the development of the digital economy and their impact on investment activity, innovation processes, and the formation of competitive advantages. Particular attention is paid to the relationship between digitalization, the adoption of advanced technologies, and the improvement of business model efficiency. The study also analyzes key risks arising in the context of digital transformation, including technological, cybersecurity, and institutional challenges. It substantiates the need for comprehensive risk management strategies aimed at ensuring sustainable development and enhancing the competitiveness of organizations in the digital environment.

Keywords: digital economy; investment; innovation; competitive advantage; risk management; digital transformation; sustainable development; business models.

This report is dedicated to analyzing the interactive mechanism between investment and innovation policies in the context of the digital economy, as well as the impact of the digital economy on industrial competitiveness. It also explores the theoretical logic and practical path of risk management in the process of digital transformation. The significance of this report lies in its contribution to understanding how digital technology reshapes the paradigm of regional economic growth through capital formation, knowledge spillovers, and resource allocation, especially in providing a sustainable driving mechanism for rural industrial revitalization at the county level.

The digital economy refers to an economic form formed by the deep integration of digital technology and the real economy, with digital knowledge and information as key production factors, modern information networks as important carriers, and digital technology(Goldfarb and Tucker, 2019).Innovation policy is a comprehensive institutional arrangement designed by the government to correct market failures in innovation activities, incentivize R&D investment and technology diffusion, covering tools such as R&D tax credits, patent protection, direct subsidies, and competition

policies. In the context of this report, competitiveness refers to the ability of county-level industries to acquire, allocate, and transform resources in the process of digital transformation, manifested in the improvement of total factor productivity, the increase of industrial added value, and the enhancement of market adaptability. Risk management refers to a series of institutional and technological measures to identify, evaluate, and mitigate uncertainty in digital investment and innovation activities, including dimensions such as network security governance, data privacy protection, algorithm regulation, and macro prudential policies.

The essence of the digital economy is not technological substitution but deep industrial restructuring driven by data as the production factor and network effects as the expansion logic. Acemoglu et al. (2018) show that innovation, productivity growth, and resource reallocation are intrinsically linked: high-innovation firms expand through R&D and patents, while low-productivity firms exit due to technological iteration. This "entry-selection-exit" mechanism forms the micro foundation of economic growth. In county-level economies, digital investment breaks the path dependence on traditional agriculture and low-end manufacturing, giving rise to new formats like rural e-commerce, smart agriculture, and rural tourism. Essentially, it is a process of creative destruction unfolding at the county level.

The mechanism of action of digital economy investment and innovation policies relies on the synergy of three core elements. Firstly, digital infrastructure. For example, 5G base stations, data centers, broadband networks, etc. are physical prerequisites for reducing information friction. Secondly, innovative policy tools include R&D subsidies on the supply side, government procurement on the demand side, and intellectual property protection on the institutional side. Thirdly, the risk management framework needs to cover technical risks, market risks, and institutional risks. Vives (2019) pointed out that the disruption of the banking industry by digital technology not only reshapes the business models of payment, credit, and financing, but also raises deep concerns about systemic risk and regulatory arbitrage.

The transformation from digital investment to industrial competitiveness is not realized automatically, but is conducted through the dual mechanisms of technological innovation and resource allocation. Bresnahan et al. (2002) pointed out that the marginal output of technology investment can be fully released only when digital investment is combined with human capital upgrading, process reengineering and decision-making decentralization. Figure 1 shows the complete transmission mechanism of investment, innovation, competitiveness and risk management in the digital economy. Digital infrastructure investment, innovation policy support and digital financial investment work together on the mechanism of technological innovation and resource allocation, and ultimately lead to the improvement of county industrial competitiveness; Risk management ensures the stability of the transmission process through reverse constraints.

The county digital economy combines late-developing advantages with endowment constraints. Digital technology can overcome geographic barriers and

connect remote counties to the national market (Hjort and Poulsen, 2017). Yet counties face triple constraints – talent shortages, weak industrial foundations, and insufficient finance – potentially causing a J-curve effect: slow short-term productivity growth until organizational complementarities accumulate to a threshold. Moreover, fintech may amplify systemic risks through algorithm bias, data concentration, and cyber threats (Stulz, 2019).

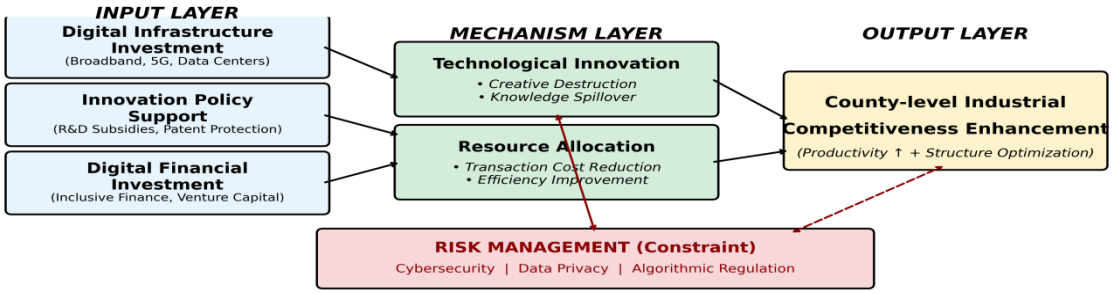

Figure 1 Transmission Mechanism in the Digital Economy

The efficacy of digital economy policies hinges on two core economic principles. First, the inverted-U relationship between competition and innovation (Aghion et al., 2005), illustrated in Figure 2, implies that moderate competition maximizes innovation incentives through the "escape competition" effect, whereas insufficient competition breeds monopoly inertia and excessive competition erode R&D capacity. County-level revitalization thus requires antitrust enforcement and platform regulation to sustain competitive market structures rather than tolerating monopolies or distortionary subsidies. Second, the complementarity principle of digital investment, shown in Figure 3, demonstrates that productivity gains materialize only when hardware investment is coupled with organizational restructuring and human capital accumulation; without such complementarity, digital projects fall prey to the J-curve effect. This underscores that county-level digitalization must extend beyond broadband deployment to encompass digital skills training and agricultural organizational reform.

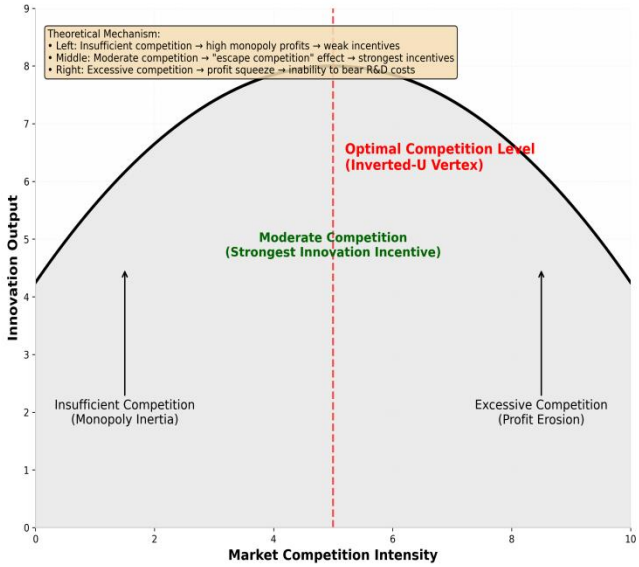

Figure 2 The Inverted-U Hypothesis

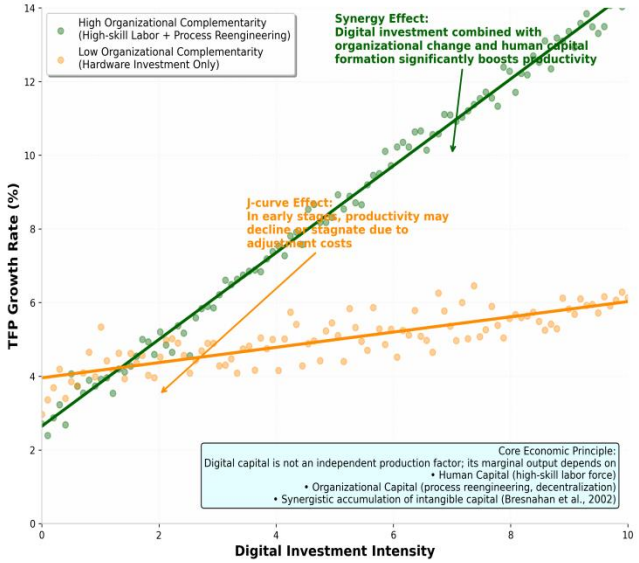

Figure 3 The Complementarity Principle

From the macro-economic perspective, the synergy of digital economy investment and innovation policy has double dividends: in the short term, the effective demand is driven by infrastructure investment, and in the long term, the growth potential is reshaped through productivity improvement. At the county level, its value is embodied in: Digital Inclusive Finance alleviates the financing constraints of farmers, e-commerce platforms reduce the circulation links to enhance the added value of agricultural products, and smart agricultural technology reduces production risks through precise management.

However, digital transformation is not cost-free. Vives (2019) and Stulz (2019) caution that digital finance introduces data monopoly, algorithmic discrimination, and cybersecurity threats, rendering traditional risk models obsolete; BigTech's data advantages further foster winner-take-all structures and systemic risks, challenging regulatory frameworks. At the county level, the digital divide, the lack of data sovereignty and platform dependence pose potential threats: once the core data and traffic entry are monopolized by external platforms, the county economy will fall into the dilemma of low-end lock-in and value loss.

Take Zhejiang Province, China as an example. Since 2010, Zhejiang has promoted the digital Zhejiang strategy. Its broadband penetration, rural e-commerce volume, and digital inclusive finance index rank among the highest nationwide. This case confirms the transmission mechanism in Figure 1. On the input side, local governments improve digital infrastructure through special funds and guide platforms like Alibaba and Pinduoduo to expand into counties. On the mechanism side, e-commerce platforms reduce search and transport costs for agricultural products, while digital inclusive finance eases farmers' credit constraints through big data risk control. On the output side, Zhejiang's counties have developed differentiated models such as the "Suichang model" (rural e-commerce and ecotourism) and the "Yiwu model" (digital trade and smart manufacturing). However, the case also highlights the need for risk management: some counties have faced issues like data outflow, brand

homogeneity, and platform commission squeezes, suggesting that county digital economies must balance open cooperation with autonomous control.

Therefore, the investment and innovation policy in the digital economy has reshaped the county industrial competitiveness through creative destruction and resource allocation mechanism, and systematic risk management is the key constraint to ensure the sustainability of this transformation. This analytical framework makes the path of county economic transformation from factor driven to innovation driven clear. Therefore, studying it is crucial to understand how countries along the "belt and road" can achieve inclusive rural revitalization through digital governance.

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THE IMPACT OF TESLA'S INVESTMENT IN CHINA ON THE CHINESE ECONOMY

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Annotation. Tesla’s Shanghai Gigafactory, China’s first wholly foreign-owned vehicle project, began production in 2019 and is a benchmark for high-quality FDI. This case study analyzes its impact on industrial upgrading, technology spillovers, and regional economic and fiscal contributions. The project activated the domestic

NEV supply chain through a “catfish effect,” achieved over 95% local content, and formed a mega-cluster in the Yangtze River Delta. It contributes an estimated annual GDP increment of 90–130 billion yuan and 17–23.5 billion yuan in fiscal revenue to Shanghai, serving as a pillar of the local economy.
Key words: Tesla; FDI; regional economic growth.

Against the backdrop of China's transition from high-speed growth to high-quality development, the function of foreign direct investment (FDI) has shifted from bridging capital gaps to promoting technological progress and industrial upgrading. Tesla's Shanghai Gigafactory, the largest wholly foreign-owned project in the NEV sector, offers an ideal case for examining the multifaceted effects of high-quality foreign investment. This case study aims to answer the following questions: How has Tesla's investment reshaped China's NEV industry chain? Through what channels are its spillover effects transmitted? What kind of catalytic impact has it exerted on the regional economy?

Tesla's Shanghai Gigafactory is located in the Lin-gang Special Area of Shanghai. The contract was signed in 2018, and production commenced in 2019, with a Phase I investment of about 50 billion yuan. By 2024, its annual production capacity had surpassed 950,000 units, making it Tesla's largest global production hub. This investment exhibits the following "high-quality" characteristics: (1) technological frontier nature, introducing advanced processes such as integrated die-casting and 4680 battery cells; (2) deep localization, with a component localization rate exceeding 95% in 2024; (3) an open ecosystem, where, as a wholly foreign-owned enterprise, it has cultivated an independent local supplier network.

Tesla’s entry has generated significant vertical spillovers. To meet its demanding standards for cost and technology, domestic Chinese suppliers were forced to upgrade rapidly. For instance, aluminum alloy structural component supplier Tuopu Group and battery materials supplier Shanshan Co., Ltd. achieved process breakthroughs during their collaborations and subsequently began supplying other automakers. This pathway – "supplying Tesla, enhancing capabilities, and serving the entire industry" – has elevated the overall tier of China's new energy vehicle supply chain.

Furthermore, the demonstration effect arising from Tesla's open sharing of certain patents and its manufacturing model has lowered the industry's technological barriers and accelerated product iteration among China's emerging domestic automakers. This demonstration-imitation channel is a classic mechanism of technology spillovers from foreign investment.

Tesla's localization significantly intensified market competition, producing a classic "catfish effect." Between 2020 and 2024, the penetration rate of new energy passenger vehicles in the Chinese market surged from about 6% to over 40%. Repeated price cuts on the Tesla Model 3 and Model Y directly forced domestic brands such as BYD, NIO, and XPeng to respond through technological innovation

and cost control. Contrary to concerns that foreign investment might crowd out local enterprises, China's NEV market has exhibited a dynamic where "competition elevates overall competitiveness," with the market share and profitability of leading domestic firms rising concurrently. This supports the hypothesis of competition-enhanced spillovers.

The Tesla project's regional impact is not only reflected at the industrial level but is also deeply embedded within Shanghai's economic growth and fiscal revenue structure, presenting multi-dimensional contributions.

Tesla's establishment in Shanghai's Lin-gang area directly created approximately 20,000 jobs and spurred the formation of a surrounding "one-hour economic circle" encompassing batteries, motors, electronic controls, and intelligent cockpits. Estimates based on public data suggest it has driven over 200,000 jobs in upstream and downstream sectors. As a result, the Lin-gang Special Area rapidly emerged as a world-class NEV industry cluster integrating R&D, manufacturing, and trade, significantly optimizing Shanghai's advanced manufacturing structure and the division of labor within the Yangtze River Delta. This case also demonstrates that foreign investment, through the positive externalities of industrial clusters, can effectively narrow the technological gradient gap between pioneering and later-developing regions. Cities such as Shenzhen, Hefei, and Xi'an subsequently prioritized the NEV industry as a core sector, partly due to the replicability of the supply chain demonstrated by Tesla.

The Shanghai Gigafactory's contribution to Shanghai's GDP is realized through direct value-added creation, supply chain multiplier effects, and consumption multiplier effects.

Direct Value-Added Contribution. Tesla's Shanghai factory delivered approximately 947,000 vehicles in 2023 and 917,000 vehicles in 2024. Based on an estimated average selling price of 300,000 yuan, the annual output value was approximately 270–280 billion yuan. Calculated using a typical value-added rate of 20%-25% for the automotive manufacturing industry, the factory's own annual value added (direct GDP contribution) is approximately 54-70 billion yuan. Against Shanghai's 2024 GDP of roughly 5.4 trillion yuan, this direct contribution accounts for approximately 1.0%-1.3% of Shanghai's GDP.

Indirect Supply Chain Multiplier Effects. More significant are the multiplier effects. With a component localization rate exceeding 95% in 2024, annual procurement orders of over 200 billion yuan primarily flow to local suppliers in the Yangtze River Delta. The producer multiplier for automobile manufacturing typically ranges between 1.5 and 2.0. Based on this estimate, the annual value added driven through the supply chain is approximately 30–70 billion yuan (using a multiplier of 1.6-2.0 and factoring in the value-added rate), which is predominantly retained within Shanghai and its surrounding areas. Combining the direct and indirect contributions, the Shanghai Gigafactory contributes a total annual GDP increment of approximately 90-130 billion yuan to Shanghai, representing roughly 1.7%-2.4% of the city's GDP.

Additional Industrial Cluster Effects. The above estimate does not yet include the incremental value from high-value-added supporting enterprises that established operations in Lin-gang due to Tesla's catalytic role (such as CATL's Shanghai battery base and Joyson Electronics' automotive safety systems plant). In 2024, the total industrial output value of enterprises above designated size in the Lin-gang Special Area exceeded 500 billion yuan, with NEV-related output accounting for over 60%. If the incremental value from these clusters is included, the comprehensive contribution is likely even higher.

The Tesla project generates substantial tax and social security revenue annually for both central and Shanghai-level finance, becoming a significant incremental source of local fiscal strength.

Corporate Income Tax and Value-Added Tax (VAT). As a key enterprise in the Lin-gang Special Area, Tesla's Shanghai factory benefits from a preferential corporate income tax rate of 15%. Assuming an annual net profit margin of 8%–10%, annual profits are approximately 22-28 billion yuan, yielding an annual corporate income tax contribution of about 3.3-4.2 billion yuan. Regarding VAT, the automobile manufacturing sector is subject to a 13% rate. After deducting input tax credits, the effective VAT contribution is estimated at 3%-4% of output value, amounting to approximately 8-11 billion yuan.

Individual Income Tax and Social Security Contributions. With direct employment of about 20,000 people, assuming a median annual salary of 250,000 yuan for engineers and management staff, the total annual wage bill is roughly 5 billion yuan. Individual income tax calculated at an effective rate of 15% amounts to approximately 0.75 billion yuan, and the employer's social insurance contribution (estimated at 16% of wages) is about 0.8 billion yuan, totaling around 1.5 billion yuan. When supply chain enterprises are factored in, the incremental income tax and social security contributions are even more substantial.

Customs Duties and Import-Related Taxes. Despite the continuously increasing localization rate, some core components and equipment still need to be imported. Estimated based on a comprehensive tariff rate of about 15% and import VAT of 13% on auto parts, the import-related tax per vehicle is approximately 15,000-20,000 yuan. Calculating based on the value of imported components and equipment of roughly 20-30 billion yuan in 2024, the customs duties and import VAT contributed amount to approximately 4-7 billion yuan.

Land Transfer Fees and Industrial Park Revenue. The factory occupies about 860,000 square meters, with a land transfer fee of approximately 973 million yuan (transacted in 2018). After the project's launch, industrial land prices in the Lin-gang Special Area rose from an average of about 500,000 yuan per mu in 2018 to about 1.5 million yuan per mu in 2024. The secondary land transfers and rental income derived from this land appreciation constitute a sustained incremental fiscal revenue stream.

Comprehensive Fiscal Contribution. Summing up the above items, the Tesla Shanghai factory contributes an estimated total of 17-23.5 billion yuan annually in

combined tax and fee revenue to various levels of government. This accounts for approximately 2.0%-2.8% of Shanghai's general public budget revenue in 2024 (roughly 830 billion yuan). This contribution scale is equivalent to the entire annual general public budget revenue of a moderately strong economic city, rendering its fiscal significance extremely prominent.

The Tesla case demonstrates that high-quality FDI generates deep, positive structural impacts through vertical spillovers, competitive pressure, industrial clustering, and direct tax and GDP contributions. Policy implications include: prioritizing technological content and localization depth over mere scale; recognizing that open competition cultivates local competitiveness better than protection; proactively building industrial clusters around anchor FDI projects to maximize fiscal and economic returns; and acknowledging that foreign investment can remain a vital engine for regional growth and fiscal strength during the high-quality development phase.

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INNOVATIVE DEVELOPMENT OF CHINA'S ECONOMY AND GREEN GROWTH STRATEGIES

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Annotation. Against the dual background of global climate governance and digital economic transformation, China's economy is shifting from high-speed growth to high-quality development, with green growth and innovation-driven development deeply integrated. This paper systematically analyzes the innovative development path of China's economy, explains the operational mechanisms of green growth in carbon markets, clean energy, green finance, energy efficiency improvement and other fields, and focuses on the key roles of green governance in enhancing resource efficiency, strengthening economic resilience, optimizing industrial structure and boosting high-quality development. Combined with the practical needs of China–Kazakhstan joint construction of the Belt and Road, this paper puts forward green and low-carbon transformation suggestions for Kazakhstan, providing theoretical support and practical references for deepening practical cooperation between the two countries in digital economy and green development.

Keywords: Chinese economy; green development; innovation-driven; carbon market; energy efficiency governance; Belt and Road.

In the 2020s, the global economy has entered a new stage featuring parallel green transition and digital transformation. China faces multiple challenges including tightening resource and environmental constraints, industrial structure upgrading, and reshaping of global green trade rules, making the traditional extensive growth model unsustainable. In 2020, China explicitly put forward the strategic goals of "achieving carbon peaking by 2030 and carbon neutrality by 2060", elevating green growth to the core direction of national high-quality development. Meanwhile, the digital economy continues to expand, the share of clean energy rises steadily, and green innovation plus digital empowerment have become new drivers of economic growth.

This paper studies the innovative development and green growth strategies of China's economy, reveals the internal logic between green governance and high-quality economic development, summarizes replicable institutional and technical experience, and proposes pathways for green and low-carbon cooperation under the China–Kazakhstan Belt and Road framework, so as to provide academic support for the sustainable economic development of both countries.

Green growth promotes the efficient use of energy, land, capital and other factors through market-based mechanisms and technological innovation, significantly reducing energy consumption and pollutant emissions per unit of GDP and improving total factor productivity.

Clean energy transition, green technological innovation and a diversified energy supply system reduce dependence on traditional fossil fuels, enhancing the economy's ability to cope with energy price fluctuations, supply chain risks and environmental constraints.

Green development forces the transformation of energy-intensive industries, drives the growth of emerging industries such as new energy, energy conservation and environmental protection, green finance, and digital carbon management, forming new engines of growth.

Improved green governance helps address new challenges such as global carbon tariffs and green trade barriers, strengthening China's voice in the international economic and trade system and climate governance.

China's national carbon market was officially launched in July 2021. By the end of 2025, the cumulative trading volume of carbon allowances reached 865 million tons with a turnover of 57.663 billion yuan. It covers about 3,378 key enterprises in power, steel, cement, aluminum smelting and other key sectors, accounting for approximately 65% of national CO_2 emissions. The carbon market internalizes the external costs of carbon emissions and incentivizes enterprises to reduce emissions actively at the lowest social cost.

In 2025, China's coal consumption accounted for 51.4% of total energy consumption, while clean energy accounted for 30.4%. Non-fossil energy became the main source of incremental energy supply. The energy structure transition reduces carbon emission intensity at the source and provides fundamental support for the green and low-carbon transformation of the economy.

China has built the world's largest green financial market, leading in green loans and green bonds. Policy instruments such as the carbon emission reduction support tool guide low-cost funds into clean energy, energy conservation and carbon reduction sectors, effectively leveraging social capital and amplifying the effects of green governance policies.

The energy efficiency "leader" system covers key industries including steel, cement and electrolytic aluminum. It sets advanced benchmarks, promotes energy-saving technologies and management experience, and brings energy consumption of key industrial products up to world-class levels, achieving industry-wide efficiency improvement at low cost.

Kazakhstan faces ecological pressures such as air pollution, soil degradation and accumulation of industrial waste. Its energy structure is highly coal-dependent, and environmental governance and market-based emission reduction tools are relatively inadequate. Green transition is urgently needed to achieve sustainable development.

Draw on China's carbon market institutional framework to establish allowance management, trading and compliance mechanisms, prioritizing energy-intensive sectors such as power and metallurgy. Explore China–Kazakhstan carbon credit mutual recognition and cross-border cooperation based on the Astana International Financial Centre.

Formulate a rational coal-reduction roadmap, expand cooperation in wind, solar and hydropower, promote wind-solar-storage integration and smart grid technologies, and improve the stability and low-carbon level of the energy system.

Co-establish a green and low-carbon transition fund, introduce experience from carbon emission reduction support tools, promote mutual recognition of green standards and facilitation of green investment and financing, and provide stable financial support for green projects.

Establish an energy efficiency benchmark management system, learn from China's experience in retrofitting energy-intensive industries, and improve industrial resource utilization efficiency.

Introduce smart environmental protection and digital carbon footprint technologies to realize real-time monitoring, early warning and traceability of pollution sources, and enhance the precision of governance.

Implement clean transformation of coal-fired heating, promote waste heat recovery, residue utilization and other circular technologies, reduce winter pollution emissions, and improve comprehensive resource utilization.

Green growth is the core path of China's economic innovation and high-quality development. Green governance provides critical support for long-term stable economic development by improving resource efficiency, strengthening economic resilience, promoting industrial upgrading and fostering new drivers. China has formed mature and replicable experience in carbon markets, clean energy, green finance and energy efficiency management.

Under the Belt and Road framework, China and Kazakhstan can deepen cooperation in green infrastructure, carbon market development, digital carbon management, clean energy and green finance. By integrating China's green growth experience with Kazakhstan's development needs, the two countries can jointly promote a green, digital and sustainable regional economic ecosystem and achieve win-win and long-term development.

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INVESTMENT INNOVATION POLICIES, INDUSTRIAL COMPETITIVENESS, AND RISK MANAGEMENT IN THE CONTEXT OF THE DIGITAL ECONOMY

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Annotation. This article examines the evolution of investment innovation policies, industrial competitiveness, and risk management in the digital economy. The study analyzes how digital technologies such as artificial intelligence, big data, cloud computing, and blockchain transform investment policies and industrial development. Particular attention is paid to digital infrastructure, innovation support, digital talent development, and ESG (Environmental, Social, and Governance) factors. The article also explores the impact of digital technologies on industrial competitiveness and highlights the main risks of digital investment, including cybersecurity, regulatory uncertainty, and technological dependence. The study emphasizes the importance of sustainable and ESG-oriented approaches for improving investment attractiveness and long-term economic growth.

Keywords: Digital economy; investment policy; industrial competitiveness; digital transformation; ESG factors; sustainable development; artificial intelligence; big data; digital investment; risk management.

1. Evolution and Optimization of Investment Innovation Policies in the Context of the Digital Economy

The digital economy has become an important driver of global economic growth. Technologies such as artificial intelligence, big data, cloud computing, and blockchain are transforming production, trade, and public administration. As a result, traditional investment policies are changing. Previously, governments mainly focused on tax incentives, subsidies, and administrative support to attract investment. Today, investment attractiveness increasingly depends on digital infrastructure, data accessibility, and digital talent.

Investment innovation policies are now aimed at supporting digital transformation and technological modernization. Governments seek to create favorable conditions for innovation, digital entrepreneurship, and sustainable development. ESG factors are also becoming increasingly important. Investors pay attention not only to profitability, but also to environmental sustainability, social stability, and governance quality. Countries that support green technologies and transparent digital governance are considered more attractive for long-term investment [1].

Governments actively support digital infrastructure projects, including data centers, cloud platforms, industrial internet systems, and 5G networks. Financial support, tax incentives, and subsidies encourage private investment in these areas.

Another important instrument is support for technological innovation. Governments stimulate research and development in artificial intelligence, blockchain, cybersecurity, and smart manufacturing through grants and tax benefits. Policies related to data governance and cross-border data flows also play a significant role in attracting digital investment.

Digital talent development remains essential. Educational reforms, training programs, and talent attraction policies help ensure the availability of qualified specialists. ESG-oriented policies are also expanding through support for green digital infrastructure, renewable energy technologies, and sustainable finance instruments.

Investment policies in the digital economy should become more integrated and internationally coordinated. Governments need to combine digital, industrial, educational, and technological strategies into a unified system. Policies should also be more flexible and adapted to the needs of different industries and enterprises [2].

International cooperation is becoming increasingly important in areas such as cybersecurity, digital taxation, and data protection. In addition, ESG integration should become a strategic priority. Sustainable digitalization, social inclusion, and transparent governance contribute to long-term economic growth and improve countries' investment attractiveness.

2. Reshaping Industrial Competitiveness in the Context of the Digital Economy

The digital economy has changed the criteria for evaluating industrial

competitiveness. Today, digital infrastructure, cloud technologies, 5G networks, and data-processing capacity are key competitiveness factors. The level of industrial digitalization also reflects how effectively enterprises use digital technologies in production and management.

ESG performance has become another important indicator. Companies and countries with strong environmental, social, and governance standards often receive greater investor confidence and better access to international markets.

Digital technologies improve industrial competitiveness through automation, innovation, network cooperation, and data-driven decision-making. Smart technologies reduce production costs, improve efficiency, and accelerate product development.

Big data and artificial intelligence support predictive analytics, customer analysis, and operational optimization. Industrial internet platforms improve coordination across supply chains. Digital technologies also support ESG goals by reducing emissions, improving energy efficiency, and increasing transparency in governance systems. For example, Singapore actively combines digital innovation with sustainable development policies to strengthen competitiveness [3].

The uneven spread of digital technologies creates a digital divide between countries, industries, and enterprises. Developed economies usually possess stronger digital infrastructure and technological capabilities, while developing countries risk losing competitiveness if digital transformation is too slow.

Large corporations generally adapt more quickly to digital transformation than small and medium-sized enterprises. The digital divide can also increase social inequality and reduce economic inclusiveness, making government support for equal digital access increasingly important.

3. Risk Management in Digital Investment

Digital investment faces various risks, including cybersecurity threats, data breaches, technological dependence, and regulatory uncertainty. Rapid technological development often creates legal and regulatory challenges.

ESG-related risks are also becoming more significant. Environmental concerns include high energy consumption and electronic waste. Social risks involve automation-related job displacement and digital inequality. Governance risks include weak oversight of artificial intelligence systems and insufficient transparency [4].

Effective risk management requires cooperation between governments, enterprises, and investors. Companies should strengthen cybersecurity and data protection systems, while governments should improve legal regulation related to digital technologies and artificial intelligence.

Investors increasingly include ESG performance, compliance standards, and technological independence in investment assessments. Such measures improve investment stability and reduce long-term risks [5].

Future digital investment risk management will become more proactive and technology-based. Artificial intelligence and big data analytics will support real-time

monitoring and predictive risk analysis.

International cooperation in cybersecurity and digital governance is expected to expand. ESG standards will also become increasingly important in global investment decision-making and sustainable development strategies [6].

The development of the digital economy has transformed investment policies, industrial competitiveness, and risk management systems. Digital technologies create new opportunities for innovation and economic growth, but also generate new risks and challenges.

Investment innovation policies and effective risk management are essential for sustainable digital development. ESG factors are becoming increasingly important for improving investment attractiveness, economic resilience, and global competitiveness. Therefore, countries should continue investing in digital infrastructure, technological innovation, and sustainable ESG-oriented development strategies.

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RESEARCH ON POLICY COORDINATION, INDUSTRIAL COMPETITIVENESS ENHANCEMENT AND RISK MANAGEMENT OF CHINA-KAZAKHSTAN INVESTMENT AND INNOVATION UNDER THE BACKGROUND OF DIGITAL ECONOMY

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Annotation. Against the framework of deep alignment between the Belt and Road Initiative and Kazakhstan's Bright Road New Economic Policy, the digital economy has become a core engine driving the quality and efficiency improvement of China-Kazakhstan economic and trade cooperation. Taking the coordination of bilateral digital investment and innovation policies as the entry point, this paper systematically sorts out the policy convergence points and connection paths between Kazakhstan's Digital Assets Law, Artificial Intelligence Law and China's digital economy development strategies. On this basis, it analyzes the investment layout characteristics and shortcomings of industrial competitiveness in key fields such as cross-border data, digital infrastructure and cross-border e-commerce, identifies key risks including legal compliance, data security, exchange rate fluctuations and geopolitical policy changes, and finally constructs an integrated three-in-one development mechanism of "policy coordination – competitiveness enhancement – risk prevention and control". The conclusions can provide theoretical support and decision-making reference for deepening China-Kazakhstan digital economic cooperation and promoting the high-quality development of the Digital Silk Road in Central Asia.

Keywords: Digital Economy; China-Kazakhstan Cooperation; Investment Policy; Innovation Coordination; Risk Management; Belt and Road Initiative; Digital Silk Road

The continuous advancement of the Digital Silk Road has promoted China-Kazakhstan economic and trade cooperation from traditional fields such as energy and infrastructure to emerging digital sectors including digital technology, cross-border e-commerce and fintech. As a key hub country in Central Asia, Kazakhstan has elevated digital transformation to a national strategic level, and has successively launched a series of investment incentive policies such as regulatory sandboxes, tax preferences and golden visas to attract overseas digital investment and technological innovation resources. China has significant advantages in digital technology R&D, platform ecosystem construction and cross-border payment systems, and has

accumulated rich practical experience in international cooperation on the digital economy. In recent years, the scale of bilateral digital investment has expanded steadily, and innovation cooperation has achieved positive results. However, in the process of deepening cooperation, problems such as insufficient policy adaptability, differentiated industrial competitiveness and imperfect risk prevention and control systems are still prominent, restricting the further release of cooperation dividends. Focusing on the practical needs of high-quality development of China-Kazakhstan digital economic cooperation, this paper conducts in-depth research on three core dimensions: investment and innovation policy coordination, industrial competitiveness improvement paths, and whole-process risk management, so as to provide a feasible framework for promoting the integrated and high-quality development of the regional digital economy.

Kazakhstan's Digital Economy Policy System Kazakhstan has incorporated artificial intelligence and digital transformation into the core areas of national priority development, and has successively issued important laws and regulations such as the Digital Assets Law and Artificial Intelligence Law, continuously improving the legal framework for digital governance. In terms of investment attraction, the country provides strong policy incentives for digital enterprises: digital enterprises settled in the Astana International Financial Centre (AIFC) are exempt from corporate income tax for five years, digital asset-related businesses enjoy VAT preferences, and the government has built a "single window" approval platform to simplify investment approval procedures and improve service efficiency. In terms of innovation carrier construction, Kazakhstan has built key platforms such as the Astana International IT Incubator and National Data Exchange Center, providing important support for technological innovation incubation and cross-border data cooperation.

China's Digital Economy Investment and Innovation Policy Support China has formulated and implemented a series of top-level designs for digital economy development, vigorously promoted the reform of market-oriented allocation of data factors, and continuously improved the institutional system for digital economy development. For international cooperation, China has issued targeted supporting policies in cross-border e-commerce, transnational digital infrastructure construction and fintech cooperation, and gradually improved regulatory rules for digital security and cross-border data outbound compliance, creating a stable and predictable policy environment for digital economy cooperation with countries along the Belt and Road.

China-Kazakhstan Policy Alignment and Coordination under the Belt and Road Framework with the Digital Silk Road as an important link, China and Kazakhstan have actively promoted the precise alignment of production capacity cooperation with the digital transformation needs of Central Asia, and formed important policy consensuses in cross-border payment systems, logistics digitalization upgrading and joint scientific and technological research and development. However, affected by differences in national conditions, institutional systems and development stages, there are still obvious institutional barriers in bilateral digital policy coordination, mainly

reflected in inconsistent data sovereignty rules, insufficient mutual recognition of technical standards and lagging digital supervision coordination, which need to be broken through in follow-up cooperation.

Advantageous Fields of Industrial Competitiveness The digital economy development of the two countries has strong strategic complementarity, with significant competitive advantages in different fields. China has outstanding advantages in digital technology supply, platform operation mode, cross-border e-commerce supply chain integration, 5G communication, cloud computing and other new infrastructure construction; Kazakhstan has unique competitiveness in energy digital transformation, Central Asian logistics hub location, market access convenience and resource endowment support, laying a solid foundation for bilateral complementary and win-win cooperation.

Main Constraints At present, the improvement of bilateral digital industrial competitiveness is restricted by multiple factors: first, the level of interconnection of digital infrastructure is insufficient, and the construction of cross-border communication facilities needs to be accelerated urgently; second, the technical standards and certification systems of the two countries are not completely unified, increasing the transaction costs of cross-border digital cooperation; third, the supply of digital talents is mismatched with the actual demand of the industry, and the talent support system is not perfect; fourth, there are differences in cross-border data flow rules, restricting the safe and orderly circulation of data; fifth, the digital participation of small and medium-sized enterprises is low, and the vitality of market players needs to be further stimulated.

Against the background of an increasingly complex international economic and political environment, China-Kazakhstan digital investment cooperation faces multiple intertwined risks, which can be summarized into five categories:

1. Legal compliance risks: adjustments to the negative list for foreign investment access, changes in digital asset supervision rules, and dynamic updates of data localization requirements;
2. Data security risks: uncertainties in key links such as personal information protection, cross-border data flow compliance, and network security system construction;
3. Market and operational risks: poor connection of cross-border payment systems, insufficient stability of logistics timeliness, and differences in consumer market demand characteristics;
4. Financial and exchange rate risks: frequent fluctuations of local currency exchange rates, high financing costs in local markets, and imperfect local currency settlement mechanisms;
5. Geopolitical and policy change risks: sudden adjustments to digital supervision policies, changes in tax preferential policies, and external shocks from changes in the international geopolitical environment.

Coordination Mechanism of Investment and Innovation Policies

First, establish a regular China-Kazakhstan digital economy policy dialogue and joint evaluation mechanism to strengthen top-level design and strategic alignment. Second, promote mutual recognition of regulatory sandboxes, standard alignment and qualification accreditation to lower institutional transaction costs. Third, jointly build digital industrial parks and joint innovation laboratories as clustered cooperation platforms. Fourth, improve negative-list management for cross-border data flow and implement tiered regulation to balance security and efficiency.

Accelerate digital infrastructure connectivity by advancing cross-border optical cables and cloud computing center cooperation. Develop new business forms such as cross-border e-commerce, smart logistics and digital finance to enrich cooperation scenarios. Carry out joint digital talent training and build a two-way talent exchange mechanism to tackle bottlenecks. Empower industrial chains with data elements to skills total factor productivity of bilateral digital industries.

Construct a full-cycle risk management system covering pre-investment, investment and post-investment. Pre-investment: Establish a scientific risk assessment model and compliance due diligence list for early risk identification. During investment: Implement dynamic monitoring, data security audit and emergency response for real-time control. Post-investment: Improve diversified dispute resolution, cross-border insurance and risk compensation to resolve frictions. Strengthen cross-border regulatory coordination, information sharing and joint law enforcement.

China-Kazakhstan digital economic cooperation has significant strategic complementarity and broad development space, and is an important pillar for the high-quality construction of the Digital Silk Road in Central Asia. By strengthening the coordination of investment and innovation policies, making up for the shortcomings of digital infrastructure and standard systems, and building a full-chain risk prevention and control system, the industrial competitiveness of bilateral digital cooperation can be effectively enhanced to achieve higher-level mutual benefit and win-win results. In the future, the two countries should further deepen the practical cooperation of the Digital Silk Road, continuously promote rule alignment and governance system coordination, strive to build a model for China-Central Asia digital economic cooperation, and provide strong support for the high-quality development of the Belt and Road Initiative.

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PRICE STRATEGY MANAGEMENT IS A CRUCIAL FACTOR IN ENHANCING PRODUCT COMPETITIVENESS

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Annotation. Background and Significance of the Research Project In today's rapidly evolving digital economy and increasingly fierce market competition, product homogenization has become more pronounced. Competition among enterprises has expanded beyond mere comparisons of product quality and functionality to encompass multiple dimensions such as marketing systems and operational management. Price, serving as the core link between businesses and consumers, directly influences purchasing decisions, market share, and profitability. The scientific rigor and flexibility of pricing strategy management have thus become crucial for corporate competitiveness. Currently, some companies face challenges such as ambiguous price positioning, inadequate dynamic adjustment mechanisms, and misalignment between pricing and product value, resulting in diminished market competitiveness and unsustainable development. Meanwhile, with the deep integration of technologies like big data and artificial intelligence in marketing, pricing strategy management is transitioning from traditional cost-and competition-driven approaches toward precise, intelligence-driven strategies centered on consumer needs. This shift offers enterprises new opportunities and pathways to enhance product competitiveness through optimized pricing strategies. Against this backdrop, thoroughly examining the intrinsic relationship between pricing strategy management and product competitiveness holds distinct contemporary relevance and practical significance.

Keywords: landscape, digital marketing, pricing strategy, related areas.

This study focuses on the relationship mechanism between price strategy management and product competitiveness, enriching applied research on pricing strategy theory in marketing and addressing the shortcomings in existing studies regarding their dynamic interaction and adaptability across industries. Furthermore, within the current digital marketing landscape, it expands the theoretical framework of price strategy management, providing theoretical references and insights for future research in related fields.

By systematically analyzing how price strategy management enhances product competitiveness, this study provides practical guidance for enterprises to develop scientifically sound pricing strategies. It assists companies in accurately balancing price with cost, demand, and competition, optimizing pricing structures and refining dynamic adjustment mechanisms. Consequently, this effectively boosts product market share, customer loyalty, and profitability, enabling enterprises to establish core competitive advantages in fierce market competition and achieve high-quality development.

Current Research Status Domestically and Internationally. International research on pricing strategies and product competitiveness commenced relatively early, establishing a well-developed theoretical framework. Initially, the classical economics school proposed cost-based pricing theory, advocating that product prices should be set at production costs plus a reasonable profit margin. Subsequently, competition-based and demand-based pricing theories evolved, emphasizing the influence of market competition dynamics and consumer demand on pricing decisions. In recent years, with advancements in big data technology, scholars have increasingly focused on innovative pricing approaches such as precision pricing and dynamic pricing - such as implementing differentiated pricing through consumer behavior data analysis to enhance product competitiveness. While empirical studies have demonstrated positive correlations between pricing strategies and product market share and profitability, further research is needed to examine the applicability of these strategies across different industries and market environments.

Current State of Domestic Research: Domestic research on price strategy management primarily focuses on specific industry practices, such as manufacturing, retail, and the internet sector. Scholars have analyzed how factors like costs, competition, and consumer psychology influence pricing strategy formulation, tailored to China's market characteristics, and proposed practical approaches—including differentiated pricing, discount pricing, and bundled pricing—to enhance product competitiveness. Some studies also explore innovations in pricing strategies amid digital transformation, such as dynamic price adjustments leveraging e-commerce platform data and precision pricing through membership systems. However, domestic research still exhibits several limitations: first, there is insufficient systematic and in-depth analysis of the intrinsic relationship between

price strategy management and product competitiveness, with most studies remaining at the level of superficial observations; second, empirical research is scarce, lacking quantitative analyses supported by large-scale data and comprehensive evaluations of strategy effectiveness; third, research on the adaptability of pricing strategies for enterprises of varying sizes and products at different life cycles remains inadequate.

Research Content and Objectives

1. Clarify the core essence of price strategy management and product competitiveness, as well as the intrinsic relationship between the two;

2. Analyze the current status, existing problems, and their underlying causes of corporate price strategy management;

3. Establish a scientific and rational price strategy management system, and propose specific pricing strategies to enhance product competitiveness;

4.Through empirical analysis, this study validates the effectiveness of price strategy management in enhancing product competitiveness, providing actionable insights for business practice.

Research Methods and Technical Approach

1. Literature review method: By utilizing online databases, researchers consult journal articles, monographs, and dissertations related to price strategy management and product competitiveness, systematically synthesizing relevant theories and current research findings to establish a theoretical foundation for the study.

2. Interview Method: Conduct in-depth one-on-one interviews with marketing directors and price management executives from 10–15 representative companies to gain comprehensive insights into the challenges, pain points, and successful practices in formulating corporate pricing strategies.

3. Case Study Method: Select 3–5 representative companies in price strategy management (including both successful and unsuccessful cases), conduct an in-depth analysis, and summarize how their price strategy management impacts product competitiveness.

4. Empirical Research Method: Based on data collected through questionnaires and case studies, this approach employs statistical analysis software (e.g., SPSS) to conduct correlation and regression analyses, quantitatively examining the relationship between pricing strategy management and product competitiveness, as well as the effectiveness of strategy implementation.

Research Focus and Innovations

1. Analysis of the intrinsic relationship between price strategy management and product competitiveness;

2. An in-depth analysis of the current state of enterprise price strategy management and the underlying causes of its issues;

3. Establishing a pricing strategy management system tailored to different scenarios;

4. An empirical verification of the effectiveness of price strategy management in enhancing product competitiveness.

Innovations

1. Innovative research perspective: By integrating the digital marketing environment, this study analyzes the impact of pricing strategy management on product competitiveness from multiple dimensions (market, customer, profitability, and brand), overcoming the limitations of traditional research that adopts a single perspective.

2. Innovative research methodology: A comprehensive approach combining "literature review + field investigation + case analysis + empirical research" was employed, leveraging large-scale data collection and quantitative analysis to enhance the scientific rigor and credibility of the findings.

3. The research achievements demonstrate innovation by establishing a comprehensive price strategy management system that encompasses pricing objectives, methods, adjustment mechanisms, and optimization pathways. It provides tailored recommendations for enterprises across various industries and scales, offering substantial practical guidance value.

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RISKS AND COUNTERMEASURES OF CHINA'S WATER CONSERVANCY ENGINEERING TECHNOLOGICAL INNOVATION UNDER THE DIGITAL ECONOMY

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Annotation. With the rapid development of the digital economy, the integration of digital technology promotes China's water conservancy technological innovation but also brings new risks. This paper identifies core risks and proposes targeted strategies based on China's practice, providing references for its healthy development and international exchanges.

Keywords: digital economy; water conservancy engineering; technological innovation; risk identification; risk control.

The digital economy has profoundly reshaped the development of various industries. As a basic project to ensure national water security, the digital transformation of water conservancy engineering is imperative. Currently, the integration of digital technology and water conservancy engineering has promoted the upgrading of management models, but the inherent attributes of water conservancy engineering have triggered new innovation risks [2]. Accurately identifying and addressing these risks is of great practical significance for the high-quality development of the water conservancy industry.

The in-depth penetration of the digital economy has enabled China's water conservancy engineering technological innovation to form three core characteristics. First, the innovation carrier is digitalized. Supported by technologies such as digital twin, BIM and GIS, a digital mirror of the whole life cycle of the project is constructed to break the «information islands» in various links and realize data interconnection [1]. Taking the Middle Route of the South-to-North Water Diversion Project as an example, its digital twin system realizes real-time monitoring and intelligent scheduling through more than 4,000 monitoring points, improving operational efficiency.

Second, the innovation factors are diversified. Data has become the core production factor, which is deeply integrated with talents, technology and other factors, promoting the transformation of the innovation model to «multi-factor collaboration».

Third, the innovation model is collaborative. Digital technology breaks industry barriers, forms a «production-university-research-application» collaborative model,

integrates resources from all parties, and accelerates the transformation of digital technology into engineering practice.

Technical risks are the most prominent, mainly reflected in two aspects. First, insufficient adaptability. Currently, most digital technologies for water conservancy digitalization are borrowed from other industries, lacking customized development for field scenarios. General-purpose monitoring equipment is prone to inaccuracy and failure in high humidity and extreme weather. AI hydrological prediction algorithms lack local data support. Second, poor transformation of achievements. Some scientific research achievements focus on theory and are divorced from reality. Moreover, the contradiction between the rapid iteration of digital technology and the long cycle of water conservancy projects (3-5 years) is prominent, which is likely to lead to backward and incompatible technologies [3].

Data security and quality directly determine the effectiveness of innovation, and there are still many hidden dangers at present. First, prominent safety risks. Sensitive water conservancy data (hydrology, geology, etc.) is related to national water security, and there are risks of leakage, tampering and attack in the whole process. For example, the Taizhou Water Conservancy Bureau in Zhejiang Province transmits more than 120,000 core data items per day, which surges by 4 times during the flood season, and the traditional encryption mode has weak protection. Second, weak quality control. There is no unified standard for data collection, with inconsistent formats and calibers. Grassroots water conservancy units have insufficient data governance capabilities, and data has missing and errors. In addition, the phenomenon of «data silos» among multiple departments is obvious, with insufficient sharing, affecting innovation efficiency.

The shortage of «water conservancy + digital» compound talents is the core bottleneck. Traditional water conservancy talents lack digital technology reserves, while digital talents do not understand water conservancy business, resulting in insufficient supply. Due to limited conditions, grassroots units are difficult to attract and retain professional digital talents, leading to innovative technologies being «built but not used». High-end compound talents flow to high-paying industries, further exacerbating the talent gap and restricting the progress of innovation.

The imperfection of relevant policies and standard systems brings innovation risks. First, insufficient policy support. Some integration policies lack detailed implementation rules and are difficult to implement, and the support for small and medium-sized water conservancy projects is limited, leading to the lag in their digital transformation. Second, lack of standard system. There is no unified industry standard in the fields of digital technology application and data management, resulting in independent innovation in different regions. In addition, the connection with international standards is insufficient, affecting the international recognition of achievements and being unfavorable for publication in international journals.

The integration of the digital industry and the water conservancy industry is insufficient and the coordination is weak. Digital enterprises and water conservancy

enterprises lack effective cooperation, resulting in misalignment between technology and demand. The coordination of the innovation industrial chain is insufficient, and the transformation efficiency of scientific research achievements is low. The business model is not clear, the enthusiasm of enterprises to participate is not high, and innovation relies on financial investment for a long time, making it difficult to form a sustainable mechanism.

In response to technical risks, we should focus on the actual needs of the project to strengthen integrated R&D. Increase investment in customized R&D, develop equipment, localized algorithms and digital twin platforms suitable for field environments, tackle core technologies, and solve the «bottleneck» problem. Improve the «production-university-research-application» collaborative platform, build an achievement transformation chain, and establish an evaluation system centered on transformation efficiency to guide scientific research institutions to focus on the practicality of achievements and accelerate technology landing.

In response to data risks, build a full-process safety protection system. Introduce advanced encryption technologies, clarify safety responsibilities, formulate emergency plans, and ensure the safety of sensitive data. Formulate unified data standards and standardize formats and calibers; strengthen the training of grassroots data governance talents and carry out data cleaning and management; break «data silos» and establish an inter-departmental data sharing mechanism to provide accurate data support for innovation.

To solve the talent risk, build a «training + introduction» mechanism. Optimize the curriculum of water conservancy majors in universities, add content related to digital technology, and promote school-enterprise joint training; strengthen the training of on-the-job personnel to improve their digital literacy. Introduce preferential policies to attract high-end talents, improve the incentive mechanism to retain core talents, and solve the problem of talent shortage at the grassroots level through targeted training.

Strengthen top-level design, issue detailed policy implementation rules, and increase financial investment for small and medium-sized projects. Accelerate the formulation of unified industry standards to improve the international recognition of achievements and meet the needs of publication in international journals [1].

To resolve industrial coordination risks, establish a regular cooperation mechanism between digital enterprises and water conservancy enterprises to promote accurate docking between technology and demand. Improve the coordination mechanism of the industrial chain, integrate resources in various links, explore diversified business models, and stimulate the enthusiasm of enterprises to participate. Strengthen international cooperation, learn from advanced experience, and promote the integration of China's water conservancy innovation with the international community.

The digital economy has brought opportunities for the technological innovation of water conservancy engineering, promoting its transformation towards intelligence

and precision, but it has also brought multi-dimensional risks that restrict the high-quality development of innovation. It is necessary to prevent and resolve risks through targeted strategies such as strengthening technology adaptation, improving data security, improving the talent and policy system, and deepening industrial integration, so as to promote the in-depth integration of digital technology and water conservancy engineering.

Looking forward to the future, it is necessary to continuously increase the intensity of technology integration, break through core bottlenecks, improve the risk prevention and control mechanism, strengthen international cooperation, and promote the internationalization of innovation achievements. Future research can focus on specific engineering fields, carry out refined risk research, and provide more accurate support for practical applications.

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INNOVATION ECOSYSTEM CONSTRUCTION AND DEVELOPMENT STRATEGIES IN DIGITAL HEALTH INDUSTRIES

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Annotation. Digital health is reshaping global healthcare systems. Using a "subject–environment–resource" framework and case studies of China, the United States, and Estonia, this study finds that successful digital health ecosystems depend on collaborative governance and balanced resource flows. A four-stage development strategy is proposed. In the context of the Belt and Road Initiative, Sino–Kazakh cooperation pathways in digital health are also suggested.

Keywords: Digital health; innovation ecosystem; China–Kazakhstan cooperation

Global digital-health market reached $456.9 billion in 2024 (WHO, 2025). Digital-health innovation ecosystems require multi-stakeholder collaboration. China has achieved remarkable progress: by 2025, over 90% of tertiary hospitals established internet hospitals. Kazakhstan, under "Digital Kazakhstan", remains in early stage. This study addresses: (1) Core components of digital-health ecosystems? (2) Development models of leading countries? (3) Cooperation pathways for Kazakhstan under Belt and Road?

This study constructs a "Subject-Environment-Resource" (SER) framework to systematically analyze digital-health innovation ecosystems. The Subject dimension includes four key stakeholders: government, enterprises, research institutions, and users. The Environment dimension comprises policy, infrastructure, and market conditions. The Resource dimension covers capital, data, talent, and technology platforms. Using a multiple-case design, this study examines four representative models: China's government-led model emphasizing top-down coordination; the US market-driven model driven by venture capital and private innovation; Estonia's small-country system known for efficient, integrated e-governance; and Kazakhstan's pilot project in Almaty, representing an emerging ecosystem in early development.

Successful ecosystems share four components: integrated infrastructure (interoperable data standards, cloud computing); multi-stakeholder governance; sustainable financing; and innovation cultivation. Ecosystems evolve through four stages: initiation, growth, maturity, and renewal. China's model enables rapid deployment but faces data sharing challenges. US model excels in innovation but creates access inequality. Estonia's model demonstrates comprehensive coverage with limited resources – a key reference for Kazakhstan.

Kazakhstan's digital-health ecosystem remains at the initiation stage, characterized by fragmented infrastructure and limited institutional integration. Four strategic priorities are identified: (1) a national roadmap to align stakeholders and define milestones; (2) regulatory sandboxes to enable safe piloting of telemedicine and AI-based diagnostics; (3) public-private partnerships (PPPs) to mobilize investment and technical expertise; (4) digital health training programs to build local capacity in health informatics and data governance. Under the Belt and Road Initiative, five Sino-Kazakh cooperation pathways are proposed: (1) joint deployment of cross-border telemedicine infrastructure; (2) alignment of health data governance standards, including privacy and interoperability; (3) collaborative talent development through exchange programs and joint research; (4) design of cross-border service mechanisms for patient referral and digital certification; (5) establishment of innovation hubs in Astana and Almaty to support incubation, knowledge transfer, and public-private experimentation.

In addition to the proposed cooperation pathways, the successful implementation of digital health systems in Kazakhstan requires gradual strengthening of institutional coordination mechanisms. Establishing a centralized digital health authority could significantly improve policy coherence, reduce fragmentation among healthcare providers, and ensure more efficient allocation of digital resources across regions. Such an institution would also facilitate long-term strategic planning and international cooperation.

Moreover, the role of data governance is becoming increasingly critical in shaping digital health ecosystems. Clear regulatory frameworks for data ownership, sharing, and protection are essential to build trust among patients, healthcare providers, and technology companies. Without well-defined data governance mechanisms, the scalability and sustainability of digital health solutions may be significantly constrained.

Another important aspect is the integration of artificial intelligence and advanced analytics into healthcare decision-making processes. AI-driven diagnostic systems, predictive healthcare models, and intelligent patient monitoring tools can greatly enhance the efficiency and accuracy of medical services. However, their adoption requires strong validation systems, ethical guidelines, and continuous monitoring to ensure reliability and safety.

In addition, the development of digital health infrastructure should prioritize rural and underserved regions to reduce healthcare inequality. Expanding telemedicine services and mobile health applications can help bridge the gap between urban and rural healthcare systems, ensuring more equitable access to medical services across Kazakhstan's diverse geographic landscape.

Furthermore, sustainable financing mechanisms are essential for the long-term development of digital health ecosystems. Blended financing models that combine public funding, private investment, and international support can provide the necessary capital for infrastructure development, innovation projects, and capacity building. This approach also helps reduce financial risks and encourages broader participation from stakeholders.

Finally, continuous evaluation and performance measurement systems should be integrated into the digital health transformation process. Establishing key performance indicators (KPIs) for service quality, accessibility, efficiency, and user satisfaction will allow policymakers to monitor progress and adjust strategies accordingly. This evidence-based approach will ensure that digital health initiatives remain aligned with national development goals and international best practices.

Three conclusions: (1) Digital-health ecosystems require systematic coordination captured by SER framework; (2) Four evolutionary stages need different policy tools; (3) Belt and Road offers cooperation opportunities. A four-stage strategy for Kazakhstan: Stage 1 – digital infrastructure; Stage 2 – telemedicine integration; Stage 3 – data-driven innovation; Stage 4 – regional hub. Recommendations:

establish coordination agency, tax incentives, regulatory sandboxes, and cross-border cooperation.

In addition to the above findings, it is important to emphasize that the development of digital health ecosystems is not only a technological process but also a long-term institutional transformation. Countries that succeed in this field are those that are able to continuously adapt their governance structures, legal frameworks, and healthcare delivery models to rapidly evolving digital technologies. Therefore, institutional flexibility becomes a key determinant of sustainable digital health development.

Another critical factor is data interoperability. Without unified data standards and compatible digital infrastructure, even advanced digital health systems face fragmentation and inefficiency. The establishment of national and cross-border interoperability frameworks will be essential for ensuring seamless data exchange between hospitals, platforms, and research institutions, especially in international cooperation contexts such as China-Kazakhstan collaboration.

Furthermore, cybersecurity and data privacy protection represent growing challenges for digital health systems. As healthcare becomes increasingly digitized, the risks of data breaches, cyberattacks, and unauthorized access to sensitive medical information also increase. Strengthening cybersecurity governance and implementing robust encryption and data protection mechanisms are therefore essential for maintaining trust in digital health systems.

Human capital development is another decisive element. The successful implementation of digital health technologies requires a workforce that combines medical knowledge with digital competencies such as data analytics, artificial intelligence, and health informatics. This highlights the need for reforming medical education systems and expanding interdisciplinary training programs.

In addition, the role of patients is becoming increasingly important in the digital health ecosystem. With the rise of mobile health applications and telemedicine platforms, patients are no longer passive recipients of care but active participants in health management. This shift toward patient-centered care improves efficiency, enhances accessibility, and supports preventive healthcare models.

From a macroeconomic perspective, investment in digital health infrastructure can significantly reduce long-term healthcare costs by improving efficiency, reducing hospital burdens, and enabling early disease detection. Governments should therefore view digital health not as a cost center but as a strategic investment that contributes to overall economic productivity and public welfare.

Finally, international cooperation remains a key driver for accelerating digital health development. Under frameworks such as the Belt and Road Initiative, countries like China and Kazakhstan have the opportunity to jointly develop technological standards, share best practices, and build integrated health innovation ecosystems. Such cooperation will not only strengthen bilateral relations but also

contribute to the formation of a more connected and resilient global digital health landscape.

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ECONOMIC EFFICIENCY OF GOVERNMENT SUPPORT MECHANISMS FOR SMEs

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Annotation. Small and medium-sized enterprises (SMEs) remain one of the most important generators of employment, innovation and territorial resilience. At the same time, they are more vulnerable than large firms to credit shortages, technology gaps and market volatility. For this reason, governments use grants, guarantees, subsidized finance and digital support programs to stabilize and upgrade the SME sector. The core economic problem is not only whether support should be provided, but whether the chosen mechanism converts public expenditure into measurable business outcomes efficiently. In this paper, economic efficiency is defined as the relationship between public cost and four expected results: revenue growth, employment expansion, survival probability and capability upgrading. The analytical logic follows recent studies arguing that policy quality depends on targeting accuracy, implementation simplicity and the match between a firm's bottleneck and the support instrument [1, 2, 3].

Key words: small and medium-sized enterprises, innovation, government spending, economic efficiency, subsidized financing.

All numerical values in the tables and figures are synthetic and are used only to illustrate comparative logic. A stylized portfolio of 120 supported SMEs per mechanism is assumed for one annual cycle. The calculations do not claim factual measurement; instead, they provide a compact benchmark for comparing instruments under equal reporting rules. Such an approach is useful for conference discussion because it highlights relative efficiency rather than absolute national performance.

Table 1. Synthetic cost structure of main SME support mechanisms

Mechanism	Public cost per SME	Main target	Admin share
Innovation grants	24k USD	R&D and prototypes	14%
Credit guarantees	9k USD	Loan access and liquidity	10%
Interest subsidies	13k USD	Borrowing-cost relief	12%
Digital vouchers	7k USD	Software, cloud, training	8%

Table 1 indicates that the least expensive instruments are credit guarantees and digital vouchers. From an efficiency perspective, these programs start with an advantage because they require less direct fiscal expenditure and lower administrative processing per supported firm.

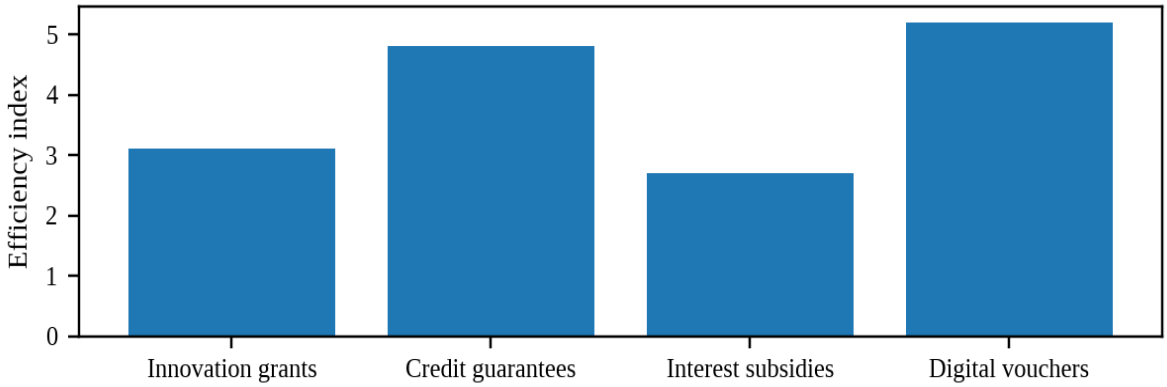

Figure 1. Synthetic composite efficiency index by support mechanism

Figure 1 confirms that digital vouchers and credit guarantees occupy the highest positions in the synthetic ranking, underscoring their prominent role in economic policy tools. Their advantage primarily arises from a modest public cost and a robust crowding-in effect: for example, digital vouchers stimulate additional private consumption by incentivizing firms and households to contribute their own funds, while credit guarantees enhance bank confidence, leading to loan volumes that significantly exceed the direct fiscal expenditure. This multiplier effect amplifies the reach of public investments, making these instruments highly efficient in the short term.

By contrast, innovation grants show a lower short-run efficiency score despite a stronger strategic orientation, often focusing on sectors like renewable energy or digital infrastructure to foster long-term growth. This does not mean such grants are ineffective. Rather, their benefits appear with a longer time horizon and often include spillovers that are not fully captured by immediate revenue or employment indicators, such as technology diffusion, skill development, and ecosystem building. These grants may initially seem less cost-effective but can yield substantial returns through sustained innovation and structural transformations in the economy.

The pattern in Table 2 is consistent with the analytical expectation that different instruments solve different bottlenecks. Innovation grants create the strongest growth profile, while guarantees and vouchers provide balanced operational gains that are easier to scale. This interpretation is broadly compatible with Li and Zhang (2024) and Chen, Wang and Zhang (2025) [4, 5].

Figure 2 shows that revenue and employment do not move in perfect proportion. The highest revenue effect is associated with innovation grants, but the most balanced cost-adjusted profile belongs to guarantees and vouchers. Interest subsidies remain useful as a stabilizing instrument, although their efficiency is weaker when budgets are tight.

Table 2. Simulated firm-level outcomes after one support cycle

Mechanism	Revenue growth	Job growth	Strategic outcome
Innovation grants	+18%	+8%	Export readiness 61/100; survival 90%
Credit guarantees	+14%	+6%	Default risk down 6 p.p.; survival 93%
Interest subsidies	+10%	+4%	Default risk down 4 p.p.; survival 89%
Digital vouchers	+16%	+5%	Digital adoption 78/100; survival 92%

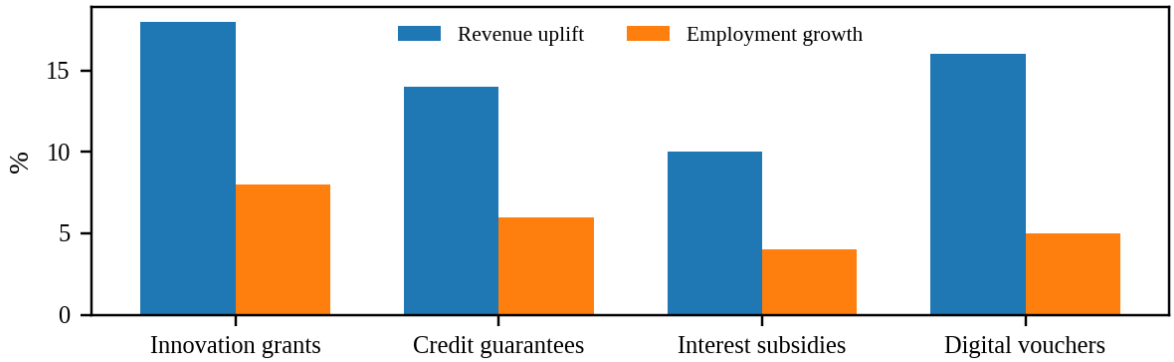

Figure 2. Revenue and employment effects under synthetic assumptions

Table 3. Comparative efficiency ratios and policy ranking

Mechanism	Benefit-cost ratio	Break-even period	Rank
Digital vouchers	2.6	8 months	1
Credit guarantees	2.4	9 months	2
Innovation grants	1.9	14 months	3
Interest subsidies	1.6	15 months	4

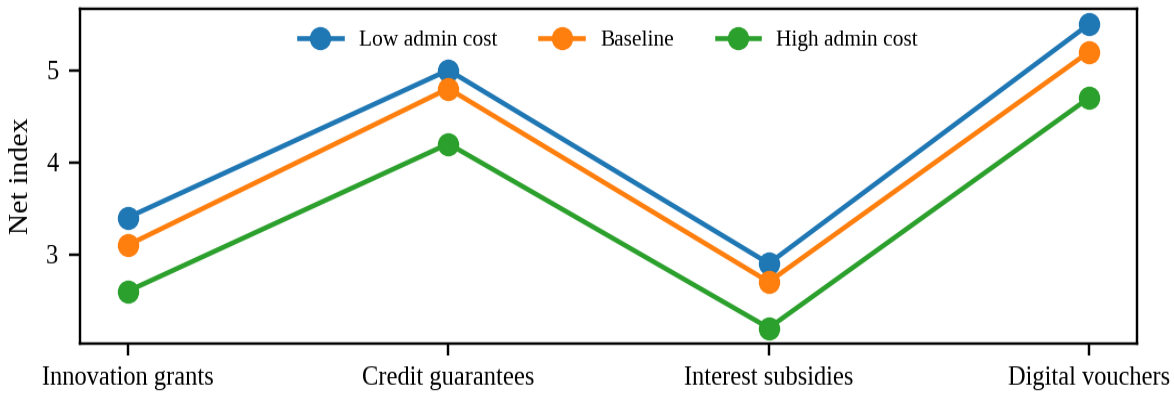

Figure 3. Sensitivity of net efficiency to administrative cost scenarios

Table 3 and Figure 3 lead to one clear conclusion. The most economically efficient government support for SMEs is not the largest subsidy, but the mechanism that targets a concrete constraint with the lowest delivery cost and the strongest private response. In the synthetic benchmark, digital vouchers and credit guarantees dominate because they combine modest budget requirements, relatively fast break-even periods and manageable administrative burdens. Innovation grants remain justified when governments seek technological upgrading, green transition and knowledge spillovers, but they should be reserved for selective, high-potential cases. Effective SME policy therefore requires differentiated instruments, strong screening, simple administration and periodic evaluation against explicit output metrics.

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INVESTMENT AND INNOVATION POLICIES, COMPETITIVENESS AND RISK MANAGEMENT IN THE DIGITAL ECONOMY

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Annotation. This paper systematically explores the synergistic mechanisms between investment policies, innovation policies, and risk management in the era of

the digital economy, as well as the pathways for reconstructing competitiveness and strategies for international cooperation. Through a combination of theoretical analysis and case studies, the article argues that large-scale digital infrastructure investment forms the material foundation for innovation ecosystems; flexible innovation policies significantly enhance investment efficiency; the development and utilization of data elements and the construction of platform ecosystems are key to generating new competitive advantages; while cybersecurity and systemic risks require a multidimensional management framework, including a "technology versus technology" approach. Focusing on the cooperation between China and Kazakhstan under the framework of the "Digital Silk Road," the paper analyzes existing collaborative achievements and proposes avenues for deeper cooperation in areas such as the artificial intelligence industry, green data centers, talent cultivation, and joint risk management. Finally, the study offers policy recommendations, including formulating a national-level overarching strategy, adhering to the principle of "extensive consultation, joint contribution, and shared benefits" in international cooperation, establishing a risk prevention and control system that balances development and security, and intensifying efforts to cultivate interdisciplinary digital talent.

Keywords: Digital Economy; Investment Policy; Innovation Policy; Risk Management; Competitiveness; Digital Silk Road; China-Kazakhstan Cooperation; Data Elements; Platform Ecosystem; RegTech

In the context of the accelerated digital transformation of the global economy, the digital economy has become a strategic high ground that countries are competing to develop. According to a 2024 study by the International Monetary Fund, the contribution rate of the digital economy to global GDP has exceeded 15%, and this proportion is still growing rapidly. In this process, the synergy among investment policy, innovation policy and risk management directly determines the position of countries and enterprises in the new round of global competition. Especially under the framework of the Belt and Road Initiative, digital economy cooperation between China and countries along the route such as Kazakhstan not only concerns the deepening of bilateral economic and trade relations, but also has a profound impact on the digital economy landscape of Eurasia. This paper aims to systematically explore the synergy mechanism of investment and innovation policies in the digital economy era, the reconstruction path of competitiveness, and the response strategies of risk management through a combination of theoretical analysis and case studies, with the expectation of providing references for relevant policy-making and international cooperation.

The development of the digital economy primarily depends on the construction of high-quality digital infrastructure. The "East Data West Computing" project launched by the Chinese government is a model in this regard. The project builds a national integrated computing power network system by establishing national-level

computing power hub nodes in regions rich in renewable energy and with suitable climates such as Guizhou, Inner Mongolia, Gansu and Ningxia. By the end of 2024, the project has driven more than 400 billion yuan of social investment, built more than 8 million data center racks, and achieved a total computing power of 230EFLOPS (exascale). More importantly, this large-scale infrastructure investment does not exist in isolation but is closely integrated with the construction of local innovation ecosystems. Take the GUI 'an New Area in Guizhou Province as an example. The local government has not only provided preferential policies in terms of land and electricity, but also established a big data industry development fund, talent introduction program and industry-university-research cooperation platform, forming a virtuous cycle of "infrastructure - industrial agglomeration - innovation incubation". At present, GUI 'an New Area has gathered data centers of well-known domestic and foreign enterprises such as Huawei, Tencent and Apple, and has incubated hundreds of local big data application and service enterprises, with an annual output value exceeding 100 billion yuan.

Complements infrastructure investment with a flexible and efficient innovation policy system. Kazakhstan has made beneficial explorations in this regard, and the "regulatory sandbox" mechanism implemented by its Astana International Financial Centre (AIFC) is quite representative. The mechanism allows fintech companies to test innovative products and services in a controlled environment, and regulators adjust regulatory requirements in a timely manner based on the test results. With the support of this policy, Kazakhstan's Kaspi Bank's mobile payment system was able to iterate rapidly, completing the entire process from pilot to nationwide rollout in just 18 months. Currently, the number of users has exceeded 10 million, and the average daily transaction volume exceeds 5 million. This success story shows that appropriate innovation policies can significantly lower the market entry threshold for new technologies and new models, and increase the willingness and efficiency of social capital to invest. It is notable that the AIFC has extended this mechanism to emerging fields such as blockchain and digital assets, laying the institutional foundation for Kazakhstan to build a regional fintech hub.

In the digital economy era, data has become a key production factor, and the level of its development and utilization directly determines the level of competitiveness. The practice of Suzhou Industrial Park in China provides strong evidence for this. The "industrial brain" system built in the park integrates production data, supply chain data and energy consumption data of more than 3,000 manufacturing enterprises in the area. Through artificial intelligence algorithms for analysis and mining, it provides precise production scheduling suggestions, supply chain optimization plans and equipment maintenance warnings for enterprises. According to statistics, since the system was put into use, the overall capacity utilization rate of the park has increased by 18.7%, the average inventory turnover days have been reduced by 12 days, and energy consumption per unit of output has decreased by 9.3%. This case clearly shows that the effective use of data elements

can bring about real efficiency and benefit improvements that traditional production factors cannot achieve. More importantly, this data-driven competitiveness is self-reinforcing: the more data is accumulated, the more accurate the analytical model is, the greater the value generated, creating a virtuous cycle.

In addition to data elements, platform ecosystem building is also an important source of competitiveness in the digital economy. The cooperation between Alibaba's eWTP (Electronic World Trade Platform) and Kazakhstan fully demonstrates this. Through the platform, Kazakhstan's agricultural producers can directly connect with global consumers, reducing the middlemen by more than 60 percent. The digital traceability system provided by the platform enables every batch of exported honey and flour to be traced to specific production batches and processing procedures, greatly enhancing the trust of overseas buyers. At the same time, the platform's integrated logistics services and cross-border payment solutions have compressed the customs clearance and settlement processes that would take weeks in traditional trade to just a few days. As of now, more than 500 Kazakh companies have conducted cross-border trade through the eWTP platform, with an average annual growth rate of over 45 percent. This case shows that in the digital economy era, competitiveness is increasingly manifested as ecosystem competitiveness, and the advantages of a single enterprise must be embedded in a larger platform ecosystem to be fully exerted.

With the in-depth application of digital technology, technical risks such as cyber security and data leakage have become increasingly prominent. The "Regulatory Technology Lab" established by the Shenzhen Stock Exchange in China has made forward-looking arrangements in this regard. The lab uses artificial intelligence technologies such as natural language processing and knowledge graphs to monitor the announcements of listed companies, media reports and social network information around the clock and automatically identify abnormal patterns and potential risks. In 2023, the system successfully warned of 32 violations by listed companies, with an average early warning time of 14 working days, buying valuable time for regulatory intervention and market stabilization. In addition, the laboratory has also carried out application research on cutting-edge technologies such as quantum encrypted communication and blockchain evidence storage, continuously enhancing the technical content of risk prevention and control. This "technology against technology" approach represents the advanced direction of risk management in the digital economy.

Another feature of the digital economy is that the speed and extent of risk transmission far exceed those of the traditional economy, making it prone to systemic risks. The collaboration project between Ant Group and CIMB Bank of Malaysia provides a valuable reference for this. The cross-border microloan risk control model jointly developed by the two sides combines China's mature digital credit assessment experience with Malaysia's local financial data characteristics to establish a dynamic risk assessment system. The system not only examines the borrower's traditional credit record, but also incorporates multi-dimensional data such as digital footprint,

social relationships, and consumption behavior, achieving more precise risk pricing. For three years since the project was implemented, the non-performing loan ratio has consistently been kept below 1.5%, far below the industry average. More importantly, the two sides have set up risk isolation mechanisms and emergency liquidity arrangements to ensure that fluctuations in a single market do not spread to the entire cooperative system. This design concept, which focuses on both micro-risk control and systemic risk prevention, is worthy of wide reference in cross-border digital economy cooperation.

Consolidation and Expansion of Existing Cooperation Foundation China and Kazakhstan have established a good cooperation foundation in the field of digital economy, and the digital transformation of the Khorgos Port is a successful example. By deploying Internet of Things (iot) devices, automated inspection systems and blockchain platforms, the port's clearance time has been significantly reduced from 72 hours to less than 3 hours, and the annual cargo handling capacity has increased to 35 million tons. Behind this achievement lies years of coordination and cooperation between China and Kazakhstan in areas such as technical standards, data interfaces, and mutual recognition of supervision. In the future, this model can be extended to other border crossings and extended to digital collaboration among multiple departments such as customs, taxation, and transportation to create a complete ecosystem of "smart borders".

In addition to the digitalization of traditional trade, China and Kazakhstan have many new growth points for cooperation in the digital economy. In terms of cooperation in the artificial intelligence industry, the two sides can jointly build research and development centers, focusing on special areas such as multilingual natural language processing and cross-border e-commerce recommendation algorithms. In terms of digital talent cultivation, the scale of joint education can be expanded, and specialized directions such as digital trade and blockchain application can be added to cultivate no less than 500 high-quality compound talents each year. In the field of green digital economy, Kazakhstan's abundant renewable energy can be utilized to jointly build zero-carbon data centers, providing green computing power support for the development of digital economy in both countries and the entire region.

As cooperation deepens, it becomes particularly urgent to establish a sound risk management mechanism. It is suggested that a sub-committee on digital economy cooperation be established under the framework of the China-Kazakhstan Cooperation Committee, specifically responsible for coordinating relevant policies, standards and regulatory matters. At the same time, drawing on international experience, a management model of "negative list + positive incentives" can be established to promote innovation to the greatest extent while maintaining the bottom line of safety. In addition, a system of regular risk assessment and emergency drills should be established to enhance the ability to respond to sudden risk events.

Through an in-depth analysis of typical cases, it can be found that the healthy

development of the digital economy requires the organic integration of investment, innovation and risk management. Infrastructure investment lays the material foundation for innovative development, flexible innovation policies release investment efficiency, and sound risk management provides a stable guarantee for the entire system. Based on this understanding, this paper puts forward the following policy recommendations:

First, formulate an overall strategy for the development of the digital economy at the national level, identify key areas of investment and priority directions of innovation, and avoid scattered resources and redundant construction. Particular emphasis should be placed on the establishment of interdepartmental coordination mechanisms to break down "data silos" and "policy barriers".

Second, in international cooperation, adhere to the principle of "extensive consultation, joint contribution and shared benefits", and resolve key issues such as technical standards, data flow and market regulation through equal consultation. China and Kazakhstan can promote the establishment of regional rules for digital economy cooperation within multilateral frameworks such as the Shanghai Cooperation Organization and the Conference on Interaction and Confidence Building Measures in Asia.

Third, establish a risk prevention and control system that suits the characteristics of the digital economy and strike a balance between development and security. We should encourage innovation and provide room for trial and error for new technologies and new models, while ensuring that systemic risks do not occur.

Fourth, we should intensify efforts to cultivate digital talents. Through various channels such as school-enterprise cooperation and international exchanges, we should foster compound talents who are proficient in both technology and economics, familiar with domestic conditions and have an international perspective.

Looking ahead, the digital economy will continue to profoundly transform the global economic landscape. Only those countries and enterprises that can effectively integrate investment, innovation and risk management policies will stand out in the fierce international competition. China and Kazakhstan, as important neighbors and strategic partners, have broad prospects for cooperation in the digital economy, which will surely bring more benefits to the people of both countries and inject new impetus into regional development.

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DIGITAL-ECONOMY TRANSFORMATION AND INDUSTRIAL STRUCTURE OPTIMIZATION IN RESOURCE-DEPENDENT REGIONS FROM THE PERSPECTIVE OF ENGINEERING CONSULTING

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Annotation. This study explores the role of the digital economy in promoting industrial structure optimization in resource-dependent regions, with a focus on engineering consulting support. The digital economy facilitates industrial upgrading through improved resource allocation, technological innovation, and green transformation.

The research shows that engineering consulting plays a key role in enhancing decision-making, investment efficiency, and risk management throughout the project lifecycle. However, challenges such as low digitalization levels, structural dependence, and limited innovation capacity remain.

To address these issues, the study proposes strengthening digital infrastructure, developing digital consulting services, and improving interdisciplinary talent training. The findings highlight the importance of coordinated development to achieve sustainable and high-quality economic growth.

Keywords: Digital Economy; Industrial Structure Optimization; Resource-Dependent Regions; Engineering Consulting

Against the backdrop of global high-quality development, resource-dependent regions generally face dilemmas such as single industrial structure, high transformation costs, and strong pressure for green development. The digital

economy has become a key driving force to break resource path dependence and promote industrial upgrading. As a professional service industry for project decision-making, planning and design, investment management and risk assessment, engineering consulting plays a core supporting role in regional transformation, major project implementation and industrial structure adjustment. Integrating digital economy, resource-based regional transformation and engineering consulting practice conforms to both industrial policy orientation and your major and research direction.

Enrich interdisciplinary research on resource-dependent regional transformation, digital economy and industrial structure optimization; supplement the interdisciplinary theoretical framework of engineering consulting + digital economy + regional economy; improve the theory of engineering consulting service transformation under the background of digital empowerment.

Provide decision-making references for industrial transformation for governments and platform companies in resource-dependent regions; offer paths for engineering consulting enterprises to expand digital consulting, green consulting and industrial planning consulting; improve the digital and scientific management level of the whole life cycle of engineering projects.

Research on transformation of resource-dependent regions and solving the "resource curse". Research on the mechanism of digital economy driving industrial structure optimization. Research on the role of engineering consulting in regional development and major projects. Research on the development of digital engineering consulting, intelligent consulting and green consulting.

Research Review: Existing studies rarely integrate resource-based regional transformation, digital economy empowerment and engineering consulting support into a unified framework, which is the innovation point of this paper.

Research Ideas: Status diagnosis → Mechanism analysis → Empirical test → Case support → Engineering consulting path → Countermeasures and suggestions.

Research Methods: Literature research method, mechanism analysis method, empirical analysis (panel data / regression), case analysis method, comparative research method.

Construct an analysis framework of digital economy – industrial structure optimization – engineering consulting support.

Reveal the transmission mechanism and empowerment path of engineering consulting in the digital transformation of resource-dependent regions.

Propose a digital engineering consulting service system and implementation plan for resource-dependent regions.

Form implementable policy and industry suggestions combined with empirical and typical cases.

Industrial structure characteristics of resource-dependent regions: dominated by heavy industry, weak service industry, insufficient innovation, high green pressure.

Transformation pain points: path dependence, low investment efficiency, unscientific project decision-making, low digital level, weak risk management and control.

Digital economy empowerment potential: data elements, digital technology and digital platforms reconstruct production and resource allocation.

Digital infrastructure empowerment: reduce transformation costs and improve factor flow efficiency.

Data element reconstruction mechanism: optimize resource allocation and promote industrial chain upgrading.

Technological innovation driving mechanism: promote the development of high-tech industries and modern service industries

Green and low-carbon transformation mechanism: promote energy consumption reduction, circular economy and sustainable development.

Engineering consulting support mechanism: scientific decision-making → precise investment → risk prevention and control → benefit improvement.

Planning and strategic consulting: Compile digital economy development planning, industrial transformation planning and territorial spatial planning.

Project decision-making and investment consulting: Digital project feasibility study, investment estimation, performance evaluation.

Whole-process engineering consulting: Intelligent construction site, BIM consulting, digital supervision, cost management and control.

Risk and compliance consulting: Data security, intellectual property rights, green and low-carbon, compliance review.

Industrial investment and operation consulting: Digital industry introduction, park operation, industrial chain cultivation.

Domestic resource-based city cases: Digital transformation + engineering consulting practice in resource-dependent regions of Shanxi / Shaanxi / Inner Mongolia Beijing (intellectual resource-based region) case: Construction of a global digital economy benchmark city and application of whole-process engineering consulting China-Kazakhstan cooperation cases: Cross-border projects, digital infrastructure, engineering consulting services for energy projects.

Improve digital infrastructure and promote the marketization of data elements.

Introduce high-level engineering consulting institutions to improve the scientific of project decision-making.

Establish a project database for digital transformation and industrial upgrading.

Accelerate digital transformation and develop intelligent consulting, digital consulting and green consulting.

Expand special consulting services for transformation of resource-dependent regions.

Build a comprehensive capability of "digital technology + engineering consulting + industrial services".

Improve engineering consulting standards and digital specifications.

Strengthen the training of digital talents and interdisciplinary consulting talents.

Promote the sharing of government-enterprise data to improve consulting accuracy.

The digital economy can effectively promote the high-end, intelligent and green industrial structure of resource-dependent regions; engineering consulting is the key support for the implementation of digital transformation, and plays an important role in the whole chain of planning, investment, risk and operation; coordinated promotion should be carried out from multiple dimensions of policy, technology, industry and talents.

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DIGITAL ECONOMY INVESTMENT, INNOVATION POLICY AND RISK GOVERNANCE: EVIDENCE FROM CHINA-KAZAKHSTAN COOPERATION UNDER THE BELT AND ROAD INITIATIVE

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Annotation. In this context of global digitalization and BRI, digital economy becomes an important force for sustainable economic growth; Digital economy investment and innovation policy is one of the key institutional measures to enhance industry's competitive power and avoid systematic risk [1,2].This paper pays attention to the institutional logic, implementation path and governance mechanism of developing digital economy, and then comprehensively studies the synergy of investment policy with innovation policy, digital competition and risk management [2,5]. Taking China-Kazakhstan's actual collaboration as an example, this paper analyzes the direction of policy optimization and the path of transnational risk prevention. Our results suggest that science policy coordination and effective risk management can lead to more efficient resource reallocation, foster technological innovation, and promote high-quality development in the digital economy. This paper can provide some references to further deepen China-Kazakhstan's digital economic cooperation.

Keywords: Digital economy investment; Innovation policy; Risk governance; China–Kazakhstan cooperation; Belt and Road Initiative

The global information revolution accelerates changes in industry structures, factors allocation mode and international competition pattern. Digital economy, with data as an important production factor, is one of the main areas for international economic competition [1, 2]. Investment in digital infrastructure, technological R&D and key industries directly determine the developmental capacity for a nation or territory [1, 3]. At the same time, innovation policy offers institutional incentives to technological breakthroughs, industrial integration and business model innovation.

However, the rapid development of the digital economy is accompanied by multiple risks such as data security, platform monopoly, cross-border regulatory differences and financial volatility. Inadequate risk governance will directly restrict innovation vitality and industrial competitiveness. This paper focuses on the coordinated development of investment, innovation and risk governance, and provides implications for bilateral digital cooperation [3, 5].

Digital investment has become a key component of global FDI [1]. Digital infrastructure and policy coordination determine competitiveness [2], while digital development trends highlight the importance of innovation and governance [3]. Empirical studies show that digital innovation improves resource allocation and firm competitiveness [4], although risks related to data and regulation remain significant [5].

Digital economy investment refers to capital input in digital technology R&D, infrastructure construction, platform operation, enterprise digital transformation and industrial cultivation. It includes public investment in new infrastructure such as 5G networks, big data centers and cloud computing platforms, and private investment in technological innovation, platform development and market-oriented application [1,3].

Innovation policy comprises a set of institutional mechanisms designed to foster research and development, the translation of research outcomes into practical use, and their integration into industrial processes. It includes fiscal subsidies, tax incentives, intellectual property protection, talent introduction policies, regulatory sandboxes and industry-university-research cooperation mechanisms [2, 4].

Digital competitiveness is a comprehensive capability reflected in technological innovation, infrastructure, data governance, institutional environment and international cooperation. It denotes the capacity to acquire, distribute, and deploy digital resources in order to secure competitive advantages on the global stage [2, 3].

Digital risk governance is a systematic mechanism covering risk identification, assessment, early warning and control in data flow, platform operation, cross-border investment and financial activities. Its goal is to balance innovation vitality and operational security [3, 5].

Functions of Investment and Innovation Policies

•Direct investment toward priority digital sectors—including foundational technologies, digital infrastructure, and small- and medium-sized digital firms—to address market failures.

•Support independent innovation, strengthen technological security and reduce external dependence in key core fields.

•Promote closer integration between information technology and the real economy, and accelerate industrial digitization and upgrading [3].

•Enhance the business environment, lower institutional transaction costs, and invigorate market participants.

•Promote cross-border investment cooperation, technology exchange and standard docking under multilateral and bilateral frameworks.

Dimensions of Digital Competitiveness

•Innovation capability: Including the level of R&D spending, quantity and quality of patents produced, the capacity for basic technology breakthroughs, and the success with which such breakthroughs are commercialized:

•Digital infrastructure level: Including network coverage, computing power supply, cloud service penetration rate and blockchain infrastructure popularization.

•Data governance and application capacity: Including data collection, processing, analysis, open sharing, security protection and value realization ability [3,5].

•Governance structure: Including strength of rule of law, regulatory quality, protection from expropriation, and the uniformity in application of the policy.

•Ability to access new markets (including FDI) and technology transfer: multinational operating skills, and market penetration and development capabilities.

Major Risks in the Digital Economy

•Technological R&D uncertainty: High investment, long cycle and unpredictable results lead to investment loss and resource mismatch [1].

•Data security and privacy risks: Data leakage, abuse, illegal trading and network attacks damage rights and interests [3,5].

•Platform monopoly and unfair competition: Super platforms use data, traffic and capital advantages to exclude competitors and damage market fairness.

•International investment risk/regulatory considerations: Differences in laws, regulations, and political situations increase investor uncertainty [6].

•Digital financial volatility risks: Virtual assets, online lending and cross-border capital flows may trigger liquidity and systemic risks.

To achieve high-quality development of the digital economy, a multi-dimensional coordinated governance system must be constructed.

•Policy coordination: Integrate fiscal, tax, financial, talent, industrial and regulatory policies to form a joint force and avoid policy conflicts or gaps [2,6].

•Innovation and governance balance: Use regulatory sandboxes to conduct inclusive and prudent supervision, encourage trial and error in new formats and control risks within a limited range.

•International coordination: Promote the connection of digital rules, standards and regulatory systems among countries, improve cross-border risk prevention and control and reduce institutional barriers [3,5].

•Stakeholder collaboration: Create collaborative policy environment with the participation of public agencies, industry, industry groups, research communities, and civil society actors in order for them to be able to share information among themselves as well as take responsibility together.

China has built digital economy pilot zones and guidance funds to support innovation and industrial upgrading, and strengthened anti-monopoly and data security governance to balance development and security.

In China-Kazakhstan cooperation, both sides have achieved practical results in cross-border optical cables, digital logistics platforms and e-commerce. However, problems such as inconsistent regulatory standards and insufficient risk early warning still exist. Promoting policy alignment and joint risk prevention will help improve bilateral digital competitiveness and deepen practical cooperation.

Digital economy Investment, Innovation Policy & Risk Governance is closely related to each other as well as complementing one another [2,4]. Well-structured science institutes will promote innovations, support industry competitiveness, and provide effective risk management. Under the BRI initiative, furthering Sino-Kazakh information technology cooperation will depend on greater coordination in this area, greater institutional interoperability, and creation of an open collaborative environment, stability, and predictability [1,6]. This would not only promote the healthy development of the digital economy in both countries, but also provide experience for global digital governance.

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BIG DATA-DRIVEN PRODUCT INNOVATION AND PROCESS OPTIMIZATION

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Annotation. In the era of digital economy, enterprises urgently need to enhance the efficiency of product innovation and optimize the innovation process. Big data has become the core driving force for achieving this goal. This article systematically analyzes the role and mechanism of big data in enterprise product innovation, the ways in which big data promotes the optimization of the innovation process, and the

challenges encountered in practice. It has been discovered that big data effectively accelerates product innovation and improves innovation performance by optimizing innovation processes, shortening innovation cycles, enhancing innovation accuracy, and improving the ability to integrate resources.

However, in practice, there are still issues such as uneven data quality, data security risks, and mismatched organizational cultures. Specific management suggestions have been put forward to address these problems.

Key words: Big data; Product innovation; Process optimization; Product development

With the vigorous development of the digital economy, big data has become a crucial strategic resource that influences the development of enterprises. An increasing number of manufacturing enterprises are attempting to apply big data to product research and development, hoping to gain an advantage in innovation-driven competition in the fierce market environment [1]. Big data not only provides a new type of innovative element for product innovation, but also offers a new technical path for reconfiguring the product innovation system. Although many enterprises have recognized the potential of big data, they still encounter numerous practical obstacles in the actual process of promoting product innovation and process optimization driven by big data. These obstacles are manifested as difficulties in data acquisition and integration, uneven data quality, and insufficient data security guarantees. Many enterprises lack a clear data strategy in product development, and the optimization of traditional innovation processes is relatively slow [2].

Especially for some small and medium-sized enterprises that have insufficient investment in digitalization, they still lack systematic guidance on how to initiate innovation driven by big data. The issue of how process optimization can effectively support the release of data value has not been fully addressed. Based on this, this article aims to clarify the intrinsic relationship between big data and enterprise product innovation, deeply explore the mechanism by which big data optimizes the product innovation process, and put forward corresponding management implications.

The role of big data in product innovation is not only to provide new decision-making basis, but also to reshape the entire process of product development. From idea generation, concept design, prototype testing to market launch, big data can offer strong support at every stage [3]. From a process perspective, the mechanism by which big data optimizes and innovates processes can be explained from the following three aspects.

The traditional product innovation process usually proceeds in a linear sequence, with each stage completed before moving on to the next. This model largely limits the speed of innovation and the flexibility of market response. The introduction of big data enables the R&D team to obtain market feedback and user behavior data more promptly and in real time, allowing them to simultaneously advance multiple

innovative tasks and significantly shorten the overall innovation cycle. This non-linear and iterative process arrangement provides the technical possibility for enterprises to respond quickly to market changes and reduce development costs.

By conducting in-depth analysis of production data, sales data and user behavior data through big data, enterprises can more accurately understand the potential needs of customers and detect functional flaws and quality shortcomings of products earlier. This evidence-based decision-making approach helps to reduce the risk of product failure, increase the additional features that customers are willing to pay for, and eliminate redundant or unnecessary functions [4]. Compared with traditional judgments that rely on experience and intuition, innovative decisions supported by big data are more objective and accurate, thereby effectively enhancing the quality of new products and their market success rate.

From a theoretical perspective, optimizing the innovation process is the inherent path through which big data enhances the performance of product innovation. Big data transforms from an underlying production factor into a real production factor. The mechanism for this transformation lies in the digital analysis that enhances an enterprise's innovation capabilities and performance through a closed-loop model involving resources, data, and usage [5]. Specifically, big data enhances an enterprise's ability to integrate resources, accelerates its learning capabilities and the update of routines, thereby systematically improving the performance of product innovation. This process reflects the transformation of big data from an external technological tool to an internal growth driver.

Although the role of big data in promoting product innovation has been widely recognized, it still faces multiple challenges in practical application. This section analyzes the main problems in practice from two dimensions: data quality and security, as well as organizational culture and capabilities, and then proposes corresponding solutions.

Data quality is a fundamental factor that restricts product innovation. In practice, enterprises often accumulate vast amounts of data but lack a clear data governance strategy, getting stuck in the predicament of "having abundant data but scarce information", making it difficult to effectively transform raw data into genuine innovation impetus [6]. Therefore, enterprises need to establish a systematic process model framework to guide them in formulating clear strategies for data collection, cleaning, storage and analysis during product development. At the same time, the issue of privacy and security protection in big data cannot be ignored. When enterprises collect and analyze user data to optimize product design, if there is a leakage of user privacy or improper use of data, it may lead to legal disputes and reputational damage. Enterprises should establish a compliance management system throughout the entire lifecycle of data collection, storage and usage, strengthen technical security measures, and clearly define the ethical boundaries for data usage.

The in-depth optimization of the innovation process requires the support of corresponding organizational culture and dynamic capabilities. The flexible and

iterative new product development process relies on the data utilization strategies and dynamic capabilities of the enterprise, and dynamic capabilities are an important way for enterprises to achieve business model innovation and process innovation in the digital economy [7]. Successful cases both at home and abroad have shown that the effective implementation of data-driven innovation cannot be achieved without a comprehensive data strategy and an adaptable agile organizational culture [8]. Therefore, when enterprises leverage big data for product innovation and transformation, they not only need to make technological investments, but also need to simultaneously adjust their organizational structures, cultivate a data-driven corporate culture, and strengthen the reserve of relevant talents.

Big data has become one of the core driving forces for enterprise product innovation. If enterprises want to maintain their leading position in the fierce market competition, they must systematically rely on big data technology. Big data mainly optimizes the innovation process by shortening the innovation cycle, improving the innovation accuracy, and enhancing the "conversion efficiency" of data usage. During the practical application process, enterprises must pay close attention to key challenges such as data quality, data security, and organizational culture alignment. Future research could further focus on how the deep integration of emerging technologies such as big data and artificial intelligence will continuously optimize the product innovation process. How do enterprise product innovations in different institutional and cultural contexts get influenced by the application models of big data? And more empirical studies based on the Chinese context will reveal the specific paths for effectively leveraging big data to drive product innovation.

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TECHNOLOGICAL INNOVATION AND ETHICAL REGULATION IN AI INDUSTRIES

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Annotation. Artificial intelligence (AI) has become the core driving force of the new round of technological revolution and industrial transformation globally. As the world's second-largest economy and a leading AI technology power, China has made remarkable achievements in AI technological innovation in recent years, while also establishing a systematic ethical regulatory framework to guide the healthy development of the AI industry. Against the background of the "Belt and Road" (BRI) initiative, China's AI technology and regulatory experience can provide important reference for cooperation with Kazakhstan and other BRI countries in the digital economy field, promoting the sustainable development of the global AI industry.

Key words: Artificial Intelligence (AI), technological innovation, industrial transformation, digital economy.

China has formed a complete AI industrial ecosystem covering the basic layer, technology layer, and application layer. As of 2025, the number of AI enterprises in China exceeded 4,300, accounting for 28% of the global total. In the field of large models, more than 80 general large models with parameters exceeding 10 billion have been released, covering industries such as manufacturing, finance, education,

and medical care. In terms of infrastructure, China's total intelligent computing power reached 23 EFLOPS, ranking second in the world, providing strong support for AI technology iteration. China's AI technology has been widely applied in smart city construction, intelligent transportation, and cross-border e-commerce, with the industrial scale exceeding 650 billion yuan in 2025.

China has established a multi-level AI ethical regulatory system combining top-level design, industry norms and platform self-discipline. The 2021 "New Generation Artificial Intelligence Ethics Governance Code" clarified basic principles of fairness, justice, safety and controllability. The 2023 "Interim Measures for the Management of Generative Artificial Intelligence Services" is the world's first special regulatory regulation for generative AI services, clarifying service providers' main responsibilities, algorithm filing requirements and data security obligations. As of 2025, more than 1,200 generative AI products have completed algorithm filing, with 94% pass rate of AI-related cross-border data transmission security assessment. China adheres to the principle of "inclusive and prudent supervision", setting up 17 AI innovation supervision pilot zones nationwide to explore replicable regulatory experience for different application scenarios, effectively balancing technological innovation and risk prevention.

A sound AI ethical regulatory system has become an important driving force for the high-quality development of China's AI industry, rather than a constraint on technological innovation. From the perspective of technological innovation incentive, the clear regulatory boundary reduces the institutional cost of enterprise R&D investment: from 2022 to 2025, the R&D investment intensity of China's AI industry increased from 18.7% to 26.3%, and the number of authorized AI-related invention patents increased at an average annual rate of 38.2%, which is significantly higher than the average growth rate of 22.7% in the three years before the introduction of the Generative AI Regulation Measures. The algorithm filing system also promotes the standardized iteration of technology: as of 2025, the proportion of AI enterprises that have established a full-cycle ethical risk assessment mechanism for R&D processes has increased from 12% to 78%, effectively reducing the repeated R&D investment caused by non-compliance risks.

In terms of market fairness guarantee, the regulatory system effectively curbs unfair competition behaviors such as algorithmic discrimination and malicious data monopoly, creating a fair market environment for small and medium-sized AI enterprises. From 2023 to 2025, the number of newly established AI enterprises in China increased by an average of 21% annually, and the market share of the top 10 AI enterprises in the general market decreased from 76% to 62%, while the market share of specialized and innovative small and medium-sized AI enterprises in the segmented scenario increased from 24% to 38%. The clear copyright identification rules for AI-generated content have also stimulated the prosperity of the AI application ecology: the scale of China's AI-generated content industry reached 120 billion yuan in 2025, with a year-on-year growth of 87%.

In terms of international competitiveness improvement, a sound regulatory system helps Chinese AI enterprises meet the compliance requirements of overseas markets. As of 2025, 42 Chinese AI enterprises have passed the EU AI Act high-risk product certification, and the number of Chinese AI products entering the Southeast Asian market increased by 56% year-on-year in 2025, which is significantly higher than the global average growth rate of 29%. The unified domestic regulatory standard also reduces the compliance cost of enterprises expanding to overseas markets: according to the survey of China AI Industry Alliance, the average overseas market access cycle of Chinese AI enterprises has been shortened from 18 months to 7 months after the establishment of the domestic AI regulatory system.

As a core node of the China-Central Asia Economic Corridor, Kazakhstan has huge demand for AI technology empowerment in cross-border trade, transportation and public services. In the field of cross-border intelligent logistics, the application of AI intelligent customs clearance and route optimization systems can reduce the average border waiting time of China-Kazakhstan freight vehicles by 42%, and reduce the comprehensive logistics cost of cross-border goods by 18.7%, which strongly supports the development of cross-border e-commerce and trade cooperation between the two countries.

In the field of cross-border AI government services, the two sides are exploring the construction of a mutual recognition system for AI identity authentication and electronic certificate verification, which can shorten the processing time of cross-border business licenses, visa and other government services for residents and enterprises of the two countries by more than 60%, and effectively improve the convenience of cross-border personnel exchanges and business cooperation.

In the field of AI vocational education, China's mature AI talent training system and course resources can support Kazakhstan to train more than 2,000 AI applied talents every year, helping Kazakhstan build its own AI talent echelon and industrial development foundation, which is of great significance for promoting the digital transformation of Kazakhstan's economy and narrowing the global digital divide.

China's practice in AI technological innovation and ethical regulation has proved that a sound regulatory system can effectively promote the healthy and sustainable development of the AI industry. The positive correlation between China's AI regulatory system construction and industrial innovation growth in the past three years provides practical evidence for the coordinated development of governance and innovation. The multi-level implementation path of BRI regional AI governance rule coordination constructed by China has expanded the application scenarios of global AI governance consensus in emerging economies, providing a replicable reference for cross-regional AI governance cooperation. In the context of global digital economic integration, strengthening international cooperation in AI governance, sharing technological innovation achievements and regulatory experience will help all countries better enjoy the dividends of AI technology, and promote the construction of a more inclusive, fair and win-win global digital governance system

and the realization of the UN Sustainable Development Goals in the digital field.

Furthermore, the rapid evolution of AI technologies requires continuous updates and adaptive adjustments to existing regulatory frameworks. Static governance models are no longer sufficient in addressing the complexity and speed of innovation in the AI sector. Therefore, China's experience highlights the importance of flexible, forward-looking regulatory mechanisms that can evolve alongside technological advancements while maintaining ethical standards and societal safety.

In addition, capacity building and talent development play a crucial role in strengthening AI governance systems. Developing skilled professionals in AI ethics, data security, and algorithmic accountability is essential for ensuring effective implementation of regulatory policies. International collaboration in education and training programs can further enhance mutual understanding and reduce governance gaps between participating countries in the BRI framework.

Moreover, the integration of AI governance with broader digital infrastructure development is becoming increasingly significant. Issues such as data sovereignty, cybersecurity, and cross-border data flow management must be addressed in a coordinated manner to ensure the stability and reliability of global AI ecosystems. This integrated approach can help prevent regulatory fragmentation and promote interoperability among different national systems.

Finally, as AI continues to reshape global economic and social structures, it is essential to prioritize human-centered values in technological development. Ensuring transparency, accountability, and fairness in AI applications will be key to maintaining public trust. By aligning technological progress with ethical governance principles, the international community can maximize the benefits of AI while minimizing potential risks.

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THE DIGITIAL "BELT AND ROAD": CHOOSING PATHWAYS FOR INVESTMENT INNOVATION AND COMPETITIVENESS ENHANCEMENT

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Annotation. Based on the international landscape from 2022 to 2025, this paper conducts a comprehensive analysis of "Belt and Road" digital economy cooperation across three dimensions: investment and innovation policies, competitiveness, and risk management. The study finds that "Belt and Road" digital economy cooperation has formed a regional pattern characterized by "strong hardware manufacturing but weak digital services." China holds significant advantages in digital markets and infrastructure but still has room for improvement in digital technology and digital governance. The cooperation model exhibits the characteristics of the "Three Connections" - physical connectivity (infrastructure), institutional connectivity (rules and standards), and people-to-people connectivity (talent development)—which have effectively promoted regional digital economic interconnectivity. At the same time, the study reveals risk challenges such as data sovereignty conflicts, technological dependence, and rising compliance costs, and proposes strategies for prevention and control through technical standard coordination, localized operations, and multilateral risk-sharing mechanisms. The findings indicate that digital economy cooperation has become a new engine for the high-quality development of the Belt and Road Initiative, but it also requires a more systematic risk management framework to address the complex international environment.

Keywords: Digital Economy; Belt and Road Initiative; Digital Silk Road

The digital economy has become a new engine for global economic growth. In 2024, the scale of global digital trade reached $7.23 trillion, with an average annual growth rate of 12.1%, exceeding the average annual growth rate of total global trade during the same period. Against this backdrop, digital economy cooperation under the Belt and Road Initiative (i.e., the Digital Silk Road) is moving from concept to practice, becoming a key driver for promoting connectivity and industrial upgrading among countries along the route.

The concept of the digital economy originated with Don Tapscott's 1996 book «The Digital Economy», which first systematically articulated the concept and characteristics of the digital economy, emphasizing the transformative impact of the internet on the nature of business and government. Since then, digital economy theory has evolved from a single-dimensional approach to a multidimensional analytical framework, specifically the "technology-economy-governance" three-dimensional framework (Goldfarb and Tucker, 2019). Currently, academic research on the digital economy is gradually shifting toward the economic functions of digital technologies and their transformative effects on production relations (Turcan and Juho, 2014) . Research indicates that some scholars focus on digital technologies as the core drivers of productivity transformation – including the internet, blockchain, big data, and artificial intelligence – and how these technologies reshape social production methods (Choi and Hoon Yi, 2009; Landefeld and Fraumeni, 2001) ; other scholars focus on the reshaping of economic structures by the digital economy, including the formation of data factor markets and the rise of the platform economy(Hulka et al., 2020) , as well as how digital technologies influence economic growth, employment structures, and income distribution(Ghasemaghaei and Calic, 2019) .Against the backdrop of today's booming digital economy, how to leverage the digital economy to build a high-quality "Belt and Road" initiative is key to China's current response to global governance risks. Regarding the definition of risk agents for the "Belt and Road" initiative, foreign scholars tend to view the participating countries as the primary risk agents, focusing particularly on the fiscal and financial risks associated with infrastructure construction and investment—including risks related to national finances and mega-projects, institutional and governance risks, environmental risks, and economic and social inequality(Dappe et al., 2019; Hughes et al., 2020) ; whereas Chinese scholars tend to view China itself as the primary risk agent.

In 2025, China's merchandise trade with "Belt and Road" partner countries reached 23.6 trillion yuan, a year-on-year increase of 6.3%, with significant growth in exports of digital products such as electronic components and machinery.China's digital trade exports reached $793.7 billion, a year-on-year increase of 10.7%, ranking among the world's highest. At the same time, digital economy cooperation under the "Belt and Road" initiative faces multiple challenges, including conflicts over data sovereignty, technological dependence, and rising compliance costs, necessitating systematic research into its investment and innovation policies, competitiveness performance, and risk management strategies (Aris, 2016) .

This paper will conduct a comprehensive study of "Belt and Road" digital economy cooperation from four dimensions: the construction of a digital economy development index, analysis of investment and innovation cooperation models, competitiveness assessment, and risk management strategies, with the aim of providing theoretical support and practical guidance for promoting the high-quality development of the Digital Silk Road.

To systematically assess the state of digital economic development in "Belt and Road" countries, this paper constructs a Digital Economic Development Index comprising four major dimensions: 1. Digital Infrastructure: including indicators such as internet penetration rate, mobile broadband coverage, and the number of fixed broadband subscribers per 100 people; 2. Digital Technology Application: including the share of ICT goods and services exports, digital payment penetration rate, and the scale of electronic signature adoption; 3. Digital Innovation: including R&D expenditure as a percentage of GDP, patent applications, and the number of scientific journal articles;4. Digital Governance: including the level of e-government development, the completeness of data security regulations, and the prevalence of digital literacy. Data sources are primarily based on the World Bank's WDI database, the ITU's 《Global Connectivity Report 2025》, and statistics from the United Nations Conference on Trade and Development (UNCTAD). The entropy method was used to determine the weights of each indicator, reflecting the degree of influence of different indicators on digital economic development.

Based on regional divisions, "Belt and Road" countries can be categorized into six major regions: East Asia, Southeast Asia, South Asia, Central Asia, West Asia and North Africa, and Central and Eastern Europe. The development of the digital economy varies significantly across these regions, forming an overall gradient pattern characterized by "strong in the west, weak in the east; weak in the south, strong in the north." Table 1 shows that the East Asia and Pacific region (China, Singapore, etc.) has the highest level of digital economic development, with an average TIMG index of 81.42;followed by the ASEAN region (Singapore, Malaysia, etc.), with an average of 75.34; the Central and Eastern Europe region (Poland, Hungary, etc.), with an average of 65.86; while Central Asia (Kazakhstan, Uzbekistan, etc.) and South Asia (India, Pakistan, etc.) have lower averages, at 58.21 and 56.37, respectively.

Table 1. Regional Differences in the Digital Economy Development Index of "Belt and Road" Countries

Region	Number of Countries	Average TIMG Index	Development Characteristics
East Asia and the Pacific	2	81.42	Leading in Digital Markets and Infrastructure
ASEAN	11	75.34	E-commerce is growing rapidly, but digital governance lags behind
Central and Eastern Europe	20	65.86	Regulatory frameworks are well-established, but technological investment is insufficient

West Asia and North Africa	19	62.15	Strong demand for energy digitization, but weak innovation foundation
Central Asia	5	58.21	Infrastructure is underdeveloped, but government support is strong
South Asia	8	56.37	Significant demographic dividend, but poor R&D environment

In terms of development trends, the digital economy in Belt and Road countries exhibits the following characteristics:

First, an overall acceleration in catching up: Since 2017, the level of digital economic development in Belt and Road countries has surpassed that of non-Belt and Road countries, with the average TIMG index rising from 43.98 in 2013 to 58.16 in 2021, representing an annual growth rate of 2.83%.Second, regional disparities are intensifying: Asia accounts for 80% of global ICT hardware exports, while Africa, Latin America, and the Caribbean account for less than 2.5% of digital service exports, and the digital divide continues to widen. Finally, the late-mover advantage is evident: low- and middle-income countries have experienced the fastest growth in digital economic development (42.87% growth from 2013 to 2021), but the TIMG index for low-income countries (such as Yemen and Laos) has shown a downward trend.

Cooperation on the digital economy between China and "Belt and Road" countries has formed a multi-level, multi-dimensional policy framework and mechanism: China has established bilateral e-commerce cooperation mechanisms with 29 countries and signed memorandums of understanding on digital economy investment cooperation with 18 countries. For example, China and Saudi Arabia have established a "Belt and Road," major project construction, and energy working group to promote the digital transformation of the energy sector. At the same time, platforms such as the SCO Digital Economy Forum (which signed 12 digital economy cooperation projects in 2025) and the China-LAC Forum (which released the "Joint Action Plan for Cooperation in Key Areas between China and CAREC Member States" in 2025) have become important platforms for regional digital economy cooperation. China is working with "Belt and Road" countries to promote mutual recognition of digital product standards, electronic certification standards, and data security standards. It has signed digital standard mutual recognition agreements with 28 countries, covering major digital trade sectors such as cloud computing and artificial intelligence, thereby achieving standard coordination. The National Data Administration has proposed a systematic cooperation model of "Hard Connectivity + Soft Connectivity + Heart Connectivity" (the "Three Connectivity's" model): "Hard Connectivity" involves enhancing connectivity levels through infrastructure solutions such as the Beidou Satellite Navigation System and smart ports; "Soft Connectivity"

involves participating in the formulation of global data governance rules and promoting cooperation mechanisms such as the mutual recognition of electronic signatures; and "Heart Connectivity" involves enhancing digital literacy through talent training and digital education cooperation.

By 2025, the "Silk Road E-commerce" initiative had expanded to 36 partner countries, establishing more than 120 online and offline national pavilions. Shanghai's Pudong New Area aims to basically complete the "Silk Road E-commerce" comprehensive service system by 2025, generating over 10 replicable and scalable innovative outcomes, thereby expanding the initiative's network of partners. Initiatives such as the "One Network, One Cloud, One Platform" model at the China-Egypt TEDA-Suez Economic and Trade Cooperation Zone, the Huawei Cloud project in Karamay, Xinjiang, and the Inspur Smart Technology Digital Economy Industrial Park promote cross-border industrial chain synergy, the upgrading of traditional industries, and regional economic integration through integrated platforms. China has collaborated with Thailand, Ghana, and other countries to establish digital skills training platforms, having trained over 12,000 local technical professionals. Meanwhile, "Luban Workshops" have conducted training in the field of artificial intelligence in countries such as Ethiopia, cultivating digital technology talent for the East African region.

Based on the TIMG Index, there are significant disparities in the level of digital economic development among countries along the Belt and Road. Table 2 shows that in 2021, Singapore (87.55), China (81.42), and the United Arab Emirates (76.18) ranked in the top three.

Table 2. Competitiveness Ranking of Digital Economic Development in "Belt and Road" Countries (2021)

Country	**TIMG Index**	**Digital Technology**	**Digital Infrastructure**	**Digital Market**	**Digital Governance**
Singapore	87.55	93.65	91.35	89.06	97.50
China	81.42	90.15	89.33	89.06	66.61
United Arab Emirates	76.18	87.12	87.47	87.00	87.12
Israel	75.91	85.94	85.27	85.87	85.94
Malaysia	74.03	85.03	80.20	85.87	86.44
India	72.17	81.40	76.70	81.33	76.41
Russia	71.43	82.51	81.00	82.51	82.51

Saudi Arabia	70.46	80.46	79.06	80.46	80.46
Turkey	70.13	79.83	78.53	79.83	79.83
Estonia	68.88	86.44	79.46	86.44	86.44

By sub-sector, China holds a significant advantage in the digital market and digital infrastructure sectors, ranking second and third globally, respectively; however, there is room for improvement in digital technology and digital governance, where it ranks 15th and 41st globally. Singapore, on the other hand, leads across the board in digital technology, digital infrastructure, and digital governance, ranking among the top three globally.

Through analysis of relevant data, this paper finds that the trade-promoting effects are primarily reflected in the following aspects. First, the scale of trade continues to expand: in 2024, the global digital trade volume reached $7.23 trillion, of which exports of digitally delivered services amounted to $4.64 trillion, with an average annual growth rate of 9.7%; exports of digitally ordered services reached $2.62 trillion, with an average annual growth rate of 16.7%, significantly higher than that of digitally delivered trade. Second, there are differences in regional trade structures: in Asia, exports and imports of digitally delivered services grew by 53.9% and 39.3%, respectively, both exceeding the global average. In the Middle East, imports of digitally delivered services grew by 43.7%, far exceeding the global and other regional levels. In Africa, although the base for digital trade is relatively low, the growth rates of both exports and imports over the past five years have exceeded the global average. Third is the trade promotion effect of the "Silk Road E-commerce" initiative: In 2025, the import and export trade volume among "Silk Road E-commerce" partner countries reached 20.48 billion yuan, a year-on-year increase of 20.9%. Of this, exports grew by 35.8%, significantly outpacing the 8% growth in imports. Following the implementation of the Shanghai Hongqiao "Silk Road E-commerce" Three-Year Action Plan, cross-border e-commerce import and export volumes surged by 380%, with import order volume and transaction value accounting for 61.9% and 53.6% of Shanghai’s total, respectively. Finally, logistics efficiency has improved: The SCO Demonstration Zone has significantly shortened container turnaround times through a "three-tier global warehouse network system" (consolidation warehouses + forward warehouses + overseas warehouses). Eight overseas warehouses in locations such as Moscow and Almaty serve over 1,000 Chinese enterprises, greatly alleviating the financial pressure and time constraints associated with cross-border trade. The "single declaration, bilateral clearance" mechanism has increased monthly shipment volumes to the EU to 30,000 shipments, significantly improving clearance efficiency.

Through a detailed analysis of the international landscape in recent years, this paper finds that digital economy cooperation under the Belt and Road Initiative still

faces numerous risks: as countries increasingly prioritize data sovereignty—for example, Russia's Federal Law No. 242-FZ requires that citizens' personal data be stored within Russia, while Vietnam, Indonesia, and other countries impose strict restrictions on cross-border data flows – data sovereignty risks are gradually coming to the fore (Godehardt, 2021) ; reliance on a single technology provider in some countries may pose long-term risks. For instance, frequent policy changes in countries like Indonesia and Vietnam have led to compliance uncertainties for Chinese enterprises regarding cross-border data transmission—a phenomenon known as technology dependency risk. Furthermore, the EU's Digital Markets Act (DMA) and Digital Services Act (DSA) impose strict compliance requirements on Chinese cross-border e-commerce platforms. Following the official implementation of the EU's DMA in 2023, Chinese platforms such as AliExpress and Temu were designated as Very Large Online Platforms (VLOPs), facing the risk of fines of up to 6% of their global annual turnover. TikTok has already been fined 345 million euros for improper handling of children's data, reflecting rising compliance costs; the U.S. Submarine Cable Control Act (H.R. 2503) restricts China's access to critical equipment needed for submarine cable construction, attempting to block China's path to expanding global cooperation through digital infrastructure. Meanwhile, the U.S. Cloud Act allows law enforcement agencies to access data across borders, creating a conflict with China's Data Security Law and ultimately posing a geopolitical risk.

In response to the potential risks identified in the aforementioned study, this paper also proposes several appropriate risk prevention and control strategies.

First, a strategy for technical standard coordination should be established: jointly formulate technical standards with "Belt and Road" countries to reduce the risk of technical incompatibility. For example, China and Russia have achieved mutual recognition of over 450 standards, providing technical support for the joint development of wide-body passenger aircraft by China and Russia . Promote mutual recognition of international standards for key technologies such as 5G and cloud computing; for instance, Huawei Cloud's Cairo node provides localized cloud services to Egypt, reducing reliance on foreign suppliers. Second, deepen localization strategies: Build localized data centers in partner countries. For example, Huawei's data center in Egypt increased local internet penetration from 43% to 70%. Haojing Cloud Computing Technology Co., Ltd. developed a "self-controlled, secure, efficient, and ecosystem-driven" cloud-native solution for Pakistan, addressing issues such as rigid traditional IT infrastructure, reliance on imported cloud services, and stringent data security and compliance requirements. Emu has launched a "peer-to-peer" merchant recruitment program in Switzerland, allowing Swiss retailers to open stores directly and ship from local warehouses, thereby reducing the need for cross-border data flows. Third, we must establish multilateral risk-sharing mechanisms: build a "Belt and Road" digital governance cooperation framework to promote collaboration among countries along the route in areas such as data security and cross-border data flows. We should advance the construction of the "Digital Silk

Road" and mitigate geopolitical risks through regional cooperation mechanisms. For example, China and the United Arab Emirates have established strategic cooperation in the field of digital governance to jointly address challenges posed by regulations such as the U.S. Cloud Act. Finally, compliance capacity building must be strengthened: enhance compliance capabilities regarding EU regulations such as the DMA and DSA, for instance by appointing EU compliance representatives and optimizing supply chain due diligence. Through the "Belt and Road" Data Security Cooperation Initiative, promote respect for other countries' data sovereignty and oppose the use of information technology to undermine critical information infrastructure or steal important data.

In response to the challenges facing the digital economic development of "Belt and Road" countries, this paper proposes the following targeted policy recommendations: 1. Develop a Regional Digital Development Index: Establish a regional digital development index covering "Belt and Road" countries, regularly publish analytical reports, and provide a scientific basis for digital economic cooperation among nations. Optimize the "Three Connections" Cooperation Model: Deepen the "Three Connections" cooperation model for the Belt and Road digital economy by strengthening digital infrastructure interconnectivity (hard connectivity), promoting the alignment of digital rules and standards (soft connectivity), and enhancing cooperation in digital talent development (heart connectivity). 2. Improve the Digital Trade Risk Prevention and Control System: Establish a Belt and Road digital trade risk prevention and control system, including mechanisms such as data sovereignty risk early warning, technology dependency risk assessment, and compliance cost monitoring, to enhance risk prevention and control capabilities. Strengthen multilateral digital governance cooperation: Actively participate in the formulation of global digital governance rules and promote the establishment of a more open, inclusive, and mutually beneficial international cooperation system for digital trade. 3. Leverage China's market and technological advantages in the digital economy to jointly explore with "Belt and Road" countries the establishment of new cooperation mechanisms adapted to technological development.4. Promote the high-quality development of the Digital Silk Road: Seize the opportunity presented by the construction of the "Digital Silk Road" to strengthen alignment with regional cooperation mechanisms such as China–Central and Eastern Europe and China–ASEAN, and extend digital economy cooperation from "hard connectivity" to "soft connectivity" and "heart-to-heart connectivity," thereby achieving high-quality development.

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ECONOMIC COOPERATION BETWEEN CHINA AND KAZAKHSTAN UNDER THE BELT AND ROAD INITIATIVE: BASED ON INFLUENCING FACTORS AND EFFICIENCY OF CHINA'S OUTWARD FOREIGN DIRECT INVESTMENT

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Annotation. This study examines the economic cooperation between China and Kazakhstan under the framework of the Belt and Road Initiative, with a particular focus on the influencing factors and efficiency of China's outward foreign direct investment (OFDI). The research analyzes the role of trade integration, infrastructure connectivity, energy cooperation, institutional environment, and digital transformation in strengthening bilateral economic relations. Special attention is given to the effectiveness of Chinese investments in key sectors of Kazakhstan's economy, including energy, transportation, manufacturing, and logistics. The study evaluates the impact of OFDI on regional economic development, industrial

modernization, and investment cooperation between the two countries. The findings indicate that policy coordination, favorable investment conditions, and strategic infrastructure projects significantly contribute to improving the efficiency of Chinese outward investment and enhancing sustainable economic cooperation. The paper also identifies existing challenges related to investment risks, regulatory differences, and external economic uncertainties. The results of the study may be useful for policymakers, researchers, and business representatives involved in international investment and regional economic integration.

Keywords: economic cooperation, outward foreign direct investment, OFDI efficiency, China, Kazakhstan, Belt and Road Initiative, digital economy, investment efficiency, infrastructure development, regional integration, international trade.

The Belt and Road Initiative (BRI) has become a core framework for China to carry out outward foreign direct investment (OFDI) and economic cooperation with Eurasian countries. As the initiator and pivotal strategic partner of the BRI in Central Asia, Kazakhstan occupies a geographically pivotal position on the new Eurasian land bridge, connecting East Asia, Europe and the Middle East. The economic and investment cooperation between China and Kazakhstan is not only a typical case of China's OFDI along the Belt and Road, but also an important embodiment of strategic docking, resource complementarity and industrial integration between the two countries. Studying the influencing factors and investment efficiency of China's OFDI in Belt and Road countries helps to clarify the internal logic of China-Kazakhstan economic cooperation, identify existing constraints, and optimize the layout of future investment and industrial collaboration [1]. This paper analyzes the current situation, driving factors, investment efficiency performance and existing challenges of China-Kazakhstan economic cooperation under the BRI framework, and puts forward targeted optimization paths.

Since the launch of the Belt and Road Initiative in 2013, China-Kazakhstan economic cooperation has entered a stage of deepened and diversified development. China has long been Kazakhstan's largest trading partner and one of the most important source countries of foreign investment [2]. Driven by the strategic docking between China's BRI and Kazakhstan's Bright Road New Economic Policy, the two countries have achieved in-depth layout in energy and mineral resources, infrastructure construction, manufacturing, agriculture, logistics and digital economy.

In terms of investment stock and flow, China's OFDI in Kazakhstan has maintained steady growth with periodic fluctuations. Investment sectors show obvious hierarchical characteristics: resource raw materials account for the largest proportion, followed by manufacturing, energy infrastructure and financial service industries. By 2025, China's investment in Kazakhstan's raw material sector accounts for 46% of the total investment, manufacturing rises to 18%, and energy investment remains at a stable proportion. Chinese enterprises have expanded from simple trade export to technology output, standard output and localized industrial supporting

investment, with the local employment rate of key projects exceeding 60%, realizing real industrial embedding and economic driving effect. In infrastructure, cross-border railways, highway corridors, port logistics parks and energy pipeline projects have become landmark achievements, greatly improving the connectivity between China and Central Asia and even Europe.

Combined with the general influencing factors of China's OFDI in Belt and Road countries, the driving factors of China's investment in Kazakhstan can be summarized into policy, geographical endowment, economic complementarity and institutional environment.

First, policy synergy and institutional communication are the core driving factors. The high-level political mutual trust between China and Kazakhstan has built a stable policy cooperation mechanism. The docking of the BRI and the Bright Road strategy has realized the alignment of development plans, tariff preferences, investment tax incentives and convenient approval policies. Kazakhstan's new investment policy offers up to 10-year tax reductions, land concessions and duty-free import of equipment for priority industries, which greatly reduces the institutional cost of Chinese enterprises' overseas investment [3].

Second, geographical location and resource endowment are natural driving factors. Kazakhstan is rich in oil, natural gas, rare metals and mineral resources, which can make up for China's resource demand gap. At the same time, its central location in Central Asia makes it an indispensable hub for China to open up the European and Central Asian markets, and the cross-border logistics and transit trade value is prominent.

Third, economic and industrial complementarity is the economic foundation of investment. China has advantages in capital, complete industrial chain, infrastructure construction capacity and manufacturing technology, while Kazakhstan has advantages in resources, land and market potential. The two countries form a perfect complementary pattern of "Chinese technology + Kazakh resources + Eurasian market", which promotes continuous expansion of capacity cooperation and cross-border investment [4].

Fourth, institutional environment and regional economic integration are important external factors. The promotion of the Eurasian Economic Union, the improvement of Kazakhstan's foreign investment access system, and the deepening of bilateral financial cooperation such as local currency settlement have reduced exchange rate risks and transaction costs, and further optimized the investment environment for Chinese enterprises.

Investment efficiency reflects the matching degree between China's OFDI input and economic output, including resource allocation efficiency, industrial driving efficiency and long-term economic growth contribution. Overall, China's investment efficiency in Kazakhstan is at a medium-high level among Belt and Road countries, showing characteristics of high resource efficiency, steady infrastructure efficiency and room for improvement in emerging industries.

In traditional fields such as energy, mineral resources and infrastructure, investment efficiency is significantly high. Long-term pipeline projects, railway transit and mineral development projects have stable cash flow and sustained driving effect on bilateral trade and regional economic growth. The large-scale investment of Chinese energy enterprises in Kazakhstan has guaranteed China's energy import security, while bringing fiscal revenue, employment and industrial technology upgrading to Kazakhstan, achieving a win-win efficiency.

In manufacturing, agriculture and logistics, investment efficiency is steadily improving. With the transfer of China's advantageous production capacity, Kazakhstan's manufacturing supporting capacity has been enhanced, and the cross-border agricultural product cold chain and logistics system have been improved, expanding the trade scale of agricultural and sideline products between the two countries [5].

However, there are also efficiency constraints: the investment layout is overly concentrated in resource and infrastructure sectors, and the layout in digital economy, green energy and high-tech industries is insufficient; project cycle is long, capital recovery is slow, and some small and medium-sized enterprises face low operational efficiency due to unfamiliar local laws and regulatory policies. In addition, exchange rate fluctuation, geopolitical uncertainty and cross-border cultural differences also restrict the further improvement of investment efficiency.

Although China-Kazakhstan economic and investment cooperation has achieved remarkable results, it still faces multiple challenges under the BRI framework. First, the industrial investment structure is unbalanced, over-reliance on energy and mineral fields, and insufficient cooperation in emerging strategic industries. Second, institutional, and legal differences exist in market access, antitrust review and labor policies, increasing the compliance cost of Chinese enterprises. Third, geopolitical game and regional great power competition bring uncertain risks to cross-border investment. Fourth, the financing mechanism is single, relying too much on policy bank loans, and the participation of private capital and market-oriented financing is insufficient, affecting the flexibility and sustainability of investment [6].

To improve the efficiency of China's OFDI and deepen China-Kazakhstan economic cooperation, targeted optimization measures can be taken from multiple dimensions. Firstly, continue to strengthen policy strategic docking, improve the bilateral investment protection agreement and dispute settlement mechanism, and further reduce institutional transaction costs. Secondly, optimize the investment industrial structure, expand cooperation in green energy, digital economy, cross-border e-commerce and modern agriculture, and disperse investment risks while cultivating new growth points. Thirdly, strengthen localization operation of enterprises, adapt to local laws, labor systems and cultural customs, enhance local industrial supporting links, and raise the spillover level of investment. Fourthly, innovate financial cooperation methods, promote local currency settlement, expand multilateral financial cooperation under the framework of the Asian Infrastructure

Investment Bank and the Silk Road Fund, and guide private enterprises to participate in BRI projects. Finally, strengthen cross-border logistics and digital infrastructure interconnection, build a more efficient Eurasian logistics channel, and consolidate the foundation of integrated economic cooperation.

Kazakhstan is a core node country of the Belt and Road Initiative, and China-Kazakhstan economic cooperation is deeply affected by policy synergy, geographical endowment, industrial complementarity and institutional environment, which are also the key influencing factors of China's OFDI along the Belt and Road. At present, China's investment in Kazakhstan has high efficiency in traditional fields, and emerging industries have great potential for efficiency improvement. Facing the challenges of unbalanced industrial structure, institutional differences and geopolitical uncertainty, the two countries need to further strengthen strategic docking, optimize investment layout, expand emerging industry cooperation and innovate financial and institutional cooperation modes. Under the BRI framework, deepening China-Kazakhstan economic and investment cooperation will not only continuously improve the efficiency of China's outward direct investment, but also set a typical model for win-win cooperation among Belt and Road countries, and inject lasting impetus into regional economic integration and common development.

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ANALYSIS OF FACTORS INFLUENCING REGIONAL INVESTMENT ATTRACTIVENESS IN KAZAKHSTAN (CASE OF THE ALMATY REGION)

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Annotation. The article examines factors influencing regional investment attractiveness in Kazakhstan using the Almaty region as a case study. The study is based on dynamic, comparative, and factor analysis. The results show that the region demonstrates higher investment growth rates and forms a sustainable investment model based on internal sources and agglomeration effects.

Keywords: investment attractiveness, regional development, investment, Almaty region, agglomeration, economic growth

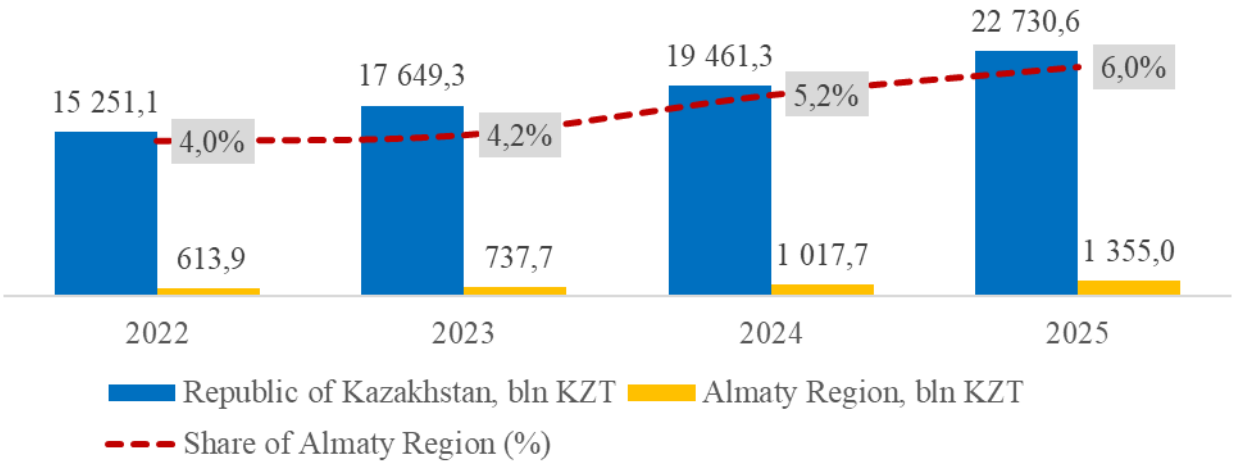
In modern economic research, regional investment attractiveness is considered an integral characteristic reflecting the conditions influencing investment decisions, including economic development, institutional environment, infrastructure, and access to resources [1]. Increasing attention is given to the spatial dimension, particularly agglomeration processes that concentrate economic activity and create advantages for investors [2]. In this context, investment attractiveness is interpreted as a dynamic system shaped by the interaction of multiple factors.

The study applies dynamic, comparative, and factor analysis to examine investment processes and identify key determinants of regional investment attractiveness. Statistical data were processed with the calculation of growth rates and structural indicators, allowing a quantitative assessment of changes in investment activity.

The empirical base includes official data from the Bureau of National Statistics of Kazakhstan, the National Bank of Kazakhstan, and materials related to the development of the “Alatau” Special Economic Zone [3-5].

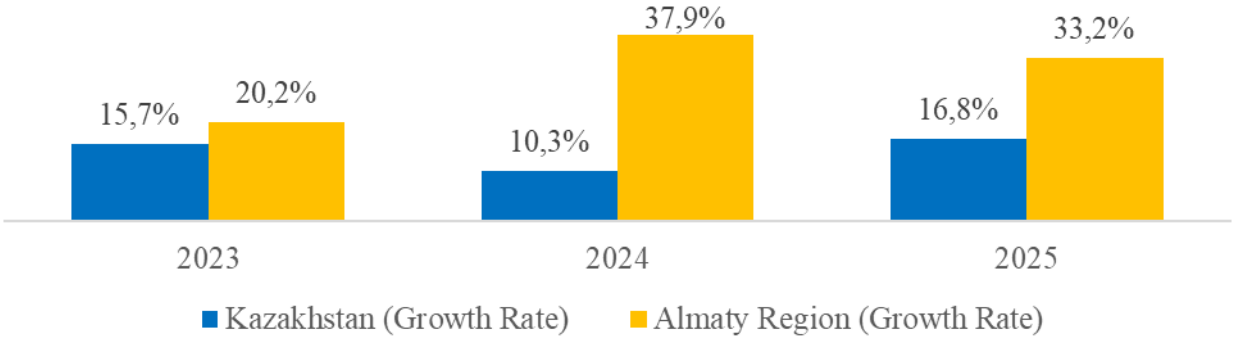
The Almaty region, as one of the most dynamically developing regions of Kazakhstan, benefits from its proximity to Almaty city, which ensures integration into agglomeration processes and access to infrastructure, financial resources, and labor markets. To assess investment activity, the dynamics of fixed capital investment, its share in the national structure, and growth rates were analyzed.

Figure 1 – Dynamics of Investment in Fixed Capital and the Share of Almaty Region in the Republic of Kazakhstan, 2022-2025



Source: Bureau of National Statistics of the Republic of Kazakhstan; National Bank of Kazakhstan

Figure 2 – Growth Rate of Investment in Fixed Capital in Kazakhstan and Almaty Region, 2023–2025



Source: Bureau of National Statistics of the Republic of Kazakhstan; National Bank of Kazakhstan

The analysis shows that investment activity in the Almaty region demonstrates stable growth. At the same time, regional indicators exhibit higher dynamics compared to national averages, indicating the strengthening of the region's investment role.

The growth of investment is accompanied by structural changes. The increasing share of the region in total national investment reflects a redistribution of investment flows and an improvement in its investment attractiveness. This trend confirms the strengthening of the region's competitive position.

A comparison of growth rates reveals a consistent outperformance of regional indicators over national values. This allows us to conclude that the investment dynamics of the region are determined not only by the scale of its economy, but also by the quality of its institutional and spatial environment.

The structure of investment sources is of particular importance. In the context of unstable external investment flows, internal sources play a key role. This indicates the formation of a stable internal investment base that ensures the sustainability of regional economic development [3].

The agglomeration factor also plays a significant role. The integration of the Almaty region into the agglomeration space provides access to markets, labor resources, and infrastructure, reducing investment costs and increasing efficiency [2].

Thus, regional investment attractiveness is formed through the interaction of economic, institutional, and spatial factors and can be interpreted as a multi-level system. A key feature is the shift from external to internal investment sources, which contributes to the formation of a more sustainable regional development model. To deepen the analysis, a systematization of investment attractiveness factors was carried out.

The systematization of factors shows that economic and investment parameters form the foundation of investment activity, while institutional conditions and infrastructure ensure its sustainability.

The development of the "Alatau" Special Economic Zone and industrial zones creates a basis for the concentration of investment projects and supports industrial development, providing additional incentives for investors [5].

The growth of innovation activity enhances the long-term investment potential of the region and contributes to the transition toward a more technologically advanced development model.

The scientific novelty of the study lies in refining the structure of regional investment attractiveness factors by incorporating the agglomeration component, as well as identifying the dominant role of internal investment sources under conditions of unstable external investment flows.

The conducted study confirms that the Almaty region is forming a sustainable model of investment development and demonstrates higher growth rates compared to national averages.

Investment attractiveness in the region is shaped by the interaction of multiple factors, among which the spatial component associated with agglomeration processes plays a crucial role.

Table 1. Factors of Investment Attractiveness of the Almaty Region

Indicator	Value (2024)	Change vs 2023	Analytical Interpretation
Economic Factor			
Gross Regional Product (GRP)	6,040.6 bln KZT	+11.1%	GRP growth reflects the expansion of the regional economic base and increasing investment potential
Investment Factor			
Investment in Fixed Capital	1,017.7 bln KZT	+35.9%	Accelerated investment growth indicates increased investment activity
External Economic Factor			
Foreign Direct Investment (FDI)	347.1 mln USD	−34.7%	Volatility of FDI indicates dependence on external economic conditions
Demographic Factor			
Population	1,560.1 thsd people	+1.8%	Population growth forms labor resources and domestic market demand

Entrepreneurial Factor			
SMEs	151,138 units	+6.5%	SME development strengthens business activity and investment environment
Industrial Factor			
Industrial Output	1,930.5 bln KZT	+10.1%	Industrial growth reflects the development of the real sector
Innovation Factor			
R&D Expenditures	3,598.2 mln KZT	+56.4%	Growth in innovation activity enhances long-term investment attractiveness
Infrastructure & Institutional Factors			
SEZ "Alatau" and Industrial Zones	SEZ area ~98,000 ha, cluster formation	Active development	Development of SEZ and industrial zones creates an integrated investment ecosystem and reduces barriers for investors

Source: Author's compilation based on official statistics

Thus, the Almaty region can be considered a territory with an emerging sustainable investment system based on the combination of economic, institutional, and spatial conditions. The results obtained can be used in the development of regional policy instruments aimed at improving investment attractiveness and increasing the efficiency of investment processes.

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ECONOMIC ACTIVITIES OF RETIREES: SOCIAL MOTIVATIONS AND LIMITING FACTORS

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Annotation. Against the backdrop of the profound integration of population aging and the digital economy, the participation of retirees in economic activities has emerged as a significant social phenomenon. This paper, grounded in activity theory and digital inequality theory, systematically analyzes the social motivations and restrictive factors affecting retirees' engagement in digital economy activities. The research identifies that the expansion of social interaction space, the smooth transition of social roles, the balance of family relationships, and the re-realization of self-worth are the primary social motivations driving this demographic. Conversely, restrictive factors manifest as structural limitations of individual digital capabilities, insufficient institutional space, platform design exclusion, the persistent digital divide, and the risk of new forms of digital exploitation. The paper proposes that a supportive digital economy environment for the elderly should be constructed by improving policy systems, strengthening digital literacy education, and optimizing platform design to fully unleash the social value of «silver-haired power».

Key words: Retirees; Digital economy; Social motivation; Limiting factors; Silver economy; Digital divide

The global aging process is accelerating at an unprecedented rate. According to United Nations projections, the proportion of the world's population aged 60 and above is expected to rise from approximately 12% in 2020 to over 20% by 2050 [1]. In China, this demographic shift is equally significant, with the period from 2021 to 2025 identified as a critical window for active response to population aging [2]. Simultaneously, the digital economy is reshaping the nature of labor and economic participation. Through the gig economy, e-commerce, and content creation, digital platforms offer retired individual’s possibilities for flexible participation in economic activities [3].

However, the engagement of retired people in the digital economy is not merely an economic behavior; it is embedded in a complex structure of social motivations. At the same time, their participation faces multi-dimensional limitations. This article aims to systematically explore the main social motivations for retired people to participate in digital economy activities, the structural limiting factors they face, and how a more inclusive environment can be constructed.

This analysis is based on two complementary theoretical frameworks. The «Activity theory», proposed by Havighurst (1961), emphasizes that elderly individuals maintain life satisfaction and mental health through continuous role participation and social activities. This theory posits that successful aging requires maintaining active social roles, and digital economy activities can serve as new role carriers in later life stages.

The «Digital inequality theory», expounded by DiMaggio and Hargittai (2001), transcends the binary perspective of the traditional «digital divide». It emphasizes that even with internet access, differences in users' skills, usage patterns, and benefit

capabilities constitute multi-level digital inequalities [1]. This framework helps clarify the structural obstacles faced by retirees.

The retirement from professional roles often leads to a sharp contraction of social networks. Field research indicates that many elderly people's daily activities are confined to their immediate community, leading to repetitive social content [4]. Digital platforms provide opportunities to interact beyond physical limitations. For instance, a study on silver-haired ride-hailing drivers found that the «temporary coexistence» between drivers and passengers triggers a «heterogeneous information flow», achieving cross-class cognitive expansion [3]. Emotional interaction and social satisfaction itself constitute a powerful participation motivation.

Retirement is a process of role transition rather than a single event. Many newly retired individuals experience a psychological gap after the initial «honeymoon phase» of idleness [3]. Digital economy activities, due to their inherent flexibility, become effective carriers for this transition. Survey data shows that among silver-haired drivers, 80% work approximately 3 to 4 days a week. This «half-day labor» model suggests that retirees do not view platform labor as «re-employment» but as «transitional retirement» [3].

After retirement, individuals may transform from «independent providers» to «dependents», which can trigger family tensions. Research indicates that some retirees engage in the digital economy to maintain economic autonomy and reduce dependence on their children [5]. By maintaining social participation, retirees foster more balanced intergenerational relationships, embedded in family ethics and social value expectations.

The deep-seated motivation lies in seeking a sense of dignity. Surveys show that «making money» is often shorthand for «proving utility» [6]. Recognition—such as being called «professional» by a passenger or receiving likes on a video—serves as a source of self-worth confirmation. This non-economic emotional return often provides more motivation for continuous participation than financial rewards [3].

Declining physical functions and reaction speeds put the elderly at a disadvantage in operating digital devices. The internet penetration rate among Chinese netizens aged 60 and above is significantly lower than the national average [5]. Psychological barriers, such as «fear of setbacks», create a vicious cycle of «not knowing—not daring—even less knowing» [4].

The impact is three-fold: the «accessibility divide» (complexity and price), the «usability divide» (complex processes and poor voice recognition), and the «value divide» [1]. Many apps fail to address real usage pain points, focusing instead on superficial «age-friendly» packaging that ignores the actual consumption preferences of the elderly [5].

Algorithm mechanisms are typically defaulted to young users. Dispatching algorithms often encourage high-intensity patterns that ignore the physiological conditions of elderly drivers [3]. A deeper issue is the treatment of elderly users as «traffic tools» rather than service recipients. Some platforms use incentive

mechanisms to induce long-term advertisement viewing, creating a «new type of digital disadvantaged group» or «digital serfs» [6].

From a policy perspective, retirees face ambiguous areas regarding rights protection. Labor remuneration, social security, and safety risk prevention for this group lack a clear institutional definition [2]. Existing frameworks mostly focus on non-economic volunteer services, lacking normative arrangements for digital economic participation [5].

The stereotype that the elderly are «technologically slow» is embedded in platform design logic. This «grey digital divide» involves cognitive, emotional, and intergenerational barriers [1]. These cultural biases have a disproportionate impact on the elderly during the digital transformation process.

The participation of retirees is driven by social needs, role buffering, and the pursuit of meaning. However, skill gaps, digital divides, and institutional absences restrict equal participation. Based on the analysis, this paper proposes:

1. Improve institutional guarantees: Define the rights of retirees in the digital economy regarding social security and risk control [2].
2. Strengthen digital literacy: Develop training programs based on peer teaching, as retirees trust familiar, community-based learning scenarios [4].
3. Promote platform adaptation: Incorporate inclusive design, simplify procedures, and optimize algorithms to move beyond pure efficiency logic.
4. Cultivate positive aging culture: Recognize retirees as human resources and break age stereotypes to release «silver power».

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DIGITAL TRANSFORMATION AND ENTERPRISE COMPETITIVENESS: PATHWAYS, MECHANISMS AND PROSPECTS

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Annotation. Digital transformation is becoming a strategic choice for enterprises to enhance their core competitiveness. This article, starting from three paths - technological empowerment, organizational transformation, and ecological collaboration, systematically analyzes the mechanism by which digital transformation boosts the competitiveness of enterprises, including improving operational efficiency, reducing operational costs, enhancing digital innovation capabilities, promoting the growth of total factor productivity, and optimizing the structure of human capital. Currently, the prospects for digital transformation of Chinese enterprises are broad, but they still face challenges such as high investment costs, data barriers, and talent shortages. This article proposes systematic countermeasures and suggestions at the levels of enterprises, the government, and industry organizations.

Key words: Artificial intelligence; Service industry innovation; Innovation path; Effect evaluation

Under the backdrop of the new round of technological revolution and industrial transformation, the digital economy has become the core driving force for global economic growth. The Central Economic Work Conference emphasized that we should vigorously promote the deep integration of the digital economy and the real economy. As the micro entities driving economic development, enterprises are currently confronted with unprecedented opportunities and challenges. How to leverage the profound reshaping effects of digital technology on production factors, operational models, and resource allocation methods, and through digital transformation enhance the competitiveness of enterprises, has become a research focus that is widely concerned by both the academic community and the business sector [1].

Digital transformation refers to the process in which enterprises utilize modern information technologies such as the Internet, big data, cloud computing, and artificial intelligence to deeply integrate digital technologies with their corporate strategies, organizational structures, business processes, and product services. [2]. This enables the optimization of value chains, improvement of efficiency, and the creation of new business models. For modern enterprises, digital transformation is not only an inevitable choice to adapt to the trend of the information age, but also a

crucial strategic deployment to enhance their core competitiveness. Currently, the external pressures that enterprises are facing, such as the highly competitive market environment, the rapid update of industry technologies, and the increasing emphasis of the government on digitalization, are all driving enterprises to accelerate their digital transformation [3]. However, not all enterprises can achieve the expected results after implementing digital transformation. Revealing the intrinsic relationship between digital transformation and enterprise competitiveness, and exploring differentiated transformation paths that suit the characteristics of each enterprise, have become urgent practical issues that need to be addressed [4].

The technology empowerment path is the fundamental approach for digital transformation to enhance the competitiveness of enterprises. As a general-purpose technology, digital technology has strong penetration and empowerment effects, and can empower enterprises at multiple levels such as production, operation, and management [5]. Digital technologies such as the Internet of Things, big data, and artificial intelligence have significantly enhanced the efficiency and quality of information collection, transmission, processing, and analysis. Real-time collection and intelligent analysis of customer information, business information and market information can provide enterprises with precise decision-making basis, significantly improving the accuracy and speed of decision-making.

The wide application of digital technology has reduced the degree of information asymmetry both within and outside enterprises. By establishing digital platforms, enterprises can break down information silos and achieve information sharing and collaborative work. Technologies such as blockchain can enhance the transparency and traceability of supply chains, thereby increasing consumers' trust in product quality and safety [6]. The digitization of processes has enhanced the completeness and accuracy of data, thereby strengthening the competitive edge of enterprises. In the era of data elements, data quality has become a strategic resource for enterprises to build their core competitiveness.

Digital technology has optimized resource allocation and enhanced efficiency. By digitizing and automating the business processes, enterprises can reduce manual intervention, lower operational costs, shorten production cycles and enhance production efficiency. The integrated application of digital technology in production, procurement, sales, human resource management and other aspects can achieve dynamic allocation and optimization integration of resources, maximizing the utilization rate of resources [7].

Digital transformation is not merely a technological change; it is also a reconfiguration at the organizational level. It mainly functions through three aspects: flattening of the organizational structure, dativization of the management model, and intelligence of the decision-making mechanism.

Digital transformation has driven enterprises to evolve from the traditional hierarchical structure towards a flatter, networked and platform-based mode [8]. Through digital platforms, enterprises can achieve cross-departmental and cross-level

information sharing and business collaboration, reducing management levels, shortening decision-making chains, and improving organizational operational efficiency. This flat organizational structure helps to stimulate the innovative spirit of employees and enhances the enterprise's ability to respond quickly to market changes.

Data-driven methods have replaced experience-based judgment as the primary basis for management decisions. Under the traditional management model, enterprise decisions were mostly based on the experience and intuition of managers. However, with digital transformation, enterprises can conduct quantitative analysis and precise predictions based on real-time data, making management more scientific and refined [9]. By conducting data analysis to identify the bottlenecks and inefficient links in the business process and implementing targeted optimizations, the operational efficiency and resource allocation efficiency can be significantly enhanced.

Digital transformation has facilitated the shift of enterprises from closed innovation to open innovation. Digital platforms enable enterprises to break through organizational boundaries and widely integrate internal and external innovative resources, including those from various stakeholders such as customers and suppliers. This helps accelerate knowledge creation and technological iteration, thereby enhancing the continuous innovation capabilities of the enterprises [10]. Digitalization promotes collaborative innovation among enterprises, accelerates the spillover of technologies and the diffusion of knowledge, and thereby boosts the overall competitiveness of the industry.

With the deepening of digital transformation, enterprise competition has shifted from individual competition to ecosystem competition. The ecological collaborative path emphasizes that enterprises can achieve collaborative development with suppliers, customers and partners by building or integrating into a digital ecosystem.

Digital technology enables enterprises to achieve real-time information sharing and business linkage with their upstream and downstream partners, thereby enhancing the transparency and response speed of the supply chain. The supply chain management system based on the cloud platform can achieve real-time tracking and dynamic adjustment of information such as orders, inventory and logistics, reducing the bullwhip effect, lowering inventory costs and improving the overall efficiency of the supply chain. Leading enterprises build digital platforms to attract various participants to join, thereby forming a platform ecosystem. Platform enterprises, by establishing rules, providing infrastructure and data services, integrate resources within the ecosystem and achieve value creation and benefit sharing. Digital transformation has blurred industry boundaries, enabling enterprises to engage in cross-border operations and achieve business integration. Traditional manufacturing enterprises can transform into service-oriented manufacturing through digital platforms, providing value-added services based on products; while internet enterprises can leverage their data advantages to extend their offline physical business. Cross-border integration not only expands the profit space of enterprises, but also enhances their ability to withstand risks and overall competitiveness.

The country's emphasis on the development of the digital economy has been continuously increasing. The in-depth implementation of the "Digital China" strategy will provide more powerful institutional guarantees and policy support for the digital transformation of enterprises. In recent years, the state has successively issued a series of policy documents such as the "Digital Economy Development Strategic Outline" and the "Digital Economy Development Plan for the 14th Five-Year Plan", clearly defining the goals, paths and key tasks for the development of the digital economy. Local governments have also launched a series of special support plans for digital transformation, providing enterprises with substantial support in areas such as financial subsidies, tax incentives, and talent recruitment. With the continuous advancement of the market-oriented allocation reform of data elements, the institutional rules for data ownership, transactions and circulation will be continuously improved. This will create a favorable institutional environment for enterprises to unlock the value of data and build data-driven competitiveness. The policy benefits continue to be released continuously, and the policy certainty for enterprise digital transformation will further increase.

New-generation information technologies such as artificial intelligence, quantum computing, 5G/6G will continue to make breakthroughs, providing more powerful technological tools for enterprises' digital transformation. Artificial intelligence is evolving from perceptual intelligence to cognitive intelligence and decision-making intelligence, which can provide enterprises with deeper business insights and automated decision-making capabilities. The large-scale deployment of 5G networks and the advancement of 6G technology will significantly enhance data transmission rates, connection density, and low latency performance, providing a solid network foundation for scenarios such as industrial internet, vehicle networking, and remote control. The collaborative development of cloud computing and edge computing enables enterprises to obtain computing resources at a lower cost. The integration and innovation of technologies have given rise to more digital transformation scenarios. The technical feasibility of enterprise digital transformation has been continuously enhanced, and the transformation costs have been steadily reduced.

The demand from consumers for digital products and services continues to grow, providing a vast market space for enterprises to carry out digital transformation. Currently, digital lifestyles such as online consumption, remote working, and online education have become increasingly widespread. Consumers' demands for convenience, personalization, and real-time performance are constantly rising. In order to adapt to changes in market demands, enterprises need to accelerate the digital upgrade of their products and services, and enhance customer experience and service response speed. The B-end market has also witnessed an explosive growth in demand for digital supply chain management, intelligent manufacturing, and data services. The development of industrial internet has created tremendous market opportunities for digital collaboration among enterprises. The virtuous cycle

of demand driving supply and supply creating demand is taking shape, which will continue to drive enterprises to increase their investment in digital transformation. In addition, the rapid development of cross-border e-commerce and digital trade under the Belt and Road Initiative has opened new markets for Chinese enterprises, further accelerating the need for digital transformation to meet international standards and consumer expectations.

Enterprises should, based on their own industry characteristics, resource endowments and development stages, formulate differentiated digital transformation plans, and avoid blind following and formalism. The transformation strategy should be closely integrated with the core business goals and competitive advantages of the enterprise, ensuring that the digital investment can yield actual benefits. The main person in charge should personally drive the digital transformation efforts, integrating the digitalization concept into the corporate culture and daily management. Establish a dedicated position for digital transformation management, equip with a professional team, and establish a sound cross-departmental collaborative working mechanism to ensure the smooth progress of the transformation work. Establish and improve the incentive mechanism for digital talents, and through various means such as internal training, external recruitment, and cooperation between universities and enterprises, build a comprehensive digital talent team that is proficient in business, technology, and management.

The government should improve the institutional environment and policy support system for digital transformation. Increase the financial subsidies and tax incentives for the digital transformation of small and medium-sized enterprises, establish a special fund for digital transformation, and reduce the initial investment threshold and trial-and-error costs for enterprises' digital transformation. Improve the institutional rules for data ownership, transactions and circulation, establish and improve the protection and trading norms for data property rights, promote the compliant and efficient circulation of data elements, and stimulate the enthusiasm of enterprises for data development and application. At the same time, we will continue to promote the construction of new infrastructure such as 5G networks, industrial internet, and data centers, expand network coverage, improve network service quality and security levels, and provide solid hardware support for enterprises' digital transformation.

Industry organizations should play the role of a bridge and a link. Establish an industry digitalization standard system, promote the standardization of data interfaces and the normalization of business collaboration, and reduce the technical barriers and transaction costs for digital collaboration among enterprises. Provide public services such as technical consultation, scheme evaluation, talent training and resource sharing for small and medium-sized enterprises, helping them overcome the problems of information asymmetry and insufficient capabilities in the process of digital transformation. It can also lead the entire industry towards digital transformation through demonstration and guidance, forming replicable and scalable digital

transformation paths and methodologies, and promoting the overall improvement of the industry's digitalization level.

This article, starting from three paths - technological empowerment, organizational transformation, and ecological collaboration, systematically analyzes the mechanism and development prospects of digital transformation in enhancing the competitiveness of enterprises. Digital transformation effectively enhances a company's competitiveness by improving operational efficiency, reducing operational costs, strengthening digital innovation capabilities, promoting total factor productivity growth, and optimizing the structure of human capital. Under the combined influence of policy-driven, technology-enabled and market-demand factors, the prospects for digital transformation of Chinese enterprises are vast. However, practical challenges such as high investment costs, data barriers and talent shortages still exist. It requires the joint efforts of enterprises, governments and industry organizations to jointly create a favorable ecosystem conducive to digital transformation, and to help enterprises achieve high-quality development.

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ATTRACTING FOREIGN INVESTMENT IN THE CONTEXT OF GLOBALIZATION: STRATEGY AND REGULATORY MECHANISMS

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Annotation. Attracting quality FDI requires a balance between proactive strategy and robust regulation. This paper argues that states must shift from tax incentives to "institutional openness" – using negative lists and rule-based frameworks – while deploying investment screening, national security reviews, and anti-monopoly controls. A global FDI policy split is emerging advanced economies tighten screening, while emerging economies liberalize. China can leverage this divergence by maintaining a stable, transparent legal environment to become a haven for productive capital. The optimal model is "Selective Openness," where regulation disciplines FDI to serve, not subvert, national interests.

Keywords: FDI; Globalization; Investment Strategy; Regulatory Mechanisms, China

In the global age, FDI – is still important for developed countries. Despite the fact that globalization attracts money, it also makes host countries vulnerable to monetary shifts, monopolies and danger. As far as the government is concerned, it is more about drawing better quality FDI than simply attracting larger amounts of foreign investment.

FDI previously was about cheap labor, fiscal enticements & trading barricades. But with the 4th industrial revolution comes a change in how we hire. And as for now they just focus on getting to the market, clarifying all about laws and protecting your rights of ownership instead of making money.

Tactics give us openings, but laws act like wardens. A main pattern is more ISMs coming along. Initially used mostly by US (CFIUS), ISMs have spread all over the place, from the EU's Regulation (EU) 2019/452 to lots of different OECD states.

National Security Reviews

Now it is mainly about national security assessment. Like concerns about overseas M&As, it's possible that foreign money could give other companies a strong hold on important parts of the country like microchips and vital networks. Thus, legislation has to define "national safety" in wide terms but still maintain the supervision of judicature. Moiseeva and Kulinich find out that it is similar to the financial securitization of Europe as they use risk discourses in order to create authority about investment rules [1].

Beneath the safety there's worry about financial consolidation. Foreign power could use the lower prices to get rid of its domestic competitor, making them monopolized and hurting the long term of industry. Legislative frameworks need to have strong anti-monopoly evaluations which would explicitly look at the actions of foreign invested businesses in the national market [2].

A basic idea change is about changes in governance framework. Previously we had grown internationally through positive integration – deregulate and let it flow. Nowadays it's negative integration – shared rules to watch over things. According to the MGIMO review of international relations, the EU has changed from neoliberal capital movement to an offensive screening structure that is united. Facilitating capital but also intensifying it: that is the prevailing period.

It is China that is exceptional. It's made markets easier to enter at the same time it's become stricter: like in 2020 with Foreign Investment Law, but also more scrutiny like in Anti-Foreign Sanctions law or data moving across borders. Internally, it's disorganized. Recently there is a "Global FDI Policy Divide": EU and US are going in direction of mandatory preauthorization vetting, which is being formulated by the EU with stricter guidelines starting from 2026. While developing countries like Saudi and India are deregulating to attract investment. For China there is a difference. To keep it constant, clear and fair – not too isolating nor perilously porous – China would be a safe spot for honest beneficial capital to reside [3-6].

China as for the future it is about fine-tuning laws: And the very same statues and equitable execution might decrease worries regarding western "threat removal." The object of laws is not to restrict FDI, but to regulate it so that funds support our national priorities and not the other way around. In the age of regulated rivalry, states which are best at strategic magnetism and sophisticated oversight will win out.

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THE IMPACT OF THE DIGITAL ECONOMY ON THE COMPETITIVENESS OF NEW ENERGY PRODUCT EXPORTS UNDER THE BELT AND ROAD INITIATIVE

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Annotation. The digital economy-new energy trade nexus is key for the Belt and Road Initiative (BRI). This review synthesizes three strands—digitalization's trade effects, drivers of renewable energy export competitiveness, and BRI energy cooperation – to identify gaps and motivate examining how digital economy development shapes export competitiveness of specific new energy products (PV, wind, batteries, EVs) in BRI countries. No study integrates these for disaggregated new energy product trade competitiveness under the BRI, motivating this study.

Key words: Digital economy; Competitiveness of new energy product exports; Belt and Road Initiative; Expanded gravity model; Threshold effect; Revealed comparative advantage.

The BRI has increasingly pivoted toward a "Digital Silk Road" and green energy cooperation, positioning China' s new energy exports-solar cells, wind equipment, lithium batteries, and electric vehicles-as flagship sectors. Simultaneously, the digital economy is transforming international trade by reducing

costs and enabling new service delivery modes. Despite the policy emphasis on digital-green synergy, no study has systematically linked the digital economy to the bilateral export competitiveness of new energy products within the BRI framework. Existing research examines trade effects of digitalization at the aggregate level or treats renewable energy deployment as a domestic outcome, while trade competitiveness in specific high-technology energy goods remains unexplored. This paper addresses this gap by asking: How does the digital economy development of both the exporting and importing countries affect the bilateral export competitiveness of new energy products? We contribute to the literature in three ways: first, by constructing a multi-dimensional digital economy index and integrating it into a gravity model for product-level new energy trade; second, by empirically testing three transmission mechanisms; and third, by employing instrumental-variable and threshold techniques to ensure credible causal inference and to uncover potential nonlinearities.

Three streams of literature inform this study. The first demonstrates that digitalization reduces trade costs and enhances export performance. Freund and Weinhold established that internet adoption fosters trade, while Chiappini and Gaglio showed that sectoral digital intensity improves export quality. However, these contributions focus on aggregate flows or services and do not isolate new energy manufactured products. The second stream examines the determinants of renewable energy product exports. Using revealed comparative advantage indices, researchers emphasize the roles of R&D, policy support, and scale economies, yet digital economy variables are entirely absent from these frameworks. The third-stream documents the BRI' s role in energy trade. Zhu et al. (2024) found that the BRI facilitated photovoltaic trade deflection to participating countries. At the macro level, Zhang et al. (2022) showed that the digital economy positively moderates globalization' s effect on renewable energy development in BRI countries and identified a single threshold, with the strongest enhancement occurring when digital development remains below a level of 0.061. An emerging branch directly examines the digitalization-renewable energy nexus, revealing a nonlinear, threshold-dependent relationship in BRI countries. Despite these insights, three gaps persist: (i) the digital-trade and new-energy-competitiveness literatures have not been integrated for product-level BRI analysis; (ii) the mechanisms through which digitalization may enhance new energy exports remain empirically uncharted; (iii) product aggregation and endogeneity concerns are widespread. Our study bridges these gaps.

We propose three channels through which the digital economy enhances the export competitiveness of new energy products. (1) Trade cost reduction: digital platforms and paperless customs procedures lower information and coordination costs, particularly for complex goods. (2) Technological innovation: digital tools accelerate R&D cycles and product upgrading, raising the technological sophistication and uniqueness of exports. (3) Standard-setting and lock-in effects: the digital economy facilitates the overseas adoption of home-country technical

standards, generating complementary network effects and market persistence. Accordingly, we formulate the following hypotheses:

H1: A higher digital economy level in the exporting country increases bilateral new energy product competitiveness.

H2: The digital economy indirectly enhances competitiveness by stimulating technological innovation (mediation).

H3: Partner-country recognition of digital or energy standards positively moderates the competitiveness-enhancing effect.

Baseline extended gravity model

We estimate a panel fixed-effects gravity equation:

$$RSCA_{ijt}=\beta_1 Digital_{it}+\beta_2 Digital_{jt}+\gamma X_{ijt}+\mu_{ij}+\lambda_t+\varepsilon_{ijt}$$

where $RSCA_{ijt}$ denotes the Revealed Symmetric Comparative Advantage index for new energy product exports from country i to j in year t; Digitalit and Digitaljt are the digital economy indices of the exporter and importer, respectively. The vector Xijt includes standard gravity variables (GDP, population, distance, contiguity, common language, free trade agreement) augmented by BRI specific controls: institutional distance (the absolute difference in Worldwide Governance Indicators), the digital infrastructure gap, and renewable energy policy support.

Threshold and mediation models

To detect nonlinearities, we apply Hansen' s (1999) panel threshold model:

$RSCAijt=\alpha0+\alpha1Digitalit\cdot I(Thjt\leq\gamma)+\alpha2Digitalit\cdot I(Thjt>\gamma)+\gamma Xijt+\varepsilon ijt$

where the threshold variable Th is the importer's human capital index. Additionally, we employ a mediation model in which the exporter' s stock of new energy technology patents serves as the mediator for the innovation channel.

Baseline fixed-effects estimates show that the exporter' s digital economy index significantly improves the RSCA ($\beta = 0.218$, $p < 0.01$). The 2SLS estimate (0.256) confirms robustness, with a Kleibergen-Paap F-statistic of 24.7 ruling out weak instruments. Mediation analysis supports the innovation channel: digitalization increases new energy patent applications, which in turn raise competitiveness. A positive interaction with the mutual recognition of digital or energy standards corroborates standard-locking effects. By product, the effect is largest for electric vehicles and lithium-ion batteries, followed by photovoltaic panels, and weakest for wind turbines, consistent with the intensity of digital after-sales engagement. High-income and high-human-capital markets exhibit stronger effects. Panel threshold estimation identifies a single human capital threshold of 0.62; below it, the coefficient is insignificant ($\alpha_1 = 0.03$), whereas above it, the coefficient rises to 0.31 and becomes highly significant, indicating that the digital boost is conditional on absorptive capacity.

This study demonstrates that the digital economy significantly enhances the bilateral export competitiveness of new energy products among BRI countries,

operating through cost reduction, innovation, and standard-setting channels, yet only after the importer' s human capital exceeds a critical threshold. Three policy implications emerge. First, China' s new energy enterprises should prioritize digitally intensive after-sales service networks for consumer-facing exports. Second, BRI digital cooperation programs should include targeted capacity-building measures to assist partner countries in surpassing the human capital threshold. Third, promoting mutual recognition of digital and energy standards can amplify the competitiveness gains. Future research could extend the analysis to digital services trade and investigate how geopolitical risks moderate these effects.

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ARTIFICIAL INTELLIGENCE AS A DRIVER OF SUSTAINABLE DEVELOPMENT: THE IMPACT OF INNOVATIVE TECHNOLOGIES ON EXPORT INSPECTION SYSTEMS

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Annotation. Balancing trade growth with environmental and social limits is central to sustainable development. Artificial intelligence (AI) and big data can make export inspection more efficient, more risk-aware, and more compliant. This short paper explains how AI supports sustainable growth, how data and smart tools reshape inspection together with single windows and Authorized Economic Operators

(AEOs), and which governance risks - data, algorithms, and mutual recognition - must be managed. Credible design can cut institutional trade costs and support green, rule-based trade while keeping quality and safety.

Keywords: artificial intelligence; big data; sustainable economic development; export inspection; trade facilitation.

Export conformity with quality, safety, and technical standards underpins market trust. Legacy inspection still depends heavily on physical sampling, manual document checks, and poorly linked IT; scale and speed of trade raise delay, weak traceability, and costly duplicate certification. Climate and fairness concerns also tie growth, regulation, and the environment. AI and big data - pattern recognition, analytics, and linked records - can improve inspection at tolerable cost and support risk-based oversight consistent with intergenerational sustainability.

Artificial intelligence (AI) is increasingly recognized as a transformative force shaping sustainable economic development by improving productivity, optimizing resource allocation, and enabling more efficient and evidence-based decision-making across both public and private sectors. Unlike previous waves of technological change, AI combines automation with advanced data analytics, allowing economies to simultaneously pursue growth, efficiency, and sustainability objectives.

One of the most significant contributions of AI lies in its ability to enhance economic productivity. By automating routine processes and supporting complex decision-making, AI reduces operational costs and increases output efficiency across industries. According to the OECD, AI-driven technologies are expected to significantly reshape labor markets and productivity structures by complementing human labor rather than fully replacing it, thereby contributing to long-term economic growth [1].

AI also plays a critical role in resource efficiency and environmental sustainability, which are central components of sustainable development. Intelligent systems can optimize energy consumption, reduce waste, and improve supply chain efficiency. Research published in Nature Communications demonstrates that AI applications can directly and indirectly support most Sustainable Development Goals (SDGs), particularly in areas related to climate action, responsible consumption, and sustainable infrastructure. In addition, AI accelerates innovation and technological transformation, particularly in green technologies and digital infrastructure. The World Economic Forum highlights that AI can enhance climate modeling, renewable energy integration, and smart city development, thereby enabling more sustainable economic systems. Similarly, the McKinsey Global Institute emphasizes that AI adoption could generate substantial global economic value while simultaneously improving resource efficiency across sectors [2].

Furthermore, AI strengthens economic governance and policy effectiveness by enabling data-driven decision-making. Governments and institutions increasingly rely

on AI-based analytics for forecasting economic trends, managing risks, and improving public service delivery. The World Bank notes that data-driven development strategies supported by AI contribute to more transparent, efficient, and adaptive governance systems. Overall, AI acts as a multidimensional driver of sustainable economic development by simultaneously fostering economic growth, environmental responsibility, and institutional efficiency. Its integration into economic systems represents a shift toward a more intelligent, adaptive, and sustainability-oriented global economy [3].

The 2030 Agenda links inclusive, green growth to better productivity and fairer outcomes. As a general-purpose family of tools (e.g. machine learning, language and vision models, knowledge graphs), AI raises productivity, reduces information frictions, and can lower emissions from smarter processes in industry and transport. With sound institutions, it helps shift the economy from "high input, high pollution" to higher efficiency, leaner resource use, and better-managed risk.

Mechanisms Firms: smart quality control, predictive maintenance, and supply-chain analytics cut defects, rework, and waste. Ecosystem: shared data and inspection know-how support new services (e.g. inspection-with-data, traceability-as-a-service). Public sector: the same staff and budget can target risk more effectively, rewarding steady compliance with predictable treatment. Sustainability is not automatic: data-center energy and biased training data require safeguards; coordinating test frequency, sample movement, and port lab flows can still cut empty hauls and idle emissions. Energy prudence, transparency, accountability, and SME inclusion should accompany any "AI for sustainability" push [4].

Export inspection - statutory and voluntary checks, pre-shipment steps, in-house systems, and papers for foreign rules - imposes compliance and time costs. Tying design to risk, credit, and clear rules can lower average border costs while preserving policy goals.

Big data Merging IoT, enterprise, lab, customs, return, and alert data supports dynamic risk scores and differentiated intensity; time-series and peer benchmarks can flag drift early, easing costly ex post tracing. Verifiable e-documents, within privacy and sovereignty rules, back mutual recognition and single-window "submit once, reuse by many," cutting duplicate forms and dwell time, with secondary gains for green logistics (less idling and repositioning).

AI Machine vision, spectroscopy, and similar signals with deep learning improve detection of composition, defects, and fakes; some lines allow non-destructive, high-throughput checks. Natural language tools and knowledge graphs can verify certificates and tariff lines. With AEOs and paperless customs, semantic mapping between systems limits re-keying. The aim is not weaker safety but the same safety objective with evidence-based focus and lower institutional friction. The model is data-linked, risk-visible, auditable, machine-assisted; it lasts only if data governance, standards, mutual recognition, and SME access advance together [5].

Effects Shorter handling times, higher marginal value of interceptions, steadier treatment for compliant firms, less pointless movement, indirect support for green trade. Conditions solid metadata and data quality, interoperable systems, cyber resilience, upgraded labs, and affordable SME tools.

Data and cross-border flows need classification, minimization, and auditable access. Algorithmic tools tied to risk or licensing need explainability where feasible, appeal, and impact review. Adoption gaps (large v. small, region v. region) call for public platforms, training, and size-sensitive fees. Fragmented global rules call for bilateral/regional mutual recognition, digital provisions in accords (e.g. RCEP), and WTO TFA implementation to cut redundant tests. Metrics should combine time, return rates, SME pass rates, and simple carbon proxies - not speed alone [6].

AI and big data help move export inspection from labor-intensive routine toward data-driven, risk-based, human–machine work. If aligned with the SDGs and green, inclusive goals, the shift can cut institutional costs and use public inspection resources better while meeting safety and treaty duties. Next steps: standard data and metadata, lawful cross-border data channels, accountable algorithms, affordable SME digitalization, and electronic mutual-recognition bridges - so smart inspection underpins sustainable development and a rules-based trading system.

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INVESTMENT AND INNOVATION POLICIES, COMPETITIVENESS AND RISK MANAGEMENT IN THE DIGITAL ECONOMY

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Annotation. Against the background of the deep integration of the digital economy and the Belt and Road Initiative, investment and innovation policies have become the core tools to enhance industrial competitiveness and prevent digital risks. Based on the practice of China-Kazakhstan digital economy cooperation, this paper analyzes the reshaping mechanism of the digital economy on investment models, innovation ecosystems, competitiveness and risk transmission. It sorts out the current problems such as unbalanced investment structure, insufficient innovation coordination, and weak risk prevention and control.

Then it proposes an integrated system of investment incentives, innovation support, competitiveness improvement and whole-process risk management adapted to the digital economy, so as to provide policy references for the high-quality development of the digital economy in China, Kazakhstan and other countries along the route.

Keywords: Digital Economy; Investment Policy; Innovation Policy; Industrial Competitiveness; Risk Management

The digital economy, with data as the key production factor and digital technology as the core driving force, has profoundly changed the global economic operation mode and international cooperation pattern. Under the Belt and Road Initiative, China's Digital Silk Road and Kazakhstan's Digital Kazakhstan strategy have been effectively connected, and cooperation in digital infrastructure, cross-border e-commerce, artificial intelligence, cross-border finance and other fields has been deepening continuously. Investment is the capital guarantee for the development of the digital economy, innovation is the core driving force, competitiveness is the concentrated embodiment of cooperation effectiveness, and risk management is the bottom line requirement for steady and long-term development. At present, bilateral cooperation still faces challenges such as single investment structure, insufficient coordination of innovation chains, prominent data security and cross-border compliance risks. Therefore, it is urgent to build an integrated policy system to promote the high-quality development of digital economy cooperation.

The digital economy has driven investment from traditional heavy assets to a three-dimensional structure: digital infrastructure, technology R&D and scenario application. 5G networks, data centers and cross-border optical cables have become priority investment directions; investment in R&D of big data, artificial intelligence, blockchain and other fields has increased; investment in scenarios such as smart ports, cross-border e-commerce and digital finance has grown rapidly. Digital investment is characterized by light assets, high iteration and high risk, which is difficult to adapt to traditional investment and financing models.

Digital innovation is characterized by cross-border integration, open sharing, and industry-university-research linkage. China has obvious advantages in technology, scenarios and industrial chains, while Kazakhstan has market, location and resource potential. Bilateral joint R&D, technology transfer and incubator

cooperation have been gradually promoted, but problems such as inconsistent innovation standards, insufficient connection of intellectual property rights, and low efficiency of achievement transformation still exist.

In the digital economy, competitiveness is reflected in data control, technological innovation, scenario penetration and rule discourse power. Digital technology enables the transformation and upgrading of traditional industries, improving product added value and status in the global value chain; cross-border digital trade, smart ports and single windows have greatly reduced trade costs and enhanced the level of bilateral trade facilitation.

Digital interconnection makes risks characterized by cross-border diffusion, rapid superposition and amplified contagion, mainly including: data security and privacy protection risks, core technology dependence risks, platform monopoly and market access risks, and policy and regulatory difference risks.

Insufficient adaptability of investment policies: the structure focuses on infrastructure, with insufficient investment in R&D and small and medium-sized enterprises; single investment and financing channels, and low level of cross-border investment facilitation.

Lack of coordination of innovation policies: Insufficient connection of bilateral innovation policies, shortage of digital talents, and insufficient depth of industry-university-research integration.

Weak support for competitiveness improvement: Insufficient cluster effect of digital industries, weak discourse power of standards and rules, and low added value of products.

Imperfect risk management system: Insufficient risk identification and early warning, fragmented prevention and control mechanisms, and lack of bilateral collaborative governance mechanisms.

Build a differentiated incentive system to provide fiscal and tax support for core technologies, digital infrastructure and cross-border trade; establish a China-Kazakhstan digital economy investment fund to guide patient capital investment; broaden channels such as venture capital, intellectual property pledge and cross-border financing; simplify cross-border investment processes, establish green channels, and reduce institutional costs.

Establish a bilateral innovation policy coordination mechanism to unify R&D standards, patent examination and achievement transformation rules; jointly build joint laboratories, incubators and technology transfer centers; strengthen joint training, mutual recognition and exchange of digital talents; promote in-depth integration of industry-university-research, and focus on joint research on key technologies.

Cultivate digital industrial clusters, give play to the leading role of leading enterprises, and promote the digital transformation of small, medium and micro enterprises; jointly participate in the formulation of international rules for the digital economy, and enhance the discourse power of data, technology and platform

supervision; support enterprises to build international brands, improve the added value of digital products and services, and enhance their status in the global value chain.

Establish a monitoring and early warning platform for data security, technology, market and policy risks; implement classified and graded protection of data and standardize cross-border data flow; strengthen independent R&D of core technologies and reduce external dependence; improve bilateral investment protection, intellectual property protection and dispute settlement mechanisms; build a China-Kazakhstan digital economy risk collaborative governance platform to create a safe and stable cooperation environment.

The digital economy provides a new engine for the joint construction of the Belt and Road between China and Kazakhstan. The coordination of investment and innovation policies, and the integration of competitiveness improvement and risk management are the keys to promoting the quality upgrading of bilateral cooperation. In the future, the two countries should strengthen policy connection, capital linkage, innovation coordination and risk co-governance, and build a more open, efficient and safe digital economy cooperation system, so as to provide strong support for the high-quality development of regional economy and common prosperity.

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INNOVATIVE PATHWAYS FOR EMPOWERING CORPORATE ECONOMIC MANAGEMENT WITH DIGITAL TECHNOLOGIES IN THE CONTEXT OF THE DIGITAL ECONOMY

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Annotation. In the context of the rapid development of the digital economy, digital technologies are driving comprehensive transformations in corporate economic management by reshaping decision-making mechanisms, optimizing resource allocation efficiency, innovating business operation models, and enhancing risk management capabilities.

This paper aims to explore the deep integration pathways between digital technologies and corporate economic management against the backdrop of the digital economy, analyze the challenges encountered during digital transformation, and propose systematic innovation strategies to provide references for enterprises striving for high-quality development.

Keywords: Digital economy; Digital technologies; Risk management; Investment innovation

In the context of the digital economy, corporate decision-making is being reshaped by digital technologies, gradually shifting from traditional experience-driven approaches to data-driven ones [1]. By establishing data collection platforms, enterprises can obtain real-time internal and external data and leverage big data analytics and artificial intelligence algorithms to unlock data value. This effectively transforms corporate decision-making from reactive to proactive, significantly improving decision-making efficiency and accuracy. With the advancement of digitalization, the level of intelligent decision-making is continuously rising, and enterprises are gradually transitioning from a passive response model to an active predictive management model.

In corporate economic management, intelligent financial management systems leverage Robotic Process Automation (RPA) technology to automatically handle repetitive financial tasks such as document entry, data reconciliation, and report generation, thereby significantly improving operational efficiency and accuracy. At the same time, through visualization tools and predictive models, financial analysis achieves multi-dimensional display of financial data and trend forecasting, allowing financial professionals to focus more on data interpretation and strategic analysis. Furthermore, the application of blockchain technology in the financial field is

gradually enhancing transaction transparency and traceability, consequently reducing the risk of fraud.

The digital transformation of supply chain management is becoming key for enterprises to improve operational efficiency and respond to market fluctuations [2]. By utilizing Internet of Things (IoT) technology, digital supply chains enable full-visibility monitoring of logistics processes, allowing real-time tracking of the flow status of raw materials, semi-finished products, and finished goods. Smart demand forecasting systems, which integrate market data with historical sales data, optimize inventory management strategies, reducing inventory costs while ensuring timely supply.

Driven by digital technologies, human resource management can leverage intelligent recruitment systems powered by natural language processing (NLP). These systems use algorithms to match job requirements with candidate capabilities, enabling automated resume screening and improving the efficiency of talent selection. Additionally, data analytics can be used to assess employee development potential and deliver personalized training recommendations, helping enterprises accurately allocate training resources.

In the process of corporate economic management, digital technologies enable enterprises to shift risk prevention from a passive response model to an active prevention model [3]. For example, intelligent risk monitoring systems, equipped with anomaly detection algorithms, can identify risk signals in real time within financial operations — such as suspicious payments or abnormal expense reimbursements — thereby safeguarding corporate assets. At the same time, cybersecurity protection systems utilizing artificial intelligence technologies can identify network attack patterns and protect the security of enterprise data assets.

In terms of information system construction, many enterprises, especially small and medium-sized ones, suffer from fragmentation. Independent operation of systems across departments leads to severe data silos, making comprehensive integration difficult. Outdated network facilities result in slow data transmission speeds and poor stability, failing to support real-time business processing needs. Untimely updates of hardware equipment led to limited storage capacity and insufficient computing power, unable to effectively support big data analytics and artificial intelligence applications.

Traditional organizational structures and management mindsets struggle to meet the demands of digital transformation. Hierarchical, pyramid-shaped organizational structures lead to low information transmission efficiency and lengthy, cumbersome decision-making processes, failing to meet the requirement for rapid response to market changes in the digital age. Moreover, severe departmental silos and insufficient collaboration awareness, characterized by fragmented operations, hinder data sharing and business coordination [4].

The digital transformation of corporate economic management faces a severe talent bottleneck. There is a significant scarcity in the market of versatile talents who

possess both business expertise and digital skills, making it difficult to meet enterprise transformation needs. Traditional economic management personnel often lack data literacy and digital skills, and may exhibit resistance to adopting new technologies.

As the degree of enterprise digitalization increases, while collecting, storing, and processing large volumes of data, enterprises face increasingly complex cyberattacks and rising risks of data breaches. Inadequate internal data management systems and weak employee awareness of data security lead to frequent operational errors or internal leaks.

Advancing digital transformation requires first establishing a clear strategic plan and implementation framework. Defining the goals, pathways, and phased plans for digital transformation based on actual business needs is essential for a successful digital management strategy [5]. For example, enterprises can initiate digitalization in production processes, using smart sensing devices to collect equipment operation data and establish production process monitoring systems, before gradually expanding to supply chain management and customer service areas.

The significance of digital technologies lies not only in automating existing management processes but also in driving process reconfiguration. For instance, enterprises can use process mining techniques to extract real process operation data from system logs, thereby identifying efficiency bottlenecks and optimization opportunities. For example, in procurement approval processes, they can identify duplicate work or unnecessary waiting.

Enterprises can ensure a pool of digital composite talents by combining internal cultivation with external recruitment [6]. For example, in internal training, efforts should focus on developing digital strategic thinking and change leadership capabilities for senior managers; for middle managers, data analysis skills and digital project management capabilities should be strengthened; and for frontline employees, practical training on the operation of digital tools should be provided. These measures ensure that employee competencies align with the evolving needs of the enterprise.

As the value of data becomes increasingly evident, enterprises need to establish comprehensive data governance and security assurance systems to ensure effective management of data assets. First, enterprises need to establish unified data classification standards to resolve inconsistencies in data definitions across different systems. Simultaneously, establish data quality and security management mechanisms, using automated tools to regularly inspect data integrity, accuracy, and security, promptly correcting data issues and encrypting data to ensure security.

In summary, in the context of the digital economy, empowering corporate economic management with digital technologies is an inevitable choice for enterprise transformation and upgrading in the new era. Enterprises should view digital transformation strategically, recognizing it as a key initiative to enhance core competitiveness, rather than merely applying technological tools. As technologies continue to evolve and application scenarios expand, the integration of digital

technologies and corporate economic management will deepen further, creating greater value spaces for enterprises and supporting them in achieving sustainable development.

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RISKS, CHALLENGES, AND BUSINESS MODELS IN PROMOTING SMART WATER TECHNOLOGY

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Annotation. This paper talks about the real problems we face when promoting smart water technology in China's wastewater treatment plants, based on my own experience running a company in Zhejiang Province. Not everything is smooth. First, workers are afraid. When we first enter a plant, older workers often think the smart system will replace them. They might even try to break the sensors. Second, state-owned companies worry about data security. They ask: who owns the data? What if your company goes out of business? Does your algorithm have a back door? Third, there is the risk of cyber-attack. If a hacker takes control of a plant, polluted water could flow into a river – a very serious problem. This paper explains how we solve these problems. We change our message: the system is an assistant, not a replacement. We install everything on the customer's own servers, not our cloud. We offer to put our source code in third-party escrow. We build safety checks and keep a human in the loop. This paper also explains our business model. We do not just sell software. We help customers get government funding. We guarantee results – for example, 15% electricity savings – and pay a penalty if we fail. We train their staff so they can run the system themselves after two years. We also sell ongoing maintenance and consumables as a steady income stream. This paper is based on three years of my real work experience, not just library research.

Keywords: smart water, risks, worker fear, data trust, cyber security, business model, real case study.

Not everything is smooth. Let me be honest about the challenges.

First, workers are scared. When we first go into a plant, the older workers often think the smart system will replace them. They might even try to break the sensors. So we learned to change our message. We tell them, "The system is your assistant, not your replacement. With data-driven monitoring, you can watch the plant second by second. Real-time instructions will also be sent to our technical engineers. You will become a supervisor. Your job will be safer and more precise." At the same time, we provide training. After three months, most workers are happy.

Second, state-owned companies worry about data security. They ask questions like: "Who owns the data? What if your company goes out of business? Does your algorithm have a back door?" These are fair questions. Our solution is to install everything on the customer's own servers – not our cloud. We also promise to put our source code in a third-party escrow account. Even if our company fails, the customer can get the code and run it themselves. This builds trust.

Third, there is the risk of cyber-attack. If a hacker takes control of a plant, polluted water could flow into a river. That is very serious. So, we build safety checks. The system always has a human in the loop. It can only make small changes automatically. For big changes, a human must approve. Also, we have backup manual controls.

We do not just sell software. We sell a complete solution package.

First, we help customers get government funding. We help them write applications for treasury bonds and special bonds.

Second, we install the technology and guarantee real results – for example, 15% electricity savings. If we fail to meet the target, we pay a penalty.

Third, we train the customer's staff. After two years, they can run the system themselves.

In addition, we provide ongoing system maintenance and consumables (like sensors and test kits) as a steady income stream. In Zhejiang alone, the annual maintenance market is about 35 million RMB. That does not include new installations. So, this is a sustainable business.

Through my market experience, here is my simple advice for other entrepreneurs and for government officials.

For entrepreneurs: Be a one-stop solution provider. Help customers get funding. Use technology to achieve cost savings. Reduce government spending in the long run. Train team members. Build trust through soft details and technical support. Use real data to prove your strength.

For government officials: Policy is great, but please make sure the money goes to projects that actually perform. Tie funding to real outcomes, not just paper plans. Also, please help workers who lose old jobs to learn new digital skills. That is the only way to make the transition fair.

For researchers: Do not just study the algorithms. Also make sure the user interface is simple and efficient, and that operations are easy. Ask real companies: what is their attitude toward automation? What are their real concerns? How should we measure trust? These questions are just as important as the technology.

Digital technology really works for green development – at least in the wastewater industry in Zhejiang, China. Our STEM-X platform has saved real electricity and real chemicals. But technology alone is not enough. You need to manage risks: worker fear, data trust, cyber security.

You need a good business model: funding help, guaranteed results, training, and steady maintenance income. I hope my experience can help others who want to do the same thing.

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I thank the postdoctoral team from Tsinghua University for their technical work. I also thank the Wenzhou city government and the owners of the three demonstration plants for trusting us.

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HOW DIGITAL TECHNOLOGY HELPS GREEN DEVELOPMENT: A REAL STORY FROM ZHEJIANG, CHINA

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Annotation. This paper is based on my real experience running a technology company in Zhejiang Province, China, that focuses on smart wastewater treatment. Zhejiang is one of the richest provinces in China. The local government has made clear policies to push wastewater treatment plants to become smarter and greener. My company works with a team of postdoctoral researchers from Tsinghua University. We built a platform called STEM-X that uses digital twin technology and smart algorithms to control treatment plants automatically. We tested it in several real plants in Zhejiang. The results showed that electricity use dropped by about 18.5% on average, chemical use dropped by about 22.3%, and water quality became much more stable. Electricity and chemicals are the two biggest costs for a treatment plant – together they make up about 80% of total operating expenses. This paper explains why Zhejiang is a good market. The province has more than 320 wastewater plants. Its 14th Five-Year Plan says that by 2025, 60% of city plants must meet green low-carbon benchmark standards. The city of Wenzhou, where our company is based, has a special wastewater plan that makes smart control a core direction. The central government also provides money through ultra-long-term bonds and local special bonds. This paper is based on three years of my real work experience, not just library research.

Keywords: digital economy, green economy, smart water, Zhejiang market, wastewater treatment, local policy, real case study.

I run a company called Zhejiang Zhengyi Environmental Technology. We are based in Wenzhou, Zhejiang Province. Zhejiang has mountains and rivers. The local government follows strict environmental rules. They really care about clean water and green development.

Why is Zhejiang special? First, there are a lot of wastewater treatment plants here. As of 2023, Zhejiang had about 320 city-level plants. Second, these plants face pressure to save energy and reduce chemical use. Third, the local government has made smart water a hard requirement. They want artificial intelligence, AI analysis, automatic alarms, precise aeration, and smart chemical dosing.

Let me give you a concrete example. The Wenzhou city government made a wastewater plan that covers 2021 to 2035. In that plan, they clearly say that smart control is a core direction. They want to use digital tools to manage both the plants and the pipe networks. This plan matches the national 15th Five-Year Plan. That means for us, there is a clear long-term market, not just a short-term fad.

The Zhejiang provincial government's 14th Five-Year Plan for wastewater treatment says two important things. First, by 2025, all city-level plants must finish upgrading to higher standards. Second, 60% of those plants must become green low-carbon benchmark plants. That is a hard target.

Let me do the math for you. Zhejiang has about 320 plants. Sixty percent of that is about 190 plants. Each plant needs to spend money on smart controls, better equipment, and monitoring tools. Based on our experience, the average cost for a medium plant is about 3 to 5 million RMB. So the total market in Zhejiang just for smart retrofitting is about 1 to 1.5 billion RMB. That is a big number for a small company like ours.

But that is not all. The central government also has a policy called "100 benchmark plants by 2025." These are national demonstration projects. If we can get one of our projects in Zhejiang to become a national benchmark, that experience can be copied to other provinces. That is how we grow.

With slow economic growth, getting starting money is hard for state-owned enterprises. Many plant managers tell me, "We want to upgrade, but we have no money." That is a real problem, especially for smaller cities. But in 2025, the Chinese government has created new ways to get money.

One is ultra-long-term special treasury bonds. These bonds last 20 to 50 years and have low interest rates. They can cover up to 60% of the cost of pipe network and plant upgrades. But you have to apply the right way. If you just ask for money to fix one pipe, you might get rejected. But if you package the project as a "drainage and flood control upgrade" that combines pipes, plants, and smart systems, your chance is much higher.

Another source is local government special bonds. These can be used as capital for building or upgrading plants. In Zhejiang, a typical funding mix is 20% local money plus 80% special bonds. That is what we did for a 100,000-ton plant in a prefecture-level city in Zhejiang. We helped them write the application, and they got about 30 million RMB from treasury bonds and 50 million RMB from special bonds. Then we installed our STEM-X system. After six months, they saved 16.3% on electricity and 22.1% on chemicals. Everyone was happy.

Our STEM-X platform is a digital twin system. That means we build a computer model that acts exactly like the real plant, whether online or offline, and can monitor the plant in real time. Sensors in the plant send data instantly to the model. The model can predict what will happen in the next few hours – for example, water quality and bacteria living conditions – then it automatically adjusts the air flow or chemical dosage to keep the system stable and meet discharge standards.

The smart part is that the model learns from historical data over years of operation. When something changes – for example, in winter when temperatures drop and water concentration is higher during dry seasons – the model adjusts itself. We have tested the platform in three real plants in Zhejiang with different processes: AAO, oxidation ditch, and SBR. The sizes range from 20,000 to 100,000 tons per day. We collected data for 12 months before and after. The results: electricity down 16–20%, chemicals down 19–25%, and water quality variation down about 35%. That is really proof.

Digital technology really works for green development – at least in the wastewater industry in Zhejiang, China. Our STEM-X platform has saved real electricity and real chemicals. But the technology alone is not enough. The right local policies – like Zhejiang's 60% benchmark target and Wenzhou's smart water plan – create a market. The right funding tools – like treasury bonds and special bonds – make projects affordable. And the right technical people make it all happen. I hope my experience can help others who want to do the same thing.

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I thank the postdoctoral team from Tsinghua University for their technical work. I also thank the Wenzhou city government and the owners of the three demonstration plants for trusting us.

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INCREASING THE COMPETITIVENESS OF CHINESE HIGH-TECH COMPANIES IN THE INTERNATIONAL MARKET: AN ANALYSIS BASED ON SMARTPHONE COMPANIES

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Annotation. Using Chinese smartphone manufacturers as an example, this research paper summarizes the strengths and weaknesses of Chinese technology companies in the international market and offers actionable recommendations for improvement from a strategic perspective. The paper highlights the influence of geopolitics and cultural narratives on enhancing international competitiveness and develops a framework for mitigating geopolitical risks. This study not only expands the analytical framework for corporate international competitiveness in the new global environment but also provides practical recommendations for Chinese high-tech companies to overcome development bottlenecks and achieve high-tech upgrading in global value chains.

Keywords: high-tech companies; international market competitiveness; smartphone industry; geopolitical risk; cultural narrative; global value chain

Importance and significance: Enhancing the competitiveness of Chinese high-tech companies in overseas markets, so as to achieve more complete and well-rounded development. Existing problems: Core technological capabilities are still insufficient; product added value needs to be raised; there is a lack of promotion of fine traditional Chinese culture; and companies face ever more prominent political intervention factors such as geopolitical conflicts and trade protectionism.

From the perspective of cultural confidence, Lin Ye conducted an in-depth study of the many problems Chinese brands face in their international communication strategies, and on this basis proposed pathways and countermeasures for brand international communication grounded in cultural confidence, making an important contribution to this field [1]. Limitation: The proposed measures to enhance the cultural influence of Chinese brands' international communication are not sufficiently forceful.

In planning overseas locations for high-tech companies and avoiding single-market risks, Du Debin carried out systematic research [2]. Limitation: The study did not take political factors into account, which is especially relevant today amid increasingly turbulent political situations and rising trade protectionism.

In analyzing the current situation and countermeasures concerning the Sino-U.S. game in the information and communication technology (ICT) industry, Zhou Xinhong made an important contribution [3]. Limitation: The focus is solely on China and the United States, without attention to the broader global transformations.

Research on corporate international competitiveness has been mainly influenced by classical economic thought. Adam Smith’s (1776) theory of absolute advantage and David Ricardo’s (1817) theory of comparative advantage established a cost-advantage framework based on differing resource endowments. Later, Michael Porter’s (1990) Diamond Model added factors such as production conditions, demand conditions, related and supporting industries, and corporate strategy, becoming the dominant theoretical paradigm for nearly three decades [4].

However, when the above perspectives are applied to the globalization strategies of companies entering newly developing markets and of Chinese tech companies, the traditional paradigm proves inadequate. Traditional models that fail to incorporate factors such as political risk and cultural storytelling also struggle to explain the influence of these factors.

The aim of the study is: To strengthen the competitive advantages of Chinese high-tech companies in the international market.

The objectives of the study are: First, to introduce the current situation of Chinese high-tech companies in international market competition (focusing on smartphone companies), including their achievements and challenges, with emphasis on the challenges; then, to propose detailed countermeasures in response to these challenges.

The main competitive advantages of Chinese high-tech companies:

First, Chinese companies have made significant headway in going global, possessing first-mover advantages in several sub-sectors. In the mobile phone sector, for instance, by 2025 the combined shipment market share of Chinese companies (such as Xiaomi, OPPO, vivo, and Huawei) is projected to exceed 40%, with absolute leading positions in Southeast Asia, Africa, and other countries. In other tech sectors, BYD holds roughly 20.35% of the global new energy vehicle market; Chinese photovoltaic module production capacity accounts for over 80% of the global total; and DJI commands over 70% of the global consumer drone market share, thereby forming robust global competitiveness.

Second, companies' technological strength and innovation capacity have been continuously rising, and their voice in setting international standards is growing. Huawei has ranked first in PCT international patent applications for eight consecutive years and also holds the most 5G standard-essential patents worldwide. Chinese AI-related patent applications account for 38.58% of the global total, and 6G patent applications represent 40.3% of the global share, both ranking first globally. In advanced packaging and memory chips, Chinese companies have also begun to reach world-class technological levels.

Third, government subsidies play a positive role in promoting companies' R&D innovation, especially for small and medium-sized high-tech companies. Policies such as direct grants, super deductions for R&D expenses, special funds, and government industrial investment funds encourage companies to increase R&D intensity, attract innovative talent, and overcome technical challenges. They help solve the financing difficulties of small and medium-sized high-tech companies and serve as an important supplementary channel for their R&D funding, assisting companies in boosting R&D investment, expanding market scale, and improving their financial situation. For a company at the forefront of innovation like Huawei, the government mainly supports the formation and development of an innovation ecosystem indirectly—for instance, through fostering a well-ordered market

environment, improving intellectual property protection mechanisms, and implementing universal preferential tax policies.

The main problems hindering the improvement of competitiveness:

1. Technology Containment and Core Technology "Bottleneck" Problems.

In recent years, U.S. and most Western countries have continuously imposed high-intensity technology blockades and export controls on Chinese high-tech companies, resulting in bottlenecks across various links from integrated circuits to software. In the mobile terminal industry, key components such as high-performance system-on-chips (SOCs), operating systems, and radio frequency components are heavily reliant on foreign supply. Even the globally leading Huawei has had to adjust its product lines after being sanctioned. The technology blockade hinders Chinese companies from upgrading and selling high-end products in the international market, constituting the greatest obstacle to their competitiveness.

2. Trade Protectionism and Geopolitical Turbulence Aggravate Business Risks.

Against the backdrop of a new wave of global trade protectionism, the market access thresholds for Chinese companies are continuously being raised. India has repeatedly increased import tariffs on electronic products and even maliciously frozen and confiscated the assets of Chinese companies such as Xiaomi in India; many countries in Southeast Asia and Latin America have successively introduced local manufacturing policies, raising the market access barriers for Chinese products… Due to frequent military coups in Africa and regional conflicts in the Middle East and Eastern Europe, Chinese companies' overseas factory deployment, asset security, and product circulation face serious threats, and supply chain resilience is severely inadequate.

3. Ideological Barriers and Insufficient Cross-cultural Narrative Capacity.

Some Western countries, in order to shift their own internal contradictions, have persistently smeared and attacked China and Chinese brands in their media and public discourse, constructing relatively strong ideological barriers. For example, Japan deliberately shifted the blame for its domestic rice shortage onto China, inciting public hostility toward China; media in the U.S. and Europe have repeatedly alleged that Chinese high-end electronic products pose "information security risks." This has also caused some foreign users to hold biases against domestic Chinese brands.

At the same time, Chinese manufacturing companies generally emphasize "product technology over brand storytelling." Brand marketing tends to focus on the hard power of the product and its price advantage, without establishing a clear core brand value or cross-cultural narrative system. They are unable to convert product strengths into the intrinsic cultural value of the brand. Even if overseas consumers purchase Chinese products with excellent hardware performance, they continue to be influenced by negative news, failing to form positive brand identification or favorable word of mouth, which further restricts Chinese brands' breakthrough into the global high-end market.

4. Insufficient Brand Premium and the Low-Value-Added Vicious Cycle.

The lack of cultural narrative ability directly leads to the lack of premium ability of Chinese brands in the global market. In the global high-end smartphone market above $800, Apple and Samsung together account for more than 92% of the market share, while Chinese brands account for less than 8%; The average per-unit price of Chinese smartphone brands in the global market is less than 40% of Apple's, and the brand premium capacity is seriously insufficient.

This insufficient premium capacity further forms a vicious cycle: low added value means that even though companies' products perform excellently in various hardware aspects, they cannot command higher prices to generate high premiums and therefore cannot increase profits. The inability to increase profits, in turn, limits investment in product R&D and employee welfare improvement. Insufficient R&D expenditure and employee welfare hamper product upgrades and employee motivation, causing product performance to lag behind user demands and technological progress, further reducing product added value. At the same time, decreased employee motivation leads to declining corporate innovation capacity and talent loss, further deepening the vicious cycle.

5. Misuse and Ineffective Supervision of Government Subsidies.

There are also phenomena of wasteful and irrational use of government subsidies. For instance, in the sales process, some merchants raise the original price of a mobile phone from 4,000 yuan to 4,500 yuan and then let consumers enjoy a 500-yuan subsidy, resulting in an unchanged actual price while siphoning off government funds. In R&D and production, some companies use subsidies to cover daily operating losses rather than for R&D innovation, and there are even cases of fabricating R&D projects and falsifying data to defraud subsidies. Moreover, large companies receive an excessive amount of subsidies, while small and medium-sized companies that truly need financial support find it difficult to obtain effective assistance. The subsidies have also given rise to more design patents and utility model patents, with insufficient incentives for invention patents, so that the "qualitative" improvement of innovation has not materialized. The root cause of the above problems lies in an inadequate oversight mechanism: supervision tends to emphasize post-audits and passive intervention, making it difficult to identify and correct violations in a timely manner.

Based on the two-dimensional analytical framework and core challenges outlined above, we propose targeted strategies for enhancing the international competitiveness of Chinese high-tech companies from four dimensions.

First, focus on tackling core technologies and build a highly resilient global supply chain system. Second, create a tiered geopolitical risk management and control system and a complete full-compliance system. Third, create a dual-line brand system that integrates technological value and cultural narrative, so as to break the vicious cycle caused by low added value. Fourth, optimize the government subsidy process to improve policy incentive effectiveness.

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MODELS OF DEVELOPMENT OF ECONOMIC SECURITY OF THE ENTERPRISE

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Annotation. Against the backdrop of global digital transformation and closer Kazakhstan-China cooperation under the Belt and Road Initiative, enterprise economic security has evolved from a single-dimension risk control issue into a systemic issue that shapes international business, cross-border trade, investment stability and macroeconomic resilience. This study constructs a structured development model of enterprise economic security that integrates digital tools and adapts to the practical scenarios of bilateral economic cooperation. Using literature review, quantitative analysis and comparative case study, this paper clarifies the connotation and structural dimensions of the model, identifies key influencing factors under digitalization, and forms an integrated framework covering risk identification, capability construction, resource allocation and dynamic adjustment. Empirical observations and case verification show that a digitally enabled collaborative security model can significantly improve the risk resilience of enterprises engaged in cross-border cooperation between Kazakhstan and China. The model provides both theoretical support and actionable paths for enterprises from two countries to carry out international business, cross-border e-commerce and investment activities in a more secure and sustainable manner.

Keywords: enterprise economic security; development model; digital transformation; Belt and Road; Kazakhstan-China cooperation; risk management

Digital transformation is reshaping production, trading and governance models across economic sectors worldwide. Meanwhile, the Belt and Road Initiative has deepened practical cooperation between Kazakhstan and China in logistics, cross-border e-commerce, industrial investment and digital infrastructure. For enterprises participating in transnational operations, the external environment has become increasingly complex, with frequent shocks from geopolitical changes, supply chain disruptions, data security risks and intensified market competition. Traditional economic security models that focus only on internal financial control or single risk prevention are increasingly unable to meet the needs of digital operation and cross-border management.

This study focuses on the construction and application of enterprise economic security development models, closely linking with the core themes of the conference, including digital transformation, international trade, investment and innovation policy, risk management in digital economy, e-commerce and cross-border trade. It aims to provide a targeted reference for enterprises in Kazakhstan and China to enhance competitiveness and risk resistance in the context of digital economic cooperation.

The development model of enterprise economic security is an integrated strategic framework that balances security maintenance and stable development. In the context of digital economy and Kazakhstan-China Belt and Road cooperation, it covers four closely linked core dimensions: financial security, supply chain security, data security and operational security. It is not only a defensive system against risks,

but also a dynamic development system supported by digital technology and cross-border resource integration.

This study establishes a four-dimensional integrated development model:

1. Risk identification and early warning subsystem: It uses big data analysis and artificial intelligence algorithms to realize real-time monitoring and early warning of risks in cross-border capital flows, logistics chains, market fluctuations and policy changes.
2. Digital capacity building subsystem: It improves the digital governance level of enterprises through cloud computing, blockchain and cross-border data management tools, and enhances independent control capacity in key links.
3. Cross-border resource allocation subsystem: Under the framework of Kazakhstan-China cooperation, it integrates logistics, capital, technology and market resources to form a stable cross-border support system.
4. Dynamic adaptation and adjustment subsystem: It forms a closed-loop feedback mechanism based on changes in international business rules, bilateral policies and market environment, so as to realize real-time optimization of the model.

This study reviews theories and empirical studies related to enterprise economic security, digital transformation and transnational cooperation in the past decade, covering Chinese and English databases such as CNKI and Web of Science. It combs the evolution of concepts, the structure of models and the limitations of existing research, so as to lay a solid theoretical foundation for model construction.

This study collects sample data from enterprises in Kazakhstan and China that are engaged in cross-border trade and investment. SPSS 26.0 and AMOS 24.0 are used to test the reliability and validity of indicators. Correlation analysis and structural equation model are used to quantitatively verify the influence of digital factors on the operational effect of the model.

This study selects representative manufacturing enterprises and cross-border e-commerce enterprises from Kazakhstan and China for multi-case comparative analysis. Data sources include enterprise annual reports, industry reports and semi-structured interviews with financial and risk management executives. The applicability and practical effects of the model in real operation are verified through on-site investigation and data triangulation.

Digital technologies including artificial intelligence and big data have become important enabling tools for enterprises to implement economic security development models. They support intelligent identification and dynamic early warning of cross-border risks, improve the efficiency and transparency of trade and investment, and help enterprises strike a balance between development expansion and risk control.

In cross-border e-commerce, logistics services and industrial investment cooperation, the model helps enterprises coordinate security and development goals, reduce risks in cross-border capital flow, data transmission and supply chain

management, and promote stable and long-term development of bilateral economic and trade cooperation.

The model effectively integrates investment and innovation policies, strengthens risk management capabilities of enterprises in the digital economy, and enhances comprehensive competitiveness.

At the same time, it helps maintain the stability of financial systems and macroeconomic operations, and supports the healthy development of regional economies.

The enterprise economic security development model constructed in this study is highly compatible with digital transformation and practical needs of Kazakhstan-China Belt and Road cooperation. It integrates digital technology application, cross-border resource integration and dynamic risk management, and can effectively respond to security challenges faced by enterprises in international business and cross-border trade. With the further development of digital economy and deepening of bilateral cooperation, the model will be continuously optimized according to policy adjustments, technological iterations and changes in enterprise practice, so as to provide stronger support for enterprises' sustainable operation and regional economic stability.

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RESEARCH ON THE FORMATION OF ECONOMIC DEVELOPMENT OF TIANJIN'S BIOMEDICAL INDUSTRY AND ITS COOPERATION POTENTIAL WITH KAZAKHSTAN

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Annotation. This study focuses on the evolution of Tianjin's biopharmaceutical industry and its potential for China-Kazakhstan cooperation. Grounded in theories of industrial clusters, value chains, and international capacity cooperation, and incorporating industrial data and policy documents from 2023 to 2025, it systematically analyzes the foundational elements, developmental stages, and core strengths of Tianjin's biopharmaceutical sector; assesses Kazakhstan's biopharmaceutical landscape and collaboration prospects; and quantitatively evaluates bilateral cooperation potential across four dimensions—policy, industry, technology, and market – to identify practical bottlenecks in cross-border collaboration and propose targeted implementation strategies aligned with each region's industrial strengths. The research reveals that Tianjin has established a comprehensive industrial cluster encompassing "innovation and R&D – pilot-scale production – high-end manufacturing – cold-chain logistics – end-user services." In 2024, the core industry's output value exceeded RMB 100 billion, with 32 national-level innovation platforms clustered in the region. Three key sectors – synthetic biology, traditional Chinese medicine, and advanced implantable medical devices – lead the northern market. As a pivotal Central Asian economy, Kazakhstan boasts a steadily expanding pharmaceutical demand market and limited domestic production capacity, creating strong complementarity with Tianjin's industrial resources. Multiple cooperative projects—including joint medical initiatives, research collaborations, pharmaceutical trade, and pilot production facilities – have been implemented, laying a solid foundation. Supported by policy alignment, streamlined channels, and platform empowerment, the feasibility of deepening bilateral cooperation is exceptionally high. This study provides actionable insights for Tianjin's biopharmaceutical enterprises expanding globally and for enhancing China-Kazakhstan synergy in the healthcare sector.

Keywords: Biopharmaceutical industry; Kazakhstan; Belt and Road; Joint capacity building

The biopharmaceutical industry is a strategic emerging sector vital to national economy, public welfare, and security, with its development level directly impacting

the country's industrial competitiveness and public health safeguards. Tianjin boasts a solid foundation in biopharmaceuticals, having established a collaborative innovation ecosystem comprising technology-leading enterprises, national key laboratories, research universities, and healthcare institutions, while progressively achieving large-scale, clustered, and high-end industrial transformation. By 2025, Tianjin's biopharmaceutical industry is projected to generate over ¥106 billion in industrial output value, hosting a cluster of leading products and renowned domestic and foreign enterprises, with 193 large-scale industrial enterprises. The city has been designated as one of China's first National Biotechnology Industrial Bases and National Pharmaceutical Export Bases. Its core advantages include:

1) High-density concentration of top-tier innovation resources: The region hosts world-class universities such as the Tianjin Institute of Industrial Biotechnology of the Chinese Academy of Sciences, Tianjin University, and Nankai University, along with national-level research institutes; it hosts nine national key biopharmaceutical laboratories and 32 comprehensive national industrial innovation service platforms. Core technologies like targeted cancer drug delivery, synthetic biology production, and extraction of active components from traditional Chinese medicine rank among the nation's best.

2) A comprehensive closed-loop industrial ecosystem: The sector encompasses five key segments—chemical generics, traditional Chinese medicine with modern approaches, genetic engineering biologics, full-range medical devices, and core biological consumables—forming a robust ecosystem where "leading enterprises guide development, specialized SMEs provide support, and public platforms deliver empowerment." Industry leaders such as CanSino Biologics, Heyuan Biotech, and Huaxi Biotech demonstrate outstanding national competitiveness.

3) Tiered, targeted policies providing full support throughout the development process. The municipal government has introduced a comprehensive set of supportive policies, including additional tax deductions for R&D expenses, a fast-track clinical trial pathway for innovative drugs, and housing subsidies for high-level pharmaceutical professionals. It has also established a special industrial fund worth tens of billions of yuan under the Haihe Initiative, specifically designed to empower all stages of new drug clinical development, the establishment of standardized pilot-scale production facilities, and enterprises' global expansion strategies. Fourth, the cross-border logistics zone boasts unparalleled geographical advantages. Tianjin Port serves as a core international shipping hub in northern China, operating regular dedicated cold-chain trains directly to Kazakhstan for China-Europe routes. With a fully standardized pharmaceutical temperature-controlled cold-chain storage and transportation system, it ensures safe and efficient cross-border transportation of pharmaceutical products and precision medical devices, providing robust infrastructure support for international industrial collaboration.

Kazakhstan is the birthplace and core hub of the "Silk Road Economic Belt." China and Kazakhstan serve as benchmarks and models for jointly advancing the Belt

and Road Initiative. The two countries have signed agreements such as the "Permanent Treaty of Good-Neighboring and Friendly Cooperation between China and Kazakhstan" and the "Action Plan for High-Quality Joint Construction of the Belt and Road," establishing them as permanent comprehensive strategic partners with frequent high-level exchanges and robust political trust. Kazakhstan ranks first in Central Asia in terms of economic size, with continuous increases in investments in healthcare and social welfare, leading to steady expansion of the essential pharmaceutical consumption market. In 2024, the compliant pharmaceutical distribution market reached USD 4.28 billion, and industry projections indicate that the total pharmaceutical market will exceed USD 5.2 billion by 2026. The country's permanent population remains stable at around 20 million, with an urbanization rate exceeding 63%. The aging population is accelerating annually, creating substantial and consistent demand for routine diagnosis and treatment of prevalent chronic diseases such as cardiovascular conditions, malignant tumors, and metabolic diabetes. Additionally, the Kazakh government has pledged to raise healthcare fiscal expenditure as a percentage of GDP from the current 3.9% to 5% by 2027, while continuously improving the distribution of primary healthcare facilities and expanding procurement lists for drugs and medical devices in public institutions, thereby unlocking a cross-border pharmaceutical cooperation market worth hundreds of billions of dollars in the medium to long term.

Leveraging the dual frameworks of the Belt and Road Initiative and the normalized cooperation under the Shanghai Cooperation Organization, China Tianjin and Kazakhstan have established diversified practical collaborations in the biopharmaceutical sector, encompassing healthcare benefits for the public, joint scientific research, product trade, and pilot small-scale production capacity projects, with a solid foundation in cooperation. First, benchmark demonstration projects have been implemented in traditional Chinese medicine (TCM) cooperation: the China-Kazakhstan jointly established Astana Traditional Medicine Center in Kazakhstan operates routinely, with Tianjin University of Traditional Chinese Medicine deeply involved in technology transfer of TCM diagnosis and treatment, cross-border mutual recognition of TCM compliance standards, and specialized training programs for grassroots healthcare professionals. Second, long-term collaboration mechanisms have been established between Tianjin's top-tier hospitals and Kazakhstan's national medical institutions; Tianjin Huanhu Hospital and Tianjin Medical University Cancer Hospital have signed strategic cooperation agreements with the Kazakhstan National Medical Science Center and the National Cancer Diagnosis and Treatment Center, conducting regular cross-border remote consultations, online teaching of minimally invasive surgeries, and joint pathological research on oncology, while facilitating large-scale rotational training exchanges of key medical personnel. Third, cross-border joint development of innovation platforms has yielded tangible results: the Tianjin Institute of Industrial Biotechnology of the Chinese Academy of Sciences partnered with the National University of Kazakhstan to establish a specialized joint

research platform, focusing on targeted research in the deep processing of Central Asian medicinal plant resources and the improvement of industrial medical microorganisms, yielding multiple practical and scalable scientific achievements. Fourth, cross-border pharmaceutical trade has operated routinely and stably. Local pharmaceutical enterprises in Tianjin have leveraged Tianjin Port's cold-chain logistics and the China-Europe dedicated pharmaceutical freight trains to regularly export traditional Chinese medicine formula granules, in vitro diagnostic reagents, and rehabilitation-assisting medical devices to Kazakhstan. Multiple compliant products have been successfully included in the centralized procurement catalog of Kazakh public medical institutions. Bilateral drug regulatory authorities have simultaneously initiated specialized consultations on simplified drug registration and mutual recognition of GMP qualifications, removing compliance barriers for subsequent large-scale cooperation.

Assessment of Biomedical Cooperation Potential between Tianjin and Kazakhstan

1. Cooperation Foundation and Favorable Factors. At the policy level, there is highly synchronized alignment in both directions: China's Belt and Road industrial empowerment policies precisely align with Kazakhstan's Bright Path New Economic Plan; the Shanghai Cooperation Organization has established a cross-border health industry cooperation forum; and Tianjin's municipal-level initiatives have included Central Asian pharmaceutical cooperation in its key foreign trade empowerment list. At the industrial level, resources from both sides complement each other precisely: Tianjin boasts comprehensive advantages—including cutting-edge technological innovation, mature mass-production capacity, ample industrial funding, and high-caliber professionals—while Kazakhstan possesses untapped incremental markets, indigenous medicinal biological resources, and favorable cross-border investment policies. At the logistics level, cross-border transportation is efficient and convenient: Tianjin's direct China-Europe freight trains to Almaty operate with full coverage of pharmaceutical temperature-controlled cold chains, ensuring stable cross-border transport timelines of 15 to 20 days while maintaining product quality throughout. At the platform level, multi-tiered mechanisms facilitate collaboration: municipal science and technology departments have launched dedicated projects for cross-border pharmaceutical cooperation, and numerous universities and research institutes maintain long-term partnerships with Kazakhstani counterparts, with a strong track record of successful collaboration requiring no additional coordination.

2. Comprehensive Assessment of Cooperation Potential. Based on a holistic evaluation of four core dimensions—mutual industrial compatibility, policy support intensity, existing foundations for practical cooperation, and cross-border logistics convenience—Tianjin and Kazakhstan possess significant potential for deepening bilateral cooperation in the biopharmaceutical sector. In the short term (1–2 years), rapid implementation is achievable through large-scale export of pharmaceutical products, point-to-point transfer of lightweight technologies, and simplified short-

term rotational training programs for healthcare professionals. Over the medium term (3–5 years), steady progress can be made in jointly establishing standardized production facilities, establishing joint cutting-edge pharmaceutical laboratories, and advancing key regional market expansion initiatives. In the long term (5–10 years), a fully integrated cross-border industrial chain encompassing "R&D–pilot production–mass production–storage and transportation–sales" can be established, creating a national benchmark model for Sino-Kazakh cross-border biopharmaceutical collaboration.

Recommendations and Strategies

First, establish a closed-loop mechanism for bidirectional policy alignment by setting up a specialized Tianjin-Kazakhstan biomedical joint coordination framework. This framework involves point-by-point alignment with bilateral pharmaceutical market access compliance standards, streamlining cross-border enterprise registration and drug verification procedures. Additionally, the municipal government has allocated a dedicated cross-border cooperation support fund to reduce initial costs for enterprises expanding internationally. Second, strengthen the collective overseas expansion of leading enterprises by supporting domestic industry leaders such as Tianhecheng and Younuojin to conduct market research and establish operations in Harbin. Jointly establish a cross-border collaborative R&D platform to mobilize upstream and downstream small and micro enterprises for coordinated overseas ventures, enabling them to share distribution channels and mitigate risks collectively. Third, upgrade the dedicated cross-border cold-chain logistics system by leveraging Tianjin Port's core hub advantages: increase the frequency of dedicated China-Europe pharmaceutical cold-chain trains, establish temperature-controlled pharmaceutical bonded storage facilities along cross-border routes, and optimize the one-stop fast customs clearance green channel. Fourth, precisely cultivate the local end-consumer market by leveraging the Shanghai Cooperation Organization (SCO) International Pharmaceutical Exhibition and the Cross-Border Health Benefit Summit to showcase Tianjin's high-quality pharmaceutical products. Collaborate with Kazakh public hospitals to conduct clinical trial outreach campaigns, rapidly enhancing brand recognition. Fifth, deepen the long-term collaborative mechanism for bidirectional scientific and technological innovation talents by implementing rotational exchanges of key pharmaceutical research personnel, clinical healthcare professionals, and industrial operations managers. Jointly establish specialized training bases for young pharmaceutical talents to solidify the foundation for sustained talent cooperation.

The Tianjin biomedical industry has undergone multi-stage iterative development, boasting a mature full-chain industrial ecosystem, robust scientific and technological innovation capabilities, and a concentration of leading enterprises, with outstanding regional industrial competitiveness. In Kazakhstan, the essential biomedical market continues to expand steadily, while local industries face significant shortcomings, yet cooperation prospects remain clear. Both parties have already implemented multiple practical cooperation projects, laying a solid

foundation for collaboration. Leveraging multiple advantages—including synchronized policies, complementary industries, efficient logistics, and platform empowerment – the bilateral cross-border biomedical cooperation carries manageable risks, offers substantial returns, and demonstrates strong feasibility. Moving forward, focusing on three core priorities—overcoming compliance barriers, establishing long-term mechanisms, and enhancing full-chain capabilities – with concentrated efforts in four key sectors – traditional Chinese medicine, biopharmaceuticals, high-end medical devices, and healthcare services – will steadily achieve mutual benefits and win-win outcomes. This will strengthen the China-Central Asia Health and Wellness Industrial Community and facilitate high-quality, coordinated development of the biomedical industries in both regions.

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PRACTICAL BACKGROUND: THE DECISIVE ROLE OF INDUSTRY FROM THE PERSPECTIVE OF INVESTMENT PROMOTION PRACTICE

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Annotation. The author has been engaged in investment promotion for more than two decades, personally witnessing China's regional economic development transition from factor-driven to innovation-driven growth. Throughout this prolonged practice, a core observation has been repeatedly validated: industrial development plays a decisive role in regional economic growth. Whether considering the pioneering rise of coastal regions or the catch-up development of central and western China, industry has consistently served as the core driving force in the restructuring of the regional economic landscape.

From a macroeconomic perspective, since the reform and opening-up, China's aggregate economic output has risen to the second position worldwide, with sustained industrial upgrading and economic development. The total volume of foreign direct investment (FDI) ranks among the highest globally, and the total volume of import and export trade has consistently remained among the top two worldwide for many years. However, accompanying this economic growth is the increasingly pronounced disparity in inter-regional development and spatial agglomeration. Industrial structure, human capital accumulation, and foreign trade exert significant influences on inter-regional economic heterogeneity.

In frontline investment promotion work, the author has profoundly recognized that a region's industrial foundation determines its capacity to attract investment, while capital inflow further reinforces industrial advantages, forming a "cumulative causation" cycle.

Key words: Industrial enterprises, clusters and the theory of regional innovation systems, "Modern regional Economy" by Wei Houkai and "Industrial Economy" by Liu Zhibiao, agglomeration theory.

The study of the relationship between industrial development and regional economy is grounded in profound theoretical foundations. New Economic Geography, pioneered by Paul Krugman and other scholars, introduces the spatial dimension into mainstream economic analysis, revealing the intrinsic connections between industrial agglomeration and regional economic growth. This theory posits that the spatial concentration of economic activities is driven by external economies and increasing returns to scale resulting from agglomeration, including localized

labor markets, specialized input products, human capital accumulation, and knowledge spillovers generated through face-to-face interactions.

Research by Baldwin and Martin further indicates a systematic relationship between spatial agglomeration and economic growth, which can be characterized using a simultaneous equations model: economic growth influences the degree of agglomeration, which in turn affects economic growth. This theoretical framework provides rigorous analytical tools for studying the impact of industrial development on regional economies.

Furthermore, industrial location theory, industrial cluster theory, and regional innovation system theory collectively constitute the theoretical foundations of this research. The United Nations Industrial Development Organization's Industrial Development Report provides global benchmarks for industrialization, while works by domestic scholars such as Wei Houkai's Modern Regional Economics and Liu Zhibiao's Industrial Economics offer localized theoretical support for studying the relationship between industrial development and regional economies within the Chinese context.

This research possesses dual significance. At the theoretical level, existing literature on regional heterogeneity issues remains relatively fragmented, particularly lacking systematic studies from the perspective of investment promotion practitioners. This research will fill this gap by constructing a theoretical analytical framework of "industrial development—industrial agglomeration—regional economic growth" and introducing a spatial heterogeneity perspective to deepen the understanding of the applicability of New Economic Geography theory in China.

At the practical level, the research conclusions will provide scientific foundations for local governments to formulate industrial policies and investment promotion strategies. Currently, regional industrial chain investment promotion has become pivotal to investment promotion work; however, how to scientifically assess the actual contribution of industrial development to regional economies and how to identify differentiated paths of industrial development across regions remain pressing practical issues awaiting resolution. Based on over twenty years of frontline experience, this research will propose actionable policy recommendations.

Core Concept Definition

In this research, industrial development is a comprehensive concept encompassing multiple dimensions: industrial scale expansion (including industrial value-added and number of enterprises), structural optimization (involving the proportion of high-tech industries and completeness of industrial chains), agglomeration degree (measured by spatial Gini coefficient and location quotient), and innovation capacity (manifested in patent quantity and R&D investment intensity).

Impact on Regional Economy

This includes not merely traditional economic indicators such as GDP growth and per capita income improvement, but also comprehensive development outcomes

including industrial structure upgrading, employment creation, fiscal and tax revenue growth, and urbanization advancement. Simultaneously, it examines changes in inter-regional economic disparities—that is, whether industrial development narrows or widens regional gaps.

Industrial Agglomeration

This refers to the phenomenon where the same industry or related industries exhibit concentrated distribution in specific geographical spaces. According to New Economic Geography, industrial agglomeration affects regional economic performance through mechanisms such as economies of scale, knowledge spillovers, and labor pool effects.

This research focuses on provincial and prefecture-level regional units in China, with a time span set from 2000 to 2023. The rationale for selecting this period is that after China's accession to the WTO in 2000, industrialization and globalization accelerated, and the regional economic landscape underwent profound transformations. Simultaneously, data availability is favorable, facilitating rigorous econometric analysis.

The research boundaries are defined as follows: the analysis concentrates on the impact of manufacturing (secondary industry) on regional economies, moderately addressing the integrated development of producer services and industry, but not extensively discussing agriculture or pure services. In terms of spatial scope, consideration is given to the four major regional blocks of eastern, central, western, and northeastern China, with particular emphasis on regional heterogeneity analysis.

Based on the above definitions, this research addresses the following core questions:

Impact Mechanism: How does the level of industrial development affect the speed and quality of regional economic growth? Specifically, which dimensions of industrial scale, structure, agglomeration degree, and innovation capacity contribute most significantly to regional economies?

Spatial Heterogeneity: Does the impact of industrial development on regional economies exhibit spatial heterogeneity? That is, will identical industrial development policies produce different effects across regions? Do essential differences exist in industrial development paths between eastern and central-western regions, or between coastal and inland areas?

Role of Agglomeration: What role does industrial agglomeration play in the process through which industrial development affects regional economies? Is it a simple linear relationship, or does it exhibit nonlinear characteristics or threshold effects?

Policy Optimization: Based on investment promotion practice, how should local governments optimize industrial development strategies to promote coordinated regional economic development?

References:

1. First, official statistical data are accessible. The primary data required for this research are sourced from the China Statistical Yearbook, China Industry Statistical Yearbook, China Regional Economy Statistical Yearbook, and provincial (municipal) statistical yearbooks. These data cover core variables including industrial value-added, number of enterprises, fixed asset investment, employment population, and patent authorizations, featuring long time spans, broad coverage, and high authority.

2. Second, micro-level enterprise data serve supplementary functions. To deeply analyze industrial agglomeration mechanisms, the China Industrial Enterprise Database (1998–2013) or National Tax Survey Data will be utilized. These micro-level data can be used to calculate total factor productivity (TFP) at the enterprise level and measure the micro-foundations of industrial agglomeration, providing solid support for macro-level analysis.

3. Third, geospatial data are integrated. The research will integrate Geographic Information System (GIS) data, including geographical locations, transportation infrastructure, and development zone distributions of prefecture-level cities, for constructing spatial weight matrices and conducting spatial econometric analysis.

4. Fourth, case investigation data are collected. Relying on personal work networks, field investigations can be conducted in typical regions (such as Kunshan, Dongguan, and Chongqing) to collect policy documents, enterprise interview records, and project archives as first-hand materials, enriching case studies.

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INVESTOR BEHAVIOR AND FORMATION OF INVESTMENT STRATEGIES IN CONDITIONS OF UNCERTAINTY

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Annotation. This paper focuses on investor behavior and investment strategy formation under market uncertainty. It identifies typical behavioral biases such as loss aversion, anchoring, and overconfidence under different uncertainty levels, and constructs a personalized strategy framework matching investor profiles. By comparing passive diversification, tactical hedging, and adaptive AI-assisted strategies, it proves that rule-based, behavior-corrected and AI-supported strategies can effectively improve risk-adjusted returns and portfolio stability in volatile environments. The research provides practical portfolio rules for investors to mitigate irrational decisions and enhance long-term performance.

Key words: Uncertainty; Investor behavior; Behavioral bias; Investment strategy; Portfolio construction; Risk adjustment; AI-assisted investment.

The article systematically investigates how market uncertainty reshapes and transforms investor behavior patterns systematically reshapes and patterns, and profoundly influences the formulation and optimization of investment strategies profoundly influences formulation and optimization. The purpose of the study is to identify the main behavioral reactions of investors under unstable expectations and to show how these reactions can be translated into practical portfolio rules and operational guidelines and operational guidelines. The article combines concise literature arguments with specific case analyses, rather than overly technical econometric models, to supplement academic positioning. This approach is both conducive to academic readers' understanding and suitable for practical investment professionals to reference and apply.

Recent studies confirm that uncertainty changes both risk perception and asset allocation. Baker et al. [1] show that policy uncertainty affects household portfolio choices, while Liu et al. [2] stress that uncertainty may amplify managerial overconfidence and distort investment decisions. In financial markets, geopolitical instability encourages the formation of alternative strategies based on hedging and safe-haven assets. At the same time, adaptive and AI-supported approaches may reduce the influence of behavioral heuristics when portfolio decisions are taken under radical uncertainty [3].

Table 1. Behavioral responses of investors across uncertainty regimes

Indicator	**Low**	**Moderate**	**High**
Risk tolerance	High	Selective	Low
Portfolio concentration	Sector-focused	Balanced	Defensive
Rebalancing frequency	Quarterly	Monthly	Bi-weekly
Demand for hedging	Weak	Medium	Strong

Figure 1. Change in portfolio structure as uncertainty rises

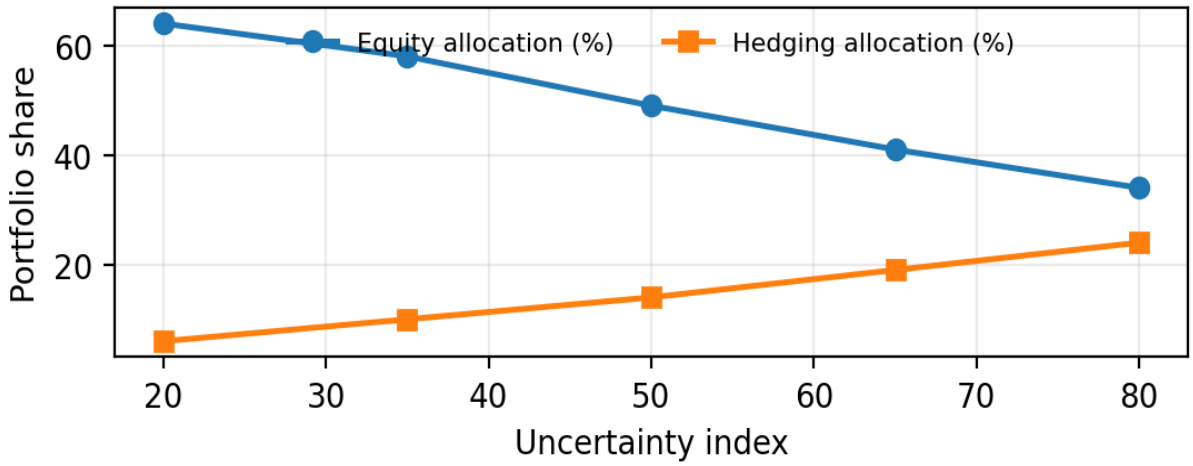


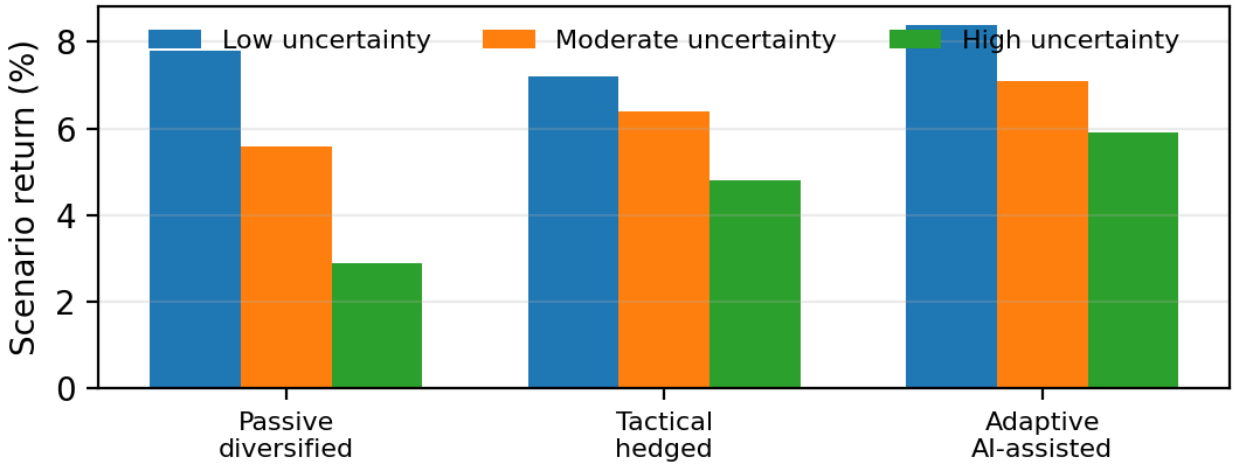
Figure 1 demonstrates a clear substitution effect in portfolio allocation: as market volatility rises or investor risk perception shifts, the share of risky equity positions gradually decreases, while hedging instruments such as options and futures become more important for managing downside exposure and controlling tail risks and controlling tail risks. This trend underscores the urgent need to incorporate behavioral insights into modern investment strategies urgent need...modern. Therefore, the first stage of strategy formation should prioritize the diagnosis of behavioral bias -like herd mentality or disposition effect -rather than relying solely on the observation of price changes, which may overlook underlying psychological drivers and emotional triggers and emotional triggers. By identifying these biases early and accurately and accurately, advisors can tailor approaches that mitigate irrational decisions and enhance long-term investment outcomes investment.

A practical framework for strategy formation should systematically distinguish between investor profiles based on risk tolerance, investment horizon investment horizon and behavioral tendencies. Conservative investors, for instance, usually react to uncertainty through pronounced loss aversion and a strong liquidity preference, often opting for safer assets like bonds or cash equivalents to avoid potential capital losses to avoid potential capital losses. Balanced investors, while moderate in risk-taking, are more exposed to cognitive biases such as anchoring on past prices and slow adjustment to new information, leading to suboptimal rebalancing and missed market opportunities and missed market opportunities. Aggressive investors, driven by high-risk appetites, often suffer from overconfidence and excessive trading, which can erode returns through transaction costs and timing errors. For this reason, strategy design must be personalized and directly linked to the dominant behavioral bias, incorporating tools like nudges, education, or structured products to align actions with long-term financial goals long-term. This customized approach ensures that strategies are not only theoretically sound but also practically effective in diverse and volatile market conditions and volatile [4].

Table 2. Strategy-formation logic by investor profile

Profile	Dominant bias	Core instruments	Monitoring rule
Conservative	Loss aversion	Bonds, cash, gold	Capital preservation threshold
Balanced	Anchoring	ETF mix, dividend stocks	Monthly range review
Aggressive	Overconfidence	Equities, crypto, themes	Drawdown and stop-loss rule

Figure 2. Strategy returns under three uncertainty regimes



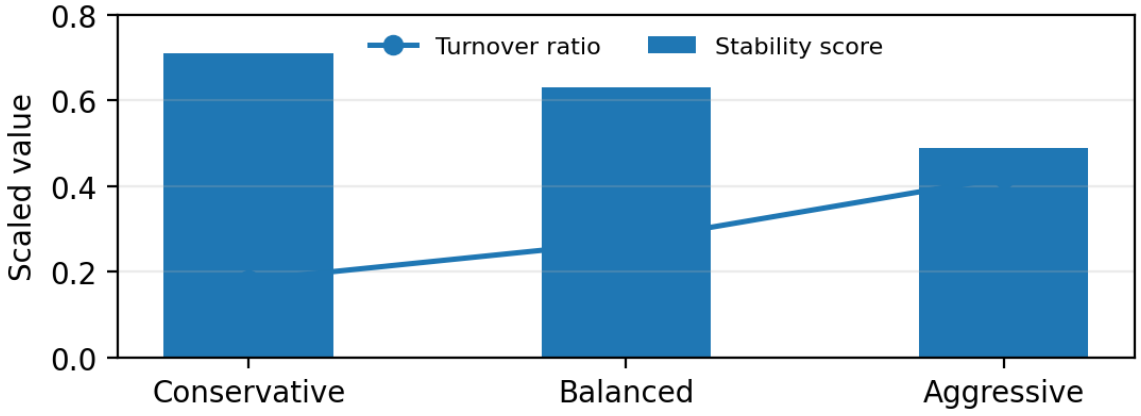
The synthetic comparison reveals that passive diversification performs adequately in stable market conditions, delivering consistent returns with minimal oversight. Tactical hedging enhances resilience by dynamically combining broad diversification with active downside protection measures, such as options or futures, which mitigate losses during market downturns. The best stability-adjusted result is achieved by the adaptive AI-assisted strategy, which systematically follows pre-defined rules based on real-time data analysis, thereby eliminating emotional reactions and ensuring disciplined execution.

This approach underscores that investors should not rely exclusively on intuitive market timing, which often leads to biases and suboptimal decisions. Instead, they should proactively define specific parameters, including diversification limits to control concentration risk, liquidity buffers to maintain flexibility during crises, stop-loss mechanisms to cap potential losses, and regular review intervals to adjust strategies as conditions evolve [5].

Table 3. Synthetic performance profile of alternative strategies

Strategy	Expected return, %	Max drawdown, %	Turnover, %	Stability score
Passive diversified	5.4	-18	20	0.56
Tactical hedged	6.1	-11	29	0.67
Adaptive AI-assisted	7.1	-9	36	0.73

Figure 3. Stability and turnover by investor profile



The combined evidence from Table 3 and Figure 3 suggests that higher stability is consistently associated with more disciplined monitoring practices and a lower sensitivity to short-term market noise. Conservative investment profiles preserve stability primarily through lower portfolio turnover and a focus on long-term fundamentals, whereas aggressive profiles tend to increase transaction activity, often reacting to volatility, and consequently face a weaker stability score over time.

In conclusion, uncertainty does not simply raise market risk; it fundamentally reorganizes investor behavior and changes the core principles by which investment strategies are formed.

The paper shows that robust strategy formation depends on recognizing dominant cognitive biases, selecting financial instruments appropriate to the prevailing uncertainty regime, and maintaining continuous, structured monitoring. A balanced combination of diversification, hedging, and rule-based analytical support appears to be the most promising path for investors operating under unstable expectations, enabling them to navigate volatility without sacrificing strategic coherence or long-term performance.

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UDC (330.341)

THE ROLE OF DIGITAL TRANSFORMATION IN THE DEVELOPMENT OF E-COMMERCE

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Abstract. The article examines the impact of digital transformation on the development of e-commerce in the context of globalization and economic digitalization. The relevance of the study is determined by the rapid development of digital technologies, changes in consumer behavior, the expansion of online markets, and the need for businesses to adapt to the new digital environment. The paper investigates the key areas of digital transformation influencing the efficiency and competitiveness of e-commerce. These include the development of digital infrastructure, the implementation of artificial intelligence, big data, cloud technologies, digital platforms, mobile applications, and electronic payment systems. Particular attention is paid to current trends in the development of e-commerce in the Republic of Kazakhstan, issues of business digitalization, logistics infrastructure, the level of digital literacy among the population, and consumer trust in online trade. Based on the conducted analysis, the main factors of sustainable e-commerce development were identified, and recommendations for improving the digital ecosystem in the context of the digital economy were proposed. The results of the study may be applied in the activities of government agencies, e-commerce enterprises, as well as in scientific research in the field of digital economy and strategic management.

Keywords: digital transformation, e-commerce, digital economy, digital technologies, digital platforms, artificial intelligence, big data, electronic payments, business digitalization, innovations.

Introduction. Under current conditions, digital transformation is becoming one of the key factors of economic development and increasing organizational competitiveness. The development of digital technologies has a significant impact on the structure of the global economy, transforming traditional business models, communication channels, and interaction mechanisms between sellers and consumers. One of the fastest-growing sectors of the digital economy is e-commerce.

The growing popularity of online platforms, mobile applications, digital

payment systems, and artificial intelligence technologies is expanding the capabilities of electronic trade and shaping new models of consumer behavior. The COVID-19 pandemic further accelerated digitalization processes, significantly increasing online sales volumes and encouraging enterprises to transition to digital business formats. In the Republic of Kazakhstan, the development of e-commerce also demonstrates stable positive dynamics. Government programs aimed at digitalization, the development of internet infrastructure, the increase in the number of mobile internet users, and the improvement of financial technologies create favorable conditions for the growth of online trade. At the same time, certain issues related to insufficient digital literacy, logistical limitations, cybersecurity, and consumer trust remain unresolved.

The purpose of the study is to analyze the impact of digital transformation on the development of e-commerce and identify the key factors for increasing its efficiency in the digital economy.

Main Part. Digital transformation refers to the process of integrating digital technologies into all areas of organizational activity and is accompanied by changes in business processes, organizational structure, and methods of interaction with customers. In scientific literature, digital transformation is considered not only as technological modernization but also as a strategic tool for increasing business efficiency and competitiveness [1].

E-commerce is a form of entrepreneurial activity based on conducting trade operations through information and communication technologies and the Internet. Modern e-commerce includes a wide range of areas such as B2B, B2C, C2C, marketplaces, mobile commerce, and social commerce.

The main elements of digital transformation in e-commerce include [2, 3]:

- digital platforms;
- artificial intelligence;
- big data;
- cloud technologies;
- the Internet of Things;
- mobile technologies;
- electronic payment systems;
- digital marketing.

The use of digital technologies enables companies to increase the speed of information processing, optimize logistics, improve customer service quality, and personalize offers for consumers.

Digital transformation has a comprehensive impact on the development of e-commerce. One of the key factors is the transformation of the interaction model between businesses and consumers [4]. Modern digital platforms provide high accessibility to goods and services, allowing consumers to make purchases regardless of time and geographical location.

Artificial intelligence and big data analytics technologies play a special role in

the development of e-commerce [5]. Based on user behavior analysis, companies can forecast demand, create personalized offers, and improve the effectiveness of marketing campaigns.

Mobile commerce is actively developing in the digital economy. The use of smartphones and mobile applications significantly simplifies the online purchasing process and contributes to the growth of electronic sales volumes.

One of the important directions of digital transformation is the development of electronic payment systems [6, 7]. The implementation of contactless payments, QR technologies, and mobile banking services accelerates financial transactions and increases user convenience. In addition, digitalization also affects logistics processes. The use of automated warehouse systems, digital order tracking, and supply chain analytics reduces delivery times and lowers company costs.

In recent years, Kazakhstan has demonstrated steady growth in the e-commerce sector. The development of the "Digital Kazakhstan" state program has become one of the key factors accelerating economic digitalization and expanding online trade [6].

The main factors contributing to the growth of e-commerce in Kazakhstan are:

1. Growth of the Internet audience;
2. Development of mobile Internet;
3. Increase in the number of digital services;
4. Expansion of online payments;
5. Active development of marketplaces;
6. Increase in the level of digital literacy of the population.

The most popular areas of e-commerce in Kazakhstan include online retail, food delivery, digital services, e-learning, and marketplaces. Despite the positive dynamics, the development of e-commerce is accompanied by several challenges.

Table 1 – Problematic Aspects of E-Commerce Development in the Republic of Kazakhstan

Problem	**Description**
Insufficient logistics infrastructure	Limited delivery opportunities in the regions
Cyber threats	Risk of personal data leakage
Insufficient level of trust	Consumer concerns regarding product quality
Digital inequality	Differences in Internet accessibility between regions
Staff shortage	Lack of specialists in the field of digital technologies
- *compiled by the author*	

For the further development of e-commerce, it is necessary to improve the regulatory framework, develop digital infrastructure, and support innovative

entrepreneurship.

The prospects for the development of e-commerce are closely associated with the further implementation of innovative technologies. In the coming years, active development is expected in the following areas:

– artificial intelligence and automation;
– virtual and augmented reality;
– blockchain technologies;
– omnichannel sales;
– digital personalization;
– development of social commerce platforms;
– environmentally sustainable digital solutions.

One of the promising directions is the implementation of ESG principles in e-commerce [8, 9]. Companies are increasingly introducing environmentally friendly solutions, optimizing packaging materials, and using digital tools to reduce their carbon footprint. In addition, international cooperation in the field of the digital economy plays an important role [10, 11]. The development of cross-border e-commerce contributes to the expansion of sales markets and enhances the competitiveness of national businesses.

Conclusion. Thus, digital transformation is one of the key factors in the development of e-commerce in the modern digital economy. The implementation of digital technologies contributes to increasing the efficiency of business processes, improving customer service quality, developing logistics, and expanding sales channels. The conducted analysis demonstrated that e-commerce in Kazakhstan is characterized by stable growth trends [12]. However, for the further development of the sector, it is necessary to address issues related to digital infrastructure, cybersecurity, logistics, and the training of qualified personnel. Under modern conditions, the competitiveness of companies is determined by their level of digital maturity and their ability to adapt to rapidly changing market conditions. In this regard, digital transformation is not only a technological necessity but also a strategic factor for the sustainable development of e-commerce. The results of the study confirm the need for further development of state policy in the field of economic digitalization, stimulation of innovation, and improvement of mechanisms for supporting e-commerce.

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SUPPLY CHAIN INNOVATION MANAGEMENT DURING ENTERPRISE DIGITAL TRANSFORMATION

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Annotation. This study examines supply chain innovation management in enterprise digital transformation from a technology–organization integration perspective. A qualitative analysis based on industry reports and existing literature is adopted to identify four core structural challenges: data silos, lengthy decision-making processes, shortages of interdisciplinary talent, and insufficient supply chain resilience. A four-dimensional optimization framework covering technology, organization, talent, and risk is proposed. The findings indicate that integrated digital platforms, organizational restructuring, systematic talent cultivation, and resilience-oriented supply chain strategies can significantly improve innovation efficiency and coordination. This study enriches existing literature by constructing a systematic analytical framework and offers practical implications for improving supply chain innovation management in the digital era.

Keywords: Digital transformation; Supply chain innovation management; Data silos; Supply chain resilience

Digital transformation has reshaped the way businesses interact with customers and suppliers, while also posing new challenges to traditional supply chain management. However, existing literature mostly focuses on single-point technology applications, lacking systematic integration of challenges such as data silos, organizational inertia, talent shortages, and insufficient resilience. Therefore, this

study identifies these four core issues and proposes a technology-organizational collaborative optimization strategy.

In the current supply chain innovation management of enterprise digital transformation in China, the industry has established several core dimensional indicators, as shown in the table below (Table 1).

During the digital transformation of many enterprises, data cannot flow effectively across different departments and systems, forming so-called "data silos". For instance, the lack of unified data standards and interfaces specifications for procurement, production, and sales systems prevents real-time information sharing throughout the supply chain.

Table 1. Core Indicators of China's Supply Chain Digital Transformation

Indicator	Core Data	Source
Digital transformation progress	By the end of 2025, 89.6% of industrial enterprises have adopted digital transformation; digital equipment penetration rate: 57.7%	CAICT, 2025
Data silos	89% of firms face severe data silos; avg. 8.3 systems per firm, data interoperability <30%	CAICT survey
Digital talent gap	Total gap 25–30 million; hybrid technical-managerial talent are especially scarce	Industry reports (2024–2026)
Supply chain risk perception	66% rank 2025 supply chain as high risk (up from 62% in 2024)	Rapid Ratings, 2026

Traditional corporate organizational structures often exhibit hierarchical characteristics, where innovation decisions require multi-level approvals, resulting in lengthy processes and low efficiency. This is particularly evident in supply chain collaborative innovation, which involves multiple departments and external partners in innovation activities. Such structures create decision-making chains, which may result in missed market opportunities.

Digital transformation and supply chain innovation management have raised the standards for talent competence. Enterprises require not only technical and data analytics professionals, but also versatile talents proficient in both business operations and supply chain governance.

In recent years, supply chain disruptions have significantly increased due to uncertainties such as pandemics, geopolitical tensions, and natural disasters. Many enterprises lack adequate resilience against external shocks, exhibiting issues like single-source suppliers, rigid inventory management, and information opacity, which reveal weaknesses in supply chain resilience.

It is recommended that enterprises establish integrated digital supply chain platforms by consolidating systems such as ERP, SCM, and CRM to achieve seamless data integration across procurement, production, logistics, and sales processes. Through unified data standards and interfaces, enterprises can eliminate

organizational barriers between departments and systems, thereby boosting the efficiency of information sharing.

Enterprises should promote the transformation of their organizational structures toward a flatter and more networked organizational forms, reducing management hierarchies and shortening decision-making chains. Furthermore, firms shall establish cross-departmental innovative collaboration mechanisms, encourage employees to propose innovative ideas, and build rapid response channels. Simultaneously, enterprises need to optimize innovation incentive mechanisms, enhance tolerance for failures, and foster an organizational culture that encourages exploration.

Enterprises should develop systematic programs for cultivating interdisciplinary talents, utilizing various approaches such as internal training, external recruitment, and industry-university collaboration to build a multi-tiered talent pipeline that encompasses technical expertise, business acumen, and management skills.

Enterprises should strengthen supply chain resilience through diversified supplier networks, establishing safety stock mechanisms, and deploying digital real-time risk monitoring solutions.

This study first identifies and analyzes four core challenges in the supply chain innovation management of enterprises amid digital transformation, from the technological, organizational, talent, and risk perspectives. Corresponding optimization strategies are further proposed. This research contributes by constructing a novel four-dimensional analytical framework that includes technology, organization, talent and risk, which enriches the existing literature. Practically, the findings offer actionable guidance for enterprises to eliminate data silos and shorten decision-making chains. In terms of research limitations, this paper lacks first-hand empirical data. Future studies can conduct cross-industry case analyses to further verify and supplement the research conclusions. Overall, this paper establishes a systematic multi-dimensional framework to support the integrated innovation and management of modern digital supply chains.

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Section 5. ARTIFICIAL INTELLIGENCE AND INNOVATIVE TECHNOLOGIES IN INTERNATIONAL BUSINESS

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FOREIGN EXPERIENCE OF SUSTAINABLE DEVELOPMENT OF INDUSTRIAL ENTERPRISES

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Annotation. This article will consider in detail foreign experience in the sustainable development of industrial enterprises. Analyzing the features of the implementation of the principles of sustainability in developed countries in corporate strategies, the author highlights their role in ensuring economic, environmental and social efficiency. The importance of modern approaches such as "Triple Bottom Line", ESG and GRI Standards is revealed, and an overview of practices in Europe, the United States, Japan, South Korea and Scandinavian countries is given. In addition, the activities of large international companies in the mining industry (Rio Tinto, BHP Group, Vale, Anglo American, Glencore) in the direction of Sustainable Development Strategies, the introduction of innovative technologies, increasing environmental safety and social responsibility are analyzed. As a result of the study, it is proved that sustainable development is the main factor in increasing the long-term competitiveness of enterprises. The article substantiates the possibilities of adapting foreign experience in the industrial sector of Kazakhstan.

Key words: Sustainable Development, Industrial Enterprises, ESG, corporate social responsibility, "triple efficiency", green economy, mining, innovation, environmental sustainability, strategic management.

The study of foreign experience in the sustainable development of industrial enterprises is important for the effective formation of long-term growth strategies for domestic companies. In developed countries, sustainability principles have become an integral part of corporate policy and strategic management [1]. Sustainable development allows enterprises not only to improve economic performance but also to strengthen social responsibility, reduce environmental impact, and increase competitiveness.

One of the main approaches to sustainable business development is the concept of the “Triple Bottom Line” proposed by John Elkington. According to this concept, enterprise performance should be evaluated not only through financial indicators but

also through environmental and social contributions. Today, sustainable development is considered a strategic necessity in the European Union, the United States, Japan, South Korea, and other developed economies [1].

In the European Union, sustainable development is regulated at the state level. The European Commission introduced requirements for large companies to disclose non-financial reports according to ESG and GRI standards. Industrial enterprises in Germany, Sweden, and the Netherlands actively implement renewable energy technologies, digital emission control systems, and waste recycling practices. Companies such as Siemens, BASF, and Volkswagen develop environmental programs aimed at reducing carbon emissions and energy consumption [2].

In Japan, sustainable development is based on the philosophy of "Kaizen," which emphasizes continuous improvement. Japanese corporations such as Toyota and Hitachi implement environmental innovations, create energy-efficient production systems, and use closed-loop technologies. Significant attention is also paid to human capital development, corporate culture, and cooperation with local communities [3].

The United States demonstrates a model of close interaction between business, the state, and society. Companies such as General Electric, IBM, and Coca-Cola actively implement corporate social responsibility programs focused on environmental innovation, education, and healthcare. International standards ISO 14001 and ISO 26000 are widely applied to improve environmental management and social responsibility [3].

Scandinavian countries consider sustainable development an important part of national policy. Enterprises in Norway, Denmark, and Sweden actively use circular economy principles, where industrial waste is treated as a reusable resource. Companies such as IKEA, Ericsson, and Nokia demonstrate that environmental responsibility can be successfully combined with profitability and innovation [5].

South Korea also pays considerable attention to sustainable industrial development. The state Green Growth Strategy stimulates investments in environmentally friendly technologies and innovative industries. Large corporations such as Samsung and Hyundai invest in projects aimed at reducing greenhouse gas emissions and improving energy efficiency [5].

The mining industry is one of the sectors where sustainable development principles are especially important because of significant environmental and social risks. Leading international mining companies integrate ESG principles into strategic management and focus on reducing environmental impact, increasing social responsibility, and improving corporate governance [5].

Rio Tinto is one of the most notable examples of sustainable development in mining. The company implements programs focused on reducing carbon dioxide emissions, industrial waste recycling, and land reclamation after mining operations. Rio Tinto also develops automated mining technologies and robotic systems that improve safety and reduce environmental impact [6].

BHP Group has introduced a long-term strategy aimed at achieving carbon neutrality by 2050. The company invests in environmentally friendly technologies for copper, nickel, and iron ore extraction, as well as renewable energy projects. In addition, BHP develops partnership programs with local communities and supports education and healthcare initiatives [7].

Vale S.A., one of the world's largest mining corporations, significantly revised its sustainability strategy after environmental accidents in Brazil. The company introduced dry waste filtration technologies, reduced risks related to water pollution and launched biodiversity protection programs. Vale also aims to achieve full carbon neutrality by 2050 [6].

Anglo American implements the "FutureSmart Mining" strategy, which focuses on intelligent and environmentally responsible mining technologies. The company uses artificial intelligence, automation systems, and water-saving technologies to improve efficiency and reduce environmental impact. Anglo American also pays attention to workforce diversity and local community development [8].

Glencore prioritizes integrated risk management in its sustainability strategy. The company plans to reduce greenhouse gas emissions, increase transparency in supply chains, and improve recycling processes for non-ferrous metals. Glencore cooperates with international organizations in developing common standards for sustainable mining [5].

The experience of Canada is also important in the field of sustainable mining development. Companies such as Teck Resources and Barrick Gold invest in land restoration, energy efficiency, and environmental protection projects. Considerable attention is paid to cooperation with Indigenous communities and the implementation of social support programs [5].

Thus, foreign experience demonstrates that sustainable development has become a key element of modern corporate governance. Leading industrial and mining companies integrate environmental, social, and governance principles into strategic planning and production processes. Sustainable development not only improves environmental and social stability but also increases investment attractiveness and long-term competitiveness [5].

For Kazakhstan, the adaptation of foreign experience may contribute to improving the efficiency of industrial enterprises, strengthening environmental safety, and increasing the competitiveness of the national economy. The implementation of ESG principles, support for innovation, and cooperation between business and the state can become important factors for sustainable industrial growth [5].

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UDC 338.5

APPLICATION OF ARTIFICIAL INTELLIGENCE IN INTERNATIONAL SUPPLY CHAIN

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Abstract. Against the background of global digital transformation, artificial intelligence has become a core technology to promote sustainable development of the digital economy. The optimization and innovation of international supply chain are crucial to the stability of global trade and economic cooperation. This paper focuses on the application scenarios of AI in international supply chain, including intelligent forecasting, risk management, logistics optimization and cross-border customs clearance. It analyzes the practical value of AI in improving efficiency, reducing costs and enhancing anti-risk ability. Combined with the cooperation background of Kazakhstan-China and the Belt and Road Initiative, this paper puts forward the development path of intelligent supply chain, so as to provide reference for the sustainable development of international trade and supply chain system.

Keywords: Artificial Intelligence, International Supply Chain, Digital Economy, Logistics Optimization, Risk Management, Sustainable Development, Smart Logistics, Belt and Road Initiative, Cross-border Trade, Data Governance

Introduction

With the rapid development of the digital economy, artificial intelligence has been widely applied across various economic sectors and has become a key driver of sustainable growth. International supply chains involve complex processes such as production, transportation, customs clearance, storage, and distribution, all of which are characterized by high uncertainty and dynamic changes.

Traditional supply chain models are increasingly unable to meet the demands of globalization and digitalization. In contrast, AI technologies enable data-driven decision-making, intelligent scheduling, and real-time monitoring. These capabilities significantly enhance the efficiency, flexibility, and resilience of international supply chains, thereby supporting high-quality economic development.

Core Application Scenarios of AI in International Supply Chain

Artificial intelligence provides strong technological support for the modernization of international supply chains through big data analytics, machine learning, and intelligent systems.

Firstly, AI-based demand forecasting improves accuracy in predicting market demand, helping companies reduce inventory costs and avoid shortages. Secondly, intelligent logistics systems optimize transportation routes and resource allocation, increasing efficiency and reducing operational expenses.

Thirdly, AI-driven risk management systems enable real-time monitoring of potential disruptions such as policy changes, transportation delays, and supply interruptions. These systems provide early warnings and support proactive decision-making.

Finally, AI-powered Customs clearance technologies facilitate cross-border trade by automating document processing, improving inspection efficiency, and reducing clearance time, thereby enhancing trade facilitation.

Advantages of AI-Driven Supply Chain for Sustainable Economic Development

The integration of AI into international supply chains contributes significantly to sustainable economic development. On the one hand, intelligent optimization reduces energy consumption and minimizes resource waste, supporting green and low-carbon logistics.

On the other hand, improved operational efficiency enhances the competitiveness of enterprises in the global market. In the context of Kazakhstan–China cooperation under the Belt and Road Initiative, AI-driven supply chains can strengthen trade connectivity, promote cross-border investment, and facilitate regional economic integration.

Challenges and Countermeasures

Despite its advantages, the application of AI in international supply chains faces several challenges. These include limited data sharing, lack of unified technical standards, and potential data security risks.

To address these issues, countries should enhance international cooperation in data governance and promote the development of unified standards. Establishing secure and reliable data-sharing mechanisms is essential for building trust among stakeholders.

In addition, strengthening interdisciplinary talent development is critical. Educational institutions should focus on cultivating professionals with expertise in AI, logistics, and international trade to support the digital transformation of supply chains.

Future Development Trends

Looking ahead, the development of AI in international supply chains will be characterized by deeper technological integration and higher levels of automation.

The convergence of AI with technologies such as blockchain and the Internet of Things (IoT) will improve transparency and traceability. Blockchain ensures data security, while IoT enables real-time tracking of goods throughout the supply chain.

Another important trend is the use of digital twins, which allow companies to simulate supply chain operations and optimize strategies in a virtual environment. This enhances resilience against global disruptions.

Moreover, AI will play a key role in sustainability management by optimizing energy use and reducing carbon emissions. This aligns with global environmental goals and strengthens corporate responsibility.

Regional cooperation will also become increasingly important. Kazakhstan and China can jointly develop smart logistics corridors and digital infrastructure, further promoting economic integration.

Conclusion

Artificial intelligence, as an important driver of sustainable economic development, has broad application space and practical value in international supply chain. It can effectively improve the efficiency, stability and sustainability of the supply chain system. Under the framework of Kazakhstan-China cooperation and the Belt and Road Initiative, promoting the deep integration of AI and international supply chain will help to optimize cross-border trade environment, boost digital economic cooperation and inject strong impetus into the sustainable development of regional economy.

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UDC (331)

THE EMPLOYMENT EFFECTS OF AI: TRANSFORMATION AND RESHAPING OF THE LABOR MARKET

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Abstract. The rapid advancement of artificial intelligence (AI) technologies is triggering a systemic reshaping of the global labor market. Guided by the strategic imperatives of "building a modern industrial system" and "solidly promoting common prosperity for all people," this article analyzes the employment effects of AI-driven labor market transformation. The study shows that AI profoundly restructures employment patterns and labor forms through the intertwined effects of "substitution—creation—transformation." Based on these findings, the study constructs a coordinated governance framework comprising four key components—technology, skills, institutions, and governance—and proposes implementation pathways such as adopting technology-oriented approaches that are employment-friendly, establishing a lifelong vocational skills development system, and improving flexible social security mechanisms. These measures aim to steer the development of AI technologies toward positive outcomes, fostering industrial upgrading while achieving high-quality and full employment.

Key words: Artificial Intelligence; Labor Market Transformation; Employment Effects

According to a 2025 research report by the International Labour Organization (ILO), approximately one-quarter of global jobs will be directly impacted by generative AI. Meanwhile, China's shortage of AI talent has already exceeded 5 million, with a talent supply-demand ratio reaching as low as 1:10, reflecting a significant structural imbalance. Against this backdrop, this article systematically elucidates the intrinsic mechanisms driving employment changes under the impetus of artificial intelligence, identifies the multidimensional risks arising from these changes, and proposes precise and forward-looking top-level design measures. It is hoped that these efforts will provide theoretical support for accelerating the achievement of the goals of "ensuring stable employment" and "promoting common prosperity."

The overall impact of artificial intelligence on the job market has shifted from theoretical discussion to a real-world challenge. According to the World Economic Forum's "Future of Jobs Report 2025," by 2030, technological advancements will create 170 million new jobs, while simultaneously displacing as many as 92 million existing jobs. This dual effect has given rise to a complex employment landscape

characterized by both opportunities and risks. As a major manufacturing power and a global leader in the digital economy, China stands at a critical juncture where industrial upgrading and technological advancement intersect. A deep analysis of the employment effects of artificial intelligence is of great significance for achieving high-quality economic development and social stability.

I. The Intrinsic Mechanism of AI-Driven Transformation in the Labor Market

(1) Substitution Effect: The Dissolution of Routine Tasks and Changes in Job Structures

The most direct impact of artificial intelligence on the labor market is evident in its substitution of traditional jobs. Based on task characteristics, occupations can be categorized into four types: routine non-cognitive, non-routine non-cognitive, routine cognitive, and non-routine cognitive. AI technologies - especially large language models - demonstrate strong substitution potential for routine tasks that are clearly defined and highly repetitive, including certain cognitive tasks.

The ILO points out that occupations with strong adaptability to digital transformation will follow markedly different development trajectories from those with weak digital skills; the latter will be hit much harder, highlighting the highly heterogeneous nature of substitution effects. Meanwhile, the “digital divide”—caused by uneven distribution of infrastructure and training resources—further exacerbates the risk of polarization in the labor market. Vulnerabilities to AI-driven substitution effects vary significantly across different industries, regions, and demographic groups, underscoring the need for policy responses that are both precise and targeted.

(2) Creation Effect: The Emergence of New Occupational Clusters and Convergent Job Roles

Alongside the substitution effect, artificial intelligence primarily drives the emergence of numerous new occupations and job roles through its creation effect. While automation technologies replace existing tasks, they also give rise to new tasks that offer comparative labor advantages, thereby spurring transformations in both the content of production and organizational approaches.

(3) Transformation Effect: Restructuring of Labor Forms and Deepening Human-Machine Collaboration

Beyond substitution and creation, AI has also triggered profound transformations in working methods and employment patterns. Smart recruitment platforms have enabled precise matching between talent and job positions; meanwhile, governments, leveraging big data, are dynamically monitoring employment structures, thereby enhancing the targeted effectiveness of policy interventions. The “AI+” initiative has effectively optimized the efficiency of employment resource allocation.

II. Multidimensional Challenges in the Transformation of the Labor Market Driven by Artificial Intelligence

(1) Structural Unemployment and the Mismatch Between Skills Supply and Demand

AI is accelerating structural imbalances in the labor market. On the one hand, low-skilled jobs are rapidly declining; according to data from the National Bureau of Statistics, as China's economic structure undergoes deeper transformation, the focus of employment growth is steadily shifting from the secondary sector to the tertiary sector. On the other hand, the shortage of highly skilled talent continues to widen—within the AI sector, the ratio of supply to demand has reached 1:10, highlighting a severe mismatch between supply and demand. The issue of skill mismatch is particularly pronounced. Technological advancements have exacerbated the misalignment between workers' skills and job requirements. Based on a study of 509 college graduates, Tao（2025）found that employment skills are significantly positively correlated with employment quality, highlighting the fundamental importance of skill enhancement. Even more concerning is that the pace at which AI is reshaping skill demands has outstripped the responsiveness of the education system. Existing educational curricula are slow to update, and vocational training lacks both broad coverage and targeted relevance, leading to a supply-demand mismatch between workers' up-to-date skills and market needs.

(2) Polarization of Income Disparities and Solidification of the Distribution Pattern

AI applications have, to some extent, widened the income gap between different groups. While AI reduces the demand for low-skilled labor, it simultaneously boosts the wages of high-skilled workers, leading to a surge in demand for highly skilled talent and causing the income gap between high- and low-skilled workers to continue expanding. The underlying mechanism behind this phenomenon lies in the differential rewards that AI confers on workers with varying skill levels. In terms of employment, AI is redefining both the quantity and nature of job positions, thereby influencing work patterns and skill requirements. At the level of income distribution, AI's initial impact on industry and occupation is markedly heterogeneous; while enhancing productivity, it is also exerting structural effects on the existing income distribution pattern.

(3) Lack of Labor Protection and Institutional Lag in New Business Models

Emerging industries spurred by AI exhibit relatively obvious shortcomings in terms of labor protection. In areas such as algorithm development, data annotation, and platform operations, the labor rights of some workers—including employment contracts, social insurance, and paid leave—have yet to be fully safeguarded. Algorithm management gives rise to new types of labor risks. Faced with new employment models like platform-based work and digital labor, traditional criteria for identifying labor relationships have become increasingly ambiguous, leaving workers vulnerable to gaps in the protection of their social security and occupational safety rights. Meanwhile, the widespread adoption of algorithmic management has also raised questions about the fairness of work intensity and performance evaluations, while lacking adequate legal regulations to address these issues.

(4) Group Differences and the Escalation of the "Digital Divide"

The impact of AI exhibits significant heterogeneity across different groups and regions. According to ILO data, female workers face substantially higher risks of automation: in high-income countries, 9.6% of female jobs are at high risk of automation, compared to just 3.5% for males—a disparity that is particularly pronounced in white-collar positions. For groups such as migrant workers, the challenges posed by intelligent transformation are even more severe. Based on empirical research using data from the China Family Panel Studies, Yang Ye found that the digital economy significantly hinders migrant workers' access to high-quality employment, with industrial structural upgrading playing an intermediary role in this process [3]. This suggests that, without targeted support, vulnerable groups may fall further behind in the wave of technological advancement.

III. Policy Response: Building a Coordinated Governance System of "Technology — Skills — Institutions — Governance"

(1) Implement technology-oriented approaches that are employment-friendly and stimulate new momentum for job creation.

Policies should guide the deep integration of AI with the real economy and strengthen AI's role in job creation. Priority should be given to supporting R&D in human-machine collaboration and augmented enhancement technologies in sectors such as manufacturing, agriculture, and lifestyle services, thereby fostering new occupations and business models. As a major channel for flexible employment, the platform economy needs to strike a balance between stimulating vitality and safeguarding workers' rights and interests. It is essential to establish an employment monitoring and early-warning platform that covers both regions and industries, integrating data on labor demand, skill requirements, and other relevant information. By developing indicators such as the job-creation coefficient and the skill-mismatch index, we can achieve early identification of structural risks and implement targeted interventions.

Build a lifelong vocational skills development system to bridge the gap between skill supply and demand.

To address the mismatch between skills and job requirements, the fundamental solution lies in deepening educational reform and building a lifelong learning system. Higher education should strengthen the development of interdisciplinary "AI+" courses, promote the deep integration of industry, academia, and research, and cultivate versatile, high-tech talents. Vocational education needs to reinforce teacher development, optimize curriculum design, and offer general education courses such as AI fundamentals, data analysis, and machine learning. Moreover, it should develop specialized application modules tailored to industry needs.

(3) Improve the flexible social security mechanism and solidify the bottom line for people's livelihoods.

To effectively address the various risks arising from economic transformation, we should systematically enhance workers' resilience by fully integrating new-form employment workers into the social security safety net, leveraging technological tools

to improve employment monitoring and assistance, updating labor laws to keep pace with emerging employment models, actively exploring flexible protection mechanisms shared among multiple stakeholders, and developing tailored insurance products.

(4) Enhance digital governance capabilities and guide technology toward positive development.

Government guidance and resource allocation profoundly influence the effectiveness of technology-driven job creation. Based on a textual analysis of municipal government work reports, Zhou (2025) et al. found that for every 1 standard deviation increase in government attention to digital technology, the migrant workers' employment quality index rises by approximately 16.3%, highlighting the pivotal role of policy orientation. A comprehensive system of employment risk assessment indicators should be developed to evaluate the impact of AI on different regions, industries, and occupations, dynamically providing information on labor supply and demand as well as skill changes, thereby enabling early identification and timely warning of employment substitution risks.

IV. Conclusion

The article systematically analyzes the mechanisms, challenges, and policy responses to AI-driven transformations in the labor market, arriving at the following conclusions: First, AI reshapes the employment structure in a systemic manner through the complex interplay of three effects—substitution, creation, and transformation—and exhibits a new characteristic of high substitutability for non-routine cognitive tasks. Second, while AI enhances efficiency, it also gives rise to systemic challenges such as structural unemployment, skill mismatches, income polarization, and inadequate social protection, with particularly severe impacts on vulnerable groups. Third, addressing the impact of AI on employment requires the establishment of a comprehensive governance framework encompassing four key pillars: technology orientation, skills development, social security, and government governance. To harness AI’s potential for empowering employment transitions, coordinated efforts are needed across policy, industry, education, and society. Only by ensuring institutional safeguards, reforming education systems, enhancing skills, and fostering governance innovation can we maximize the benefits of technological advancement, mitigate its negative impacts, and create a new paradigm of high-quality, full employment.

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DIGITAL TRANSFORMATION OF CORPORATE CATERING: B2B AI PLATFORM ASTANA BASED ON COMPUTER VISION AND BIOMETRIC IDENTIFICATION

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Annotation. The current stage of digital economy development dictates the necessity for the profound digital transformation of enterprise ecosystems, including the sector of corporate catering. This article presents the results of the architectural design, development, and experimental validation of the Minimum Viable Product (MVP) of the AsTanu platform — a B2B SaaS solution for corporate cafeteria automation. The proposed system integrates real-time object detection technologies (YOLOv8) for automatic tray scanning and facial biometrics (DeepFace) for contactless payment authorization. A key innovation of the solution is the implementation of an Active Learning mechanism, which ensures continuous background fine-tuning of the machine learning model without direct developer intervention. Experimental data confirmed high object localization precision (mAP@0.5:0.95 reached 0.82), a low False Rejection Rate in biometrics (FRR = 1.2%), and an exceptionally high end-to-end service speed (2.1 seconds per transaction).

Key words: digital economy, artificial intelligence, computer vision, biometric authentication, YOLOv8, Active Learning, corporate catering, process automation.

The accelerated transition to the digital economy, actively supported within the framework of international strategic initiatives such as "One Belt, One Road", requires the profound integration of artificial intelligence technologies into all segments of

enterprise resource planning and management. One of the most promising yet underexplored areas for comprehensive digitalization is the corporate catering and food service sector. According to global predictive estimates, the food service technology (FoodTech) automation market will exceed $13.6 billion by 2026. In the Republic of Kazakhstan, the accessible market volume for food services is estimated at approximately $3.1 billion, with a significant portion concentrated in the corporate sector of major metropolitan areas such as Astana and Almaty [1].

The operational specifics of corporate cafeterias fundamentally differ from public restaurants in the HoReCa segment. The core pain points of corporate clients include the necessity for employers to strictly track food subsidies, the demand for detailed HR analytics regarding employee consumption, strictly limited timeframes for lunch breaks (which dictate the need for maximum throughput at checkout nodes), and the requirement for seamless integration with internal enterprise ERP and HR systems. Traditional automation solutions available in the CIS market (e.g., iiko, r_keeper) lack out-of-the-box computer vision modules for automatic meal recognition and native biometric payment capabilities. Conversely, custom artificial intelligence solutions developed by system integrators are characterized by unjustifiably high implementation costs (often exceeding $2,000) and excessively long deployment cycles.

The objective of this research is to develop, deploy, and experimentally evaluate the viability of the AsTanu platform MVP — a vertically integrated B2B SaaS ecosystem explicitly designed for corporate cafeterias. The platform seamlessly combines a self-service kiosk interface, intelligent tray scanning via machine vision, biometric payment authorization, and an administrative-analytical dashboard into a single unified architecture.

From an architectural standpoint, the AsTanu platform is built upon a modern, highly scalable microservices paradigm. The client-side (Frontend) is implemented using the React 18 framework, strict TypeScript typing, and the Tailwind CSS styling library; deployment is executed on the Vercel cloud infrastructure. The frontend architecture is divided into three isolated interface modules: a touch-screen web application for end-users, a cashier dashboard for real-time order flow monitoring, and an administrator panel for price management and HR analytics review [2].

The server-side (Backend) is developed in Python 3.10+ utilizing the FastAPI framework. The selection of FastAPI is justified by its asynchronous Server Gateway Interface (ASGI) model, which ensures throughput comparable to highly loaded systems based on Node.js or Go. Interaction with the relational database is facilitated through the SQLAlchemy Object-Relational Mapper (ORM). A critical architectural decision was the logical separation of the pricing database from the machine learning inference module. This separation allows cafeteria managers to dynamically update dish prices without the necessity to restart or retrain the neural network model. The backend and machine learning layers are containerized using Docker and deployed on GPU-enabled cloud instances (HuggingFace Spaces).

The core of the dish recognition system, responsible for the automatic identification of objects on a food tray, is powered by the state-of-the-art YOLOv8 (Medium version) object detection architecture developed by Ultralytics. During the second phase of the project's implementation, the training dataset was substantially expanded and currently encompasses over 24 unique classes of dishes (including soups, main courses, side dishes, pastries, salads, and beverages). To enhance the detection accuracy of small and visually similar objects (such as various types of bakery products), the input image resolution was increased from 640 to 1024 pixels. An advanced data augmentation protocol was applied: the simulation of optical motion blur, programmatic exposure adjustment, random cropping, multi-scale training, and the MixUp pixel blending strategy. The final volume of the augmented dataset comprised approximately 8,000 meticulously annotated images using the Computer Vision Annotation Tool (CVAT) [3].

A fundamental challenge in applying computer vision within the food service industry is the dynamic nature of the assortment: menus are regularly updated, seasonal items are introduced, and each cafeteria utilizes a unique set of recipes. Static neural network models degrade rapidly under such conditions. To address this problem, the AsTanu platform incorporates an innovative Active Learning pipeline. During real-time inference, if the YOLOv8 model detects an object with a confidence score below the threshold value of 40%, the system classifies it as an "Unknown Item" and broadcasts the image to the cashier's tablet. The operator (cashier) has the ability to delineate a bounding box and assign a class with a single click. This image, along with its metadata, is automatically saved to a shadow directory within the dataset. Upon reaching a predetermined limit of newly acquired images, the administrator initiates a background fine-tuning process for the model directly via the web interface. Following the completion of the training cycle, the model weights are automatically updated on the server. This approach guarantees the continuous adaptation of the system to a specific menu without requiring the involvement of machine learning engineers.

The biometric identification module ensures highly secure and rapid transaction authorization. It is engineered based on the open-source DeepFace framework and is divided into two sequential computational stages. In the first stage, the RetinaFace algorithm performs high-precision face detection of the user within the video stream from the kiosk's camera. In the second stage, the VGG-Face deep convolutional network generates biometric embeddings (high-dimensional mathematical vectors). To comply with stringent personal data protection legislation, the system physically does not store photographs of the employees. At the moment of initial registration, only an averaged mathematical hash (vector) is generated and securely stored in a protected database table known as the Biometric Ledger. During the payment process, the system calculates the Cosine Similarity between the live vector from the camera and the vectors stored in the database. If the similarity threshold is exceeded, the payment is approved, and the transaction amount is deducted from the employee's personal balance or corporate subsidy account.

To comprehensively evaluate the efficiency of the MVP, large-scale experimental testing was conducted. The training of the YOLOv8m model was executed on a cloud GPU cluster over 150 epochs utilizing the AdamW optimizer. Testing of the model's accuracy metrics demonstrated that the transition to a deeper architecture with an increased resolution of 1024 pixels resulted in a statistically insignificant decrease in the baseline mAP@0.5 metric (from 0.94 in the early prototype to 0.91 in the current version). This minor drop is a mathematical consequence of increasing the number of recognizable target classes. However, the critical metric for strict object localization, mAP@0.5:0.95, significantly improved from 0.78 to 0.82. This indicates a much more precise generation of bounding boxes around the dishes. The inference time on the GPU increased to 28 milliseconds, which, nevertheless, comfortably falls within the strict operational constraints of real-time processing systems [4].

The evaluation of the biometric pipeline was conducted on a representative sample of 60 volunteers and included over 300 authorization attempts under diverse environmental conditions. Under standard operational conditions (uniform artificial lighting, direct gaze), the False Rejection Rate (FRR) was merely 1.2%, while the False Acceptance Rate (FAR) was statistically indistinguishable from zero. During stress testing (lateral light from a window, head rotation up to 15 degrees), the FRR expectedly increased to 3.8%, which remains a highly acceptable benchmark for closed corporate ecosystems. The presence of facial makeup or optical glasses exerted a minimal impact on verification accuracy. The primary technical limitation identified remains the wearing of medical masks, which obscure critical facial landmark points and consequently elevate the FRR to 38%.

Comprehensive end-to-end testing of the integrated AsTanu platform was conducted in a real-world cafeteria environment. In a standard user scenario, involving a tray loaded with 3 to 5 dishes and a registered user with a positive account balance, the average complete service cycle time (from the moment the tray was placed under the camera to the display of the "Payment Successful" screen) was precisely measured at 2.1 seconds. Such an unprecedented transaction speed empowers a single automated checkout terminal to serve between 1,000 and 1,200 clients per hour. In highly complex scenarios involving densely packed dishes and partial occlusions of objects by one another, the YOLOv8 model successfully localized and classified 100% of the items in 89% of the observed cases [5].

In conclusion, within the framework of the conducted research, the academic concept was successfully transformed into a fully functional, publicly deployed MVP of a commercial product. The developed B2B AI platform, AsTanu, effectively resolves the critical operational bottlenecks of corporate catering: it eliminates queues by achieving a record service speed of 2.1 seconds per person, fully automates the accounting of employer food subsidies, and guarantees the long-term relevance of ML models through the Active Learning pipeline. The results of the experimental validation confirm the absolute readiness of the system for commercial pilot implementation, which is officially scheduled for June-July 2026 in the university

campus cafeterias of Astana. Future research vectors will focus on the development of periocular recognition algorithms (analyzing the region around the eyes) to mitigate the adverse effects of medical masks on biometric accuracy, as well as the optimization of tensor computations for deploying neural networks on edge computing devices (such as Jetson Nano microcomputers), which will completely eliminate the dependency of the terminals on external cloud GPU infrastructure.

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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON THE TRANSFORMATION OF INTERNATIONAL BUSINESS MODELS: A COMPARATIVE ANALYSIS OF THE EXPERIENCE OF CHINA AND KAZAKHSTAN

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Annotation. In the context of accelerating digitalization of the global economy, artificial intelligence (AI) has become a core driving force reshaping the operational logic, value creation and profit mechanisms of international business models. Artificial intelligence and innovative technologies in international business, this paper conducts a comparative analysis of China and Kazakhstan to examine how AI applications drive the transformation of cross-border operation, service supply, value chain governance and market expansion. The study shows that China relies on massive data, a complete industrial chain and platform-based ecosystem to realize platform-led, data-driven and full-scenario intelligent transformation of international business models. Relying on its geographical advantages, resource endowments and digital cooperation opportunities,

Kazakhstan promotes AI-driven transformation focusing on cross-border logistics, intelligent trade, energy digital services and regional connectivity [1, 2]. The two countries differ in development paths, application scenarios and policy support systems, but share common ground in improving operational efficiency, reducing transaction costs and enhancing cross-border competitiveness. This paper summarizes the experience and implications of AI-enabled international business model transformation under the Belt and Road Initiative, providing practical references for digital economic cooperation between China and Kazakhstan.

Key words: artificial intelligence; innovative technologies; international business models; business transformation; China; Kazakhstan; Belt and Road Initiative.

1.Introduction

Digital transformation and technological innovation have profoundly restructured the global systems of production, trade and investment. As a major innovative technology, artificial intelligence is widely used in cross-border trade, logistics, customer service, risk control and decision-making optimization, fundamentally changing the value creation methods and competitive rules of international business. Artificial intelligence and innovative technologies in international business—highlights the key role of AI in upgrading the global operation models of enterprises.

As important partners under the Belt and Road Initiative, China and Kazakhstan have distinctive resource endowments, industrial structures and digital development levels. China has formed a globally competitive AI industry system with large-scale application scenarios. Kazakhstan, as a hub in Central Asia, is accelerating digital transformation and cross-border business upgrading [3]. Comparing the experiences of the two countries helps reveal the differentiated paths of AI-driven international business model transformation and provides references for emerging economies.

This paper focuses on three core issues:

1.What mechanisms does artificial intelligence use to drive the transformation of international business models?

2.What are the similarities and differences between China and Kazakhstan in AI-driven international business transformation?

3.What experience and implications can be provided for deepening China–Kazakhstan digital economic cooperation?

2.Theoretical Basis and Analytical Framework

2.1 Artificial Intelligence and Innovative Technologies in International Business

AI technologies such as big data analytics, natural language processing, machine learning and computer vision support intelligent decision-making, precision marketing, intelligent logistics and automated risk management, forming the core infrastructure of modern international business.

2.2 International Business Model Transformation

International business model transformation refers to fundamental changes in value proposition, value creation, value delivery and profit acquisition in cross-border operations driven by technological progress, market changes and institutional adjustments.

2.3 Analytical Framework

This paper establishes a comparative analytical framework: AI technology application → business process reengineering → value creation mechanism upgrading → international business model transformation → comparative characteristics of China and Kazakhstan → experience and implications.

3.Mechanisms of AI-Driven Transformation of International Business Models

3.1 Intelligent Decision-Making and Market Insight

AI analyzes cross-border market data, consumer preferences and policy changes to support precise market positioning, product adaptation and channel optimization, reducing decision-making risks and information asymmetry.

3.2 Intelligent Operation and Cost Reduction

AI realizes the automation of cross-border document review, customs declaration, logistics scheduling and customer services, greatly improving efficiency and lowering transaction and management costs.

3.3Value Chain Reconstruction and Competitive Advantage

AI promotes the shift from traditional factor-driven models to technology-driven and data-driven models, helping enterprises build differentiated competitive advantages in cross-border operations.

3.4Cross-border Collaboration and Ecosystem Expansion

AI supports multi-agent, cross-cultural and cross-regional collaborative operations and accelerates the formation of an open and interconnected international business ecosystem [4].

4.Comparative Analysis of China and Kazakhstan

4.1 China: Platform-led, Large-scenario and Full-industry-chain Intelligent Transformation

China relies on a large user base, complete industrial chains and mature digital platforms such as e-commerce, cloud services and logistics systems. Typical applications include cross-border intelligent e-commerce, AI-driven supply chain finance, intelligent logistics networks and digital marketing systems. It is characterized by platform dominance, data intensiveness, complete scenarios and strong global expansion capability.

4.2 Kazakhstan: Regional Hub-oriented, Resource-supporting and Connectivity-focused Intelligent Upgrading

Kazakhstan relies on its status as a regional hub, advantages in energy and agriculture, and cross-border transport corridors. Typical applications include intelligent cross-border logistics, automated customs clearance, energy digital services, intelligent transportation and fintech. It is characterized by regional orientation, practical scenarios, policy support and close cooperation with China [5, 6].

4.3 Comparative Summary

Similarities: Both use AI to improve efficiency, reduce costs and enhance competitiveness; both support the construction of the Belt and Road Initiative.Differences: China focuses on a large-scale platform ecology and global layout; Kazakhstan focuses on regional hub functions and characteristic industries.

5.Implications for China–Kazakhstan Digital Economic Cooperation

Jointly build AI-enabled cross-border trade infrastructure such as intelligent customs clearance and digital logistics.

Promote cooperation in characteristic scenarios: energy intelligence, agricultural digitalization, cross-border e-commerce and financial technology.

Strengthen policy coordination, data governance and talent training to support sustainable transformation.

Expand third-party market cooperation and build a regional intelligent business ecosystem.

6.Conclusion

As a core innovative technology, artificial intelligence profoundly drives the transformation of international business models by optimizing decision-making, improving efficiency, reconstructing value chains and expanding ecosystems. China and Kazakhstan show distinct transformation paths: China adopts a platform-led, large-scenario and global-oriented model, while Kazakhstan pursues a regional hub-based, resource-matched and connectivity-focused model. Both models effectively improve cross-border operational efficiency and competitiveness [7, 8].

Under the Belt and Road Initiative, deepening AI cooperation will help the two countries accelerate business model innovation, upgrade regional value chains and promote high-quality and sustainable development of bilateral economic and trade relations.

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ETHICAL RISKS AND REGULATION OF AI-INDUSTRIAL INNOVATION

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Annotation. The rapid industrial adoption of artificial intelligence (AI) has driven the intelligent upgrading of modern industrial systems while triggering prominent structural governance dilemmas across high-end manufacturing sectors. Governments and industrial enterprises have continuously scaled up investment in frontier AI technologies, deploying intelligent systems in manufacturing, logistics, medical diagnosis, and urban governance. As the foundational hardware carrier of the digital economy, the semiconductor industry deeply integrates AI into core links including chip architecture design and wafer manufacturing. Nevertheless, large-scale algorithm deployment has exposed inherent technical defects and multi-dimensional governance hazards. This paper systematically summarizes practical ethical governance dilemmas caused by industrial AI implementation, clarifies the evolutionary logic of universal ethical risks, and identifies workshop-specific risks unique to semiconductor manufacturing. It constructs a hierarchical closed-loop compliance supervision framework aiming to standardize responsible AI innovation.

Key words: AI-industrial innovation, semiconductor manufacturing, ethical risk, intelligent regulation.

The Evolution of Ethical Risks in Industrial AI

The rapid industrial adoption of artificial intelligence (AI) has driven the intelligent upgrading of modern industrial systems while triggering prominent structural governance dilemmas across high-end manufacturing sectors. As the foundational hardware carrier of the digital economy, the semiconductor industry deeply integrates AI into core links including chip architecture design, wafer

manufacturing, and integrated packaging testing [1, 5]. Such integration effectively cuts chain-wide production costs and improves intelligent operational efficiency. Nevertheless, large-scale algorithm deployment and high-performance computing chip application have exposed inherent technical defects, poor scenario adaptability, and multi-dimensional governance hazards in high-precision industrial environments. Typical challenges include low algorithmic interpretability, structural algorithmic bias, uncontrolled cross-border transmission of sensitive industrial data, incomplete full-lifecycle accountability mechanisms, and excessive concentration of high-end computing resources [3].

Focusing on high-end computing infrastructure in the semiconductor sector, practical ethical governance dilemmas are caused by large-scale industrial AI implementation. Ordinary ethical risks evolve into compound high-level hazards with higher governance urgency than consumer AI scenarios. First, computing resource allocation imbalance in the R&D phase: historical dataset biases and efficiency-oriented scheduling ignore safety and fairness, squeezing the survival space of small and medium-sized supporting enterprises [2, 4]. Second, irreversible safety threats in mass production: AI inspection and automatic control directly determine production stability, process confidentiality, and personnel safety. Minor algorithm anomalies may trigger batch chip scrapping, equipment overload failure, and core technology leakage. Third, enterprise institutional vacancies: most manufacturers prioritize capacity expansion while ignoring standardized AI auditing, classified data archiving, and third-party evaluation systems. Simple moral advocacy cannot meet the rigorous compliance demands of high-end chip manufacturing. Regulators must build a unified governance system covering quantitative early warning indicators and joint government-enterprise accountability [5, 6].

Table 1. Main ethical risks and economic implications in AI industry innovation

Risk type	Typical manifestation	Expected economic effect	Monitoring priority
Bias and discrimination	Unequal outcomes in scoring or selection	Rework costs, litigation, trust losses	Very high
Opacity	Low explainability of automated decisions	Adoption delays, compliance costs	High
Privacy breach	Uncontrolled use or leakage of personal data	Fines, remediation, customer churn	Very high
Weak oversight	No review or escalation for high-risk outputs	Operational incidents, reputation damage	High

Economic Externalities and Monitoring Instruments

The superposition of general ethical vulnerabilities and semiconductor industrial risks generates obvious negative economic externalities. Algorithmic opacity and bias raise operational costs, compress profit margins, and damage corporate credibility [1, 3]. Data security loopholes weaken investor confidence and cross-border collaboration reliability. Actively investing in AI ethical compliance mechanisms, such as special audit committees and real-time traceability platforms, only slightly increases short-term costs but effectively avoids catastrophic losses including system paralysis and severe regulatory punishment [2, 5]. Proactive ethical governance is highly compatible with existing quality control systems and significantly improves industrial safety resilience.

Multi-type regulatory tools can fully match the whole AI innovation lifecycle. Optimized for semiconductor workshops, these instruments form a coordinated differentiated governance matrix. Source-side data audits prevent leakage and resource imbalance; process-side full-log archiving ensures traceable compliance; production-side targeted assessments secure safety boundaries; daily operation-side joint mechanisms realize dynamic risk elimination [4]. Isolated supervision measures cannot address compound industrial risks; only systematic hierarchical governance can simultaneously resolve universal AI ethical vulnerabilities and semiconductor-specific safety threats, ensuring stable and sustainable technological innovation.

Table 2. Monitoring instruments across the AI innovation cycle

Instrument	Main phase	Primary function	Expected effect
Dataset audit	Development	Detect bias and quality flaws	Lower redesign risk
Model card and logs	Testing	Record assumptions and outputs	Better traceability
Impact assessment	Deployment	Evaluate high-impact use cases	Safer launch decisions
Complaint registry	Post-launch	Capture incidents and harms	Faster correction cycle

Cross-industry Governance Shortages and Policy Optimization

Cross-industry comparison confirms that semiconductor intelligent manufacturing faces the most severe governance shortages among all AI industrial scenarios. Different from scattered, low-risk public service AI applications, chip manufacturing relies on enclosed production lines and highly confidential core processes, featuring rapid risk diffusion and irreversible economic losses [1, 5]. Core supervision priorities include standardized computing compliance architecture, full-lifecycle confidential data control, and mandatory human on-site oversight. Regulators should abandon rigid command-and-control supervision and regard AI ethical governance as essential digital infrastructure for high-end industrial upgrading, rather than innovation barriers. By implementing unified compliance filing, professional chip certification, and regulatory

sandboxes, authorities can set clear benchmarks for leading firms while reserving trial-and-error space for emerging startups [6].

Table 3. Synthetic effects of monitoring intensity on AI innovation outcomes

Scenario	Monitoring cost	Incident rate	Investor confidence	Innovation outcome
Low	1.2% of R&D	High	Low	Fast launch, weak long-run legitimacy
Moderate	2.4% of R&D	Medium	High	Balanced diffusion and stable scaling
Strong	3.6% of R&D	Low	Medium-high	Safer growth, slower early rollout

Ethical compliance governance delivers positive capital market signal effects and industrial chain credit enhancement. Semiconductor enterprises with complete computing compliance architectures are more likely to obtain capital support, undertake national projects, and enter government procurement lists [5]. Compliance governance relieves negative externalities of disordered AI application and expands high-end compliant market access, consolidating industrial reputation and enhancing bargaining power.

Conclusion

The reasonable layout, accurate adaptation, and deep scenario coupling of compliance measures realize full-process predictable risk management for AI innovation. A high-quality AI innovation ecosystem relies on coordinated ethical review, hardware performance verification, and flexible supervision rather than relaxed regulation. Under the dual trend of AI industrial expansion and semiconductor independent R&D, full-cycle compliance governance capability determines digital economy competitiveness and social governance credibility, steadily supporting the coordinated high-quality development of AI and semiconductor real economy in China.

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AI-DRIVEN INNOVATION AND SUSTAINABLE ECONOMIC COMPETITIVENESS: A CASE STUDY OF GUANGDONG-HONG KONG-MACAO GREATER BAY AREA

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Annotation. This paper explores the core mechanism of artificial intelligence (AI) driving regional sustainable economic competitiveness, with the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) as the core research case. Based on the theoretical framework of digital economy and sustainable development, this paper verifies the positive effect of AI-driven innovation on improving total factor productivity (TFP), promoting green low-carbon transformation and enhancing cross-border economic competitiveness, using the latest industrial data from 2024 to 2026 and typical enterprise cases in the GBA. Combined with the theme of China-Kazakhstan digital economy cooperation under the Belt and Road Initiative (BRI), this paper finally puts forward targeted enlightenment for bilateral cooperation, providing practical reference for the sustainable economic development of both countries.

Keywords: Artificial Intelligence; Sustainable Economic Development; China-Kazakhstan Cooperation; Belt and Road Initiative; Guangdong-Hong Kong-Macao Greater Bay Area; Digital Economy

1. Introduction

Under the background of slowing global economic growth and increasingly prominent climate and environmental challenges, sustainable economic development has become a global consensus. As the core driving force of the fourth industrial revolution, AI has broken the growth bottleneck of traditional production factors, and become a key engine for countries and regions to enhance sustainable economic competitiveness.

The BRI has built a core platform for China-Kazakhstan economic and trade cooperation and digital interconnection. As the most dynamic economic growth pole

and digital economy highland in China, the GBA has formed a mature practice system of AI-driven sustainable economic development. Its experience in AI technology innovation, industrial intelligent transformation and cross-border digital cooperation has important reference value for deepening China-Kazakhstan digital economy cooperation under the BRI framework [1].

2. Theoretical Mechanism of AI Driving Sustainable Economic Competitiveness

AI enhances regional sustainable economic competitiveness through three core paths, forming a closed-loop system of innovation, growth and sustainability:

(1). Innovation empowerment: AI accelerates the whole process of technology R&D, achievement transformation and iterative upgrading, improves regional TFP, and builds a sustainable core driving force for economic growth.

(2). Green transformation: AI enables the intelligent optimization of production, energy and resource allocation in the whole industrial chain, reduces energy consumption and carbon emission while improving economic efficiency, and realizes the coordinated development of economic growth and ecological protection.

(3). Cross-border value enhancement: AI breaks the barriers of cross-border factor flow, improves the efficiency of international trade and industrial chain cooperation, and enhances the regional position in the global value chain, which is an important support for sustainable international competitiveness [2].

3. Empirical Evidence and Case Studies from the GBA

3.1 Core Data of AI-Driven Sustainable Development in the GBA

The GBA has formed a complete AI industrial ecosystem, with significant economic and environmental benefits from AI-driven innovation, and the latest core data are as follows:

Industrial scale and economic contribution: In 2025, the core industry scale of AI in the GBA reached 326 billion yuan, accounting for 31.2% of China's total AI core industry scale, with a year-on-year growth of 18.7%. The digital economy represented by AI contributed 62.8% to the GBA's GDP growth in 2025, directly driving 1.2 percentage points of GDP growth.

Innovation output: In 2025, the number of AI-related PCT international patent applications in the GBA exceeded 9200, accounting for 12.3% of the global total AI patent applications, of which patents related to green AI and intelligent manufacturing accounted for more than 40%, ranking among the top bay areas in the world.

Sustainable development performance: Driven by AI-enabled industrial transformation, the energy consumption per unit of GDP in the GBA decreased by 4.2% year-on-year in 2025, and the proportion of days with good air quality in core cities reached 91.4%, realizing the coordinated development of economic growth and green low-carbon transformation.

3.2 Typical Cases of AI-Driven Sustainable Competitiveness

(1). AI-enabled intelligent manufacturing and green transformation: BYD Case

BYD, headquartered in Shenzhen GBA, has fully deployed AI industrial large models in its production bases. Through AI optimization of production scheduling,

supply chain management and energy consumption control, the production efficiency of its Shenzhen base increased by 22% in 2025, the energy consumption per unit product decreased by 18.3%, and the carbon emission in the production link decreased by 16.5% year-on-year. Meanwhile, its annual new energy vehicle production capacity exceeded 3.8 million units, ranking first in the global market, realizing the win-win of economic benefits and green sustainable development.

(2). Cross-border collaborative AI innovation: Huawei & Guangdong-Hong Kong-Macao Joint Laboratory Case [3].

Huawei, based in the GBA, has built the Pangu AI large model system, which has been widely used in industrial, energy and transportation fields. In 2025, Huawei, together with the Chinese University of Hong Kong and the University of Macau, established the GBA AI Innovation Joint Laboratory, which has incubated more than 120 AI innovation projects. Among them, the AI solutions for green energy and cross-border digital services have been promoted to BRI countries, including the energy digitalization project in Kazakhstan, realizing the cross-border spillover of AI innovation achievements.

(3). AI-enabled smart city and sustainable governance: Shenzhen Urban Brain Case

Shenzhen has built a city-level AI urban brain system, realizing intelligent management of urban transportation, water supply, energy and ecological environment. In 2025, the traffic congestion index of Shenzhen's central urban area decreased by 15%, the water supply leakage rate dropped to 6.8% (leading global level), and the real-time early warning and accurate treatment of environmental pollution were realized. This case verifies that AI can effectively improve the efficiency of urban governance and support the sustainable development of regional economy and society [4]

4. Enlightenment for China-Kazakhstan BRI Cooperation

Combined with the GBA's practical experience and the core theme of this conference, the enlightenment for deepening China-Kazakhstan AI and digital economy cooperation under the BRI framework are as follows:

(1). Build a China-Kazakhstan AI collaborative innovation platform. Learn from the GBA's industry-university-research collaborative model, promote the joint construction of AI innovation laboratories between universities and scientific research institutions in Kazakhstan and the GBA, focus on technology R&D in key areas of bilateral cooperation such as energy digitalization, intelligent agriculture and cross-border trade, and accelerate the transformation of AI innovation achievements [5].

(2). Promote AI-enabled transformation of Kazakhstan's real economy. Draw on the GBA's experience in AI-driven green transformation of manufacturing and energy industries, introduce mature AI technologies and solutions from the GBA for Kazakhstan's core industries such as energy, agriculture and mining, improve industrial TFP, reduce energy consumption and carbon emissions, and enhance the sustainable competitiveness of Kazakhstan's core industries.

(3). Deepen China-Kazakhstan cross-border digital trade cooperation based on AI. Relying on the GBA's advantages in cross-border e-commerce and digital services, combined with Kazakhstan's geographical advantages as a Eurasian hub, build an AI-driven cross-border trade service platform between China and Kazakhstan, improve the efficiency of customs clearance, logistics and settlement of bilateral trade, and promote digital interconnection under the BRI framework [6].

5. Conclusion

AI has become the core driving force of global sustainable economic development. The practice of the GBA fully verifies that AI-driven innovation can effectively improve regional total factor productivity, promote green low-carbon transformation, and enhance cross-border economic competitiveness, forming a replicable and scalable experience system for sustainable economic development.

Under the BRI framework, China and Kazakhstan have broad cooperation space in AI and digital economy. Drawing on the practical experience of the GBA, deepening bilateral AI innovation cooperation, industrial intelligent transformation and cross-border digital interconnection, will effectively enhance the sustainable economic competitiveness of both countries, and promote high-quality development of BRI cooperation between China and Kazakhstan.

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STRATEGIC ANALYSIS OF INTERNATIONAL TRADE DYNAMICS BETWEEN KAZAKHSTAN AND CHINA: CHALLENGES, OPPORTUNITIES, AND FUTURE VECTORS UNDER THE BELT AND ROAD INITIATIVE

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Abstract. The article analyzes the dynamics of trade between Kazakhstan and China within the framework of the Belt and Road Initiative (BRI), focusing on the integration with the Nurly Zhol program and the development of logistics potential. The study identifies opportunities for export diversification, as well as risks related to commodity dependence, trade barriers, and the geopolitical balance.

Keywords: Kazakhstan, China, Belt and Road Initiative (BRI), foreign trade, trade turnover, economic cooperation, logistics infrastructure, Middle Corridor, export diversification, investment, economic risks, structural asymmetry, Nurly Zhol, strategic partnership.

Introduction

The economic synergy between the Republic of Kazakhstan and the People's Republic of China has reached a historical zenith within the framework of the "One Belt, One Road" (OBOR) initiative and Kazakhstan's "Nurly Zhol" (Bright Path) economic policy [2]. As a crucial transit hub and strategic partner in Eurasia, Kazakhstan's bilateral relationship with China is undergoing a critical transition. This report critically examines the current state of international trade and business between the two nations. By utilizing macro-statistical trends regarding trade volumes and foreign direct investment (FDI), alongside micro-level empirical evidence from border hubs, this paper aims to identify the structural barriers that hinder growth and the emerging sectors that offer sustainable development opportunities.

Test

1. Current Challenges in International Business and Trade

Despite high-level political trust and the continuous expansion of cooperation, several severe operational and structural bottlenecks persist in the bilateral economic environment:

- Structural Trade Imbalance and Low IIT: Bilateral trade remains highly asymmetrical. Empirical analysis demonstrates that the Intra-Industry Trade (IIT) index between China and Central Asian states, including Kazakhstan, is persistently

low, typically remaining below 0.2 [3]. Kazakhstan primarily exports raw materials—such as oil, natural gas, and metallic ores—while importing Chinese industrial manufactured goods, electronics, and textiles [2]. This classic inter-industry trade model limits the value-added potential of Kazakhstan's export basket.

- Macroeconomic Volatility and FDI Over-concentration: The trade volume is highly susceptible to external shocks. For instance, due to currency depreciation and dropping oil prices, bilateral trade turnover sharply declined from $17.16 billion in 2014 to $7.9 billion in 2016 before recovering [2]. Furthermore, Chinese FDI is heavily concentrated in specific sectors. As of recent metrics, transport and warehousing accounted for 32.9% of investments, while mining and quarrying accounted for 17.3% [2], leaving high-tech and agricultural sectors underfunded.

- Institutional Frictions at Border Hubs: Micro-level empirical studies at key logistical hubs reveal significant operational inefficiencies. The Khorgos International Center of Boundary Cooperation (ICBC), a flagship OBOR project, faces practical hurdles. Survey respondents and field data point to lengthy customs clearance times, arbitrary personal cargo limits (such as the 50 kg per person per month restriction), and high tariffs that inadvertently foster informal "black market" parallel imports and reduce overall transit efficiency [1].

- Social Perception and the "Threat Theory": The success of economic cooperation is partially hindered by complex public perceptions. Independent socio-economic surveys indicate that public attitude in Kazakhstan is deeply fragmented. Only about 30% of Kazakhstani respondents strongly agree that Chinese investments are actively helping the local economy, while over half (53%) maintain a neutral or skeptical stance, citing concerns over corruption, neo-colonialism, and geopolitical risks [1].

2. Emerging Opportunities for Economic Growth

To overcome the limitations of a resource-heavy trade relationship, both nations are actively diversifying their cooperation model, moving towards a "blue ocean" of structural integration:

- Capacity and Investment Cooperation: The synergy between the OBOR initiative and the "Nurly Zhol" policy has catalyzed a strategic shift from mere resource extraction to local manufacturing and processing. A landmark achievement in this regard is the initiation of 55 joint capacity and investment projects valued at over $27.6 billion [2]. These projects, which span petrochemicals, metallurgy, machine building, and modern agriculture, are projected to create approximately 20,000 local jobs, significantly aiding Kazakhstan's industrialization and shifting FDI away from purely extractive industries.

- Financial and Digital Integration: Substantial progress has been made in financial cooperation to support trade logistics. The establishment of direct currency trading between the Chinese Yuan (RMB) and the Kazakh Tenge (KZT), alongside local currency settlement agreements, effectively mitigates exchange rate risks for cross-border e-commerce and small-to-medium enterprises (SMEs) [3]. Furthermore,

multilateral financial institutions like the Asian Infrastructure Investment Bank (AIIB) and the Silk Road Fund provide robust financial guarantees for massive infrastructural upgrades.

- Energy Security and Diversification: While transitioning away from a purely energy-based relationship, energy remains a stabilizing pillar. The stable operation of the Atasu-Alashankou and Kenkiyak-Kumkol pipelines ensures reliable revenue streams for Kazakhstan while satisfying China's demand for diversified energy imports, forming a mutually beneficial foundation of economic security [2, 3].

3. Directions for Future Development

To ensure the resilience, high-quality development, and societal acceptance of the trade partnership, the following strategic directions are proposed:

- Optimization of the Trade Structure: Both nations must formulate policies to move beyond simple inter-industry trade. China's foreign direct investment should be systematically guided toward Kazakhstan's high-tech manufacturing, green energy (such as solar and wind components), and agro-industrial complex [3]. This will elevate the IIT index and integrate Kazakhstan into higher nodes of the global value chain.

- Institutional Transparency and Customs Harmonization: Addressing the bottlenecks at Khorgos and other dry ports requires a unified, digitalized customs clearance system. Eradicating bureaucratic rent-seeking, streamlining tariff procedures, and revising outdated individual cargo limits will drastically reduce non-tariff barriers, lowering the time and cost of international business [1].

- Enhancing "Soft" Connectivity: To counteract cognitive biases, the "threat theory," and public skepticism, bilateral cooperation must prioritize "soft" infrastructure. Chinese enterprises operating in Kazakhstan must enhance their corporate social responsibility (CSR) and transparency [1]. Strengthening cross-cultural academic exchanges and localized vocational training will foster a more favorable investment climate.

Conclusion

The economic partnership between Kazakhstan and China serves as the anchor for the Belt and Road Initiative in the Eurasian continent. While the historical reliance on energy trade laid a strong, pragmatic foundation, the future success of this partnership depends entirely on resolving micro-level institutional frictions and upgrading the macro-level trade structure. By ensuring transparent border operations, accelerating the 55 capacity-building joint projects, and deepening financial integration through local currency settlements, both nations can mitigate external geopolitical risks. The focus must transition decisively from the mere "volume of trade" to the "quality of trade," ensuring an economic paradigm that is inclusive, technologically advanced, and broadly supported by the public.

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ARTIFICIAL INTELLIGENCE-DRIVEN SERVICE INDUSTRY INNOVATION: PATHWAYS AND EFFECT EVALUATION

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Annotation. Under the background of the deep integration of the digital economy and the real economy, artificial intelligence has become a key force driving innovation in the service industry. This article starts from the theoretical logic of service industry innovation, systematically examines the technological diffusion and organizational transformation paths driven by artificial intelligence in service industry innovation, and deeply analyzes the impact effect and mechanism of artificial intelligence on service industry innovation. It has been discovered that artificial intelligence significantly promotes innovation in the service industry through various channels, such as lowering the threshold for innovation, enhancing the efficiency of knowledge production, optimizing the structure of human capital, and reshaping the way services create value. This article provides a theoretical explanation for understanding the innovative evolution patterns of the service industry in the era of artificial intelligence, and also offers a reference basis for the high-quality development of the service industry.

Key words: Artificial intelligence, Service industry innovation, Innovation path, Effect evaluation.

1 Introduction

Against the backdrop of the accelerated evolution of the new round of technological revolution and industrial transformation, artificial intelligence has become the core engine for reorganizing the factor allocation in the service industry and reshaping the competitive landscape of the service sector. Promoting the evolution

of modern service industries from digital-enabled internet services to intelligent-driven new service models is an important trend in current industrial development. The service industry, as the largest sector of China's national economy, its level of innovation and development directly affects the high-quality economic growth and the improvement of people's livelihood.

The service industry has the highest penetration rate of artificial intelligence. Artificial intelligence has had a profound impact on the business models, employment structure and innovation methods of this industry. Artificial intelligence, as a general-purpose technology in the field of information and communication technology, is deeply integrating with various industries and profoundly altering the operational logic of the service economy [1]. However, the theoretical explanations regarding how artificial intelligence drives innovation in the service industry remain fragmented, and a more in-depth systematic analysis of its mechanism and heterogeneity effects is still needed. As a universal-purpose technology in the new round of technological revolution, artificial intelligence provides an important opportunity to promote the deep integration of advanced manufacturing and productive service industries. Through its technical-economic paradigm features such as data-driven nature, network externality, and industrial reconfiguration, it not only provides a technical foundation for the integration of the two industries, but also significantly reduces the integration costs and improves the integration efficiency [2]. Based on this, this paper, on the basis of existing research, constructs a theoretical analysis framework for the innovation of service industries driven by artificial intelligence from the dual perspectives of technology diffusion and organizational change. It systematically explains the impact effect and mechanism of artificial intelligence on service industry innovation, and discusses its heterogeneity characteristics.

2 Theoretical Pathways for Artificial Intelligence to Drive Innovation in the Service Industry

The process of innovation in the service industry driven by artificial intelligence is essentially a systematic transformation triggered by the shift from technology to economic paradigms. From the perspective of innovation economics, this process mainly unfolds through two dimensions: the path of technological diffusion and the path of organizational change.

2.1 Path of Technology Diffusion

Artificial intelligence, as a typical general-purpose technology, possesses strong penetration and enabling effects. Through the three pillars of data-driven approach, algorithm iteration, and computing power enhancement, it is fundamentally transforming the mode of knowledge creation, dissemination, and application in the service industry. In the early stage of technology diffusion, artificial intelligence entered the service industry in the form of tool-based integration, mainly manifested as auxiliary applications such as customer service robots and intelligent recommendation systems. With the continuous advancement of technology, the penetration of artificial

intelligence in the service industry has shifted from being an enabling tool to reshaping the element structure and the way value is created.

Artificial intelligence has driven the service industry to shift from the traditional labor- and capital-intensive models to a technology-intensive model where data is the key production factor and algorithms are the core competitiveness. This transformation has provided a brand-new technological foundation for service innovation, making it possible for new service models such as large-scale personalized services, real-time intelligent decision-making, and predictive maintenance. The deep integration of artificial intelligence technological innovation and industrial innovation is driving the global technological competition paradigm to shift from single-point breakthroughs to system-wide collaboration. As a result, service industry innovation has entered a new stage of paradigm reconfiguration [3].

2.2 Path of Organizational Transformation

The application of artificial intelligence not only alters the technological foundation of the service industry, but also triggers profound changes in the internal organizational structure, management methods and business models of service enterprises. Through reorganizing and innovating the execution methods of tasks, artificial intelligence is profoundly reshaping the innovation ecosystem of the service industry. It has also facilitated the transition from experience-driven to algorithm-based decision-making. Traditional service industries have mostly relied on the experience and intuitive judgment of managers for innovation. However, artificial intelligence has made it possible to make precise decisions for services based on real-time data analysis and prediction. Enterprises can utilize machine learning algorithms to identify consumer preferences, predict market trends, and accordingly make rapid adjustments to their service strategies and product designs [4].

3 Evaluation of the Effectiveness of Artificial Intelligence in Driving Service Industry Innovation

3.1 The Overall Impact of Artificial Intelligence on Service Industry Innovation

Artificial intelligence has lowered the technical barriers and costs for innovation in the service industry. Traditional service industry innovation often requires a large amount of upfront investment and a lengthy research and development cycle. However, through tools such as automated data processing, intelligent analysis, and rapid prototype development, artificial intelligence enables small and medium-sized service enterprises to also participate in innovation activities, thereby expanding the participants in innovation and enhancing the overall innovation activity level of the industry. At the same time, it has accelerated the iteration speed of service products. By leveraging machine learning algorithms and user behavior data analysis, service enterprises can obtain real-time consumer feedback, quickly identify product flaws and service weaknesses, and make agile adjustments accordingly. This data-driven iterative model has significantly enhanced the timeliness and specificity of service industry innovation [5].

3.2 The Mechanism of Artificial Intelligence Driving Innovation in the Service Industry

The mechanism by which artificial intelligence drives innovation in the service industry facilitates the channels for technological innovation. Through reducing the cost of trial and error in the research and development process, enhancing the efficiency of knowledge production, and strengthening the spillover effect of technology, artificial intelligence effectively promotes the technological accumulation and breakthroughs in the service industry [6]. Artificial intelligence has replaced some repetitive and procedural jobs, prompting enterprises to shift their human resources to high-skilled and highly creative innovative activities; artificial intelligence has also created new job positions and skill demands, promoting the upgrading of the skill structure of workers, and ultimately resulting in the coordinated optimization of technological capabilities and human capital in enterprises in innovative activities [7].

3.3 Heterogeneous Characteristics of Service Industry Innovation Driven by Artificial Intelligence

The promoting effect of artificial intelligence on the innovation of the service industry is not evenly distributed across all sub-sectors and enterprise groups, but rather exhibits significant heterogeneity.

From the perspective of industry attributes, the innovative driving effects of production-oriented service industries such as information technology services, financial services, and business services are the most prominent. Therefore, they can more fully exert their innovative empowerment effects. From the perspective of the nature of enterprise ownership, state-owned service enterprises have demonstrated strong adaptability and resource integration advantages in the innovation transformation driven by artificial intelligence. Private enterprises, on the other hand, are more prominent in terms of market response speed and flexibility. The innovation models of the two have distinct characteristics, jointly promoting the overall innovation level of the service industry.

4 Conclusion

Artificial intelligence drives service industry innovation through the paths of technological diffusion and organizational transformation, manifested in lowering the threshold for innovation, accelerating product iterations, and expanding the boundaries of innovation. Its mechanism of action is to promote technological innovation and optimize the structure of human capital, and this effect is more significant in the productive service industry and small and medium-sized enterprises. These conclusions provide a theoretical explanation for understanding the evolution of service industry innovation in the era of artificial intelligence.

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THE POTENTIAL FOR THE DEVELOPMENT OF CROSS-BORDER ECONOMIC ZONES BETWEEN KAZAKHSTAN AND CHINA

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Abstract. The rapid development of the "One Belt, One Road" initiative has created favorable conditions for the construction of cross-border economic zones between Kazakhstan and China. As important partner countries in Central Asia and East Asia, the two countries have unique geographical advantages, complementary economic structures, and broad cooperation prospects in cross-border trade, industrial investment, infrastructure construction, and digital economy.

This paper analyzes the current situation, advantages, existing problems and development potential of cross-border economic zones between Kazakhstan and China,

and puts forward targeted countermeasures and suggestions to promote the high-quality development of cross-border economic cooperation under the framework of "One Belt, One Road".

Keywords: Kazakhstan, China, cross-border economic zones, One Belt One Road, economic cooperation, cross-border trade, industrial investment, infrastructure construction, digital economy, Central Asia.

1. Introduction

Against the background of economic globalization and regional economic integration, cross-border economic zones have become an important carrier to promote trade and investment liberalization and facilitation, strengthen industrial chain and supply chain cooperation, and boost regional economic growth. Kazakhstan and China are connected by mountains and rivers, with a long border and close economic and trade ties. Since the "One Belt, One Road" initiative was put forward, the cooperation between the two countries in cross-border economic cooperation has achieved remarkable results. The construction of cross-border economic zones has become a key project to deepen bilateral economic cooperation, enhance regional connectivity, and benefit the two peoples.

2. Current Situation and Advantages of Cross-Border Economic Cooperation between Kazakhstan and China

2.1 Geographical and Transportation Advantages

Kazakhstan is located in the center of the Eurasian continent, serving as an important land transportation hub between Europe and Asia. China is the largest trading partner of Kazakhstan, and the two countries have multiple land ports and transportation corridors. The China-Kazakhstan Horgos International Border Cooperation Center, Khorgos-Eastern Gate dry port and other platforms have been put into use, greatly improving the efficiency of cross-border logistics and transportation.

2.2 Complementary Economic Structure

Kazakhstan is rich in energy, mineral resources and agricultural products, while China has advantages in manufacturing, infrastructure construction, digital technology and capital. The two countries have strong economic complementarity, which provides a solid foundation for the development of cross-border economic zones.

2.3 Policy Support and Institutional Guarantee

Both governments attach great importance to bilateral economic cooperation and have signed a series of cooperation documents to support the construction of cross-border economic zones. The alignment of Kazakhstan's "Bright Road" new economic policy with China's "One Belt, One Road" initiative has created a favorable policy environment for cross-border cooperation.

3. Existing Problems in the Development of Cross-Border Economic Zones

3.1 Infrastructure Connectivity needs to be improved

Although some progress has been made in infrastructure construction, there are still problems such as insufficient logistics capacity, inconsistent customs clearance standards, and inadequate supporting services in some border areas.

3.2 Industrial Cooperation Depth is Insufficient

The cooperation between the two countries in cross-border economic zones is still dominated by traditional trade, and the cooperation in high-tech industries, digital economy, green economy and other fields needs to be strengthened.

3.3 Institutional and Mechanism Barriers

Differences in legal systems, regulatory standards, and financial services between the two countries have brought certain obstacles to the long-term stable development of cross-border economic zones.

4.Development Potential and Countermeasures of Cross-Border Economic Zones

4.1 Expand the Scale of Trade and Investment

Give full play to the advantages of cross-border economic zones, promote the facilitation of trade and investment, expand the import and export of characteristic products, and encourage enterprises of both countries to carry out industrial investment and project cooperation.

4.2 Promote Digital Transformation and Smart Construction

Introduce advanced digital technologies such as artificial intelligence, big data, and cloud computing to build smart cross-border economic zones, improve the level of customs clearance, logistics, and industrial management, and adapt to the development trend of the digital economy.

4.3 Strengthen Policy Coordination and Institutional Innovation

Strengthen the coordination of customs, taxation, finance and other policies between the two countries, promote the alignment of standards and the interoperability of systems, and establish a long-term effective cooperation mechanism.

4.4 Boost Green and Sustainable Development

Focus on the development of green industries, energy conservation and environmental protection industries in cross-border economic zones, promote low-carbon transformation, and achieve sustainable economic and social development.

5. Conclusion

The cross-border economic zones between Kazakhstan and China have huge development potential and broad cooperation space. Under the framework of the "One Belt, One Road" initiative, the two countries should further strengthen strategic coordination, deepen practical cooperation in various fields, solve existing problems, and promote the construction of cross-border economic zones to a higher level and higher quality. This will not only benefit the economic development of both countries, but also play an important role in promoting regional economic integration and prosperity in Eurasia.

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UDC 336.2

ECONOMIC EFFECTS OF ARTIFICIAL INTELLIGENCE ON TRANSPORTATION INFRASTRUCTURE EFFICIENCY: EVIDENCE FROM INTELLIGENT EXPRESSWAY DISPATCHING SYSTEMS

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Annotation. Based on operational data from 2020 to 2023 for an intelligent expressway dispatching system in China, this study examines the economic effects of artificial intelligence applications in transportation infrastructure. Using a quasi-experimental design comparing periods before and after system deployment, the analysis shows that the AI-driven alert warning and intelligent dispatching system reduces average congestion distance by 24.8% and average diversions by 37.8%. Expressway accidents account for less than 5% of total road accidents but contribute approximately 10% of deaths and 30% of property losses, demonstrating the economic potential of AI intervention. The system also generates measurable fuel savings and CO_2 emission reductions. This paper provides empirical evidence on the productivity effects of AI in physical infrastructure systems.

Keywords: Artificial intelligence; transportation infrastructure; resource allocation efficiency; digital economy

1. Introduction

Transportation infrastructure is fundamental to economic development. China's expressway network reached 184,000 km by 2023, with daily traffic exceeding 40 million vehicle trips. Traditional management relying on manual patrols suffers from slow incident discovery, often taking tens of minutes. AI technologies enable 24-hour intelligent video perception and automatic alerting, transforming operations from passive detection to active warning.

Recent advances have integrated machine learning and computer vision into Intelligent Transportation Systems (ITS), improving traffic flow, safety, and sustainability [1, 2]. AI operates through three mechanisms: substituting routine cognitive tasks, complementing human decision-makers, and creating data assets for continuous improvement [3]. However, empirical evidence on expressway operations remains limited. Most studies focus on automated driving or traffic prediction rather than practical dispatching systems.

Expressway accidents constitute only 4–5% of total road accidents but cause approximately 10% of deaths and 30% of property losses. The intelligent system on Liwen Expressway in Jiangxi Province compresses incident discovery to under 10 seconds with over 90% accuracy. Monthly congestion distance decreased 24.8%, diversions fell 37.8%, and emergency response timeliness reached 100%. This study quantifies the economic effects of AI-driven dispatching using multi-dimensional real-world data from 2020 to 2023.

2. Data and Methods

The study adopts a quasi-experimental design comparing pre-deployment (January 2020 to June 2021) and post-deployment (July 2021 to December 2023) periods. The AI system entered formal operation in July 2021.

Data sources include perception and monitoring data from 24-hour video cameras and roadside radar, achieving alert latency under 10 seconds and recognition accuracy exceeding 90%. Incident handling logs cover all phases from emergency response initiation to on-site restoration. Road network operation data include diversion events, congestion distance, and duration. External statistics from public security traffic management (2024) confirm the severity disparity of expressway accidents. Emission factors are drawn from the UK National Atmospheric Emissions Inventory (2023): passenger cars emit 0.09–0.11 kg CO_2/km and heavy goods vehicles 0.46–0.78 kg CO_2/km at expressway speeds, and congestion increases emissions by 25–40% relative to free-flow conditions [4].

Efficiency indicators include average congestion distance (kilometers), year-on-year change in diversions, incident discovery-to-resolution time, and AI alert accuracy. Resource allocation is measured by patrol dispatch frequency and multi-department coordination completeness. Economic and environmental impacts include saved dispatching resources, reduced fuel consumption, and CO_2 equivalents estimated using hybrid AI frameworks [4].

3. Results

On Liwen Expressway, AI video perception compresses average incident discovery from tens of minutes to under 10 seconds, with recognition accuracy exceeding 90%. Deep learning models including DNN and ResNet-50 achieve over 91.8% detection accuracy in traffic accident tasks [5, 6].

Table 1. Key performance indicators before and after AI system deployment on Liwen Expressway

Indicator	Before deployment	After deployment	Change
Average incident discovery time	~30 minutes	<10 seconds	-99.4%
AI recognition accuracy	Not applicable (manual patrol)	>90%	—
Average monthly congestion distance	Baseline (100%)	24.8% reduction	-24.8%
Average number of diversions (year-on-year)	Baseline (100%)	37.8% reduction	-37.8%
Emergency response timeliness for cleaning and rescue	Not systematically tracked	100%	—

A Jing-Shi Expressway case from October 2025 showed total handling time of 12 minutes for an abnormal vehicle stop, significantly shorter than traditional models and comparable to the World Health Organization's 15-minute reference standard for minor accidents. Long-term data for the first ten months of 2025 on Liwen Expressway indicate a 24.8% decrease in average congestion distance, a 37.8% year-on-year decline in average diversions, and 100% timeliness for cleaning and rescue responses.

Expressway accidents account for only 4–5% of total accidents but cause approximately 10% of deaths and 30% of property losses. The Eagle Eye Guardian early warning system, jointly released in 2025 by the China Academy of Safety Science and Technology and the Amap app, achieves over 90% accuracy in predicting sudden speed drops and emergency braking. This provides several seconds of extra reaction time and prevents a substantial proportion of rear-end collisions.

AI shortens traffic restoration time by tens of minutes per incident, reducing per-vehicle fuel consumption during congestion by approximately 40%. Based on CO_2 emission factors and the 25–40% congestion multiplier, the system reduces annual CO_2 emissions by several hundred metric tons on the studied sections, corresponding to roughly ¥100,000 in fuel cost savings. Hybrid AI frameworks have demonstrated over 93% accuracy in quantifying the influence of traffic conditions on emissions [4].

The intelligent hub aggregates trajectory data and incident records, enabling proactive traffic management and precision maintenance models. Such data assets reduce uncertainty costs and are replicable to dynamic capacity expansion and vehicle-

road coordination scenarios. Recent research shows that intelligent infrastructure can reduce the lifecycle cost of vehicle-side perception and computing devices for autonomous driving from ¥126,938 to ¥42,180 [7].

4. Discussion and Conclusion

This study demonstrates that AI-driven intelligent dispatching generates substantial economic effects in expressway operations. AI perception replaces manual patrols, shortening discovery time from tens of minutes to seconds and maximizing the golden rescue window. Deep neural networks provide technical validation for these response time improvements [5].

Dynamic lane management and differentiated navigation reduce unnecessary rerouting. Over multiple years, intelligent sections exhibit smoother occupancy rates, shifting from static facility planning to computational real-time allocation. AI also reduces accident-related congestion and queuing, cutting excess CO_2 emissions by 15–30% per vehicle compared to free-flow conditions. Hybrid AI frameworks offer precise quantification of these emission reductions [4].

Improved travel time predictability reduces inventory buffer costs and late penalties for express delivery and cold chain operators. Machine learning-based delivery time forecasts consistently outperform conventional models [8, 9]. High-quality real-time traffic data become structured digital assets, enabling road–police–enterprise coordination and total factor productivity improvements. Intelligent infrastructure investment yields substantial returns [7].

Several limitations should be noted. The data are derived from a limited set of expressway sections, requiring extended validation across diverse terrains, vehicle compositions, and aging infrastructure. The evaluation window is insufficient to capture long-run marginal costs of AI system upgrades and algorithm iteration.

Future research should conduct large-scale cross-regional empirical comparisons, expand econometric frameworks for AI input-output efficiency in freight logistics and connected vehicles, and address institutional alignment on data governance and smart contracts. The findings support a shift from one-dimensional capacity expansion to smart-technology-enabled capability enhancement. Given diminishing returns to infrastructure investment and land constraints, AI-driven dispatching reduces civil engineering burdens while improving network resilience and turnover efficiency.

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UDC（331）

Artificial Intelligence Drives Sustainable Transformation of Manufacturing: Labor Adaptation Pathways for China-Kazakhstan Digital Economy Cooperation

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Abstract. High-quality development of the Belt and Road Initiative and intelligent-green transformation reshape global manufacturing. Artificial intelligence serves as the core engine of sustainable development. China and Kazakhstan share aligned strategies and complementary industries, which lays a solid foundation for digital economy cooperation. However, skill mismatch, weak mutual recognition of standards, insufficient talent training, inadequate cross-border services and low green capacity restrict in-depth cooperation. This paper explains the necessity of labor adaptation, identifies its core internal requirements, analyzes real challenges and builds a four-dimensional framework including skill upgrading, mutual recognition of standards, service guarantee and green adaptation. It provides theoretical and practical references for coordinated manufacturing transformation and high-quality development of the Digital Silk Road.

Keywords：Artificial intelligence; China-Kazakhstan digital economy cooperation; Labor adaptation.

1 Introduction

The global manufacturing sector undergoes a new round of technological revolution driven by AI, big data, robots and IoT. Intelligence, greenization and integration lead manufacturing development [1]. AI goes beyond simple automation substitution. It deeply integrates into R&D, production, supply chain and energy consumption control. It improves efficiency, optimizes resources and cuts carbon emissions. Major economies take AI-manufacturing integration as core competitiveness and speed up industrial layout[2].

China is a major manufacturing country and pioneer in AI application. It has built over 35,000 basic smart factories and more than 8,200 advanced ones. It forms a complete system covering policy guidance, R&D, corporate practice and talent training. The government issues supportive policies. Local governments launch targeted measures. Enterprises carry out digital transformation. Vocational education and enterprise training jointly cultivate talents. China provides replicable experience for global intelligent manufacturing transformation.

Kazakhstan is a key country along the Belt and Road. It values digital and intelligent development. It establishes the Ministry of Artificial Intelligence and Digital Development. It promotes intelligent upgrading in mineral processing, green energy, geological exploration and logistics. It uses resource advantages to attract international investment and improve industrial added value. China and Kazakhstan are geographically close and economically complementary. China's technology, capital and experience match Kazakhstan's resources and market demand. The two sides form a cooperation pattern of "technology + resources" and "market + capacity".

Labor adaptability directly determines AI application effect, industrial collaboration efficiency and cooperation sustainability [2]. China and Kazakhstan differ greatly in labor market, education system, skill structure, certification system and culture. Traditional workers cannot meet demands of cross-border intelligent production and green manufacturing[4]. Skill gaps, non-recognition of standards, high mobility costs and poor cross-cultural collaboration remain serious. Systematic research on labor adaptation shows strong urgency and strategic significance.

2 Internal Requirements of Labor Adaptation in China-Kazakhstan Digital Economy Cooperation in the AI Era

AI changes post structure, skill demand and collaboration mode in manufacturing[5]. Cross-border labor adaptation is no longer simple employment matching. It becomes systematic coordination of skills, standards, services, green development, and culture. It must meet six core internal requirements [3].

(1) Skill Structure Adaptation. Traditional repetitive posts decline in the AI era. Compound posts increase rapidly. Workers must master digital and technical competence as well as professional post competence. Language, learning and problem-solving abilities serve as basic literacy. Workers form a three-level skill structure: digital skills + professional skills + general abilities.

(2) Standard System Adaptation. Standard alignment provides institutional support for cross-border labor mobility. China and Kazakhstan need to unify or mutually recognize occupational classification, skill requirements, assessment content and certificate validity. Standardized adaptation reduces recruitment costs and improves talent allocation efficiency.

(3) Talent Training Adaptation. Labor adaptation relies on front-end talent training. Education and training systems must match industrial demands. Universities and vocational colleges set majors and update curricula based on post needs. Enterprises deeply participate in training. The two countries carry out joint training and build a cross-border industry-education integration model.

(4) Service Support Adaptation. Cross-border talent mobility involves visas, residence, employment, social security and housing. A convenient and integrated service system must be established. It simplifies procedures, lowers mobility costs and attracts skilled workers. It ensures stable collaboration of cross-border teams.

(5) Green Development Adaptation. Sustainable manufacturing transformation requires workers to hold green concepts and related skills. Workers use AI tools to monitor energy consumption, manage carbon emissions and optimize production. Labor adaptation integrates green goals and promotes dual-driven development of intelligence and greenization.

(6) Cross-Cultural Adaptation. China and Kazakhstan differ in language, culture, work habits and management models. Labor adaptation must include cultural adaptation. The two sides strengthen language and cross-cultural training and align management modes. These efforts improve collaboration efficiency and ensure smooth technology transfer [4].

3 Practical Challenges of Labor Adaptation in China-Kazakhstan Digital Economy Cooperation

3.1 Serious Skill Mismatch and Shortage of Compound Talents

The overall digital skill level of Kazakhstan's labor force is low. Most workers are traditional operators and lack core capabilities in AI and intelligent equipment maintenance. The talent gap in intelligent posts remains large. High-end talents are extremely scarce. Chinese enterprises going global urgently need compound talents who master technology, speak Russian or Kazakh and understand local culture.

3.2 Incompatible Skill Standards and High Institutional Barriers

The two countries hold significantly different occupational skill systems. China has a complete national standard and the "New Eight-Grade Worker" system. Kazakhstan lacks systematic intelligent manufacturing standards. Occupational certificates enjoy low cross-border recognition. The two countries lack a unified certification mechanism. Enterprises cannot accurately evaluate talent competence and face higher costs.

3.3 Backward Training System and Insufficient Industry-Education Integration

Kazakhstan launches AI education late with a weak foundation. AI courses cover a small proportion of basic education. Universities offer few related majors with

outdated curricula. Vocational colleges lack training equipment and qualified teachers. Cross-border joint training programs are small-scale and short-term. Enterprises lack motivation in talent training due to high costs and turnover risks.

3.4 Inadequate Cross-Border Services and High Mobility Costs

Visa and residence approval procedures are complicated. Cross-border permits require long cycles and numerous materials. Living and social security supporting services are insufficient. High-end talents are unwilling to work long-term abroad. No unified cross-border talent information platform exists. Supply-demand matching efficiency remains low.

3.5 Cross-Cultural Barriers and Weak Collaboration Efficiency

Language barriers block effective technology transmission. Technical materials lack accurate translation and cause operation errors. Work habits and management models differ greatly and lead to collaboration frictions. A sound cultural integration mechanism is absent. Teams integrate slowly and lack cohesion.

3.6 Insufficient Green Skills and Weak Support for Sustainable Transformation

Workers lack green and low-carbon awareness and practical skills. A complete green skill training system has not been established. Most training focuses on technical operation and ignores low-carbon management. Green incentive mechanisms are incomplete. Workers lack motivation to shift to green and low-carbon positions.

4 Practical Paths for Labor Adaptation in China-Kazakhstan Digital Economy Cooperation

This paper draws on Chinese experience and builds a four-dimensional labor adaptation path including skill upgrading, mutual recognition of standards, service guarantee and green adaptation.

(1) Skill Upgrading. The two sides jointly build the China-Kazakhstan Intelligent Manufacturing Vocational and Technical College. It adopts a training mode of language + professional skills + intelligent technology + green concept. It launches key majors and implements a school-enterprise dual-tutor system. The two sides promote the three-stage cross-border joint training model. They launch the AI + Skill Transformation Program for traditional workers. Chinese enterprises strengthen training for overseas compound talents.

(2) Mutual Recognition of Standards. The two countries jointly develop skill standards for core intelligent manufacturing posts. They establish the China-Kazakhstan Skill Certification Alliance. The alliance implements one assessment, dual-certificate mutual recognition and nationwide validity. The two countries jointly participate in international standard-setting and enhance their global voice.

(3) Service Support. The two sides build a cross-border talent information service platform. It integrates post demands, resumes, training resources and policies. They establish a convenient entry-exit and residence system and launch one-stop services. They improve supporting services and social security. They set up talent service centers in key cooperation cities. They build a cross-cultural integration mechanism and enhance team cohesion.

(4) Green Adaptation. The two sides build a systematic green skill training system. They integrate energy monitoring, carbon emission management and green production into full-process training. They promote Chinese green intelligent manufacturing cases and guide Kazakh enterprises to improve energy efficiency. They set up a special fund for green intelligent manufacturing talents and support sustainable transformation of manufacturing [5].

5 Conclusion

AI-driven sustainable manufacturing transformation is the core direction of China-Kazakhstan digital economy cooperation. Labor adaptation provides key support for technology landing, industrial collaboration, and in-depth cooperation. China and Kazakhstan enjoy close strategic alignment and strong industrial complementarity. However, skill mismatch, standard barriers, backward training, insufficient services, cultural differences, and weak green capacity restrict cooperation quality.

This paper explains the necessity and importance of labor adaptation, identifies six internal requirements, and analyzes six major challenges. It proposes a four-dimensional integrated path with skill upgrading as the foundation, standard mutual recognition as the key, service support as the guarantee and green adaptation as the orientation. A series of measures systematically solve labor adaptation problems and lift bilateral cooperation to a higher-quality stage.

In the future, China and Kazakhstan will strengthen government coordination, improve policy support, and give full play to the leading role of enterprises. They will deepen industry-education integration, expand cross-border talent training, and optimize the standard mutual recognition system. High-quality labor adaptation will inject sustained impetus into China-Kazakhstan digital economy cooperation. It will provide solid talent support for coordinated manufacturing transformation and high-quality Digital Silk Road construction.

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AI-ENABLED IMPROVEMENT OF BELT AND ROAD INITIATIVE ECONOMIC-TRADE EFFICIENCY

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Annotation. The Belt and Road Initiative (BRI) has become a key framework for global economic cooperation and cross-border trade. However, long-standing bottlenecks such as low cross-border clearance efficiency, high logistics costs, information asymmetry, and inconsistent regulatory standards restrict trade facilitation. As a core driver of the digital economy, artificial intelligence (AI) provides effective technical solutions to enhance economic and trade efficiency along the BRI routes. This paper analyzes the mechanisms of AI in improving customs clearance, intelligent logistics, cross-border payment, risk management, and market matching. It combines practical cases of China-Kazakhstan cooperation to demonstrate the application value of AI in BRI trade. Finally, it summarizes the challenges and puts forward policy suggestions to promote the deep integration of AI and BRI trade. The study shows that AI can significantly reduce transaction costs, shorten time cycles, improve risk control accuracy, and boost the high-quality development of BRI economic and trade cooperation.

Keywords: Belt and Road Initiative; Artificial Intelligence; Trade Efficiency; Digital Economy; China-Kazakhstan Cooperation

1. Introduction

Against the background of slowing global economic growth and rising trade protectionism, the Belt and Road Initiative has built an open cooperation platform covering more than 150 countries and regions, promoting infrastructure connectivity and trade liberalization along the routes. With the rapid development of digital technologies, the digital transformation of BRI trade is accelerating. As a core technology of the digital economy, AI is reshaping traditional trade patterns through

big data analysis, machine learning, intelligent perception, and natural language processing.

The China-Kazakhstan cooperation is an important part of the BRI. The two countries have close economic and trade ties, and their cooperation in cross-border transportation, energy trade, and agricultural products is deepening. However, they still face problems such as long customs clearance time, high logistics costs, and inconsistent regulatory standards. The application of AI can effectively solve these pain points, improve the efficiency and stability of bilateral trade, and provide a model for BRI regional cooperation. This paper focuses on the path and effect of AI in improving BRI trade efficiency, with a special focus on the practice between China and Kazakhstan.

2. Mechanisms of AI in Enhancing BRI Economic and Trade Efficiency

2.1 Intelligent Customs Clearance and Regulatory Efficiency

AI greatly improves cross-border customs clearance efficiency through image recognition, document automation, and risk pre-screening. Traditional customs clearance relies on manual document review and physical inspection, which is time-consuming and labor-intensive. AI systems can automatically identify and verify trade documents such as invoices, packing lists, and certificates of origin, and quickly compare them with regulatory databases to reduce human errors. At the same time, AI risk assessment models can distinguish high-risk and low-risk goods, realize differentiated inspection, shorten the average customs clearance time, and reduce compliance costs. According to estimates, AI-driven intelligent customs clearance can reduce trade compliance costs by about 30% along the BRI routes.

2.2 Intelligent Logistics and Supply Chain Optimization

Logistics costs account for a high proportion of BRI trade. AI optimizes the whole supply chain through path planning, demand forecasting, and dynamic scheduling. Machine learning algorithms analyze real-time data such as weather, transportation capacity, and port congestion to generate the optimal transportation plan, reduce empty mileage and waiting time, and shorten delivery cycles. Intelligent warehousing systems based on computer vision and robots improve sorting and storage efficiency, reduce cargo damage and loss. The application of AI in logistics can reduce transportation time by 20%–25% and lower logistics costs significantly.

2.3 Cross-border Payment and Financial Risk Control

AI empowers cross-border finance through smart contracts, big data credit evaluation, and real-time risk monitoring. It supports fast and secure cross-border payment, reduces reliance on traditional intermediaries, and lowers remittance costs and time. AI credit models use multi-dimensional data such as transaction records and operating conditions to evaluate the credit of small and medium-sized enterprises, ease financing constraints, and improve financial inclusion. In addition, AI real-time monitoring systems identify abnormal transactions and fraud risks, enhancing the security of cross-border capital flows.

2.4 Market Demand Analysis and Precise Matching

AI collects and analyzes market data, consumer preferences, and policy changes to provide accurate market intelligence for enterprises. It helps exporters predict demand trends, optimize product structure, and carry out targeted marketing. Natural language processing and multi-language translation technology break language barriers in cross-border communication, improve business negotiation and customer service efficiency, and promote the expansion of emerging markets.

3. Practical Cases of AI Application in China-Kazakhstan BRI Trade

3.1 Intelligent Cross-border Transportation and Customs Clearance

The China-Kazakhstan cross-border railway and highway transportation are important logistics channels. AI is applied in port scheduling, cargo tracking, and joint customs clearance. Intelligent monitoring systems realize real-time positioning and status tracking of containers. AI document processing systems automatically generate and review declaration materials, realizing data interconnection between the two countries' customs. These applications shorten customs clearance time and improve the stability of logistics channels.

3.2 Agricultural Products Trade and Quality Traceability

Kazakhstan is an important supplier of agricultural products to China. AI-based quality inspection and traceability systems use image recognition and spectral detection to quickly check the quality of grain, meat, and other products. Blockchain and AI form a whole-chain traceability system, recording production, processing, transportation, and customs clearance information, which enhances the credibility of imported products and speeds up market access.

3.3 Cross-border E-commerce and Digital Trade

The development of China-Kazakhstan cross-border e-commerce is accelerated by AI. Intelligent customer service systems provide real-time multi-language consultation services. AI logistics matching systems connect sellers, buyers, and freight forwarders, optimizing delivery routes. AI recommendation algorithms improve transaction efficiency and user experience, driving the growth of small and micro cross-border trade.

4. Challenges in AI-driven BRI Trade Efficiency Improvement

4.1 Uneven Digital Infrastructure

Developing countries along the BRI have insufficient network coverage, insufficient computing power facilities, and low digitalization levels, which restrict the large-scale application of AI.

4.2 Inconsistent Data and Regulatory Standards

Differences in data security, privacy protection, and customs supervision standards among countries hinder data circulation and the effectiveness of AI systems.

4.3 Shortage of Technical Talents

The training and application of AI need professional teams. Many BRI countries lack relevant talents, affecting technology landing and operation maintenance.

4.4 Investment and Cost Constraints

The construction of AI systems needs high upfront investment. Small and medium-sized enterprises and countries with limited financial resources face cost pressures.

5. Countermeasures and Suggestions

5.1 Strengthen Digital Infrastructure Cooperation

Promote the construction of 5G, cloud computing, and data centers along the routes, support joint investment between China and BRI countries, and improve digital connectivity.

5.2 Promote the Coordination of Standards and Regulations

Promote the alignment of AI application, data flow, and customs supervision standards, and build a multilateral cooperation mechanism to create a standardized institutional environment.

5.3 Enhance Talent Training and Technical Exchange

Carry out training programs, seminars, and joint R&D projects to cultivate compound talents who understand both AI technology and international trade rules.

5.4 Support Pilot Applications and Experience Promotion

Launch AI application pilots in key ports, logistics parks, and cross-border e-commerce zones, summarize replicable models, and expand application scenarios.

6. Conclusion

AI is a powerful engine to improve the efficiency of BRI economic and trade cooperation. It plays an important role in customs clearance, logistics, finance, market matching, and risk management. The practice of China-Kazakhstan cooperation shows that AI can effectively reduce costs, shorten time, and enhance stability. At present, the large-scale application of AI still faces challenges such as infrastructure, standards, talents, and investment. Through strengthening infrastructure construction, promoting standard coordination, enhancing talent support, and carrying out pilot demonstrations, we can further release the empowerment effect of AI. In the future, the deep integration of AI and the BRI will promote trade liberalization and facilitation, build a more efficient and inclusive global trade system, and make important contributions to regional economic recovery and sustainable development.

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ARTIFICIAL INTELLIGENCE AS A DRIVER OF SUSTAINABLE ECONOMIC DEVELOPMENT

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Annotation. This article examines the role of artificial intelligence as a driver of sustainable economic development. The study analyzes the main channels through which AI contributes to productivity growth, structural transformation, environmental sustainability, and institutional efficiency. Particular attention is paid to the application of AI technologies in manufacturing, agriculture, finance, energy systems, and public administration. The article highlights the potential of artificial intelligence to improve resource allocation, reduce waste, optimize operational processes, and support data-driven decision-making. At the same time, the research addresses the risks associated with digital inequality, labor market transformation, environmental costs of digital infrastructure, and ethical challenges related to algorithmic governance and data protection. The paper concludes that the long-term developmental impact of AI depends on effective governance, investment in digital infrastructure and human capital, and the integration of innovation policy with social and environmental objectives.

Keywords: Artificial intelligence; sustainable economic development; digital transformation; productivity growth; structural change; innovation; environmental sustainability; digital economy; human capital; automation; smart infrastructure; resource efficiency; AI governance; technological development; economic diversification.

Artificial intelligence has transitioned from a specialized technical tool to a broad-purpose economic ability that transforms production, trade, public management and social services. Its significance for sustainable economic growth lies not merely in more rapid automation, but in the capacity to enhance the quality of decisions in the face of uncertainty. When companies utilize AI for demand forecasting, logistics optimization, equipment monitoring, and waste reduction, they generate more value with less material input. When governments implement data-based systems in tax management, transportation planning, and energy governance, they are able to enhance institutional effectiveness and broaden the influence of scarce public resources.In this regard, AI ought to be regarded as an enabling layer for enhanced productivity, improved resource allocation, and more adaptable development policy [1; 2].

The initial way by which AI backs sustainable development is the enhancement of productivity. Numerous economies encounter a blend of less rapid labor-force growth, supply-chain instability, and the need to reduce carbon emissions in production. Under such circumstances, productivity growth turns out to be crucial for long-term income growth.Artificial Intelligence offers value by reducing prediction expenses, uncovering concealed patterns in extensive datasets and backing real-time operational decisions [3].In the field of manufacturing, anticipatory maintenance cuts down on downtime and prolongs the service duration of capital equipment.In the field of agriculture, AI-driven crop surveillance enables farmers to utilize water, fertilizers, and pesticides with greater precision. In the field of finance, risk evaluation models are capable of widening the access to credit for small-sized enterprises that were not well-served before. These impacts are significant for sustainability as development becomes more robust when economic output increases in tandem with efficiency rather than solely via extensive resource utilization.

The second pathway is structural change. Sustainable development necessitates a shift towards sectors with greater value, more robust innovation ecosystems, and a more diverse export capability.AI is capable of speeding up this shift through backing digital entrepreneurship, customized services, high-end manufacturing, and knowledge-intensive business models. At the company level, machine-learning instruments facilitate the analysis of customer conduct, enhance product development and synchronize fragmented value chains. At the national scale, AI capacity spurs complementary investment in cloud infrastructure, data governance, digital expertise, and research cooperation. These complementarities hold particular significance: AI seldom yields extensive development benefits independently; it generates greater impacts when integrated with managerial enhancement, broadband connectivity, interoperable data systems, and competition-conducive regulation [2; 4].

A further contribution of artificial intelligence is its capacity to harmonize economic growth with environmental goals. Sustainable development isn’t merely about boosting GDP; it additionally demands lowering carbon intensity, waste, and ecological pressure.AI uses in intelligent power grids can equalize electricity loads, incorporate variable renewable energy and cut down transmission losses. In city

systems, smart traffic management reduces congestion, fuel consumption and journey time. In construction and industrial set-ups, AI-directed energy management enhances efficiency and aids in the monitoring of emissions. Research on the Sustainable Development Goals indicates that artificial intelligence can directly contribute to advancement in fields like healthcare, clean energy sources, sustainable urban areas, and responsible manufacturing, even though the results rely significantly on governance decisions [5; 6].Consequently, the development value of AI reaches its peak when digital innovation is connected to quantifiable social and environmental goals instead of being regarded as a solely technological competition [5,6].

Simultaneously, AI does not inherently possess inclusiveness. If the adoption of technology is mainly in a small number of leading firms or urban areas, the technology could expand productivity disparities, labor-market inequalities, and digital reliance. Automation can supplement skilled laborers while taking over routine jobs, which brings about adjustment expenses for workers and small businesses with restricted retraining capabilities [4].Moreover, potent AI systems depend on data access, computational infrastructure, and organizational capacities that are distributed non-uniformly among countries. This implies that emerging economies could continue to be consumers of imported knowledge rather than producers of domestic innovation. Sustainable economic growth thus demands policy measures in the realm of education, continuous learning, public digital facilities, open norms, and backing for local research groups. Without these supplementary elements, AI could enhance efficiency in individual sectors while undermining social unity.

Another significant constraint is the environmental impact of the digital economy on its own. Large-scale model training and data storage use up electricity and water, and rapid hardware replacement brings extra material stress. For this cause, the query is not whether artificial intelligence is intrinsically green or detrimental, but whether institutions direct its utilization toward net public advantage. Energy-saving model creation, open reporting of computational expenses, reuse of equipment, and purchasing criteria for data centers ought to be included in sustainable industrial policy [7].Ethical management is also essential. Prejudiced algorithms, non-transparent automated judgments and feeble data safeguarding diminish public confidence and might bring about social damage that counterbalances economic benefits. A long-term AI strategy has to integrate innovation with liability, human supervision and well-defined legal accountability [7,8].

In summary, artificial intelligence has the potential to serve as a powerful catalyst for sustainable economic development when it is incorporated into a more comprehensive strategy that focuses on productivity enhancement, structural diversification, environmental effectiveness, and the development of human capital. Its most significant potential lies in enabling economies to achieve more using less: reduced waste, decreased idle capacity, and less informational resistance. However, this commitment is conditional. The assessment of AI should not solely rely on the adoption speed. Instead, it should be gauged by whether it enhances living standards,

broadens opportunities, and upholds long-term ecological balance. Nations that make concurrent investments in digital infrastructure, capabilities, governance, and mission-focused innovation policies stand a better chance of turning AI from a trendy technology into a long-lasting basis for inclusive and sustainable development.

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STRUCTURAL TRANSFORMATION OF THE LAST-MILE LOGISTICS INFRASTRUCTURE IN KAZAKHSTAN DRIVEN BY THE EXPANSION OF CHINESE CROSS-BORDER E-COMMERCE

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Abstract. The impact of Chinese cross-border e-commerce on the logistics of importing countries has been studied only fragmentarily, particularly for the last-mile segment in Kazakhstan. This paper examines how growing commodity flows from China are changing the organization of deliveries to end consumers. The aim is to identify the mechanisms and consequences of the transition from a centralized model (national operator) to a distributed network of private cargo companies in the

small-shipment segment. A comparative analysis of the efficiency of traditional and new logistics schemes was carried out using data on trade turnover and tax revenues from foreign online platforms, as well as aggregated information on the activities of private consolidation operators in Kazakhstan. It is found that the increase in demand from Kazakhstani consumers and micro-businesses for goods from marketplaces has facilitated a shift from a monocentric model to a decentralized network of private consolidation warehouses and pickup points. Private operators are shown to reduce transaction costs through consolidated shipment models. A social effect is noted: overcoming digital barriers for populations in remote regions through informal services at pickup points. The conclusion is that the structural transformation occurred as a self-organizing process of small and medium-sized business adaptation to growing consumer demand, without the involvement of government programs.

Key words: cross-border e-commerce, last-mile logistics, Kazakhstan, China, infrastructure decentralization, private cargo operators, freight consolidation.

China's influence on Kazakhstan's last-mile logistics infrastructure is driven by the growth of cross-border e-commerce. This is facilitating a shift from a model based on large national operators toward a more decentralized system involving private logistics companies. These changes can be partly explained by Kazakhstan's geographic location and the increase in bilateral trade turnover, which reached approximately $48.7 billion USD by the end of 2025 [1]. Furthermore, delivery structures are being affected by rising demand from Kazakhstani consumers and entrepreneurs for goods from Chinese marketplaces.

Kazakhstani consumers turn to Chinese marketplaces due to lower prices compared to the local market, as well as a wide product range (from clothing and electronics to construction materials and spare parts). A significant share of orders consists of purchases for resale: small entrepreneurs and micro-businesses regularly buy wholesale lots on 1688.com and Taobao. The platforms have adapted to the local market by introducing interfaces in Russian and Kazakh, supporting Visa/Mastercard payments, and enabling direct registration for users from Kazakhstan. In May 2025, Taobao launched a Russian-language version for Kazakhstan, while 1688.com opened direct purchases with payment via international cards. According to the Committee of State Revenues of Kazakhstan, receipts from foreign online platforms for the first 11 months of 2025 amounted to KZT 55.7 billion – KZT 23 billion more than for the entire year of 2024 [2]. The total volume of cross-border e-commerce between China and Kazakhstan in 2024 is estimated at $450 million USD, representing a year-on-year increase of 35.8% [3].

Traditional Kazakhstani logistics institutions (Kazpost JSC, major state-owned carriers) are demonstrating a mismatch with e-commerce parameters: high shipment frequency, low package weight, demands for delivery speed, and real-time tracking. A model focused on large batches, container shipping, and centralized processing through

a limited number of hubs leads to delivery times of 2–4 weeks, customs queues, and high last-mile costs in the regions. In contrast to the centralized model, private operators have built a distributed infrastructure capable of handling thousands of small and medium-sized parcels daily. The main consolidation hubs are located in Guangzhou, Yiwu, Ürümqi, and Khorgos. Private cargo operators place warehouses and agents there to receive orders from Pinduoduo, 1688, and Taobao, and perform sorting, consolidation, and packaging. Consolidated shipments are sent by road or rail across the border. In Kazakhstan, the main node is Almaty (home to the largest private warehouses), from which goods are distributed to regional pickup points in Astana, Shymkent, Karaganda, Pavlodar, Oskemen, and smaller settlements. Many cargo companies operate their own branch networks.

Unlike state-owned operators, which handle large container shipments and require full customs clearance for each parcel, cargo companies use a consolidated shipment model: small orders (from 1–10 kg) are combined into one large consignment in China, thereby reducing unit logistics costs and speeding up border crossing. According to 2GIS data, a significant number of specialized cargo operators operate in Almaty alone (e.g., K9 Post – 6 branches, Emir Cargo – 8 branches, as well as Silkway Cargo, Aug Cargo, Partner_cargo, Cargo Phoenix, Zhan logistic Cargo, Asau Kargo, p2p.cargo, and others) [4] Many companies offer consolidation, real-time tracking, and door-to-door or pickup-point delivery, including to remote regions.

Kazakhstani private logistics operators – mostly small and medium-sized enterprises – have faced the need to implement goods flow accounting and tracking systems with minimal investment. Traditional manual reconciliation methods and spreadsheet editors no longer provide the required throughput capacity. As a result, a demand has emerged for affordable digital tools that can integrate into existing business processes without lengthy staff training or capital expenditure. The main driver of technological adaptation has been the spread of Software-as-a-Service (SaaS) models. Instead of implementing monolithic ERP systems that require significant resources and time, small operators have switched to subscription-based platforms with an average monthly fee of USD 5–10. The typical functional core of such solutions includes:

- End-to-end tracking, implemented via API integration with Chinese data aggregators and local carriers. This mechanism allows the end recipient to track the shipment from the moment it is scanned at the consolidation warehouse in China until it arrives at the pickup point.

- QR identification of each postal item at the stages of reception, internal sorting, and delivery. Using mobile device cameras instead of stationary scanners has reduced the cost of implementing the identification system.

- Automated notification channels (SMS, Telegram bots, push notifications) that ensure communication with the customer upon cargo arrival, expiry of storage periods, and the possibility of redirecting the shipment to an alternative pickup point.

A comparative efficiency analysis of lightweight IT solutions versus traditional information systems of large logistics operators reveals three factors explaining the higher adaptability of the former in the cross-border shipment segment. First, speed of deployment: a private pickup point can launch full-fledged tracking within 1–3 working days, whereas installing a corporate system takes several months. Second, modular architecture, which allows the customer to select only the necessary functions without overpaying for excess features. Third, user-friendly interfaces designed for employees without specialized IT education.

The proliferation of private consolidation hubs and pickup points has had a significant impact on the availability of goods for the population of the Republic of Kazakhstan, especially in remote regions.

The key mechanism reducing transaction costs is demand consolidation. Private agents in small towns accumulate orders from 30–50 end consumers, submit a consolidated request to a Chinese hub, and after receiving the batch locally, carry out sorting and delivery. This model makes logistics economically viable even for villages with a population of fewer than 500 people. At the same time, there is intensive growth of small and medium-sized enterprises in the logistics service sector. A typical business model includes: opening a pickup point in rented premises, concluding agency agreements with 2–3 cargo companies, and receiving a commission of 50–150 tenge per parcel delivered.

The social effect is expressed in lowering digital inequality barriers. For a significant portion of Kazakhstan’s population – especially the elderly and residents of remote villages – receiving a parcel from China becomes their first experience with e-commerce. Pickup point employees informally act as "digital volunteers": helping with marketplace registration, explaining shipment tracking procedures, and advising on return processes. These services are provided free of charge, remaining entirely a private initiative.

The conducted study allows us to state that the expansion of Chinese cross-border e-commerce in Kazakhstan has initiated a structural shift from a monocentric to a distributed model of logistics infrastructure. The traditional model – represented by a state national operator with vertical integration and centralized sorting centers has now been supplemented (and in the segment of small shipments from China, practically replaced) by a network created by private capital. This network includes hundreds of independent cargo agents, consolidation hubs, and pickup points linked by horizontal agreements. The key properties of this network that ensure its higher adaptability compared to the monocentric model are: decentralization of decision-making, technological "lightness," and social embeddedness.

The principal conclusion is that this structural transformation occurred not as a result of government programs or targeted regulation, but as a grassroots adaptive response to explosive consumer demand. Kazakhstan’s small businesses, in a short period of time, built the missing infrastructure using minimal investment and accessible technologies. This case demonstrates that in global supply chains, the

greatest adaptability is found not in large institutional structures, but in flexible private networks capable of rapid reconfiguration in response to changing commodity flows.

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THE IMPACT OF INTELLIGENT TECHNOLOGY ON CROSS-BORDER TOURISM BUSINESS: A CASE STUDY OF BEIJING CAISSA

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Abstract. This study examines how intelligent technology adoption affects cross-border tourism business sustainability, using Beijing Caissa as a case study. Drawing upon Resource-Based View and Technology Acceptance Model frameworks, the research identifies how AI-driven platforms, big data analytics, and digital integration serve as catalysts while creating implementation burdens. Findings reveal that intelligent technology enhances operational efficiency and customer engagement but introduces significant challenges including integration costs, workforce adaptation requirements, and cybersecurity concerns. The paper contributes a dynamic sustainability evaluation framework balancing technological benefits against operational burdens.

Keywords: Intelligent Technology, Cross-border Tourism, Digital Transformation, Business Sustainability, Beijing Caissa

1. Introduction

The global tourism industry has undergone significant transformation through intelligent technology integration over the past decade. China, as the world's largest outbound tourism market, provides a compelling context for examining how travel enterprises navigate digital disruption. Beijing Caissa Touristic Co., Ltd., founded in 1999 and headquartered in Beijing, exemplifies this transformation. As a leading cross-border tourism provider operating across more than 100 countries with subsidiaries including Caissa Sports, Caissa Cruises, and Caissa Visa, the company has undergone substantial strategic evolution in response to technological advancement and pandemic-induced market disruption (Caissa Tosun, 2025).

The COVID-19 pandemic accelerated digital transformation across the tourism sector. Beijing Caissa invested approximately RMB 300 million in technology infrastructure during 2022, focusing on AI-powered customer service systems, data analytics platforms, and mobile application development. This investment yielded a 35% increase in online bookings, demonstrating the tangible impact of intelligent technology adoption (Caissa Tosun Financial Reports, 2023).

This paper critically examines how intelligent technology functions simultaneously as a catalyst for competitive advantage and a potential burden on organizational sustainability.

2. Theoretical Underpinnings

The Resource-Based View (RBV) provides a framework for understanding how technological capabilities generate sustainable competitive advantages. Barney's (1991) VRIN criteria—valuable, rare, inimitable, and non-substitutable—suggest that proprietary digital platforms and data analytics capabilities constitute strategic resources, while Warner and Wäger (2018) demonstrate that dynamic technological capabilities enable firms to adapt rapidly to market changes. Complementing this, Davis's (1989) Technology Acceptance Model (TAM) explains user adoption through perceived usefulness and perceived ease of use, with extensions incorporating trust, social influence, and facilitating conditions (Venkatesh et al., 2003). Building on Berman's (2012) digital transformation framework—which identifies business process digitization, customer experience transformation, and business model innovation as critical dimensions—this study conceptualizes intelligent technology impact as encompassing both enabling mechanisms and disruptive challenges (Verhoef et al., 2021).

3. Beijing Caissa's Digital Transformation Trajectory

Beijing Caissa's digital evolution reflects broader industry patterns while demonstrating firm-specific strategic choices. Prior to 2020, the company operated primarily through traditional distribution channels, including 100+ offline stores across 50 major Chinese cities, generating revenues of approximately RMB 3.0 billion in 2019 (Caissa Tosun Annual Reports, 2020). The pandemic prompted rapid pivoting: in 2021, the company launched an integrated online booking platform with AI-powered recommendations, processing over 1.5 million transactions in its first year. Strategic partnerships with Secoo Group (2018) and AVIC General Aviation augmented

capabilities through lifestyle service integration and low-altitude tourism development. By 2023, digital channels contributed over 40% of total transaction volume, with the company targeting 50% digital revenue share by 2025.

4. The "Catalyst" Dimension

Intelligent technology adoption functions as a catalyst across multiple operational dimensions. First, AI-powered customer service systems reduced response times by 60% while enabling 24/7 multilingual support. Chatbot implementations handled approximately 70% of routine inquiries, freeing human resources for complex interactions.Second, big data analytics enabled precision marketing strategies. Customer segmentation models increased conversion rates by 25%. Predictive analytics improved inventory management efficiency, reducing operational costs by approximately 15%.Third, digital platform integration created ecosystem network effects. The mobile application registered over 5 million active users by 2024, enabling direct customer relationships previously mediated through third-party distributors. This direct access generated valuable first-party data while reducing commission costs.Fourth, intelligent technology enhanced service personalization. AI-driven recommendation engines increased average transaction values by 18%. Virtual tour previews and AR-based destination exploration features improved customer engagement.

Finally, operational automation streamlined back-office functions including visa processing, booking confirmations, and payment settlements. Blockchain-based verification systems accelerated documentation workflows.

5. The Latent "Burden" Dimension

Despite catalytic benefits, intelligent technology adoption introduces significant operational burdens. Financial costs constitute the most immediate burden. Beijing Caissa's technology investment of RMB 300 million in 2022 represented approximately 10% of annual revenue. Return on investment timelines remain extended, with full profitability benefits projected for 2026.

Workforce adaptation presents organizational challenges. The digital transformation necessitated reskilling 30% of existing employees, requiring significant training investments while maintaining service quality during transition periods. Resistance to change among long-tenured employees created implementation friction. Technological integration complexity burdened operational systems.

Cybersecurity concerns impose ongoing risk management burdens. Beijing Caissa experienced attempted cyberattacks increasing by 200% following digital platform launches, necessitating continuous security infrastructure investments. Regulatory compliance burdens emerged as data protection requirements tightened.

6. Dynamic Appraisal of Business Sustainability

Business sustainability requires dynamic evaluation across financial, operational, and strategic dimensions. Financial sustainability indicators demonstrate positive trajectories: technology investments generated 12% revenue growth in 2023, with operating margins improving by 2 percentage points through automation-driven cost

reductions. However, increased capital expenditure elevated debt-to-equity ratios, introducing financial leverage risks. Operational sustainability metrics reveal mixed outcomes. Customer satisfaction scores for digital bookings exceeded traditional channels, indicating successful technology adoption among consumers. However, employee satisfaction indices declined, signaling workforce sustainability concerns. Strategic sustainability assessment indicates enhanced competitive positioning. Market share in premium outbound tourism segments increased by 3 percentage points, attributable to personalized service offerings enabled by AI analytics. However, technology sector entrants pose emerging competitive threats.

The dynamic evaluation framework suggests that sustainability requires balancing short-term financial pressures against long-term strategic positioning. Beijing Caissa's phased investment approach—prioritizing customer-facing applications before operational systems—demonstrates pragmatic sustainability management.

7. Conclusion

This case study demonstrates that intelligent technology adoption creates dual impacts on cross-border tourism business sustainability. Catalyst effects—enhanced customer experience, operational efficiency, and competitive differentiation—must be weighed against burden dimensions including financial costs, workforce adaptation challenges, and technology dependency risks. Beijing Caissa's experience suggests that successful digital transformation requires strategic sequencing, adequate resource allocation, and balanced attention to multiple stakeholder groups.

For policymakers, this study suggests supporting tourism enterprise digital transformation through targeted subsidies, workforce training programs, and regulatory frameworks that balance innovation encouragement with consumer protection. Future research should examine longitudinal sustainability outcomes and compare digital transformation strategies across diverse tourism enterprise contexts.

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ARTIFICIAL INTELLIGENCE AND TRADE DEVELOPMENT UNDER THE BELT AND ROAD INITIATIVE

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Abstract. This study explores the role of artificial intelligence in trade development under the Belt and Road Initiative. AI improves logistics efficiency, supports market expansion through data analytics, and enhances risk management, thereby transforming trade processes. However, its application is constrained by infrastructure gaps, data security issues, and a lack of skilled professionals. The study highlights the need to strengthen digital infrastructure, improve data protection, and develop AI talent to ensure sustainable trade growth.

Keywords: Artificial Intelligence; Belt and Road Initiative; Trade Development; Digital Transformation

1. Introduction

1.1 Background of the Belt and Road Initiative

Since its launch in 2013, the Belt and Road Initiative has become a major platform for international economic cooperation. It aims to promote an open and

mutually beneficial framework through policy coordination, infrastructure connectivity, trade facilitation, and financial integration. The Initiative has strengthened economic ties between China and participating countries and contributed to global economic governance. In the context of rising anti-globalization trends, it plays an important role in supporting multilateralism and free trade. By 2023, more than 150 countries and international organizations had joined the Initiative, reflecting its broad global influence.

1.2 Current Status of Artificial Intelligence Development

Artificial intelligence has become a key driver of technological and industrial transformation, rapidly reshaping production and economic systems. Advances in big data, cloud computing, and the Internet of Things have enabled its widespread application across sectors such as healthcare, manufacturing, finance, and transportation. In international trade, AI enhances efficiency by optimizing resource allocation, improving supply chain management, and reducing costs. Technologies such as deep learning and natural language processing support demand forecasting and cross-border communication. As a result, many countries are prioritizing AI as a strategic area of development, increasing investments to strengthen their global competitiveness.

1.3 Research Significance

Studying the role of artificial intelligence in trade development under the Belt and Road Initiative is both theoretically and practically important. AI helps overcome limitations of traditional trade models by improving logistics efficiency, reducing costs, and enhancing cross-border economic cooperation. In addition, data analytics and precision marketing enable businesses to better understand market demand and expand trade opportunities. In the context of global economic uncertainty, the application of AI provides new approaches to strengthening regional cooperation and supporting sustainable trade growth.

2. The Application of Artificial Intelligence in Belt and Road Trade

2.1 Smart logistics optimizes trade and transportation.

2.1.1 Application of Intelligent Logistics Technologies

Artificial intelligence has transformed logistics in Belt and Road trade through route planning, warehouse automation, and transport optimization. By analyzing real-time data, it improves efficiency and reduces costs. Technologies such as AGVs and smart systems increase accuracy and reduce labor, while AI also helps select optimal transport modes, enhancing logistics performance and supporting cross-border trade.

2.1.2 Impact on Trade Efficiency and Costs

The adoption of smart logistics technologies has significantly improved trade efficiency and reduced transportation costs. For example, the China-Europe freight train has reduced transit time by around 30% and costs by over 15% due to AI-based systems. Moreover, AI improves supply chain resilience by reducing handling time, optimizing warehouse usage, and minimizing losses. Route optimization algorithms

help avoid delays and ensure timely delivery. As a result, intelligent logistics has become a key driver of trade development under the Belt and Road Initiative.

3. Challenges in Using Artificial Intelligence to Promote Trade Development under the Belt and Road Initiative

3.1 Differences in Digital Infrastructure Development

Disparities in digital infrastructure among Belt and Road countries limit the application of artificial intelligence in trade. Uneven network coverage, communication technologies, and data center availability restrict data processing and the use of advanced AI solutions. These gaps hinder technological implementation, reduce innovation, and contribute to uneven trade development.

3.2 Data Security and Privacy Issues

Artificial intelligence in Belt and Road trade raises significant data security and privacy concerns. Increasing cross-border data flows and differences in national regulations create compliance risks and raise the likelihood of data misuse. These issues may weaken trust and limit the adoption of AI technologies. Therefore, ensuring data protection is essential for effective trade development.

3.3 Shortage of technical talent

The shortage of qualified AI professionals is a major barrier to the adoption of artificial intelligence in Belt and Road trade. Many countries, especially developing ones, face a significant talent gap, limiting innovation and practical implementation. In addition, education systems often lag behind technological developments, creating a mismatch between training and market needs. As a result, the lack of skilled specialists constrains the development of AI-driven trade.

4. Strategies for Addressing the Challenges Posed by Artificial Intelligence in Promoting Trade Development under the Belt and Road Initiative

4.1 Strengthen cooperation on digital infrastructure.

Under the Belt and Road Initiative, digital infrastructure is essential for the application of artificial intelligence, but disparities in its development limit adoption. To address this, countries should strengthen cooperation through joint investment and technology sharing, as well as develop cross-border technological platforms. Such measures can reduce the digital divide and support the effective use of artificial intelligence in trade.

4.2 Improve data security and privacy protection mechanisms.

As artificial intelligence expands in Belt and Road trade, data security and privacy risks in cross-border flows increase, potentially undermining trust and cooperation. To address this, countries should establish unified data protection standards, strengthen regulatory cooperation, and apply technologies such as encryption and blockchain. Effective data protection is essential for the sustainable use of AI in trade.

4.3 Step up efforts to cultivate AI talent.

The rapid development of artificial intelligence has increased the demand for qualified specialists, while many Belt and Road countries face a significant talent shortage. To address this imbalance, it is essential to strengthen AI talent development

through education, exchanges, and training.Educational cooperation, including joint programs and research initiatives, can improve the quality of training and expand practical opportunities. Talent exchange programs further support knowledge sharing and innovation. In addition, targeted training for professionals helps meet the immediate needs of the labor market.Overall, a comprehensive approach to talent development is necessary to support the effective application of artificial intelligence in trade.

5. Conclusion

5.1 Summary of Research Findings

Artificial intelligence enhances trade under the Belt and Road Initiative by improving logistics, enabling data-driven marketing, and strengthening risk management, while supporting digital transformation and economic cooperation.However, its application faces challenges such as infrastructure disparities, data security issues, and a shortage of skilled professionals. Addressing these through cooperation, regulation, and talent development is essential.Overall, AI is a transformative force in trade, but its full potential depends on coordinated policies and continued research.

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CROSS-BORDER TRADE DIGITALIZATION: RESEARCH ON MECHANISMS AND TOOLS IN CHINA-KAZAKHSTAN COOPERATION UNDER THE BELT AND ROAD INITIATIVE

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Abstract. Against the background of the steady advancement of the Belt and Road Initiative and the rapid development of the digital economy, the digital transformation of economic sectors has been continuously accelerated, which has become an important starting point for deepening bilateral international economic and trade cooperation. As a core field of economic and trade exchanges between China and Kazakhstan, the digital development of cross-border trade can effectively optimize trade processes, reduce transaction costs and strengthen bilateral linkage efficiency. Taking China-Kazakhstan cross-border trade cooperation as the research object, this paper systematically analyzes the operation mechanisms and application tools of cross-border trade digitalization combined with the development logic of digital transformation in economic sectors. On the basis of existing research achievements on digital economic cooperation, it sorts out the current development status and optimization directions of China-Kazakhstan cross-border trade digitalization, so as to provide theoretical reference and practical ideas for the coordinated development of trade digitalization between the two countries.

Keywords: cross-border trade digitalization; China-Kazakhstan cooperation; digital mechanism; digital tools; the Belt and Road Initiative

1. Introduction

With the in-depth integration of new-generation digital technologies such as big data and cloud computing with the real economy, the digital transformation of economic sectors has become a mainstream trend in global economic and trade development, profoundly reshaping the operation mode and cooperation pattern of international trade. Digital transformation is not a technological upgrade in a single field, but a systematic reform covering trade processes, management systems and

cooperation modes, which exerts a far-reaching impact on transnational operation networks and bilateral economic and trade relations (Chen & Li, 2025).

As core cooperative partners under the Belt and Road Initiative, China and Kazakhstan share a solid foundation and great development potential in bilateral cross-border trade cooperation. The rise of the digital economy provides new development opportunities for trade upgrading between the two countries, promoting the transformation of traditional trade modes towards digitalization and intelligence. At present, digital economic cooperation among countries along the Belt and Road has been deepening continuously, while it also faces practical challenges such as insufficient mechanism construction and unbalanced application of digital tools (An, 2022).

International trade digitalization can release the value of data elements and enhance the resilience of foreign trade development relying on carriers such as cross-border e-commerce, becoming a key driving force for high-quality development of bilateral trade (Wu et al., 2024). Meanwhile, sound institutional construction is the foundation to guarantee the long-term development of economic and trade cooperation under the Belt and Road, which can provide institutional support for the implementation of cross-border trade digitalization (Zhang, 2021). Based on the above background, this paper focuses on the scenario of China-Kazakhstan cooperation to explore the core mechanisms and application tools of cross-border trade digitalization, which conforms to the requirements of digital transformation of economic sectors and has important practical significance for deepening bilateral economic and trade cooperation.

2. Internal Correlation between Digital Transformation of Economic Sectors and Cross-border Trade

2.1 Core Connotation of Digital Transformation of Economic Sectors

The digital transformation of economic sectors refers to the process in which various economic entities including agriculture, industry, foreign trade and macroeconomic management optimize business processes, management modes and development concepts with the support of digital technologies. Its core is to take data as the key production factor, break the barriers of traditional offline operation, and comprehensively improve the efficiency and competitiveness of economic operation.

As an important part of export-oriented economy, the cross-border trade sector is a key area for the digital transformation of economic sectors. Traditional cross-border trade is confronted with problems such as cumbersome procedures, information asymmetry and long transaction cycles. Digital transformation can fundamentally solve these development pain points and promote the comprehensive upgrading of bilateral trade between China and Kazakhstan from traditional offline mode to digital collaborative mode.

2.2 Development Value of Cross-border Trade Digitalization

Digital transformation can significantly reshape the global network layout of multinational enterprises and inject new momentum into cross-border trade

cooperation (Chen & Li, 2025). Under the framework of the Belt and Road, promoting the digital development of China-Kazakhstan cross-border trade can not only simplify trade links such as customs clearance, settlement and logistics to reduce bilateral transaction costs, but also expand trade cooperation channels relying on digital platforms.

At the same time, the development of international trade digitalization can release the potential of economic and trade cooperation through cross-border e-commerce, data flow and platform economy (Rehman et al., 2025). The experience of digital economic cooperation between China and countries along the Belt and Road can also provide effective practical reference for the construction of China-Kazakhstan cross-border trade digitalization (Wang, 2022).

3. Core Mechanisms of China-Kazakhstan Cross-border Trade Digitalization under the Belt and Road Initiative

3.1 Bilateral Policy Coordination Mechanism

Policy coordination is the basic guarantee for the development of cross-border trade digitalization. Within the Belt and Road cooperation system, China and Kazakhstan unify relevant standards of cross-border trade digitalization and break policy barriers through regular economic and trade communication. The improved institutional construction of the Belt and Road can coordinate the work of customs, economy and trade, taxation and other departments of the two countries, creating a stable institutional environment for the development of trade digitalization (Zhang, 2021).

3.2 Data Element Circulation Mechanism

Data is the core production factor of digital transformation. Establishing a cross-border trade data sharing mechanism between China and Kazakhstan can realize the two-way circulation of trade orders, logistics information and customs clearance data, and eliminate data isolated islands. Relying on the standardized data processing system, it can improve the transparency of bilateral trade information and provide solid data support for trade decision-making and cooperation layout between the two countries.

3.3 Collaborative Risk Prevention and Control Mechanism

Current digital economic cooperation under the Belt and Road still faces various practical challenges, which requires a sound risk prevention and control system (An, 2022). Relying on international economic and trade cooperation experience, China and Kazakhstan can build a digital risk monitoring platform to effectively avoid market risks and data security risks in the process of trade digitalization, and ensure the stable development of bilateral cross-border trade digitalization.

4. Main Application Tools of China-Kazakhstan Cross-border Trade Digitalization

4.1 Cross-border E-commerce and Digital Trading Platforms

Cross-border e-commerce is the core application tool of cross-border trade digitalization, which can build online docking channels for enterprises between China

and Kazakhstan to realize integrated services including commodity display, order negotiation and online transaction. The wide application of digital platforms can significantly improve the cross-border trade performance of small and medium-sized enterprises and expand the market space of bilateral trade (Dallocchio et al., 2024).

4.2 Intelligent Government Customs Clearance Tools

As the key carrier for the digital transformation of trade economic sectors, electronic ports and intelligent declaration systems can realize online customs clearance approval. It can greatly shorten the customs clearance time of China-Kazakhstan cross-border trade, improve the efficiency of trade circulation, and complete the digital upgrading of economic and trade management departments of the two countries.

4.3 Big Data and Cloud Computing Analysis Tools

Big data and cloud computing technologies can conduct in-depth mining and analysis of bilateral trade data to accurately judge trade development trends and identify changes in market demand. Such digital tools can not only enhance the export resilience of enterprises, but also provide scientific reference for the formulation of macro trade policies (Wu et al., 2024), giving full play to the enabling role of digital technologies in cross-border trade.

5.Conclusion

The digital transformation of economic sectors is an inevitable trend of international economic and trade development in the digital era, and promoting cross-border trade digitalization is an important path to deepen China-Kazakhstan cooperation under the Belt and Road Initiative. This study shows that three core mechanisms including policy coordination, data circulation and risk prevention and control, together with digital tools such as cross-border digital platforms, intelligent customs clearance and big data analysis, can effectively promote the high-quality development of China-Kazakhstan cross-border trade.

At present, fruitful achievements have been made in digital economic cooperation between China and countries along the Belt and Road, while the construction of cross-border trade digitalization still needs continuous improvement (Wang, 2022). In the future, China and Kazakhstan should further strengthen bilateral digital cooperation, optimize the operation mechanism of trade digitalization, enrich the application of digital tools, and resolve various challenges in cooperation (An, 2022). It will give full play to the enabling effect of digital technologies on bilateral economic and trade cooperation, and promote the coordinated development of China-Kazakhstan cross-border trade digitalization to a new height.

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AI-DRIVEN PRODUCTIVITY GAINS AND ENERGY CONSUMPTION: A SUBSTITUTION EFFECT ANALYSIS BASED ON SUSTAINABLE DEVELOPMENT GOALS

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Annotation. The rapid integration of Artificial Intelligence (AI) into global economic sectors has triggered a dual impact on sustainable development. On one hand, AI enhances production efficiency through intelligent automation, optimized resource allocation, and predictive maintenance. On the other hand, the massive computational power required for AI training and inference leads to a surge in energy consumption, potentially contradicting environmental sustainability. This paper investigates the "substitution effect" between AI-driven productivity gains and energy demands within the framework of Sustainable Development Goals (SDGs). By analyzing the mechanisms of digital transformation, the study explores how AI can mitigate its environmental footprint by replacing inefficient, carbon-intensive

traditional processes. The results suggest that policy-led "Green AI" initiatives are essential to ensure that efficiency gains outweigh the incremental energy costs, fostering macro-economic stability and regional cooperation under the "Belt and Road" initiative.

Key words: Economics, Artificial intelligence, Economics of energy , Economic development, growth

Introduction

The global economy is facing severe geoeconomic and geopolitical challenges. Digital transformation has become a strategic necessity for economic resilience and competitiveness, with AI at the core of this revolution. Yet the high energy consumption of AI raises growing environmental concerns.

For first-year economics graduate students, studying the balance between technological innovation and resource sustainability is crucial. This paper analyzes how AI affects production efficiency and assesses whether efficiency gains can replace energy-intensive activities in line with the UN Sustainable Development Goals [1].

2. Theoretical Framework: AI and Production Efficiency

2.1 Mechanisms of Efficiency Enhancement

AI drives productivity through several key channels:

Optimized Resource Allocation: AI-driven big data analytics allows firms to forecast demand with higher precision, reducing inventory waste and overproduction.

Intelligent Automation: AI systems can adapt to complex manufacturing environments, increasing output per unit of labor and capital.

Predictive Maintenance and Lifecycle Management: By utilizing IoT sensors and machine learning, industries can predict equipment failure before it occurs, significantly reducing downtime and resource expenditure associated with emergency repairs.

2.2 The Substitution Effect Hypothesis

The core hypothesis of this paper is the "Substitution Effect." In economic terms, AI acts as a sophisticated input that can substitute for less efficient labor or capital. From a sustainability perspective, if AI-optimized systems (e.g., smart grids, autonomous logistics) reduce the total energy intensity of a sector more than the energy required to power the AI itself, a net positive environmental effect is achieved. This is crucial for international trade and cross-border cooperation, particularly in logistics-heavy frameworks like the "Belt and Road" initiative [2].

3. Sectoral Analysis and Empirical Observations

3.1 Digital Transformation in Manufacturing and Logistics

Manufacturing remains the backbone of many developing economies. The implementation of "Digital Twins"-AI-powered virtual replicas of physical systems—allows for testing efficiency scenarios without consuming physical resources. In

logistics, AI route optimization algorithms have demonstrated the ability to reduce fuel consumption by up to 15% in international shipping and trucking.

3.2 The Energy Cost of AI Infrastructure

However, the rebound effect (Jevons Paradox) must be considered: greater resource efficiency from technology may raise total consumption as costs decline. Data centers already use 1-1.5% of global electricity, and this share is expected to grow with more complex AI models. Thus, the substitution effect is not automatic—it depends on the energy structure (renewables vs. fossil fuels) and hardware efficiency.

Table 1: Comparative Analysis of Sectoral AI Impact on SDGs

Sector	Primary AI Tool	Efficiency Impact	Primary SDG Target
Energy Smart	Grid AI	Reduced transmission loss (20%)	SDG 7 (Clean Energy)
Trade	Blockchain & AI Logistics	Reduced transaction costs (30%)	SDG 9 (Innovation)
Agriculture	Precision Farming AI	Lowered chemical/water use (25%)	SDG 12 (Responsible Prod.)
Finance	Risk Management AI	Enhanced macro-stability	SDG 8 (Decent Work/Growth)

4. Policy Implications for Geoeconomic Stability

Given the conference's focus on international cooperation and digital economy investment, three policy directions are proposed:

1.Green Financial Supervision: Financial systems should incentivize investments in AI projects that demonstrate a net reduction in carbon footprints. This aligns with direction 7 of the conference (Financial Systems & Macro-stability).

2.Standardization of Digital Infrastructure: Under the "Belt and Road" framework, China and Kazakhstan can collaborate on standardized, energy-efficient data center protocols to ensure regional digital sovereignty and sustainability.

3.R&D in Algorithmic Efficiency: Moving from "Red AI" (focused solely on accuracy via massive data) to "Green AI" (focused on achieving results with minimal computational power).

5. Risk Management in the AI Era

Innovation policy must also account for competitiveness and risk. The concentration of AI technology in a few nations could lead to a "digital divide," exacerbating economic instability in the world market. Risk management frameworks should be integrated into the digital transformation process to protect against systemic shocks caused by algorithmic bias or infrastructure failure [3].

6. Conclusion

The digital transformation of the economy via AI offers a powerful tool for achieving sustainable development. While the energy demands of AI infrastructure are significant, the potential for a "substitution effect"—where AI leads to systemic efficiency gains across manufacturing, logistics, and energy—provides a path forward. For research and practice, the focus must remain on ensuring that AI serves as a driver for inclusive, green, and stable economic growth.

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METAVERSE INDUSTRY DEVELOPMENT: CURRENT STATUS, CHALLENGES, AND INNOVATION DIRECTIONS

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Abstract. The metaverse is an important carrier for the deep integration of digital technology and the real economy. It has now transitioned from conceptual popularization to the critical stage of industrial implementation. This paper reviews the development trends of the global and Chinese metaverse industries in terms of market size, technological support, application scenarios, and policy environment. It analyzes practical challenges such as constrained core technologies, inadequate hardware experience, unclear business models, prominent security risks, and lagging standard systems. Furthermore, it proposes innovative pathways from four aspects: technological breakthroughs, scenario deepening, ecosystem collaboration, and governance standardization, providing a reference for the high-quality development of the metaverse industry.

Keywords: Metaverse; Digital Economy; Industrial Integration; Virtual Reality; Digital Governance

Driven by the continuous advancement of technologies such as 5G, Artificial Intelligence, Digital Twins, and XR, the internet is evolving from traditional information exchange towards immersive spatial interconnection. Consequently, the metaverse has become a key direction for the development of the digital economy. Early discussions around the metaverse were largely confined to conceptual debates and capital attention. However, in recent years, the industry's focus has shifted significantly towards practical applications, gradually integrating into various real-economy sectors such as consumer goods, manufacturing, cultural tourism, and government services. Leveraging its vast market size and relatively complete industrial chain foundation, China is actively promoting metaverse-related deployments. Nevertheless, the industry is still in its early growth stage, facing numerous constraints in technological breakthroughs, commercial implementation, and security governance. Systematically reviewing the current development status and practical bottlenecks to identify the next innovation pathways holds significant practical importance for fostering the healthy and sustainable development of the metaverse.

From a global market perspective, the metaverse industry maintains steady growth, with its overall scale approaching $185 billion in 2025 and an average annual growth rate remaining at a high level. In China, the core metaverse industry scale has exceeded 350 billion RMB, with a continuously expanding user base. Hardware devices, digital content, and industry solutions are developing synergistically. The iteration speed of VR/AR terminal products is accelerating, with the cost-performance ratio of domestic brands like PICO and Thunderbird constantly improving. The 5G network and computing power infrastructure are being continuously enhanced, effectively supporting the stable operation of low-latency, high-concurrency virtual scenarios. AIGC technology has significantly reduced content creation costs, enabling the rapid promotion and popularization of applications such as virtual humans, digital cultural heritage, and immersive experiences.

1) Significant Shortcomings in Key Core Technologies

High-end XR chips, micro-display panels, and core optical components are heavily reliant on imports. The dependence on foreign core technologies and key components leads to high equipment costs and limited performance improvement. The ecosystem for domestic 3D engines and spatial operating systems is immature, with gaps in compatibility, stability, and development toolchains compared to mainstream international products. The developer ecosystem is weak, making it difficult to achieve large-scale applications. Large-scale real-time rendering demands extremely high computing power and network capabilities. Existing infrastructure still faces bottlenecks in high-concurrency, low-latency, and high-bandwidth scenarios. 6G technology has not yet been commercialized, and the supply of computing power and network capabilities is insufficient to meet the in-depth development needs of the metaverse.

2) Hardware Experience and Cost Constrain Mass Adoption

High-end XR devices remain expensive. Consumer-grade products suffer from issues such as excessive weight, short battery life, wearing discomfort, and motion sickness. The average daily usage time of users is relatively low, making it difficult to form high-frequency essential demand. Industry-grade equipment requires a high degree of customization, involves high deployment costs, and is difficult to maintain, making it unaffordable for small and medium-sized enterprises (SMEs) and limiting the large-scale promotion of the industrial metaverse.

3) Unstable Business Models and Insufficient Profitability

Consumer-grade metaverse relies excessively on models such as advertising, virtual items, and membership fees. User willingness to pay is limited, and profit margins are narrow. Areas such as virtual real estate and digital collectibles have experienced speculative trading, with subsequent activity levels declining sharply, and a sustainable model has yet to be established. Industry-grade metaverse is predominantly project-based and customized, with long implementation cycles, low replicability, and slow payment recovery. The input-output ratio is relatively low, and enterprises face significant profitability pressure. Most companies are still in the stage of technology R&D and market expansion, with small revenue scales and tight cash flows, relying on financing for survival. The immaturity of business models has become a key factor constraining industry development.

4) Prominent Security and Ethical Risks, Increased Governance Difficulty

The metaverse collects a large amount of sensitive data, including facial features, eye movements, biometric characteristics, behavioral trajectories, and location information. The risk of data leakage and misuse during storage, transmission, and usage is extremely high, easily leading to issues such as identity theft, financial fraud, and targeted advertising. There is a lack of clear legal definitions for virtual property rights, digital asset transactions, and virtual behavior norms. Behaviors such as virtual theft, online violence, pornographic and violent content, and false information are difficult to regulate effectively. Ethical issues such as digital addiction, social alienation, and cognitive bias are becoming increasingly prominent, posing potential threats to the physical and mental health of minors and social order. The superposition of security and ethical risks presents new challenges to traditional governance systems.

5) Lagging Standard and Regulatory Systems, Obvious Platform Barriers

There is a lack of unified interoperability standards globally. Virtual identities, digital assets, scenario data, and device interfaces are difficult to circulate across platforms, resulting in numerous data silos and ecosystem barriers. Domestic standards are concentrated on basic frameworks and terminology specifications, while detailed standards for hardware interfaces, content specifications, security assessment, data compliance, and property rights protection are incomplete. The standard system is not well-established. Regulatory policies face the challenge of balancing "encouraging innovation and preventing risks." Existing laws and regulations are difficult to cover new metaverse business formats, leading to regulatory gaps, rule conflicts, and compliance uncertainties.

1) Tackle Key Core Technologies to Strengthen the Industrial Foundation

Focus on core hardware such as XR-specific chips, lightweight optical modules, short-focus display solutions, and Micro OLED panels. Increase R&D investment, support collaborative efforts between enterprises, universities, and research institutions to break through technological monopolies and enhance self-sufficiency. Accelerate the R&D and ecosystem building of domestic 3D engines, spatial operating systems, and development toolchains. Improve open-source communities, lower the barrier for developers, and cultivate a domestic developer ecosystem. Promote the deployment of computing power networks, edge computing, cloud rendering, and AI-accelerated computing. Accelerate the R&D and experimentation of 6G technology to enhance support for low latency, high concurrency, and high bandwidth, meeting the demands of large-scale metaverse applications. Strengthen R&D in cutting-edge technologies such as multimodal interaction, haptic feedback, brain-computer interfaces, and digital twins to enhance immersion and interaction naturalness, creating a technological competitive advantage.

2) Deepen Scenario Integration and Implementation to Promote Practical Value Release

Prioritize the development of the industrial metaverse, focusing on key industries such as manufacturing, energy, healthcare, education, and transportation. Create replicable, quantifiable, and scalable solutions, forming a virtuous cycle of "technology investment — efficiency improvement — value creation." Encourage enterprises to undergo digital transformation, promoting applications such as digital twin factories, virtual simulation training, and remote collaborative operations, enabling the metaverse to truly serve the improvement of quality and efficiency in the real economy. Enrich high-quality content in the consumer metaverse, launching lightweight, low-cost, and high-experience hardware and content products to enhance user stickiness and reasonable willingness to pay.

3) Improve Industrial Ecosystem Collaboration to Build an Open Development Landscape

Accelerate the formulation of standard systems for hardware, data, security, digital assets, and interoperability. Promote cross-platform, cross-terminal, and cross-regional interoperability and sharing, breaking down data silos and ecosystem barriers. Strengthen in-depth cooperation among industry, academia, research, and application. Support universities in establishing metaverse-related majors and courses to cultivate composite talents in technology development, scenario design, operations management, and compliance governance. Build public technology service platforms, testing and verification platforms, and achievement transformation platforms to reduce innovation costs for SMEs.

4) Establish a Sound Security Governance System to Achieve Standardized and Healthy Development

Establish a tiered data classification and protection system. Utilize technologies such as privacy computing, federated learning, and encrypted transmission to

strengthen privacy protection while enabling data utilization, and consolidate the primary security responsibility of platforms. Improve laws and regulations to clearly define virtual property rights, platform responsibilities, user rights, behavioral boundaries, and penalty rules. Legally combat illegal and criminal activities in virtual spaces, with a focus on protecting the legitimate rights and interests of minors. Strengthen industry self-discipline, formulate ethical norms and codes of conduct, guide enterprises to operate in compliance and users to use responsibly, and prevent ethical risks such as digital addiction and social isolation.

The metaverse is moving from concept to practical application, becoming a vital direction for the integration of the digital economy and the real economy. Currently, the scale of the global and Chinese metaverse industries is steadily expanding, technological support is continuously strengthening, application scenarios are constantly enriching, and the policy environment is increasingly improving. The industry as a whole has entered a stage of pragmatic development. However, at the same time, the metaverse still faces multiple challenges, including weak core technologies, inadequate hardware experience, immature business models, prominent security risks, and lagging standard and regulatory systems. There remains a significant gap to a mature and stable industrial form.

In the future, China should adhere to the development approach of technological self-reliance, pragmatic scenario application, open ecosystem, and standardized governance. Based on breakthroughs in key core technologies, oriented towards deep industrial integration, following the path of open ecosystem collaboration, and guaranteed by secure and compliant governance, China should promote the healthy, sustainable, and high-quality development of the metaverse. This will enable it to better serve the construction of Digital China and the transformation and upgrading of the real economy, contributing Chinese solutions and Chinese practices to the development of the global digital economy.

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EMPOWERING SMES: OPPORTUNITIES AND PATHWAYS FOR CHINA-KAZAKHSTAN ECONOMIC COOPERATION UNDER THE BELT AND ROAD INITIATIVE

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Introduction. Since the proposal of the Silk Road Economic Belt at Nazarbayev University in Kazakhstan in 2013, the Belt and Road Initiative (BRI) has fundamentally reshaped China-Kazakhstan economic cooperation, shifting it from traditional resource-driven exchanges to a comprehensive, inclusive partnership. As the first country to formally endorse the BRI, Kazakhstan has become China's most strategic partner in Central Asia, with bilateral economic ties deepening rapidly over the past decade. While large-scale infrastructure projects have traditionally dominated the bilateral cooperation agenda, small and medium-sized enterprises (SMEs) — the backbone of both economies, driving job creation, innovation, and economic diversification — have emerged as a critical, yet underexplored, engine for future growth. This report examines the current landscape, untapped opportunities, and persistent challenges of SME integration into China-Kazakhstan economic cooperation under the BRI framework, drawing on empirical research and existing policy analysis.

Key words：BRI；China-Kazakhstan Economic Cooperation；SMEs'；Cross-border Trade；SME Export Competitiveness

Current Landscape of Bilateral Cooperation

Bilateral trade between China and Kazakhstan has achieved remarkable growth over the past decade. Data shows that China overtook Russia to become Kazakhstan's largest trading partner, while Kazakhstan remains China's top economic partner in Central Asia, accounting for over half of China's total trade with the Central Asian region (Duan, 2018). Historically, bilateral trade was characterized by a complementary but relatively simple structure: Kazakhstan exported raw materials and energy resources, while China exported labor-intensive manufactured goods. This pattern, while mutually beneficial, has limited the depth of bilateral value chain integration.

In recent years, however, this structure is gradually evolving. SMEs are increasingly participating in cross-border trade, filling gaps in niche markets and contributing to the upgrading of bilateral economic cooperation. In Kazakhstan, SMEs already contribute over 30% of the national GDP and employ more than half of the country's workforce. However, their participation in international trade remains significantly limited. According to recent research, only around 10% of Kazakh SMEs are engaged in export activities, constrained by various internal and external barriers that prevent them from fully leveraging the opportunities brought by the BRI (Kapparov, 2021).

Unprecedented Opportunities for SMEs

The BRI framework has created unprecedented opportunities for SMEs in both countries to expand their cross-border business. First, improved cross-border connectivity has drastically reduced trade costs. Large-scale infrastructure projects, including the China-Kazakhstan international logistics corridors and the regular China-Europe freight train services, have shortened transit time by more than 50% compared to traditional routes and cut logistics expenses significantly. This has enabled SMEs, which are more sensitive to transportation costs, to access larger regional and European markets that were previously unreachable.

Second, the development of the Digital Silk Road opens new avenues for inclusive digital trade. Kazakhstan's ongoing push for digital economic transformation, supported by technological cooperation with China, allows SMEs to leverage cross-border e-commerce platforms to bypass traditional trade intermediaries. This allows small businesses to directly reach consumers and clients in both markets, significantly reducing entry barriers to international trade (Ambalov & Heim, 2022).

Third, deepening bilateral policy coordination has lowered institutional barriers. The two countries have implemented mutual tariff reductions, simplified cross-border customs procedures, and established mutual recognition of product standards. These measures have significantly reduced the compliance costs for SMEs, which often lack the resources to navigate complex international trade regulations.

Persistent Challenges and Constraints

Despite these promising opportunities, SMEs still face significant challenges in participating in bilateral economic cooperation. The most prominent barrier is limited access to affordable finance. As highlighted by Kapparov (2021), Kazakh SMEs in particular struggle to obtain sufficient credit, as local financial institutions are often reluctant to lend to small businesses due to high perceived risks and lack of sufficient collateral. This financing gap restricts their ability to expand production capacity, invest in technological upgrading, and explore new international markets.

Second, SMEs lack sufficient international market knowledge and internal managerial capabilities. Many small businesses, especially those in remote regions of both countries, have limited understanding of foreign market regulations, consumer preferences, and cross-border trade procedures. This information asymmetry significantly hinders their export competitiveness, preventing them from effectively adapting to the demands of the bilateral market (Zhang, 2024).

Third, institutional differences and remaining non-tariff barriers create additional frictions. Despite policy efforts, discrepancies in legal frameworks, business practices, and regulatory standards between the two countries still pose challenges for SMEs. Furthermore, technical barriers to trade, such as complex certification requirements, remain a major obstacle for small businesses that lack the resources to comply with these complicated procedures.

Policy Recommendations for Inclusive Growth

To unlock the full potential of SMEs in China-Kazakhstan economic cooperation, targeted joint efforts are required. First, there is an urgent need to develop inclusive SME financing mechanisms. Value chain financing, which links SMEs to larger core enterprises in bilateral supply chains, can effectively mitigate credit risks and improve small businesses' access to finance. Both governments should also support the development of specialized financial institutions and cross-border financial products tailored for SMEs.

Second, targeted capacity building programs are essential. Governments and trade support institutions should provide targeted training, consulting services, and market information services to help SMEs understand international market rules and enhance their internal managerial and innovation capabilities. This is critical for helping small businesses overcome their internal resource constraints and improve their export competitiveness.

Third, further policy coordination is needed to deepen trade facilitation. The two countries should continue to align their regulatory standards, simplify cross-border procedures, and address remaining non-tariff barriers, to create a more transparent, predictable, and SME-friendly business environment.

Conclusion

China-Kazakhstan economic cooperation under the BRI has entered a new phase of inclusive development, with SMEs playing an increasingly important role in driving sustainable and shared growth. While significant progress has been made, challenges

such as financing constraints, capacity gaps, and institutional barriers still need to be addressed. By leveraging the opportunities brought by the BRI, and through joint efforts from both governments and the private sector, SMEs can become the key driver for the next phase of bilateral economic cooperation, promoting economic diversification, job creation, and shared prosperity for both countries.

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CHINA-KAZAKHSTAN ECONOMIC COOPERATION UNDER THE BELT AND ROAD INITIATIVE: PROGRESS, CHALLENGES, AND PATHWAYS FORWARD

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Abstract. As the BRI's origin and core, Kazakhstan has strong geographic and resource synergy with China. Their cooperation in trade, energy, connectivity, digital economy, and finance is supported by policy alignment and infrastructure linkage.

Despite progress, challenges remain in trade patterns, connectivity, institutions, and external risks. Both sides should enhance strategic coordination, explore digital and green economies, and improve risk management for high-quality growth and regional stability.

Keywords: Belt and Road Initiative; Kazakhstan; China-Kazakhstan Cooperation; Economic Cooperation; Connectivity

Introduction

In September 2013，China proposed “Silk Road Economic Belt” to Kazakhstan which was a key country of BRI. Since they’re near each other, there’s been good money cooperation (Kazakhstan goods for China’s markets and tech), plus strong planning through Kazakhstan’s “Bright Road”, so both nations feel ready to work together [1]. In a worldwide situation of lackluster economies and geopolitical shifts, building up the two commercial link ups is still needed for all parties' prosperity, domestic peace, Eurasian unity [2].

Foundations and Framework of China-Kazakhstan Economic Cooperation

Policy coordination is anchored in the official comprehensive strategic partnership and the alignment between China's BRI and Kazakhstan's "Bright Road" initiative, guiding cooperation on infrastructure, industrial capacity, and trade. Economic complementarity—Kazakhstan's resources and China's capital, technology, and industry—has enabled sustained collaboration in energy, agriculture, digitalization, and more [3]. Institutionally, mechanisms such as the state coordination board, trade and finance sub-committees, and platforms like the SCO ensure effective coordination and regional integration [4].

Key Areas and Achievements under the BRI

China and Kazakhstan’s bilateral commerce is getting larger more quickly. For a long time, China has been the main business partner and largest export destination for Kazakhstan. The trade scene has moved from just energy-based to multifaceted and high-value type as well where there is rise in percentage of machinery & electronic items, textile articles and food items [5].

Table 1 China-Kazakhstan Bilateral Trade Volume 2019–2025 (Unit: USD 100 million)

Year	Bilateral Trade Volume	YoY Growth (%)
2019	212.3	13.5
2020	214.3	0.9
2021	326.5	52.4
2022	311.7	- 4.5
2023	410.2	31.6
2024	440.0	7.3
2025	487.0	11.0

Collaboration between the two sides went beyond just energy pipelines, also including clean energy cooperation which helped Kazakhstan make its ecological move, furthermore strengthened ties and the China - Europe rail service made it an important Eurasian transport hub.

Challenges in China-Kazakhstan Economic Cooperation

The commerce still relies on energies and material goods with few high margin or high tech products so it will remain vulnerable to the world's prices. Important harbors have little capacity, output; the cost goes up. Systemic and Regulatory Changes make trades harder, Geopolitical Transitions cause problems, Exchange Rate Volatility makes money fluctuate, and Nationalism brings trouble. The industrial convergence is still quite fragile; it puts too much emphasis on mining and production; we should also develop premium industries like styling, labeling, creativity, etc[6].

Countermeasures to Deepen Bilateral Economic Cooperation

Suggestion: Strengthening strategic coordination by strengthening the level of politics, making it easier to trade and flow capital by having simpler tariffs and clearer rules for opening up more markets, improving industrial and commercial structures with more high quality industries, improving connections and modernizing supply chain renovations with smart upgrades, enhancing monetary cooperation in cross-border transactions and regional clearings between each country, fostering areas like digital commerce, ai, ecoventures, carbon cutting, etc.

Conclusion

Through adjacency, synergy, and confidence, China Kazakhstan BRI cooperation has progressed significantly in trade, hydrocarbon and IT field. To address the problem of the collaborators need to raise their strategy and build more solid prosperity for everyone.

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Section 6. E-COMMERCE AND CROSS-BORDER TRADE IN THE CONTEXT OF DIGITALIZATION OF WORLD MARKETS

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CHINA'S DIGITAL TRADE GOVERNANCE IN CROSS-BORDER E-COMMERCE: SYNERGISTIC EFFECTS, CHALLENGES AND STRATEGIC PATHS

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Annotation

Against the backdrop of the accelerating digital transformation of the global economy, e-commerce and cross-border trade have become important engines driving international economic integration. As the world's second-largest digital economy, China occupies a key position in the global digital trade governance system. This paper systematically analyzes China's strategic positioning in cross-border e-commerce governance, focusing on the synergistic mechanism between digital economic development and cross-border logistics, the institutional challenges brought by different regulatory models (the United States, the European Union, and China), as well as the strategic opportunities provided by multilateral frameworks such as RCEP, the Digital Silk Road, and pilot programs for service trade innovation.

By comprehensively reviewing China's domestic legal system (Cybersecurity Law, Data Security Law, Personal Information Protection Law), international governance practices, and related empirical studies, this paper identifies the core tension between data localization and the free flow of cross-border data, along with possible paths for institutional coordination. The study shows that China can rely on its vast e-commerce scale, platform advantages, and technological innovation capabilities to promote the construction of more inclusive and interoperable cross-border data governance rules, strengthen the coordinated development of e-commerce and logistics, and facilitate the digital transformation of trade. Finally, this paper proposes policy recommendations to achieve a dynamic balance between security, development, and international cooperation in the digital era.

Keywords: digital trade governance; cross-border e-commerce; digital economy; data flow; logistics coordination; RCEP; Digital Silk Road; institutional competition

1. Introduction. Global digitalization is profoundly reshaping the landscape of e-commerce and cross-border trade, and digital governance has become a core issue in international economic relations. According to data from UNCTAD, global e-

commerce sales reached $27 trillion in 2022, with cross-border B2C maintaining double-digit growth [1]. As the second-largest digital economy, China accounts for more than half of global online retail sales, and its influence in shaping digital trade rules continues to increase, attracting widespread attention.

Currently, global digital trade governance is highly fragmented, forming three differentiated regulatory paradigms in the United States, the European Union, and China [2]: the United States emphasizes free data flow and enterprise-led innovation; the European Union strengthens personal data protection with GDPR at its core; China adheres to a security-oriented approach, balancing national security, public interest, and economic development [3].

Based on this, this paper focuses on three core questions: How does China's digital economic development affect the coordination between cross-border e-commerce and logistics? What institutional challenges arise when aligning with global digital trade rules? And through what paths can an inclusive and secure cross-border digital trade system be constructed? The following sections combine theoretical and empirical analysis to examine China's evolving role in global digital trade governance.

2. Digital Economy: The Core Driver of E-commerce and Logistics Coordination. Our study finds that the digital economy is the core driving force behind the coordination between cross-border e-commerce and logistics, functioning at three levels: First, digital platforms and infrastructure reduce transaction costs and promote information sharing and resource integration, representing the direct effect; second, digitalization fosters new business models such as cross-border livestream e-commerce and intelligent warehousing, optimizing supply chain efficiency, representing the indirect effect; third, there exists a threshold effect—when the level of development exceeds 0.204, the synergistic effect significantly increases [3][4][5].

Empirical research by Jin Zichen further verifies that the digital economy promotes coordination through the mediating role of innovation capability, and trade facilitation—especially improvements in the regulatory environment—has a significant positive impact on cross-border e-commerce exports, indicating that digital upgrading and institutional optimization are the two key drivers [4].

3. China's Digital Governance Framework and Its Impact. Since 2017, China has gradually established a digital governance system centered on the Cybersecurity Law, Data Security Law, and Personal Information Protection Law. This system imposes data localization requirements on critical information infrastructure and regulates cross-border data flows through security assessments and standard contracts. For cross-border e-commerce platforms (such as Alibaba, JD.com, Shein, and Temu), this framework increases compliance costs related to data flows, particularly in real-time inventory management, user behavior analysis, and cross-border payments. Meanwhile, some countries view data localization as a form of hidden trade barrier.

However, this governance system also has positive effects: it enhances data

security and consumer protection, thereby improving transaction trust. In addition, China's continued investment in infrastructure such as 5G, data centers, and the industrial internet provides strong support for the development of digital trade. Studies show that digital trade significantly promotes high-quality regional economic development through technological progress and resource optimization and exhibits spatial spillover effects [6].

4. Institutional Competition and Global Governance Landscape. Research indicates that global digital trade governance has formed three mainstream models: the United States emphasizes free data flow and minimal regulation; the European Union highlights privacy protection centered on GDPR; China adopts a security-oriented approach while balancing development. These models exhibit clear institutional incompatibilities [2].

For example, cross-border transactions involving Chinese sellers, European consumers, and U.S. cloud services may be subject to regulations from all three jurisdictions, potentially leading to regulatory conflicts. This significantly increases compliance costs and operational uncertainty, particularly for small and medium-sized enterprises.

5. Strategic Opportunities: Multilateral Frameworks and Institutional Innovation. Despite the current obstacles in cross-border governance, China still possesses multiple unique strategic opportunities. As the first regional digital trade framework joined by China, RCEP has made substantial progress in cross-border data flow and rule coordination, while retaining public policy exception clauses that allow flexibility for future adaptation (RCEP Agreement, 2020 [5]). The Digital Silk Road, through the development of digital infrastructure such as data centers, submarine cables, and smart ports, directly reduces operational costs for cross-border e-commerce and enhances regional connectivity. In the long run, it may also serve as a platform for regional data governance cooperation.

6. Challenges and Strategic Paths. China still faces several challenges in participating in global digital trade governance: at the core level, there are three major challenges—lack of institutional transparency leading to a trust deficit, differences in regulatory rules across countries causing cross-border compatibility issues and increasing geopolitical tensions resulting in governance fragmentation and risks of technological decoupling. At the practical level, there are also issues such as high cross-border logistics costs, homogeneous competition among exported products, and a shortage of interdisciplinary professionals.

In response, this paper proposes several strategies: in terms of rule alignment, China can start with low-sensitivity areas to promote mutual recognition of data rules with the EU and ASEAN, while actively aligning with high-standard digital trade agreements such as CPTPP and DEPA and exploring regional data cooperation mechanisms through multilateral frameworks like BRICS and SCO. Domestically, efforts should be made to enhance regulatory transparency by regularly publishing rule assessment summaries and establishing cross-border dispute resolution

mechanisms, while continuing to improve digital technology and logistics infrastructure and cultivating interdisciplinary talent.

7. Conclusion. In the context of global digitalization, China's strategic approach to cross-border e-commerce and digital trade governance demonstrates both defensive and proactive characteristics: it safeguards security while forming a governance model distinct from the West, and actively promotes practical and replicable governance solutions through initiatives such as RCEP, the Digital Silk Road, and domestic pilot programs.

Empirical studies show that the development of the digital economy and improvements in trade facilitation have significantly promoted the coordination between e-commerce and cross-border logistics [1]. If China can better balance security and openness, it has the potential to play a more central role in promoting a more inclusive and coordinated global digital trade governance system [4].

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E-COMMERCE AND CROSS-BORDER TRADE IN THE CONTEXT OF GLOBAL MARKET DIGITALIZATION: HUAWEI'S ENABLING PRACTICES AND STRATEGIC INSIGHTS

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Annotation.

The global market digitalization wave is profoundly reshaping international trade at an unprecedented depth and breadth. As a leading global ICT infrastructure and smart device provider, Huawei serves not only as a deep participant in this transformation but also as a critical enabler and driver. From Huawei's strategic perspective, this paper systematically analyzes its multi-dimensional enabling practices in the digitalization of global e-commerce and cross-border trade. The study finds that Huawei addresses core challenges faced by Chinese enterprises going global — including compliance, branding, logistics, payment, and talent — through building a 'Global One Network' cloud infrastructure, launching the all-in-one 'Kaitian' cross-border platform, deepening fintech applications, and establishing an open collaborative digital foundation via the HarmonyOS ecosystem. Huawei's practices demonstrate that the future of global digital trade competition fundamentally rests on integrated capabilities in technology, ecosystems, and localization. This paper further explores Huawei's strategic布局 in frontier computing (e.g., ternary computing, quantum computing) and next-generation mobile payments (e.g., 4X Wallet), laying a new technological paradigm for cross-border trade. Finally, it summarizes Huawei's strategic approach — driven by the philosophy of 'Everything as a Service' and achieved through government-enterprise collaboration and ecosystem aggregation — to promote high-quality development of global digital trade.

Keywords: global market digitalization, e-commerce, cross-border trade, Huawei Cloud, HarmonyOS ecosystem, fintech, digital foundation

1. Introduction

New Global Trade Propositions and Huawei's Enabling Role in the Digital Era

Global trade is currently undergoing a profound transformation from traditional goods exchange to digital value flows. Cross-border e-commerce has evolved from a 'new business format' into 'new normal' in foreign trade, yet its development has entered 'deep waters' characterized by branding, ecosystem integration, and intellectualization. While Chinese enterprises expanding globally enjoy vast market opportunities, they simultaneously face unprecedented complex challenges: cross-cultural compliance risks, localization barriers, supply chain fragility, high cross-border payment costs, and shortages of global digital talent.

Against this backdrop, Huawei — leveraging over three decades of global operational experience, deep technological accumulation, and its 'Everything as a Service' strategic philosophy — positions itself not merely as a technology product supplier but as the 'Cloud Foundation' and 'Enabler' for enterprise digitalization and global expansion. Huawei's enabling system covers the full chain from underlying global cloud-network infrastructure and platform-based industry solutions to top-level ecosystem collaboration and talent development. This paper aims to deeply interpret how Huawei responds to the core propositions of global market digitalization through technological innovation and ecosystem building, providing

Chinese enterprise solutions and wisdom for the sustainable development of e-commerce and cross-border trade.

2. Foundation: Global Cloud-Network Infrastructure and All-in-One Platform — Building the 'Expressway' for Digital Expansion

The foundation of enterprise digital expansion lies in stable, efficient, and compliant global ICT infrastructure, and Huawei's布局 in this domain constitutes the fundamental basis of its enabling capability.

2.1 'Global One Network' Cloud Infrastructure

Huawei Cloud has built a globally extensive, unified-architecture cloud infrastructure network. This enables even business operations serving users on the opposite side of the globe — such as South American customers — to achieve smooth consultation, ordering, and payment experiences comparable to local access. Such distributed deployment capability serves as the physical foundation supporting the real-time 'buying globally, selling globally' nature of digital trade.

2.2 'Kaitian' Cross-Border Platform: Full-Chain All-in-One Services

Addressing the complex challenges faced by enterprises going global, Huawei Cloud launched the 'Kaitian Cross-Border Platform.' This platform integrates full-chain services including marketing, supply chain, logistics, payment, security compliance, intelligent operations, tariffs, and talent development. It is not a simple tool aggregation but deeply integrates Huawei's rule understanding and localization experience accumulated through its globalization process. For example, the platform helps enterprises navigate tariff categories, customs clearance rules, and other details across different countries, avoiding losses caused by unfamiliarity with local regulations. Through cooperation with local governments (e.g., partnering with the Dongguan Bureau of Commerce to build a new model for cross-border e-commerce clustering), Huawei combines platform capabilities with local industrial policies, forming a comprehensive hub of 'capability center, service center, and ecosystem center,' driving high-quality regional cross-border industry development from point to surface.

3. Core: Technology Enablement and Ecosystem Collaboration — Solving Localization and Operational Challenges

Building upon its infrastructure, Huawei directly addresses the operational pain points of globalizing enterprises through specific technological solutions and ecosystem models.

3.1 Digital Marketing and Brand Building

Targeting enterprises with insufficient overseas brand influence and low online conversion rates, Huawei Cloud provides customized marketing solutions. For instance, for Guangdong Bangze Co., Huawei Cloud built a user-centric brand-independent website and leveraged professional social media exposure and KOL marketing matrices for precise operations, significantly enhancing its overseas brand image and customer loyalty. Underlying this is Huawei's deep insight into media ecosystems and consumer behaviors across different global markets.

3.2 Intelligent Supply Chain and Logistics

The competitiveness of cross-border trade largely depends on supply chain efficiency and resilience. Huawei's solutions utilize AI and big data capabilities to help enterprises rapidly plan optimal warehousing and transportation routes, ensuring supply chain reliability. At a broader level, Huawei's own global supply chain management experience is also provided as solutions to partners, enhancing their ability to navigate complex international logistics environments.

3.3 Ecosystem Aggregation and Talent Development

Huawei deeply recognizes that digital global expansion cannot be achieved by a single enterprise. Therefore, it actively builds and integrates into ecosystem systems. On one hand, it leads or participates in establishing cross-border industry alliances, aiming to connect innovation, industry, talent, and capital chains, enhancing overall industry risk resilience. On the other hand, through the Huawei Cloud Developer Alliance and Cloud Store, it provides global distribution and monetization platforms for software and service partners, helping Chinese digital solutions — such as those for government affairs, finance, and retail — go global. Addressing the talent shortage in cross-border operations, Huawei offers professional cross-border e-commerce courses to enhance teams' digital and intelligent capabilities.

4. Frontier: Fintech and Foundational Software Innovation — Defining New Trade Paradigms

Huawei's enabling efforts not only focus on solving current challenges but also布局 at the frontier to shape the future forms of digital trade.

4.1 Fintech-Driven Payment and Settlement Innovation

Cross-border payment is a key bottleneck in trade digitalization. Huawei's continuous fintech investments — including the upgraded '4X Wallet' — demonstrate future directions: integrated security chips and distributed storage technology ensure transaction security; intelligent risk control systems (e.g., the 'Tianqiong' model) achieve efficient risk interception; most importantly, direct connections with international clearing systems such as SWIFT and CIPS build multi-currency aggregated payment and efficient clearing channels, aiming to compress cross-border payment fees to near-zero levels and achieve 'second-level' fund arrival. This is consistent with Huawei's cross-border financial service upgrade solutions for ICBC Asia — based on video customer service and secure cloud desktops — collectively pointing toward a safer, more convenient, and cost-effective cross-border financial future (Table 1).

Fintech Solution	Core Capability	Cross-Border Application	Client Example
4X Wallet	Integrated security chip + distributed storage	Multi-currency, near-zero fee, second-level settlement	Individual end users

Tianqiong Risk Model	AI-powered intelligent risk control	Real-time fraud detection for cross-border payments	Financial institutions
Video Customer Service	Secure cloud desktop + HD video	Cross-border account opening and consultation	ICBC Asia
SWIFT/CIPS Direct Connect	Multi-currency aggregated clearing channel	Efficient international fund transfer	Trade enterprises

4.2 HarmonyOS Ecosystem: Building a Self-Controlled Digital Foundation

The operating system is the cornerstone of the digital ecosystem. Through the 'Industry Showroom' model, Huawei's HarmonyOS is rapidly advancing digitalization across government affairs, finance, and healthcare. For example, after Guizhou's 'Duocai Bao' APP accessed the HarmonyOS government affairs showroom, development efficiency improved by 50%, and the intent framework enabled an innovative 'service finding the user' experience. For cross-border trade, a self-controlled, cross-device, unified-experience underlying OS ecosystem means deeper device collaboration capabilities (e.g., wearable devices, in-vehicle systems linked with payments) and greater initiative in ecosystem development, reducing dependence on single external technologies.

4.3 Frontier Computing Exploration: Injecting Long-Term Momentum into Digital Trade

Huawei's foundational innovations in computing — such as ternary computing and quantum computing — though seemingly distant, concern long-term competitiveness. Ternary computing's substantial energy efficiency advantage can provide green, efficient computing power for processing massive volumes of global trade data in future data centers. Breakthroughs in quantum computing may bring revolutionary changes in complex scenarios related to cross-border trade, such as supply chain optimization, cryptographic security, and drug discovery. These frontier布局 demonstrate Huawei's strategic resolve to drive long-term industry development through basic research.

5. Strategy and Insights: 'Finding Technology for Scenarios' and Value Symbiosis

Examining Huawei's enabling practices, its core strategy can be summarized in two points: 'Finding Technology for Scenarios' and 'Building a Value Symbiosis Ecosystem.'

5.1 The Pragmatic Philosophy of 'Finding Technology for Scenarios'

The core strategy of Huawei's enterprise business is 'finding technology for scenarios.' This means its technology R&D and innovation always orient toward solving pain points in customers' specific business scenarios. Whether resolving Bangze's brand localization challenges or upgrading ICBC Asia's cross-border video

customer service — these are not technological showcases but 'precise cures' for specific scenarios. This scenario-driven, multi-technology collaborative model (connectivity, computing, cloud) ensures that technology investments genuinely translate into commercial value.

5.2 Building a Value Symbiosis Digital Ecosystem

Huawei firmly believes that no single enterprise can 'monopolize' the vast digital transformation market. Therefore, its goal is to 'aggregate, develop, and prosper the ecosystem.' Through OpenLab joint innovation, Huawei Cloud Store distribution, and industry alliance co-building, Huawei opens its technology foundation capabilities to countless partners (developers, software vendors, integrators, sales partners), jointly serving end customers. This 'being integrated' ecosystem strategy enables Huawei to leverage industry forces far beyond its own boundaries, together expanding the 'cake' of digital trade.

6. Conclusion

In the irreversible tide of global market digitalization, the evolution path of e-commerce and cross-border trade is becoming increasingly clear: it will be an integrated complex of globalized infrastructure, localized operations, intelligent technology, and collaborative ecosystems. Huawei's practices provide a comprehensive enabling blueprint: building on global cloud networks as the foundation, one-stop platforms as bridges, fintech and operating systems as wings, and open ecosystems as the soul.

The insight is that future cross-border competition will increasingly depend on the integrated digital competitiveness provided by enabling partners like Huawei. For enterprises intending to go global, collaborating with platform-level partners possessing global vision, technological depth, and ecosystem breadth — systematically building their own digital capabilities rather than relying solely on point solutions — will become the key to achieving steady growth and sustained leadership in the 'post cross-border e-commerce era.' Huawei's journey demonstrates that through technology for good and ecosystem co-prosperity, Chinese technology enterprises can not only serve the upgrade of global digital trade but also play the pivotal role of defining future rules within it.

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CROSS-BORDER PAYMENT INNOVATION: BLOCKCHAIN EMPOWERING SUPPLY CHAIN FINANCE ON THE NEW SILK ROAD

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Annotation

With the in-depth advancement of the Belt and Road Initiative, the scale of cross-border trade along the New Silk Road has continued to expand. However, the traditional cross-border payment system has long been plagued by pain points such as long settlement cycles, high transaction costs, and information asymmetry. Employing literature research, case analysis, and mechanism analysis, this paper systematically constructs a "data layer-process layer-institution layer" three-layer penetrative analytical framework for blockchain-empowered cross-border payments. The study finds that blockchain technology compresses cross-border payment settlement time from an average of 72 hours to 2 hours, reduces comprehensive costs by 67%, decreases the information error rate by 92%, and facilitates a paradigm shift in credit from "entity credit" to "transaction credit." This paper proposes a "technology empowerment-regulatory synergy" dual-wheel drive model and a three-dimensional optimization path of "efficiency-security-inclusiveness," thereby providing theoretical support and policy references for cross-border financial innovation along the New Silk Road.

Keywords: Cross-border payment; Blockchain; Supply chain finance; New Silk Road; Central Bank Digital Currency

Introduction

Since the proposition of the Belt and Road Initiative, the scale of cross-border trade along the New Silk Road has achieved rapid growth. According to statistics from the General Administration of Customs of China, the total volume of goods trade between China and countries along the Belt and Road reached 20.28 trillion RMB in 2024, accounting for 50.4% of China's total goods trade. According to the 2025 report by the Bank for International Settlements (BIS), the global cross-border payment market size has reached 158.3 trillion US dollars, yet traditional cross-border payments still face structural dilemmas, including an average settlement cycle of 3 to 5 days and comprehensive costs as high as over 12%. A World Bank report points out that the potential financing demand of global micro, small, and medium-sized enterprises (MSMEs) reaches 4.4 trillion US dollars, while the supply is merely 2.5 trillion US dollars, resulting in a financing gap ratio as high as 43.18%. Relying on core characteristics such as decentralization, immutability, and traceability, blockchain technology provides a novel technological pathway to address the aforementioned pain points.

Existing literature mainly focuses on three directions: first, the information asymmetry and credit risk issues in cross-border supply chain finance, with Song Hua and Lu Qiang (2017) proposing supply chain finance model innovation based on virtual industrial clusters; second, the application research of blockchain technology in the financial sector, where Tapscott and Tapscott (2016) systematically elaborated on the potential of blockchain in reshaping financial businesses; third, research on cross-border payments on the New Silk Road, where the Digital Currency Research Institute of the People's Bank of China (2020) put forward framework-level reflections on the development and management of blockchain technology. Overall, existing research exhibits three major limitations: emphasizing technical descriptions over mechanism analysis, prioritizing case accumulation over theoretical elevation, and focusing on efficiency improvement while neglecting risk control. The innovations of this paper lie in: constructing the "three-layer penetrative" mechanism of blockchain empowering cross-border payments, designing a "regulatory sandbox + cross-border collaboration" dual-track regulatory framework, and proposing a three-dimensional optimization path of "efficiency-security-inclusiveness."

Core Concepts and Theoretical Foundations

The New Silk Road refers to the cross-border economic cooperation network guided by the Belt and Road Initiative, covering six major economic corridors and involving more than 60 countries and regions. Cross-border supply chain finance refers to financial activities in cross-border trade scenarios that, based on the authentic trade background along the supply chain, provide financing, credit guarantees, and risk management services for upstream and downstream enterprises. Blockchain-based cross-border payment refers to a novel payment system based on Distributed Ledger Technology (DLT) that achieves instant clearing of funds, full-process traceability of information, and intelligent risk control in cross-border trade scenarios.

This paper integrates four major theories to construct a "technology-institution synergistic evolution" analytical framework. Supply chain finance theory emphasizes the role of information sharing and credit transmission in alleviating financing constraints; transaction cost theory reveals the structural sources of search costs, negotiation costs, and execution costs in cross-border payments; information asymmetry theory explains the adverse selection and credit deficiency caused by information disparities in cross-border trade, and the immutability and traceability of blockchain precisely compensate for this defect; technology empowerment innovation theory emphasizes the dynamic synergy between technological change and institutional evolution, providing a theoretical perspective for understanding the adaptability between blockchain and cross-border regulatory systems.

Current Status of Supply Chain Finance and Cross-Border Payments on the New Silk Road

The current global cross-border payment market presents a pattern of "one superpower dominating, with multiple players advancing." According to the SWIFT 2025 Annual Report, the SWIFT system occupies a 63.2% market share in global cross-border payment message transmission; the amount processed by CIPS reached 168.5 trillion RMB, with its market share increasing to 8.7%; the processing scale of mBridge reached 8.2 trillion RMB, accounting for 3.1%. The growth rates of CIPS and mBridge are significantly higher than that of SWIFT, indicating that blockchain infrastructure is reshaping the competitive landscape of global cross-border payments (see Figure 1).

Figure 1 Processing Scale Trends of Major Global Cross-Border Payment Systems (2020-2025)

There are significant differences in financial infrastructure, digitalization levels, and regulatory maturity among various regions along the New Silk Road. The Southeast Asian region leads in blockchain penetration due to its higher digitalization level and trade activity; the Central Asian region has relatively weak financial infrastructure but high trade activity; the Central and Eastern European region features high regulatory maturity but low blockchain penetration (see Figure 2).

Figure 2 Comparison of Cross-Border Financial Development Levels in Three Major Regions of the New Silk Road

Existing Problems in Traditional Cross-Border Supply Chain Finance

Traditional cross-border supply chain finance faces structural dilemmas across five dimensions. At the payment level, relying on SWIFT message transmission and multi-tier intermediary bank clearing, the average settlement cycle is 3 to 5 days, and cost losses caused by exchange rate fluctuations and liquidity lock-up account for approximately 2% to 3% of the total transaction value. At the financing level, based on the entity credit of core enterprises, credit transmission is usually limited to first-tier suppliers, making it difficult for second- and third-tier small and medium-sized enterprises to access financing services. At the risk control level, compliance audit costs for anti-money laundering (AML) account for 15% to 20% of the total cross-

border payment costs, and cross-border recourse mechanisms are lacking. At the regulatory level, regulatory standards across different jurisdictions are inconsistent, and compliance agreements lack cross-border enforceability. At the information level, data silos among participating entities are severe, document verification costs are high, and the information re-entry rate exceeds 30%.

The Mechanism of Blockchain Empowering Cross-Border Payments and Supply Chain Finance

This paper constructs a "three-layer penetrative" mechanism framework for blockchain-empowered cross-border payments (see Figure 3). The data layer uses distributed ledgers and cryptographic consensus as the technological base to achieve multi-node co-evidencing, immutable transaction records, and full-process traceability; the process layer uses smart contracts as the core tool to achieve multi-level credit penetration, condition-triggered automatic clearing, and real-time verification of trade backgrounds, shifting "entity credit" to "transaction credit"; the institutional layer uses regulatory sandboxes, cross-border standard mutual recognition, and RegTech intelligent compliance as guarantees to achieve a unified balance of efficiency enhancement, risk controllability, and inclusive development.

Figure 3 The "Three-Layer Penetrative" Mechanism Framework of Blockchain Empowering Cross-Border Payments

Specifically, blockchain reconstructs the cross-border payment system through seven core empowering pathways: immutability renders transaction records credible, reducing verification costs; smart contracts enable condition-triggered automatic execution, compressing settlement time; distributed ledgers break down data silos, realizing full-chain data sharing in the supply chain; cryptographic algorithms and zero-knowledge proofs achieve "data available but not visible," balancing data sharing with privacy protection; decentralized architecture eliminates intermediary links, lowering transaction costs; programmable digital currencies provide a novel clearing medium for cross-border payments; and compliance node built-in mechanisms encode AML and Counter-Terrorism Financing (CTF) requirements into smart contract rules, automating compliance audits.

Application Scenarios and Case Analysis

The Multi-CBDC Bridge (mBridge) project is a cross-border payment innovation project jointly initiated by the BIS and the central banks of China, Thailand, the United Arab Emirates, Saudi Arabia, and other countries. According to the BIS 2025 report, mBridge has completed over 160 cross-border payment transactions with a total value exceeding 22 million US dollars, shortening the average settlement time from the traditional 3 to 5 days to the second level, and reducing transaction costs by over 50%. The "Digital Bill of Lading + Smart Contract" pilot for the China-Europe Freight Train converted traditional paper bills of lading into blockchain digital bills of lading, using smart contracts to automatically trigger payment upon cargo arrival. This achieved the integration of logistics, information flow, and capital flow, compressing the settlement time per transaction

from 72 hours to 2 hours, reducing document processing costs by 67%, and decreasing the information error rate by 92%.

Synthesizing the above cases and industry data, the blockchain model has achieved significant improvements in all core indicators of cross-border payments (see Figure 4). The settlement time was compressed from 72 hours to 2 hours, a compression rate of 97.2%; comprehensive costs decreased from 12.5% to 4.1%, a reduction of 67.2%; the information error rate dropped from 8.3% to 0.7%; the credit penetration level increased from 1 tier to 4 tiers; and the compliance audit time was shortened from 5 days to 1 day.

Figure 4 Efficiency Comparison of Cross-Border Payments between Traditional and Blockchain Models

Optimization Paths and Development Countermeasures

Based on the preceding analysis, this paper proposes optimization paths from five dimensions. At the technological level, it is imperative to accelerate the formulation of cross-chain interoperability standards and promote the deep integration of privacy computing technologies, such as zero-knowledge proofs and federated learning, with blockchain. At the model level, a "core enterprise + platform + MSMEs" supply chain finance ecosystem should be constructed to lower the entry threshold for SMEs through platform-based operations. At the enterprise level, a digital capability evaluation system must be established, and the echelon construction of compound talents in blockchain and finance should be strengthened. At the regulatory level, the application of RegTech should be promoted, cross-border regulatory agreements and standard mutual recognition mechanisms should be established, and a "regulatory sandbox + cross-border collaboration" dual-track regulatory framework should be explored. At the synergy level, the establishment of a Digital Silk Road governance alliance should be promoted to facilitate deep collaboration among countries along the route in technological standards, regulatory rules, and data governance.

Conclusions and Prospects

This paper draws the following core conclusions: First, by reconstructing the trust mechanism, blockchain technology shifts cross-border payments from "institutional trust" to "technological trust," fundamentally resolving the information asymmetry problem in cross-border trade. Second, the "three-layer penetrative" mechanism effectively explains the internal logic of blockchain empowering cross-border payments. Third, empirical data indicates that the blockchain model has achieved significant improvements in settlement time, transaction costs, and information accuracy. Fourth, the "technology empowerment-regulatory synergy" dual-wheel drive model is the key path to achieving the sustainable development of cross-border financial innovation.

This study still has certain limitations: the availability of macro data is restricted, and some indicators rely on industry reports and case data; blockchain technology is evolving rapidly, and the timeliness of the research conclusions

requires continuous tracking; the impact of geopolitical risks on cross-border financial cooperation has not been fully incorporated. Future research can combine frontier technologies such as quantum computing and AI large models to explore the trinity integrated development direction of "Blockchain + AI + CBDC," and construct quantitative evaluation models to conduct large-sample empirical studies.

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THR SUPPORTING ROLE OF SOFT DIGITAL INFRASTRUCTURE UNDER THE BELT AND ROAD FRAMEWORK FOR CHINA-KAZAKHSTAN DIGITAL ECONOMY COOPERATION

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Annotation. During the 15th Five-Year Plan period, the construction of Digital China has been further promoted, and the cooperation on the Sino-Kazakhstan

"Digital Silk Road" has entered a new stage. The connotation of digital infrastructure has shifted from the traditional form mainly focusing on hardware laying to the soft dimension with institutional rules, factor supply, and application ecology as the core. Based on the "5+3+1" data element development framework of the National Data Bureau, this paper defines the core connotation and hierarchical structure of soft digital infrastructure. Taking the complementary advantages of Sino-Kazakhstan digital economy cooperation as the basis, it selects two typical cases of cross-border e-commerce and smart energy to analyze the action mechanism of soft digital infrastructure supporting transnational cooperation. The research proposes an implementation path of constructing a cross-border trusted data space as the base, high-quality industry data sets as the core elements, and a normalized cooperation mechanism as the institutional guarantee, in order to provide theoretical support and practical reference for the digital transformation of the economic departments of China and Kazakhstan and the coordinated development of the regional digital economy.

Key words: Soft digital infrastructure; Digital Silk Road; China-Kazakhstan cooperation; High-quality datasets; Trusted data space; Data as a factor of production

In 2026, it is the 13th anniversary of the Belt and Road Initiative jointly built by China and Kazakhstan, and it is also a crucial period for Kazakhstan to implement the "Digital Kazakhstan 2030" strategy. When the hardware coverage rate of digital infrastructure reaches a certain threshold, the perfection degree of soft infrastructure becomes the core variable determining the effectiveness of digital transformation and the depth of international cooperation (Jiang, 2024). Under the framework of the 15th Five-Year Plan, China takes the market-oriented allocation of data elements as the core task and forms a construction path of soft digital infrastructure focusing on trusted data space and high-quality data sets.

The digital economy cooperation between China and Kazakhstan shows remarkable complementarity: Kazakhstan has a vast amount of raw data resources in energy, agriculture and other fields, but its data governance and processing capabilities are weak; China has accumulated mature experience in data system design, technology application and ecological construction (Cheng & Hu, 2025). This paper systematically constructs a theoretical analysis framework for soft digital infrastructure, explores its support mechanism in combination with typical cases, and puts forward targeted policy suggestions, providing new ideas for the construction of the Central Asian section of the "Digital Silk Road".

Soft digital infrastructure is a conceptual system relative to physical hardware such as 5G networks and data centers. Its core is the sum of the institutional rules, factor supply, and application service systems that support the full life cycle operation of data elements (National Data Bureau, 2024). According to the "5+3+1" development framework of the National Data Bureau, its core includes three dimensions:

The institutional rules dimension is the top-level core, covering institutional systems such as data property rights registration, circulation and transaction, security governance, and cross-border compliance. The "Data Property Rights Registration Work Guidelines (Trial)" issued by China provides an institutional basis for the confirmation of data element rights, and its experience can provide direct reference for cross-border data circulation between China and Kazakhstan.

The factor supply dimension is the value carrier, mainly including the construction of high-quality data sets, data annotation and processing, quality evaluation, and assetization operation. China has built more than 100,000 high-quality data sets, with a total volume of over 890 PB, forming a reproducible data element supply system (Lin et al., 2025).

The application service dimension is the implementation channel. With the trusted data space as the operating base, it supports the implementation of data development and utilization, model services, and industry solutions. The cooperation between China and Kazakhstan in cross-border e-commerce, smart energy and other fields is a typical manifestation of the application and empowerment of soft digital infrastructure.

In 2025, Kazakh President Tokayev proposed in his state of the nation address to build a "Digital Nation". China has carried out in-depth cooperation with Kazakhstan in digital infrastructure, digital technology, and digital trade, providing good conditions for Chinese enterprises to explore the Kazakh market. The governments of China and Kazakhstan have also signed a "Memorandum of Understanding on E-commerce Cooperation" to strengthen cooperation in the e-commerce field, but there are still cooperation issues in data sharing, personal privacy protection, etc. (Wu & Hu, 2025).

From the perspective of data elements, Kazakhstan is a major energy, agricultural, and trading country with a large amount of data resources, but its data cleaning, annotation, mining, and management are not perfect enough. China has great advantages in these aspects, and there is huge potential for cooperation in data between the two countries in the future. In July 2025, the Shanghai Data Exchange (SDE) and the Astana Data Exchange (ADX) signed a strategic cooperation agreement to build a Central Asian cross-border trusted data exchange platform in Kazakhstan, laying a good foundation for the subsequent construction of soft infrastructure between the two countries.

The cross-border e-commerce between China and Kazakhstan is a benchmark practice of soft digital infrastructure enabling trade facilitation. From January to July 2025, the cross-border e-commerce transaction volume at the Khorgos Port reached 29.148 billion yuan, a year-on-year increase of 814%, becoming the core engine driving bilateral trade (Beijing Securities Network, 2025). This achievement benefits from the in-depth cooperation between the two countries in the construction of soft facilities such as electronic ports, single windows, and digital authentication.

Specifically, the two sides have constructed a cross-border e-commerce data sharing mechanism to achieve the trusted exchange of transaction, logistics, and payment data. The electronic port system has compressed the customs clearance time from 3-5 days to within 24 hours. Kaspi.kz has achieved system docking with Alipay, opening up the bilateral electronic payment channel. The completion of the largest e-commerce logistics center in Central Asia has enabled the daily parcel processing capacity to exceed 1 million pieces. As of the first half of 2025, the number of participating merchants in cross-border e-commerce between China and Kazakhstan has increased by more than 120% compared with 2023, and the platform transaction volume has increased by 87% year-on-year.

This practice proves that soft digital infrastructure can effectively break through the rule barriers, data silos, and trust problems in cross-border trade. The standardized data governance process and cross-border compliance supervision mode formed provide a replicable "China-Kazakhstan model" for the countries along the "Belt and Road".

The smart energy cooperation between China and Kazakhstan has advanced from the early pipeline informatization construction to a new stage of large-scale promotion of "artificial intelligence + energy". In 2026, Kazakhstan has listed the "Year of Digitalization and Artificial Intelligence" as a national strategic priority, and the AI technology in the energy field has shifted from pilot to full deployment (Wang, K, 2026).

The Kazakhstan section of the Central Asia Gas Pipeline is a core cooperation project, with a total length of more than 1,300 kilometers. Since 2009, China and Kazakhstan have simultaneously constructed a digital management system. The project has built a unified SCADA data transmission standard and sharing mechanism, enabling the Beijing main control center to remotely monitor the pipeline in real-time. It has created a digital safety operation system empowered by AI, integrating intelligent security, intrusion detection, and emergency response systems. And a standardized joint operation and maintenance mode has been established, formulating a unified equipment management and fault troubleshooting process.

Moreover, China and Kazakhstan jointly promote three technical solutions including AI defect detection for transmission lines, robot internal inspection for heating pipelines, and intelligent gas metering, which has increased the energy equipment diagnosis efficiency and decreased the accident rate. In 2025, the two sides signed a memorandum of cooperation for the Energy Transition Joint Research Center to further deepen cooperation in the fields of energy digitalization standards and technologies. Rafik Tyrov (2026) pointed out: "Digital transformation is the only way to ensure national energy security, and the technical cooperation between China and Kazakhstan provides core support for the upgrading of Kazakhstan's energy system."

Based on the above analysis, the following policy recommendations are put forward:

First, jointly build a cross-border trusted data space between China and Kazakhstan. Based on the cooperation between the Shanghai-Astana data exchanges, establish a "regulatory sandbox" mechanism for cross-border data circulation, and give priority to conducting pilot projects in the three major fields of cross-border e-commerce, energy, and agriculture. Promote the mutual recognition of data property rights, circulation rules, and security standards between the two sides, and construct a cross-border data governance framework of "data available but not visible, and the use can be controlled and measured" to break through the compliance barriers of cross-border data flow.

Second, jointly create a high-quality industry dataset system. Focusing on the key cooperation areas between China and Kazakhstan, jointly formulate data standards and build a batch of high-quality datasets with bilateral mutual recognition. In the energy field, build oil and gas exploration and development and renewable energy databases; in the agricultural field, construct an agricultural product quality traceability and production data platform; in the trade field, improve the cross-border e-commerce and logistics datasets. Explore assetization models such as dataset pledge financing and contribution of datasets as capital and activate the value of data elements.

Third, improve the guarantee of the normalized cooperation mechanism. Establish a coordination mechanism for digital infrastructure cooperation between China and Kazakhstan, regularly hold ministerial meetings and working group meetings to promptly solve institutional obstacles and technical problems. Rely on platforms such as the Energy Transition Joint Research Center to strengthen joint research and development of digital technologies and standard setting. Carry out joint digital talent cultivation projects to provide intellectual support for the long-term cooperation between the two countries.

In the new stage of digital economy development, soft digital infrastructure has become the core force supporting transnational cooperation and industrial digital transformation. Through the "5+3+1" data element development framework, China has explored a path of soft digital infrastructure construction led by institutional rules, centered on factor supply, and oriented by application services. The successful practices of China and Kazakhstan in the fields of cross-border e-commerce and smart energy fully demonstrate the irreplaceable role of soft digital infrastructure in breaking through rule barriers, releasing factor value, and improving cooperation efficiency.

In the future, China and Kazakhstan should take the joint construction of a cross-border trusted data space as the core, deepen cooperation in areas such as high-quality data sets, digital governance, and talent cultivation, and jointly create a Central Asian model for the "Digital Silk Road". This cooperation model will not only promote the digital transformation of the economic sectors of the two countries, but also provide a replicable and promotable experience paradigm for China's digital economy cooperation with the Shanghai Cooperation Organization and countries

along the "Belt and Road", and contribute digital strength to building a closer community with a shared future.

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DIGITAL EMPOWERMENT AND GOVERNANCE COORDINATION: A STUDY ON THE HIGH-QUALITY DEVELOPMENT PATH OF CHINA–KAZAKHSTAN DIGITAL ECONOMY UNDER THE BELT AND ROAD INITIATIVE

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Annotation: Against the background of rapid global digital economy development and high-quality development of the Belt and Road Initiative, digital economy cooperation has become a key area for China-Kazakhstan strategic

partnership. This paper focuses on the current foundation, cooperation fields and practical achievements of China-Kazakhstan digital economy cooperation. It systematically analyzes major constraints including mismatched governance rules, insufficient data security coordination, unbalanced digital infrastructure, weak core technology collaboration, geopolitical pressures and digital talent shortage. On this basis, this paper proposes targeted pathways to advance high-quality development of bilateral digital economy cooperation. The research aims to provide a reference for deepening China-Kazakhstan digital cooperation, improving regional digital governance and supporting the high-quality development of the Belt and Road Initiative.
Keywords: Digital Empowerment; Governance Coordination; Digital Economy; Belt and Road Initiative; China-Kazakhstan Cooperation

The global digital economy is undergoing rapid expansion and rule restructuring. Digital technologies and artificial intelligence have become core drivers of economic growth and international cooperation. As the Jointly Built Belt and Road Initiative enters a high-quality development phase, the Digital Silk Road serves as a key platform for China's cooperation with countries along the routes. As a pivotal Central Asian hub and China's permanent comprehensive strategic partner, Kazakhstan aligns its digital transformation strategy with China's digital economy development, yielding huge cooperation potential in digital infrastructure, cross-border trade, AI and data governance. Empowering the Belt and Road Initiative with digital economy while enhancing digital governance and data security is critical to upgrading bilateral cooperation and advancing regional common development.

1 Background and Practical Foundation of China-Kazakhstan Digital Economy Cooperation

The global digital economy features a stable pattern led by the US, China and Europe with multi-tiered coordination[1]. China's digital economy added value is projected to reach 49 trillion RMB in 2025, accounting for about 35% of its GDP[2]. The Global Digital Economy Development Research Report (2025) by CAICT confirms the global digital economy as a major growth engine[3]. It is forecast to hit 24–27 trillion US dollars in 2025. Kazakhstan has designated 2026 as the Year of Digitalization and Artificial Intelligence, enacted the Digital Code and invested over 3 billion US dollars in digital transformation, forming strategic synergy with China's Digital Silk Road Initiative.

By the end of 2022, China signed 17 Digital Silk Road MoUs, 30 e-commerce cooperation MoUs and 18 digital economy investment MoUs with foreign partners. China and Kazakhstan inked a digital economy investment cooperation MoU in 2018. By 2025, the two countries had signed and upgraded digital economy and e-commerce bilateral MoUs, while digital investment cooperation relies on enterprise agreements and China-Central Asia multilateral mechanisms. The strategic alignment of the Digital Silk Road and Digital Kazakhstan underpins the high-quality development of digital economy under the Belt and Road Initiative.

China and Kazakhstan enjoy geographic proximity and economic complementarity. Their bilateral trade reached 48.7 billion US dollars in 2025, up 11% year on year, with digital economy as a new growth driver. Practical cooperation outcomes include the Khorgos Smart Port, 5G/6G construction, data exchange collaboration and AI pilot applications. The digital economy has become a key bond for the two countries' strategic partnership.

Meanwhile, global digital governance is fragmented into blocs. US-European digital trade barriers, cross-border data flow disputes and tech regulation gaps pose external challenges. Both countries face external pressure, incomplete domestic governance and rising data security risks, calling for coordinated efforts to balance digital development and security.

2 Digital Economy as a Core Part of China-Kazakhstan Cooperation under the Belt and Road Initiative

Digital economy and AI inject new momentum into China-Kazakhstan Belt and Road cooperation, covering industrial transformation, trade upgrading and sustainable development with replicable models[4].

Digital technologies and AI upgrade traditional industries in both countries. China's industrial internet and big data integrate with Kazakhstan's energy and agriculture sectors, improving efficiency via smart oilfields, precision agriculture and intelligent logistics. AI-optimized China-Europe Railway Express saw a 11.1% year-on-year growth in China-Kazakhstan rail freight to 35.6 million tons in 2025.

Digitalization boosts cross-border trade facilitation. Digital ports, e-documentation and cross-border e-commerce cut trade costs. China-Kazakhstan digital trade rose 18.3% year on year in 2025[5]. AI cooperation in smart cities, low-carbon development and public services fits Kazakhstan's national strategy and supports the dual carbon goals. Digital finance cooperation ensures stable bilateral economic and trade exchanges.

Digital economy and AI are not only technical tools but also core engines reshaping China-Kazakhstan cooperation and sustaining the high-quality development of the Belt and Road Initiative.

3 Core Challenges of China-Kazakhstan Digital Economy Cooperation

Rapid as it is, China-Kazakhstan digital cooperation faces deep-seated constraints in governance, security and capacity, hindering further upgrading.

3.1 Misaligned Digital Governance Rules and Legal Systems

Kazakhstan's Digital Code and Artificial Intelligence Law lack supporting rules, while China has a complete digital legal system. The two countries have no unified standards for data classification, cross-border flow, electronic certification and AI ethics. Kazakhstan's personal data localization requirement raises compliance costs for enterprises. No dedicated bilateral digital governance agreement exists, with cooperation only based on multilateral initiatives[6].

3.2 Absent Data Security Coordination and Cross-border Flow Mechanism

Data security cooperation remains at the initiative level without implementation mechanisms. No bilateral agreement on data security and cross-border flow has been signed, leaving critical data exit review, cyber threat intelligence sharing, and critical information infrastructure protection uncoordinated. Cyber risks threaten key cooperation projects, and the conflict between data sovereignty and circulation efficiency becomes a major bottleneck.

3.3 Structural Imbalance in Digital Infrastructure and Computing Power

Kazakhstan suffers a marked regional digital divide, with insufficient rural network coverage and limited computing power facilities[7]. Cross-border digital channels are underdeveloped, failing to support large-scale industrial digitalization and cross-border digital trade.

3.4 Weak Core Technology Collaboration and Industrial Integration

Cooperation focuses on application scenarios, lacking joint research on underlying core technologies. Both countries rely on external supplies for high-end chips, basic industrial software and core algorithms. Digitalization of Kazakhstan's traditional industries stays at the pilot stage, with low SME penetration and weak integration of digital and real economies.

3.5 Geopolitical Pressure and Limited Global Digital Governance Voice

Bloc-based global digital governance, US-European trade barriers and tech export controls restrict bilateral digital investment and supply chain cooperation[8]. China and Kazakhstan lack sufficient voice in the formulation of global digital rules, and can only passively adapt to external rules with limited cooperation autonomy.

3.6 Digital Talent Shortage and Missing Joint Training Mechanism

Kazakhstan faces a serious shortage of high-end digital and AI talents. No normalized joint training, internship or talent mobility mechanism is established between the two countries, which restricts the long-term sustainable development of cooperation.

4 Suggestions for Promoting the High-Quality Development of China-Kazakhstan Digital Economy Cooperation

Guided by the idea of small-entry breakthroughs and big-theme leadership, five practical suggestions are put forward:

First, establish a bilateral digital governance coordination mechanism. Sign a bilateral digital economy and data governance agreement, unify standards for data classification, cross-border flow and security review, connect with the China + Central Asia Five Countries Data Security Cooperation Initiative, and enhance the two countries' voice in global digital governance.

Second, strengthen data security and digital supervision cooperation. Jointly build a China-Kazakhstan Digital Security Joint Protection Center, share cyber threat intelligence, and combat cybercrime and data leakage; establish a data security certification system to protect personal information and key data, and consolidate the security bottom line of digital cooperation.

Third, promote collaborative innovation of digital infrastructure and artificial intelligence. Accelerate the construction of 5G/6G, computing power centers and Beidou Navigation application bases; set up a China-Kazakhstan Artificial Intelligence Joint Laboratory, and build a digital skills training platform to solve the talent shortage.

Fourth, deepen the integration of digital industry and cross-border trade. Build a China-Kazakhstan Digital Industry Demonstration Zone, upgrade the full-process digitalization of smart ports, and build a Central Asia-China data circulation hub to release the value of data elements.

Fifth, build a regional model for China-Kazakhstan digital cooperation. Take China-Kazakhstan cooperation as the fulcrum to radiate to Central Asian countries, form a replicable Digital Silk Road cooperation model, and support the high-quality development of the digital economy under the Belt and Road Initiative.

The digital economy is a historic opportunity, and digital governance is the core guarantee. With digital empowerment as the engine, governance coordination as the support and data security as the bottom line, China and Kazakhstan will deepen the cooperation under the Jointly Built Belt and Road Initiative, realize the digital transformation of bilateral economies and common regional development, and contribute to the improvement of the global digital governance system.

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DIGITAL TRANSFORMATION IN INTERNATIONAL MARKETS AND COMPETITIVENESS STRATEGIES

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Annotation. This article examines the impact of digital transformation on the competitiveness of international markets. Based on a literature review and analysis of current trends, the author examines the strategies companies are using to adapt to the digital economy. The results of the study allow us to draw conclusions about the importance of digital transformation for modern business processes and identify future development prospects.

Key words: digital transformation, competitiveness, international markets, strategies.

We are in the fourth industrial revolution driven by digital technologies. Big data, AI, IoT, and cloud computing are reshaping the global business landscape [1]. The digital economy has become a new engine of global growth, reconstructing global value chains and transforming international trade patterns. The COVID-19 pandemic has accelerated global digitalization, making digital transformation a compulsory choice for enterprise survival and development [2].

In international markets, traditional trade models face challenges, while cross-border e-commerce and digital service trade show strong resilience [3]. For Chinese enterprises, digital platforms lower barriers to global markets [4], but increasing complexity and uncertainty make traditional cost advantages unsustainable. Many enterprises only understand digital transformation as superficial technology application. This study focuses on how enterprises build core competitiveness through systematic digital transformation in turbulent international markets.

Research has shown that the digital maturity of enterprises is becoming a determining factor in their integration into global value chains. Companies that have mastered the principles of automation, real-time analytics, and platform integration demonstrate the ability to grow even amid global economic turbulence. In this context, digital transformation serves as a strategic alignment tool, enabling them to overcome structural and geographic limitations.

It has been found that successful digital transformation requires a comprehensive approach combining technological modernization, institutional change, and human capital development. In a highly uncertain environment, digital tools provide business flexibility, adaptability, and resilience. They enable the

development of management models capable of quickly responding to external challenges, thereby ensuring competitive advantages on the global stage.

Theoretical significance of the study:

1） Enrich international business theory by integrating digital transformation into the analytical framework of enterprise internationalization and competitiveness [5].

2） Deepen dynamic capability theory by revealing how digital transformation reshapes opportunity perception, value capture, and resource reorganization [6].

3） Construct a “technology–strategy–performance” linkage mechanism to provide an integrated theoretical model.

Practical Significance of the study:

1） Offer strategic roadmaps for multinational enterprises from emerging markets to optimize digital transformation.

2） Support policy-making for governments to promote digital globalization and new forms of digital trade.

3）Help enterprises identify digital opportunities and build sustainable competitive advantages in the VUCA era.

Foreign research defines digital transformation as a comprehensive reform of business processes, models, and organizations [7]. It focuses on digital platforms, transaction cost reduction, and new competitive advantages [8], but lacks systematic research on strategy types and mechanisms.

Domestic research focuses on manufacturing and cross-border e-commerce, with strong policy orientation linked to “Made in China 2025” and the “Digital Silk Road”. Empirical studies verify the positive correlation between digital investment and export performance, but lack theoretical originality and clear classification of strategic models.

Research Gaps:

- Insufficient empirical test on the mediating mechanism of dynamic capabilities;

- Lack of strategic management perspective matching external environment and internal resources;

- Absence of a systematic strategic framework for practice.

The increased openness and internationalization of China's economy is largely being implemented within the framework of the "dual circulation" strategy and the "One Belt, One Road" initiative. Advanced manufacturing and technology platforms are key areas for China's foreign direct investment abroad. If we rank the degree of internationalization of Chinese companies using the share of foreign revenue as an indicator, approximately 30% are only in the initial stage of internationalization, with their overseas sales accounting for no more than 10%. For 25-30% of companies, the share of foreign revenue is already in the range of 20-50%. The choice of geographic markets depends on the specifics of their industry: Chinese energy companies are

primarily targeting the markets of South Africa and Brazil, service and trading companies are targeting the European market, and internet companies and digital platforms prefer to expand into the regional market of Southeast Asia.

The international competitiveness of digital platforms is determined by their ability to scale, adapt to current realities, and create ecosystems that retain users across borders. The emergence and development of global digital platforms has been influenced by the following factors: the growth of e-commerce and online services, globalization and the need for cross-border communications and international transactions, the transition to digitalization in various industries and sectors, and consumers' desire for digital interaction.

In the digital economy, global platforms have become key drivers of economic growth and innovation. Their ability to dominate international markets is determined by a complex set of factors that go beyond traditional competitive advantages:

network effects, which create natural barriers to entry;

flexibility and adaptability enable platforms to optimize services, personalize experiences, and create new products;

ecosystem integration increases user loyalty and makes it more difficult for them to switch to competitors;

the creation of breakthrough technologies ensures a long-term competitive advantage;

adaptability to market regulation, compliance with local regulations, and geopolitical requirements are necessary when expanding into new foreign markets;

effective mechanisms for modernization, monetization, and resource allocation determine platform sustainability;

data security and protection from cyber threats.

Tencent is a notable representative of the Chinese market, with key advantages in the following areas:

a super app that integrates messaging, banking, gaming, and government services;

adapting to China's strict regulations (content censorship, data sharing with the government);

investing in global startups to expand influence abroad.

The competitiveness of digital platforms on the international stage depends on their rapid adaptation to local markets and their regulations (Tencent in China).

The sustainable competitiveness of global digital platforms will be determined not only by technological superiority but also by their ability to adapt to increasingly stringent global regulations.

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REGULATION OF CROSS-BORDER DATA FLOWS AND ITS IMPACT ON BELT AND ROAD INITIATIVE DIGITAL TRADE

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Annotation. This paper examines the regulation of cross-border data flows and its impact on digital trade within the Belt and Road Initiative (BRI). Cross-border data flows are considered a core infrastructure of digital trade, influencing payment systems, logistics, cloud services, and online platforms. The study argues that regulatory heterogeneity increases transaction costs, legal uncertainty, and barriers to market entry, particularly for SMEs. A risk-based regulatory model is proposed as the most efficient approach, balancing data security and trade openness. Using a conceptual framework supported by synthetic datasets, the paper demonstrates that interoperable and harmonized regulatory regimes improve trade efficiency, market access, and firm participation compared to fragmented or localization-heavy approaches.

Keywords: cross-border data flows; digital trade; Belt and Road Initiative; data regulation; interoperability

Cross-border data flows have become a core infrastructure of digital trade because payment verification, cloud storage, logistics management and online customer

service all depend on the movement of data across jurisdictions. For Belt and Road Initiative (BRI) economies, the policy problem is not whether data should be governed, but how it should be governed without destroying the scale advantages that make digital trade efficient. Recent scholarship links regulatory heterogeneity to rising transaction costs, legal uncertainty and weaker innovation incentives, while also recognizing that some degree of control is necessary for cybersecurity, privacy and public trust [1-3].

This paper argues that the most economically efficient support for BRI digital trade is a risk-based regulatory model that keeps sensitive datasets protected but allows ordinary commercial data to move through interoperable rules, contractual safeguards and mutual recognition arrangements. In contrast, broad localization mandates may increase formal control yet often duplicate servers, compliance teams and certification procedures, which is especially burdensome for small and medium-sized enterprises (SMEs). Because this conference paper is conceptual, Tables 1–3 and Figures 1–3 present an illustrative synthetic dataset designed to compare policy packages rather than official statistics.

Table 1. Core regulatory instruments

Instrument	Policy aim	Trade effect
Broad localization	Security control	High fixed cost
Transfer assessment	Accountability	Moderate cost
Trusted partner list	Interoperability	Lower delays
Sectoral exemption	Risk targeting	Limits spillovers

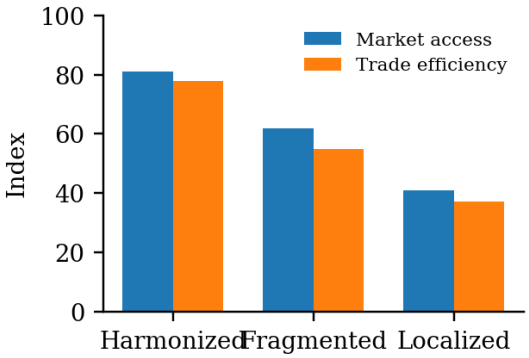

Figure 1. Market access and efficiency by regime

Table 1 summarizes the main regulatory instruments. The economically important distinction is between rules that create predictable compliance pathways and rules that create repeated market-by-market adaptation. When firms can standardize consent management, security auditing and dispute procedures, they spread fixed costs over a wider export base. Figure 1 shows that a harmonized regime delivers both stronger market access and better trade efficiency than a fragmented or localization-heavy alternative.

Table 2. Synthetic performance indices

Regime	Cost	Access	Efficiency
Harmonized	32	81	78
Fragmented	54	62	55
Localized	76	41	37

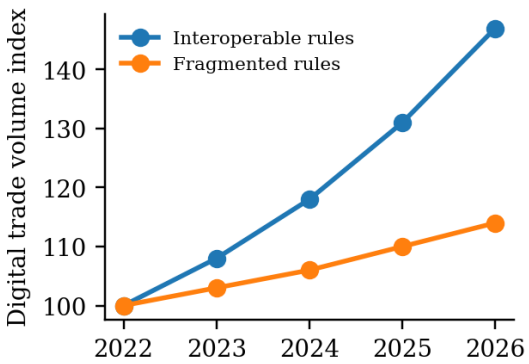

Figure 2. Digital trade volume under two rule sets

The simulated outcomes in Table 2 and Figure 2 reinforce this point. Under interoperable rules, digital trade volume rises faster because SMEs can enter new BRI markets without rebuilding their technical architecture for every jurisdiction. By contrast, fragmented regulation acts like a hidden tariff on data-intensive services: customs documents may still move, but software updates, targeted advertising, remote maintenance and platform analytics become slower and more expensive. This finding is consistent with the broader literature that links digital trade barriers to weaker expansion across BRI economies [4, 5].

Table 3. Illustrative policy scenarios

Scenario	Trade	Security	Verdict
Localization	-9.8%	High	Weak
Mutual recognition	+12.6%	Med.-high	Strong
Risk-based hybrid	+9.4%	High	Best balance

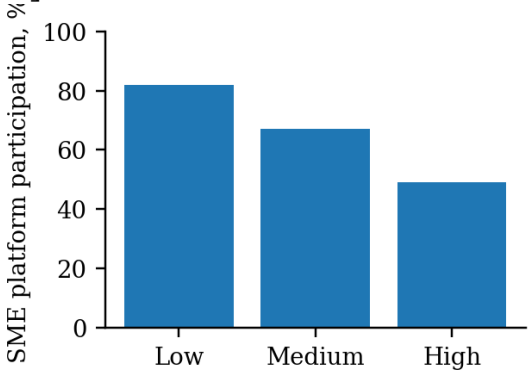

Figure 3. SME participation by compliance burden

A second economic channel concerns participation. Compliance burden does not affect all firms equally. Large platforms can absorb legal review, local hosting and multiple certifications, while SMEs usually face liquidity constraints and thinner margins. Figure 3 therefore reports a sharp decline in SME platform participation as compliance burden increases. Table 3 compares three stylized policy packages and suggests that mutual recognition or a hybrid risk-based regime gives the best balance between security and trade openness. The policy implication is not deregulation, but smarter regulation: narrower localization, transparent transfer tests, regulatory sandboxes and shared technical standards.

From a BRI governance perspective, regulatory cooperation is therefore as important as domestic lawmaking. Corridor-wide model clauses for business data transfers,

common certification for cloud providers and interoperable audit templates could reduce compliance duplication without forcing legal uniformity. Such instruments are economically attractive because they lower entry barriers for second-tier exporters, including software firms, logistics providers and business service platforms that depend on fast and lawful data exchange.

For future BRI digital trade policy, the most credible reform sequence is to classify data by risk, narrow localization to genuinely sensitive domains and negotiate interoperable compliance tools for ordinary commercial transfers. Such a sequence improves predictability for investors while preserving state capacity in areas of national importance.

The analysis also suggests a sequencing principle. Countries do not need identical laws to improve digital trade efficiency; they need compatible procedures for lawful transfer, incident reporting and business dispute resolution. Compatibility lowers uncertainty for cross-border contracts and increases the expected return on SME digitalization.

At the same time, a purely laissez-faire strategy is unlikely to be durable. Where users fear uncontrolled extraction or weak cyber protection, digital trade itself loses legitimacy. A balanced regulatory architecture is therefore economically superior not only because it cuts costs, but also because it preserves trust, which is an intangible but essential asset for long-term digital integration across the Belt and Road space.

Accordingly, the efficiency benchmark for BRI regulators should be interoperable governance with selective safeguards. This benchmark encourages digital firms to scale across markets, reduces sunk compliance investment and still leaves room for public oversight in cybersecurity and privacy. When regulation follows this benchmark, digital trade can expand with lower friction and stronger institutional credibility.

For firms operating on the Digital Silk Road, this conclusion matters operationally. Investment decisions in cloud architecture, e-commerce logistics, payment systems and remote service delivery depend on whether transfer rules are transparent and reusable across markets. The more predictable those rules become, the lower the average cost of digital expansion for new entrants and the stronger the competitive pressure on incumbent platforms.

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UDC 339.5

CROSS-BORDER E-COMMERCE AND TRADE FACILITATION UNDER DIGITALIZATION: PRACTICE AND PROSPECTS OF CHINA–KAZAKHSTAN COOPERATION

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Annotation The digital revolution has transformed how, when, and what is traded between nations. E-commerce has become an important component of global trade liberalization and more sophisticated forms of tradex[1,2]. This paper analyzes this evolution,international infrastructure , and major barriers in a global digital era .on the basis of close practical cooperation in implementation of BRI projects by China and the Republic of Kazakhstan,online access to information, overseas transportation, use of foreign currenciesand simplified customs procedure. Our findings demonstrate that cross-border e-commerce greatly lowers transaction cost,promotes efficient trading, thus increasing the economic linkages among nations.Fourth, improving information technology and coordinating policies can help promote the high-level development of Sino-Kazakh inter-regional trade[3,4].

Keywords: Cross-border e-commerce; Trade facilitation; China–Kazakhstan cooperation; Belt and Road Initiative; Digitalization

1. Introduction

The rapid development of the Internet technology brings world trade to a new stage with the help from the Internet[1]. Conventional trade is limited by its cost,long cycles and complex links.Cross-border e-commerce depends on the Internet platform to eliminate geographic constraints, reduce SMEs' market access costs and improve logistics efficiency[3,4].Become an important engine of the growth of foreign trade.
Under the BRI context, there is a strong complementarity between China and Kazakhstan to support their close Sino-Kazakh economic and trade relationship.

Cross-border e-commerce cooperation could be further developed[6]. The focus of this paper is on cross-border e-commerce and trade facilitation, the required underlying infrastructure and policy processes so that we can provide guidance on how to move forward with improving U.S.-Ukraine commerce relations.

2. Literature Review

Global e-commerce is rapidly growing and forms an important part of digital trade [1]. Digitalization improves trade efficiency and inclusiveness [2], while reducing transaction costs and improving logistics processes [3]. Empirical studies show that cross-border e-commerce facilitates trade through better connectivity and regulation [4], although barriers such as data regulation and policy differences remain [5].

3. Conceptual Framework

3.1 E-commerce

E-commerce refers to commodity transactions and service provision through digital platforms and information networks. It breaks time and space restrictions and improves transaction efficiency[3,4].

3.2 Cross-border E-commerce

International e-commerce, or simply e-commerce , is defined as any form of trade done over the Internet that occurs across international borders (i.e., it crosses aborder).distribution, collection of payments, documentation clearance and government regulations.

3.3 Trade Facilitation

Facilitating Trade means using information technology and coordination between institutions for making trade easier,reduced transaction costs , and increase efficiency and transparency in global commerce .

3.4 Digital Global Market

Digital global market is an international instantaneous trade system that is supported through digital means,connecting producers, suppliers and buyers around the world.

4. Impact of Digitalization on Cross-border Trade and Trade Facilitation

•Lower transaction costs and information asymmetry by reducing the expenditure on negotiation,search, and intermediary services.

•Lowering the barriers of entry for SMEs, so that they can participate more fully in global commerce.

•Optimize supply chain management, realize real-time tracking, intelligent scheduling and stable operation.

•Expand market coverage and break through restrictions of time, geography and scale.

•Foster the development of emerging trade models, including live-streaming e-commerce, social commerce, and short-video–enabled cross-border retail.

5. Core Supporting System of Cross-border E-commerce

5.1 Digital Trading Platform

As an important carrier, digital trading platforms provide information release, matching, transaction negotiation, credit evaluation, dispute settlement and other

services.They lower the expenses associated with information search, increase the effectiveness of transactions, and strengthen the reliability of cross-border financial exchanges.

5.2 Cross-border Logistics System

Cross-border logistics supports the physical flow of commodities, including international transportation, overseas warehousing, distribution and traceability. Intelligent logistics, big data scheduling and overseas warehouses help shorten transportation time and reduce comprehensive costs.

5.3 Cross-border Payment and Settlement

A secure, effective, and economical cross-border payment infrastructure constitutes a critical prerequisite for the development of cross-border e-commerce. It includes third-party payment, bank direct payment, digital currency application and exchange rate risk management tools.

5.4 Customs Supervision and Facilitation

The adoption of digital customs procedures, automated inspection systems, cross-border data harmonization, and expedited clearance processes significantly enhances the efficiency of customs operations while lowering institutional transaction costs.

5.5 Risk Control and Security

This system encompasses transaction risk management, data security safeguards, consumer rights preservation, and after-sales service assurance—thereby reinforcing the stability and credibility of cross-border e-commerce.

6. Development Models and Challenges

6.1 Typical Models

•B2B model: Mainly for enterprise-to-enterprise transactions, with large volume, high stability and long-term cooperation.

•B2C model: Directly facing individual consumers, with fast update speed, flexible operation and strong market response.

•Live-streaming e-commerce model: Realize scene display, interactive communication and instant transaction through live broadcast, with high conversion rate.

•Social e-commerce model: Rely on social platforms to realize fission communication, trust transmission and integrated transaction.

6.2 Main Challenges

•High logistics costs and low efficiency, especially in long-distance cross-border transportation[6].

•Payment risks, exchange rate fluctuations and high cross-border payment fees[2,5].

•Divergent national regulations (customs/taxes/standards/markets)[5].

•Data protection, information privacy, and consumers' rights issues that transcend national boundaries[5].

•Imperfect credit system, fierce platform competition and increased operational risks[4].

7. Practical Cases of China–Kazakhstan Cooperation

China-Kazakhstan cross-border e-commerce has been developing rapidly over the past few years. Digital customs clearance of China-Europe Railway Express reduces freight times. Although cross-border payments, as well as logistics traceability systems, continue to improve,delivery costs, the efficiency of regulation, and after-sales service.Based on learning from international experience, the two countries could enhance policy coordination to build up a more convenient and efficient cross-border e-commerce ecosystem[6].

8. Conclusion

Digitalization facilitates the innovation of international trade and cross-border e-commerce becomes one of the most important drivers for facilitating trade. Crossborder e-commerce contributes to reducing costs,enhance efficiencies and increase economic integration among nations.Enhancing B2B e-commerce cooperation between China and Kazakhstan will help to boost bilateral trade turnover,improves the structure of traded goods and services, and promotes high-quality development of the Belt and Road Initiatives. Enhancing information technology infrastructure,policy coordination and e-governance would provide a better environment in which to sustain cross-border trade.

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"BELT AND ROAD" SMART PHYSICAL PLATFORM: OPERATIONAL ANALYSIS AND RESEARCH OF A LOGISTICS ENTERPRISE

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Annotation. This report systematically elucidates the strategic positioning and profitability rationale of a logistics company within the multimodal transport logistics information industry. The company is committed to leveraging information technology innovations to establish a China multimodal transport logistics information platform under the backdrop of the Belt and Road Initiative and the dual-circulation strategy, aiming to reduce the proportion of total social logistics costs to GDP from 15% to below 10%, thereby creating a trillion-yuan-scale new market value.

Keywords: digital logistics; multimodal transport; platform economy; Belt and Road Initiative; supply chain digitalization.

The logistics industry is currently in a phase where "the old ceiling has been dismantled, but a new one has yet to emerge." Through "business reengineering," the company established a new entity, focusing on building the "12306" road and port freight network for external circulation as its entry point. It also developed a SaaS service platform and established industry-wide information-sharing standards to address the lack of information exchange between road and port operations, gradually expanding its reach to road and air transport sectors.

Leveraging national policy incentives such as the "Plan for Promoting the Development of Multimodal Transport" and the "Digital Transportation 14th Five-Year Plan," the company has established four core business areas: first, establishing regional multimodal transport platforms for the Maritime Silk Road, the Yangtze River Economic Belt, the Silk Road Economic Belt, and the New Land-Sea Corridor; second, entering the high-speed rail express service market; third, providing big data services to a vast number of small and medium-sized road enterprises; and fourth, developing a 50,000-kilometer local railway management platform.

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From a system perspective, these developments reflect the construction of a layered digital logistics ecosystem. The platform integrates physical transport infrastructure with digital information systems, forming a coordinated structure of data acquisition, transmission, and application. Through standardized interfaces and cloud-based architecture, fragmented logistics data across different transport modes are unified into a real-time operational network. This enables cross-modal coordination, improves resource allocation efficiency, and significantly reduces information asymmetry across the logistics chain.

The underlying strategy is to break down the "information silos" between rail, road, waterway, and air transport, enabling cross-system "information sharing, seamless connectivity, and real-time data delivery."

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The company's business model is summarized as the "33 Model," which comprises three core platforms: a multimodal transport platform, internet-based logistics physical stores, and modern logistics e-commerce transactions. It employs three key methodologies - "information sharing, seamless connectivity, and real-time data delivery" - to pioneer innovative logistics and retail models. With a market share of just 1%, the company's revenue would reach RMB 60 billion.

Business Model: Initially focused on SaaS service rental fees and membership fees, later transitioning to information service fees; offline operations utilize information technology to enhance logistics park management and pilot transportation agency services; provides systems and management models to small and medium-sized parks, charging franchise fees.

Core Competitiveness: Focus on a "gong" -shaped brand strategy (comprising seven bureaus along the southeastern coast, four along the Yangtze River, and three under the Eurasian Land Bridge, integrating three networks), adopting a phased approach - "first information sharing, then seamless integration, followed by real-time delivery."

Commercial barriers: The team leverages policy support to dismantle outdated systems and achieve shared rail-port infrastructure; possesses the capability to

reconstruct underlying architectures (having previously broken IBM's server monopoly); and boasts hands-on experience in leading national strategic projects (such as the BeiDou high-speed rail security initiative).

Positioned in the midstream of the logistics industry chain, the company employs an "integrated core with dual wings" OMO model to integrate upstream and downstream partners, fostering strong customer loyalty.

As a light-asset internet high-tech company, its high valuation is underpinned by the founding team's 16 years of unparalleled industry expertise.

A successful model: The team led the development of the 12306 platform, dismantling the traditional five-tier passenger transport hierarchy and implementing flat management with real-time resource allocation. This initiative drove a 217% surge in railway passenger volume over a decade, demonstrating the transformative power of information technology in replacing rigid planning systems.

Deep Reflection: The root cause of the failure in achieving negative growth in freight volume on the 95306 platform lies in the absence of real-time notifications to cargo owners. The company aims to replicate the 12306 model in freight services by establishing an external circulation platform that integrates resources from rail, road, waterway, and air transport, thereby unlocking substantial market potential for tens of millions of users.

Blue Ocean Analysis: By leveraging idle high-speed rail capacity for express delivery services and based on China's average daily parcel volume of 266 million, even after accounting for a 50% diversion rate, an average of 791 trains could still be operated daily. With a gross revenue of 10 yuan per parcel, the annual potential revenue reaches 485.45 billion yuan. This not only represents an "almost cost-free operation" utilizing existing investments but also aligns perfectly with the national "dual carbon" strategy.

Top-tier talents can achieve excellence by engaging in third-rate business operations. The commercial blueprint for this logistics company is not merely a pipe dream; it is grounded in the team's hands-on experience in overcoming challenges through the 12306 initiative. By replicating the "12306 transformation" model from passenger transport to freight services and elevating it into a comprehensive multimodal transport platform serving the entire society, this represents a profound industrial revolution aimed at reducing societal logistics costs and reshaping the supply chain landscape.

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STRATEGIC COMPETITIVE ADVANTAGES OF INTERNATIONAL COMPANIES IN THE GLOBAL MARKET

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Annotation.

In the modern context of globalization, sustainable competitive advantage requires more than operational efficiency; it demands sophisticated global integration. This paper examines the strategic competitive advantages of multinational corporations (MNCs) over domestic firms, focusing specifically on supply chain management and strategic resource allocation. Through theoretical analysis and an in-depth case study of Apple Inc., it reveals how global giants leverage financial strength and ecosystem control to build formidable moats. The findings indicate that while non-MNCs can compete on cost, MNCs secure dominance through resilient supply networks and strategic capital deployment. The paper concludes with actionable insights for local enterprises aiming to enhance their global competitiveness.

Key words: Strategic Competitive Advantage, International Business, Supply Chain Management, Resource Allocation, Global Market.

Introduction

The pursuit of competitive advantage is shifting from enhancing efficiency to achieving global integration. Multinational corporations often outperform domestic firms not only due to scale but also because of their unparalleled ability to coordinate global resources and manage complex supply chains. Understanding this dynamic is crucial for emerging enterprises. This paper dissects the core architectural advantages

of MNCs, using Apple Inc. as a primary case. By analyzing Apple's strategic resource deployment and supply chain supremacy, it aims to distill the essence of global competitive advantage.

1. Theoretical Framework: Resources and Global Value Chains

From a theoretical perspective, sustained competitive advantage stems from valuable and rare resources. In international business, these resources encompass not only tangible assets but also intangible management capabilities. According to World Bank data, participation in Global Value Chains (GVCs) enables firms to access foreign knowledge, technology, and markets, which are key drivers of productivity and competitiveness. However, the true advantage lies in orchestrating the value chain. MNCs excel by allocating financial and human resources across borders to optimize production, mitigate risks, and control supply network nodes, creating synergistic effects difficult for domestic rivals to replicate.

2. Core Analysis: Apple's Strategic Mastery

Apple Inc. serves as a quintessential model for understanding how strategic resource allocation and supply chain management translate into an insurmountable competitive barrier. As evidenced in its 2025 fiscal report, Apple's dominance relies heavily on massive capital reserves and sophisticated debt management, enabling unparalleled investment in its supply chain ecosystem.

2.1 Financial Resource Allocation and Supplier Control

Unlike many competitors, Apple does not rely solely on organic growth; it actively shapes its supply chain through significant capital injections. In FY2025, Apple reported holding $63 billion in cash and equivalents, supplemented by $110 billion in marketable securities. Crucially, the company utilized $89 billion in long-term debt, strategically deployed to secure favorable terms and capacity commitments from key suppliers. By providing upfront payments or purchase guarantees, Apple locks in manufacturing capacity for critical components like custom silicon chips and advanced displays. This financial leverage ensures priority access to cutting-edge technology, leaving non-MNCs and undercapitalized rivals struggling with obsolete components and longer lead times.

2.2 Supply Chain Resilience and Ecosystem Integration

Apple's supply chain is not merely a logistics network but a tightly integrated ecosystem. Its ability to coordinate suppliers across dozens of countries, ensuring just-in-time delivery while maintaining stringent quality control, constitutes a core competitive advantage. This resilience is vital in navigating global disruptions. Through centralized procurement and economies of scale, Apple reduces unit costs, sustaining industry-leading gross margins. Furthermore, Apple allocates substantial resources to R&D, much of it directed toward proprietary technologies that deepen dependence on its exclusive supply chain, thereby raising entry barriers for potential competitors.

3. Implications for Non-MNCs

A stark contrast exists between Apple's global orchestration and the operational realities of non-MNCs. Domestic firms often face capital constraints, limiting investment in supply chain resilience or advanced technology. To bridge this gap, non-MNCs must shift from competing on price to competing on value and integration. Additionally, emulating the capital-efficient practices of MNCs can provide a springboard for global expansion.

4. Conclusion

In conclusion, the strategic competitive advantage of MNCs in the global market is deeply rooted in their mastery of supply chain management and strategic resource allocation. As demonstrated by Apple, the ability to deploy vast financial resources, control supplier ecosystems, and integrate global value chains creates a sustainable competitive barrier that pure domestic players find difficult to surmount. For non-MNCs, the path forward involves a hybrid approach: leveraging local agility while progressively adopting the structured resource allocation strategies of global MNCs.

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THE IMPACT OF THE GLOBAL TREND OF TRANSITION TO A "GREEN" GLOBAL ECONOMY ON THE STRUCTURAL TRANSFORMATION OF THE COUNTRY'S ECONOMY

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Annotation. The global transition toward a green economy has moved from a normative agenda to a material force restructuring trade, finance, production, and industrial competition. Carbon disclosure rules, green taxonomies, low-emission technologies, and sustainable finance standards increasingly influence investment allocation and market access. For national economies, this shift is not merely environmental. It changes the relative competitiveness of sectors, the direction of capital accumulation, and the institutional requirements for long-term growth.

This paper examines how the global trend toward a green economy affects the structural transformation of a country's economy. The discussion is written in a concise academic style and uses synthetic analytical indicators for illustration rather than factual statistical datasets.

Keywords:green economy, green finance, structural transformation

The central argument is that the green transition accelerates structural change when environmental pressure is translated into industrial modernization, technological upgrading, and coordinated policy support; when this translation fails, the same trend may deepen adjustment costs and widen intersectoral imbalances.

The first transmission channel is cost revaluation. As external markets and investors place greater value on carbon efficiency, sectors with high energy intensity experience stronger restructuring pressure. This does not automatically imply decline. In many cases, pressure stimulates cleaner production, process innovation, and resource-efficiency improvements. Yet the outcome depends on access to finance, managerial capability, and the state's capacity to sequence supportive regulation with industrial adjustment.

The second channel is investment redirection. Green finance, industrial subsidies, and climate-sensitive lending standards tend to move capital toward renewable energy, advanced manufacturing, circular production, and environmental services. This redirection changes the internal composition of the economy by strengthening sectors with higher technological intensity and longer innovation chains. Table 1 summarizes the main channels through which the green global trend affects structural transformation at the national level.

Table 1. Transmission channels from the green global trend to structural transformation

Channel	Immediate pressure	Structural effect	Policy implication
Carbon standards	Higher compliance burden	Reallocation away from outdated assets	Support technological upgrading
Green finance	Selective capital access	Expansion of low-emission sectors	Develop blended financing tools
Trade adjustment	New export requirements	Shift toward cleaner production chains	Strengthen certification capacity
Technological diffusion	Faster innovation cycles	Rise of productivity-led industries	Invest in skills and R&D

Table 1 also suggests that structural transformation should be understood as a combination of contraction and renewal. Activities exposed to carbon-intensive lock-in may lose relative weight, while sectors linked to efficiency, digitalization, and low-emission infrastructure gain strategic importance. The policy question is therefore not whether transformation will occur, but how it can be guided so that productivity gains and social adaptation remain aligned.

Figure 1. Synthetic dynamics of green pressure, structural upgrading, and energy productivity

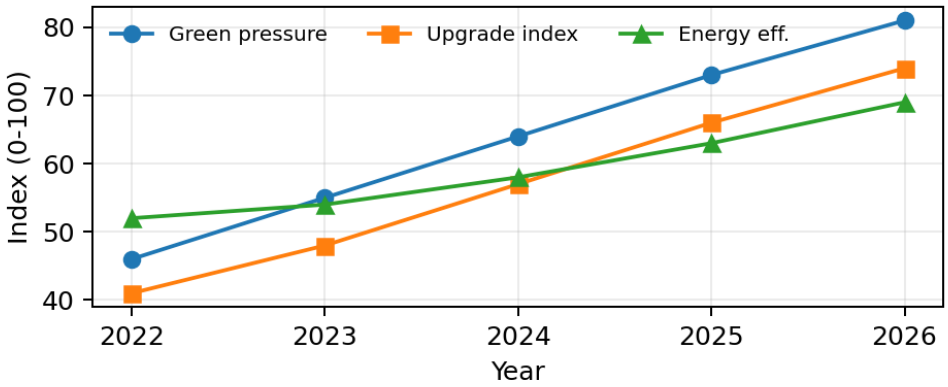

Figure 1 presents the synthetic dynamics of global green pressure, structural upgrading, and energy productivity over a specified period. The three lines, representing these key variables, generally rise together, yet their growth rates exhibit notable disparities. In the early stage, external green pressure—driven by international environmental regulations and market demands—increases more rapidly than domestic structural adjustment, which involves shifts in industrial and economic frameworks. This discrepancy creates a coordination gap, where policy and practice lag behind external pressures, potentially hindering sustainable development. Later, as the process unfolds, productivity growth begins to catch up with the other trends. This convergence suggests that learning effects from experience, widespread technology adoption, and institutional adaptation to new norms gradually transform external pressures into internal modernization efforts. Consequently, the dynamics illustrate a transition from initial imbalance toward a more harmonized progression, highlighting the interplay between global influences and domestic evolution in fostering green advancement.

Table 2. Sectoral effects of the green transition on the national economy

Sector	Adjustment speed	Main transformation feature	Expected outcome
Energy-intensive industry	High	Retrofitting and capacity replacement	Short-term pressure, long-term efficiency
Advanced manufacturing	High	Clean technology integration	Export and productivity gains
Agriculture	Medium	Resource-saving modernization	Higher resilience and quality

Sector	Adjustment speed	Main transformation feature	Expected outcome
Services	Medium	Green logistics and digital coordination	Broader support for transition

At the sectoral level, the green transition produces asymmetric effects due to varying capacities, existing infrastructures, and regulatory pressures across different industries. Energy-intensive industries, such as steel, cement, and chemicals, face the highest restructuring burden. This is primarily because compliance costs with new environmental regulations, high carbon exposure from emissions, and the need to replace obsolete capital stock interact directly, increasing operational and financial pressures and often requiring significant capital investments for retrofitting or modernization. In contrast, advanced manufacturing sectors, including electronics and automotive, exhibit the greatest upgrade potential. Green standards reward innovation in energy-efficient technologies, precision in resource use, and the adoption of cleaner production systems, thereby driving competitiveness and market advantages through enhanced product differentiation and access to green markets. Agriculture and services undergo more gradual transformations, influenced by slower adoption rates and diffuse impact pathways. However, both sectors increasingly depend on sustainable logistics for supply chain efficiency and reduced carbon footprints, advanced data systems for real-time monitoring and optimization of resources, and robust resource governance frameworks to ensure long-term sustainability and regulatory compliance. These sectoral differences are comprehensively summarized in Table 2, which details key metrics such as cost implications and adaptation timelines, and visually represented in Figure 2 to illustrate the comparative impacts and transition pathways of the green transition across industries.

Figure 2. Restructuring pressure and upgrade potential by sector

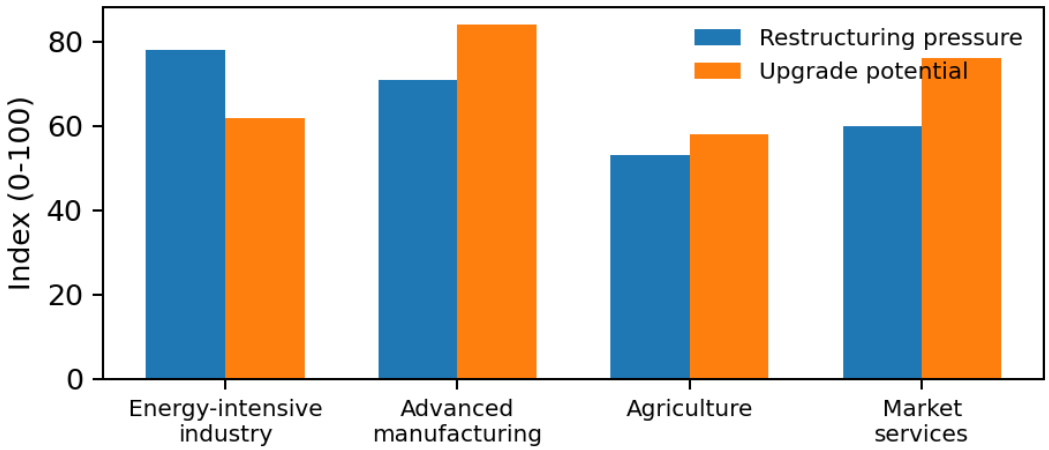

Table 3 develops a synthetic scenario comparison of national policy responses. A passive response delays costs in the short term, yet weakens future competitiveness and increases the risk of abrupt dislocation. A coordinated response, combining green finance, industrial policy, skills support, and digital infrastructure, yields the most balanced transformation path. An excessively restrictive response may improve formal compliance but slow investment and narrow the space for productive experimentation.

Table 3. Synthetic policy pathways for green structural transformation

Pathway	Fiscal cost	Transition risk	Competitiveness	Transformation outcome
Passive	Low	High	Falling	Delayed and uneven adjustment
Coordinated	Moderate	Controlled	Strong	Balanced upgrading and diversification
Restrictive	High	Moderate	Mixed	Compliance gains, weaker dynamism

Figure 3. Distribution of policy priorities in the green transition agenda

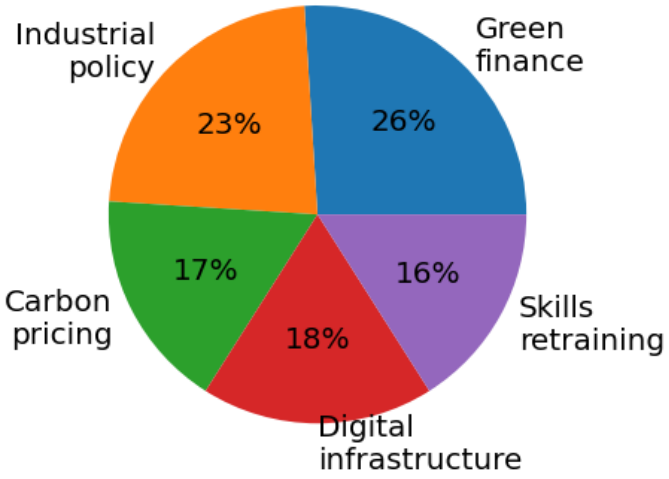

Figure 3 distributes policy priorities across the transition agenda. Green finance and adaptive industrial policy occupy the largest shares because they determine whether firms can move from compliance to innovation. Carbon pricing, digital infrastructure, and workforce retraining remain equally important as complementary mechanisms. Without them, green transformation may remain administratively visible but economically shallow.

From the perspective of structural economics, the green transition has a dual character. It raises adjustment pressure on incumbent sectors, but it also expands the developmental role of the state by legitimizing long-horizon coordination. Public institutions are required to reduce transition uncertainty, mobilize financing, support technological diffusion, and protect social stability in vulnerable regions. In this sense, the green economy should be viewed not only as an environmental target, but as a framework for reorganizing the hierarchy of sectors and capabilities within the national economy.

In conclusion, the global transition to a green economy has a significant impact on the structural transformation of the country's economy by altering incentives, reallocating capital, and redefining competitive advantages. The most effective national response is neither passive adaptation nor rigid control, but a coordinated pathway in which green standards, industrial upgrading, and social adjustment are pursued simultaneously. Under such conditions, the green trend becomes a catalyst for higher productivity, more diversified growth, and a more resilient economic structure.

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UDC (330)

TAKE THE CULTURAL AND TOURISM ECONOMY OF HISTORICAL DISTRICTS AS AN EXAMPLE TO EXPLORE THE DIGITAL TRANSFORMATION OF ECONOMIC DEPARTMENTS

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Annotation. In the context of the rapid development of the digital economy, the digital transformation of economic sectors has become the core driving force for promoting high-quality regional economic development. This paper takes the cultural and tourism economy of historical districts as the research object and systematically analyzes the trend characteristics, key technical tools and implementation mechanisms of digital transformation. By constructing a theoretical framework of "technology embedding - information integration - service co-creation", and combining typical cases such as Nanluoguxiang in Beijing, this paper analyzes the application of digital governance tools in the transformation of historical districts and their driving effect on the regional economy.

Key words: Digital transformation; Historic districts; Tourism and culture economy; Smart operations; Implementation mechanism

Introduction In the context of the rapid development of the digital economy, the digital transformation of economic sectors has become the core driving force for promoting high-quality regional economic development. China's digital economy will reach 56.4 trillion yuan in 2024 and is expected to exceed 80 trillion yuan by 2030. Historical districts, as the core nodes of the regional cultural and tourism economy, have special value in their digital transformation. Beijing Nanluoguxiang has adopted a dual-track model of "protection guidelines + smart operation", using 17 electronic eyes to achieve precise control of passenger flow. After the renovation, the proportion of cultural and creative industries has increased to 65%, and the average annual revenue of merchants has grown by 15%. This article takes this as an example to reveal the digital transformation of the economic sector.

Trend Characteristics of Digital Transformation

1) Technology Empowerment to governance Reshaping. Digital transformation goes through three stages of evolution: informationization - digitalization - digital intelligence. The current integration of technologies such as artificial intelligence, digital twins, and the Internet of Things is driving the economic sector to leap from "technology application" to "governance reshaping". The smart tourism platform of Luoyang Longmen Grottoes integrates digital twin and AI technologies to achieve high-precision digital restoration and drive the transformation of the tourism industry from ticket economy to experience economy.

2) From single-point breakthrough to system integration. Digital twins, big data, AR/VR and other technologies are intersecting to reshape production methods. Qingdao Zhongshan Road uses digital twin and AR/MR Technologies to create a "metaverse of the city's historical district", attracting 200,000 tourists in the first week of opening and increasing the turnover of surrounding supermarkets by 30%, creating a multiplier effect of the "technology cluster".

3) From efficiency First to Value co-creation. The new generation of digital transformation emphasizes multi-subject collaboration, where governments,

businesses, consumers, and community residents create services through digital platforms.

Theoretical and Methodological Foundations of the Study of Digital Transformation in Historic Districts.

The digital transformation of cultural and tourism spaces in historic districts requires a comprehensive theoretical approach that integrates institutional economics, innovation systems theory, and the concept of sustainable urban development. In this context, historic districts are considered not only as cultural heritage sites but also as complex socio-economic systems involving the interaction of government, business, and local communities.

From the perspective of institutional theory, the effectiveness of digital transformation is largely determined by the quality of formal and informal institutions regulating the use of digital technologies in tourism and urban governance. In particular, transparency in tourist flow management, data protection mechanisms, and public–private partnership frameworks serve as key conditions for the sustainable development of digital platforms.

Within the framework of innovation systems theory, the digital transformation of historic districts is viewed as the result of interactions between technological, organizational, and social innovations. Technological innovations (such as digital twins, artificial intelligence, and big data) provide the infrastructural foundation, organizational innovations introduce new models of urban governance, while social innovations create new forms of public participation in territorial development.

In addition, under the concept of sustainable development, special attention is given to balancing economic efficiency with cultural heritage preservation. Excessive commercialization of historic districts without consideration of cultural value may lead to the degradation of urban identity. Therefore, digital technologies should be used not only as a tool for economic growth, but also as a means of preserving and promoting the cultural code of a territory.

Thus, the proposed integrative approach allows for a more comprehensive understanding of the essence of digital transformation in historic districts and justifies the need for a coordinated policy that aligns economic, social, and cultural development goals.

The implementation mechanism of digital transformation

1) Technology embedding mechanism. Based on the TOE theory framework, Nanluoguxiang selects video surveillance technology with passenger flow control as the core and achieves the organic unity of system and technology through the "protection guidelines + smart operation" dual-track architecture.

2) Information integration mechanism. To break down "data silos", three layers of mechanisms need to be built: the data standardization layer, the platform sharing layer, and the application innovation layer. Empirical research shows that the digital economy promotes the high-quality development of the cultural and tourism industry

through three paths: improving government efficiency (17.70%), expanding market potential (16.49%), and strengthening innovation capabilities (13.81%).

3) Service co-creation mechanism. The government shifts from "regulator" to "platform builder", enterprises from "service provider" to "value co-creator", and consumers from "passive recipient" to "active participant".

Regional Economic Effects

After the renovation of Nanluoguxiang, the proportion of low-end restaurants dropped from 42% to 12%, and the annual rental income from the renovation of the "symbiotic Courtyard" exceeded 8 million yuan; Nanjing Laomen Dong receives more than 18 million visitors and creates more than 20,000 jobs annually. Studies on the spatial spillover effect show that the coefficient value of the spatial spillover effect of urban renewal accounts for about 83% of the total effect.

Conclusions

Digital transformation achieves the effective conversion of cultural capital into economic capital through a three-dimensional path of intelligent control, business format optimization and people's livelihood coordination. It is suggested to strengthen top-level design, increase technological investment, cultivate compound talents, promote model innovation, and focus on differentiated development.

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UDC 339.9

RAILWAY CONNECTIVITY AND REGIONAL ECONOMIC INTEGRATION IN CHINA: A CASE STUDY OF THE BEIJING-TIANJIN-HEBEI REGION FROM THE BELT AND ROAD PERSPECTIVE

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1. Introduction. The Belt and Road Initiative emphasizes connectivity as a foundation for international economic cooperation. Transportation infrastructure, especially railways, plays an important role in this process by supporting passenger mobility, freight transportation, logistics efficiency, and regional trade links [1], [2].
This logic of connectivity is also reflected in China's domestic regional development. Railway networks help connect cities, industries, markets, and resources, making them important for regional economic integration [3]. The Beijing-Tianjin-Hebei region provides a useful case for understanding this process. Beijing functions as a political, technological, and service center, Tianjin as a port and logistics hub, and Hebei as an industrial and manufacturing base [4].
This report examines how railway connectivity promotes regional economic integration in China. Taking the Beijing-Tianjin-Hebei region as a case study, it argues that this region reflects the same infrastructure-led connectivity logic emphasized by the Belt and Road Initiative.

2. Railway Connectivity and Regional Economic Integration. Railway connectivity is an important factor in regional economic integration. Transport infrastructure can reduce the economic distance between regions by lowering transportation costs, shortening travel time, and improving market access [5]. Compared with some other forms of transportation, railways have advantages in carrying large numbers of passengers and large volumes of freight over medium and long distances. This makes railways important for connecting cities, industrial areas, ports, and markets.

In regional development, railways are not only transportation tools, but also economic links between different areas. They support labor mobility, business activities, industrial cooperation, and the circulation of resources. Previous studies show that transport investment can contribute to economic growth when it improves accessibility and strengthens regional connections [6]. When railway networks become more complete, cities with different economic functions can cooperate more closely.

Therefore, railway connectivity plays a practical role in promoting regional economic integration. It helps reduce the separation between regions and supports the

formation of a more coordinated economic structure. This provides the basis for understanding the role of railways in the Beijing-Tianjin-Hebei region.

3. The Beijing-Tianjin-Hebei Region as a Case Study. The Beijing-Tianjin-Hebei region is a representative case of regional economic integration in China. The coordinated development of this region aims to strengthen functional cooperation among Beijing, Tianjin, and Hebei, and to improve the efficiency of regional resource allocation [4]. In this regional structure, Beijing plays a major role as a political, technological, educational, and service center; Tianjin functions as an important port city, logistics hub, and industrial base; and Hebei provides manufacturing capacity, resources, and industrial support.

Railway networks are important for linking these different regional functions. High-speed railways improve passenger mobility and make commuting, business travel, and talent movement more convenient. At the same time, freight railways support the transportation of raw materials, industrial products, and port-related goods. China's medium- and long-term railway planning also emphasizes the role of railway networks in strengthening regional connections and supporting coordinated development [3].

Through railway connectivity, Beijing, Tianjin, and Hebei can cooperate more closely in logistics, industry, services, and labor mobility. Railways help reduce the separation between cities and support the formation of a more integrated regional economy. Therefore, the Beijing-Tianjin-Hebei region shows how railway infrastructure can promote regional economic integration in practice.

4. Relevance to the Belt and Road Initiative. Although the Beijing-Tianjin-Hebei region is a domestic regional case, it is closely related to the connectivity logic of the Belt and Road Initiative. The Belt and Road Initiative emphasizes infrastructure connectivity, trade facilitation, logistics efficiency, and economic cooperation among countries and regions [1]. Railway development is one of the important ways to achieve these goals, especially in improving transport corridors and connecting markets over long distances [2].

The Beijing-Tianjin-Hebei case reflects this logic at the domestic level. Railway networks connect cities with different economic functions and support the movement of people, goods, resources, and industrial activities. This shows that infrastructure-led connectivity can promote economic cooperation not only between countries, but also within a large regional economy.

From this perspective, the Beijing-Tianjin-Hebei region can be understood as a domestic example of the broader Belt and Road connectivity framework. Its experience suggests that strong internal railway connectivity can provide a foundation for wider economic links, including international logistics, trade routes, and cross-regional cooperation.

5. Conclusion. In conclusion, railway connectivity plays an important role in promoting regional economic integration in China. The Beijing-Tianjin-Hebei region shows how railways can connect cities with different economic functions, support the

movement of people and goods, and strengthen cooperation in logistics, industry, and services. This regional case also reflects the broader connectivity logic of the Belt and Road Initiative. Although the Beijing-Tianjin-Hebei region is a domestic example, it demonstrates how infrastructure-led connectivity can support economic cooperation and provide a foundation for wider regional and international links.

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UDC (332.14)

COORDINATED DEVELOPMENT OF DIGITAL ECONOMY AND INDUSTRIAL INNOVATION IN BEIJING-TIANJIN-HEBEI

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Annotation. Grounded in the theories of industrial division of labor and regional innovation systems, this paper systematically analyzes the current status and core mechanisms of coordinated development between the digital economy and industrial innovation in the Beijing-Tianjin-Hebei region. Using the commercial aerospace industry as a case study, it elucidates the regional division-of-labor collaboration framework characterized by "R&D in Beijing, manufacturing in Tianjin, and operations in Xiongan." The research demonstrates that the Beijing-Tianjin-Hebei region has achieved deep integration of the digital economy and

industrial innovation through policy coordination, industrial chain specialization, and shared innovation resources. Building on these findings, the paper proposes actionable insights for Kazakhstan's regional digital economy and industrial innovation development, offering concrete recommendations for Sino-Kazakh cooperation across digital infrastructure, industrial collaboration, and commercial aerospace sectors.

Keywords: Coordinated Development of the Beijing-Tianjin-Hebei Region; Digital Economy; Industrial Innovation; Commercial Spaceflight; China-Kazakhstan Cooperation

The digital economy has become the core engine driving high-quality regional economic development. As a vital economic growth pole and innovation hub in northern China, the Beijing-Tianjin-Hebei region's coordinated development of digital economy and industrial innovation not only facilitates its own high-quality transformation but also provides a valuable practical model for other countries and regions. The 2026 Zhongguancun Forum Annual Conference explicitly called for supporting the Beijing-Tianjin-Hebei region in fostering world-class industrial clusters in artificial intelligence, commercial aerospace, and hydrogen energy, while building a collaborative innovation network centered on "one platform, two corridors, and three pivot points." Meanwhile, Kazakhstan is actively advancing its digital transformation, aiming to become a digital innovation hub in the Eurasian region. Therefore, in-depth study of the Beijing-Tianjin-Hebei region's coordinated development experience holds significant practical implications for Kazakhstan in exploring a regional digital economy development path suited to its national conditions and deepening China-Kazakhstan cooperation under the "Digital Silk Road."

In recent years, the coordinated development of the digital economy in the Beijing-Tianjin-Hebei region has achieved remarkable results. Beijing's R&D investment intensity has remained above 6%, with the number of highly cited scientists ranking first among global cities, and three trillion-yuan industrial clusters have been established. The three regions jointly developed the Zhongguancun Park, which now hosts over 9,800 enterprises; they collaboratively mapped six key industrial chains and jointly established seven national-level advanced manufacturing clusters [3]. In 2024, the added value of core digital economy industries accounted for more than 12% of the regional GDP, while the interconnectivity of digital infrastructure saw significant improvement.

The Beijing-Tianjin-Hebei region has established a coordinated development model characterized by "policy guidance - division of labor and collaboration - innovation sharing":

Policy Coordination: The three regions jointly issued multiple policy documents, established a cross-regional coordination mechanism, effectively eliminated administrative barriers, and facilitated the free flow of production factors.

Industrial Chain Division of Labor: Beijing focuses on R&D design and headquarters economy; Tianjin emphasizes high-end manufacturing and port logistics; while Hebei develops supporting industries and technology transfer bases.

Innovative Resource Sharing: Jointly establish the Beijing-Tianjin-Hebei National Technology Innovation Center, promote the open sharing of large-scale scientific research instruments and equipment, and build a cross-regional technology commercialization system [3].

Commercial aerospace serves as a prime example of the coordinated development of digital economy and industrial innovation in the Beijing-Tianjin-Hebei region, having established a precise division of labor framework characterized by "Beijing R&D – Tianjin manufacturing – Xiongan operations."

Table 1. Functional Division in the Commercial Aerospace Industry of the Beijing–Tianjin–Hebei Region

region	Core Function	Primary load-bearing area	Representing an enterprise/project
Beijing	Advancing cutting-edge technologies and clustering core enterprises	Yizhuang's "Rocket Street" and Fengtai Aerospace City	Blue Arrow Aerospace, Star Glory, Galaxy Aerospace
Tianjin	Support from production capacity and supporting manufacturing facilities	Tianjin Port Free Trade Zone	Production of rocket structural components and satellite supporting components
Xiongan New Area	Astrology Operations, Data Processing	China Star Network Headquarters	The GW Low Earth Orbit Satellite Constellation and Aerospace Information Applications

Specifically, Beijing, as the innovation hub, hosts 75% of China's commercial rocket manufacturers and related institutions, covering the entire commercial aerospace industry chain [1]. By 2025, the "Yizhuang Arrow" had successfully launched 24 times, carrying over 160 satellites, with the Zhuque-3 becoming China's first reusable launch vehicle to successfully enter orbit. Leveraging its port advantages and advanced manufacturing capabilities, Tianjin provides large-scale production support for Beijing's R&D achievements. The Xiongan New Area assumes the core responsibility for satellite constellation operations; the China Satellite Network headquarters is located here, attracting hundreds of upstream and

downstream enterprises and forming a nationally leading satellite internet industry cluster [2].

In recent years, Kazakhstan has vigorously advanced its digital transformation. By 2024, the digital economy surpassed $30 billion in size, accounting for over 15% of GDP for the first time, with an internet penetration rate of 83%. The government established the Ministry of Artificial Intelligence and enacted the Digital Code, enabling online processing for 92% of public services. The Astana Hub has attracted more than 1,300 startups from 28 countries.

Drawing on the experience of the Beijing-Tianjin-Hebei region, Kazakhstan should prioritize advancing the following four areas: First, establish a national-level regional digital economy coordination body to coordinate the development of major cities such as Astana and Almaty, avoiding homogeneous competition; Second, implement differentiated industrial specialization—Astana should focus on digital government and artificial intelligence R&D, Almaty on building a digital trade center and cross-border e-commerce hub, while other regions develop distinctive digital industries; Third, leverage its domestic resource advantages to create specialized industrial clusters in smart agriculture, smart energy, and smart logistics; Fourth, integrate domestic research resources to establish a national digital technology innovation center, fostering deep integration among industry, academia, and research.

Accelerate the construction of China-Kazakhstan cross-border optical cables to enhance data transmission capacity and security; advance the development of smart ports and promote the "one-time declaration, one-time inspection, one-time release" customs clearance model; collaborate on establishing the China-Kazakhstan Cloud Data Center to provide secure and efficient cloud computing services for enterprises in both countries.

Jointly establish the China-Kazakhstan Digital Economy Industrial Park to attract digital enterprises from both countries; enhance technical cooperation in artificial intelligence, big data, and the Internet of Things, and jointly develop digital products tailored for the Eurasian market; deepen cross-border e-commerce collaboration by building a China-Kazakhstan cross-border e-commerce platform and overseas warehouses, while improving the cross-border payment system.

Leveraging the advantages of the Beijing-Tianjin-Hebei commercial aerospace industry, assist Kazakhstan in developing its satellite application sector, with a focus on cooperation in areas such as agricultural remote sensing, disaster monitoring, and navigation positioning; explore the establishment of satellite ground stations and data processing centers in Kazakhstan to serve the Eurasian market; and engage in aerospace talent cultivation cooperation to train specialized technical professionals for Kazakhstan in the commercial aerospace field. In areas such as aerospace industry-education integration and aerospace study tours, China's Nankai University and Kazakhstan's Eurasian National University can seize the opportunity of joint educational programs to gradually expand activities including the development (including launch) of small science popularization satellites and aerospace-themed

study exchanges between China and Kazakhstan. Nankai University should effectively utilize its Tiankai Higher Education Science and Technology Innovation Park platform and resource advantages to contribute as a "host institution" to the multifaceted integrated development between the two countries.

The successful practice of coordinated development of the digital economy and industrial innovation in the Beijing-Tianjin-Hebei region demonstrates that policy coordination, industrial chain specialization, and shared innovation resources can effectively enhance regional competitiveness. Kazakhstan should leverage its national conditions and draw on the Beijing-Tianjin-Hebei experience to establish a cross-regional coordination mechanism, implement differentiated industrial division of labor, and foster distinctive industrial clusters. Meanwhile, China and Kazakhstan should deepen practical cooperation in the digital economy sector, promote interconnectivity of digital infrastructure, strengthen collaboration in digital industries and commercial aerospace, jointly build the "Digital Silk Road" and the "Space-based Silk Road" in commercial aerospace, and serve as a model and contribute to the development of the digital economy in the Eurasian region.

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UDC （338.4）

MEASURING THE CONTRIBUTION OF THE DIGITAL ECONOMY TO HIGH-QUALITY ECONOMIC GROWTH IN CHINA——AN EXTENDED ANALYSIS BASED ON THE KAZAKHSTAN-CHINA: DIGITAL ECONOMY AND THE "BELT AND ROAD" INITIATIVE – 2026 PLAN

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Annotation: Grounded in the new stage of development, this paper constructs a high-quality economic growth index for China based on the framework of the Five New Development Concepts. Using panel data from 30 provincial-level administrative regions in China (excluding Tibet, Hong Kong, Macao, and Taiwan) from 2013 to 2022, we empirically measure the marginal contribution of the digital economy to China's high-quality growth. Furthermore, in conjunction with the Kazakhstan-China: Digital Economy and the "Belt and Road" Initiative – 2026 cooperation plan, we analyze the amplifying effect of cross-border digital cooperation under the "Belt and Road" framework on the growth dividends of the digital economy. The findings are threefold. First, the digital economy has a significant positive effect on China's high-quality growth. After controlling for endogeneity, for every one-unit increase in the digital economy development index, China's high-quality growth index rises by 0.128 units, with the most prominent contributions being to innovation-driven development and green development. Second, the contribution of the digital economy exhibits significant heterogeneity. The contribution in the Eastern region (0.167) is substantially higher than that in the Central and Western regions (0.093). Moreover, since 2019, the contribution has increased by 53.9% compared to the earlier period, indicating a continuously strengthening growth-driving force. Third, the China-Kazakhstan digital economy cooperation plan for 2026 further amplifies the spillover effects of the digital economy on domestic high-quality growth through three transmission channels: market expansion, resource complementarity, and standard exportation. The marginal contribution elasticity of this amplification effect can reach 0.09. This study provides empirical support for further unleashing the growth momentum of the digital economy and advancing the construction of the Digital Silk Road.

Keywords: Digital Economy; High-Quality Economic Growth; "Belt and Road" Initiative; China-Kazakhstan Digital Cooperation

I. Introduction

Currently, the Chinese economy has transitioned into a new stage of high-quality development. With the traditional factor-driven growth model no longer sustainable, the digital economy has emerged as a core engine for promoting economic structural transformation and fostering new growth drivers. According to estimates by the China Academy of Information and Communications Technology (CAICT) (2023), in 2022, the scale of China's digital economy reached 50.2 trillion RMB, with its share of GDP increasing to 41.5%. This highlights the increasingly prominent supportive role of the digital economy in national economic growth. Against this backdrop, accurately measuring the digital economy's contribution to China's high-quality growth and clarifying its mechanisms of action not only provides empirical evidence for improving digital economy governance policies but also offers significant reference value for advancing the construction of the Digital Silk Road under the "Belt and Road" Initiative.

The "Kazakhstan-China: Digital Economy and Belt and Road Initiative - 2026" is a medium-to-long-term digital economy cooperation roadmap jointly released by research institutions from both Kazakhstan and China. It specifies cooperation goals for Kazakhstan and China by 2026 across four major areas: digital infrastructure connectivity, cross-border e-commerce, smart energy, and digital governance. This represents a landmark plan for digital cooperation in the Central Asian region within the framework of the "Belt and Road" Initiative. As a core nodal country along the "Belt and Road" Initiative, Kazakhstan's digital cooperation with China not only demonstrates the spillover effects of China's digital economy abroad but also provides support for Chinese digital industries to expand into overseas markets and iterate core technologies. This makes it a quintessential case study for analyzing the digital economy's contribution to high-quality growth under open conditions. Building upon this, this paper conducts an extended analysis in conjunction with this plan, based on empirical measurements, to further enrich research conclusions.

II. Theoretical Mechanisms and Research Design

(1) Core Concepts and Mechanisms of Action

Definition of Core Concepts: Dual Anchoring Based on Accounting Framework and Dimensional Logic. In defining the concept of the digital economy, this paper strictly follows the "Two-Dimensional" accounting framework of the China Academy of Information and Communications Technology (CAICT), dividing digital economic activities into two levels: digital industrialization and industrial digitization. Digital industrialization, the "core layer" of the digital economy, encompasses digital product manufacturing, digital product services, digital technology application services, and digital factor-driven industries, constituting the foundation and original driving force of value creation in the digital economy. Industrial digitization, the "integration layer" between the digital economy and the real economy, refers to the output increase and efficiency improvement brought about by the application of digital technologies in traditional industries, serving as the main source of scale expansion in the digital economy. Drawing upon the accounting

framework of the CAICT, the digital economy is defined as economic activities that take data resources as key production factors, modern information networks as the main carriers, and the integrated application of information and communication technologies as well as the digital transformation of total factors as the main driving forces. It is divided into two parts: digital industrialization (core industries such as digital manufacturing and digital services) and industrial digitization (the digital transformation of traditional industries). High-quality economic growth, on the other hand, is based on the five major new development concepts of innovation, coordination, green development, openness, and sharing, constructing a multi-dimensional comprehensive index that breaks through the limitation of traditional single GDP growth rate in measuring growth quality.

Mechanisms of Action: The digital economy promotes high-quality growth through three pathways: Technology Penetration Effect: Digital technologies penetrate various production sectors, enhancing total factor productivity and driving innovation-driven development. Structural Upgrading Effect: The digital economy shortens the matching chain between supply and demand, promotes the flow of factors between regions and between urban and rural areas, advances the sophistication of industrial structures, reduces energy consumption per unit of output, and facilitates coordinated and green development. Openness and Linkage Effect: The digital economy reduces the cost of cross-border trade. Relying on the construction of "Belt and Road" digital infrastructure, China's digital industries can expand overseas markets, amortize R&D costs, feed back into domestic technological upgrading, and amplify their contribution to high-quality growth. The China-Kazakhstan 2026 cooperation plan is a concrete practice of this openness and linkage effect.

(2) Variables and Data Description

Dependent Variable: High-Quality Growth Index (HQI). This paper selects 13 secondary indicators from the five developmental dimensions (Innovation dimension: R&D investment intensity, number of invention patents per 10,000 people, digital technology patent density; Coordination dimension: urban-rural income ratio, industrial structure upgrading, regional digitalization balance; Green dimension: energy consumption per unit of GDP, forest coverage rate, pollution treatment rate; Openness dimension: foreign trade dependence, proportion of digital service exports; Sharing dimension: per capita disposable income, basic public service coverage rate). The entropy method is used for weighting to obtain a composite index, with a value range of 0 to 1. A higher value indicates better growth quality.

Core Explanatory Variable: Digital Economy Development Index (DEI). Referring to the method of Zhao Tao et al. (2020), this paper selects 5 secondary indicators from three dimensions (digital infrastructure, digital industrialization, and industrial digitization) and uses the entropy method to calculate the DEI for each province, with a value range of 0 to 1.

Control Variables. Four control variables are selected to mitigate omitted variable bias: government expenditure scale (fiscal expenditure as a share of GDP), human capital level (number of higher education students per 100,000 population), urbanization rate (urban population as a share of total population), and financial development level (total deposits and loans of financial institutions as a share of GDP).

The data in this paper are sourced from the China Statistical Yearbook and the China Digital Economy Development Report for each year. Extreme values are winsorized at the 1% level. Descriptive statistics for the variables are presented in Table 1.

Table 1. Descriptive Statistics of Variables

Variable	Sample Size	Mean	Std. Dev.	Minimum	Maximum
HQI	300	0.327	0.131	0.112	0.684
DEI	300	0.184	0.125	0.027	0.639
Government Expenditure Scale	300	0.241	0.098	0.102	0.587
Human Capital Level	300	3124	1027	1326	5218
Urbanization Rate	300	0.596	0.121	0.367	0.898
Financial Development Level	300	2.87	1.12	1.46	5.72

(3) Model Specification

This paper constructs a two-way fixed effects baseline regression model as follows:

$$HQIit=\alpha+\beta DEIit+\gamma Controlsit+\mu i+\nu t+\varepsilon itHQIit=\alpha+\beta DEIit+\gamma Controlsit+\mu i+\nu t+\varepsilon it$$

where ii denotes province, tt denotes year, μiμi is the province fixed effect, νtνt is the time fixed effect, and εitεit is the random disturbance term. The core coefficient of interest is ββ, which captures the marginal contribution of the digital economy to high-quality growth. To address the endogeneity issue, this paper selects the fixed telephone penetration rate of each province in 1984 as an instrumental variable, satisfying the conditions of relevance (historical telecommunications infrastructure affects subsequent digital economy development) and exogeneity (historical telephone penetration does not directly affect current high-quality growth).

III. Empirical Results and Analysis

(I) Baseline Regression Results

The baseline regression results are presented in Table 2. Column (1) shows the regression results without control variables, Column (2) includes control variables and two-way fixed effects, and Column (3) presents the instrumental variable (IV) regression results.

Table 2: Baseline Regression Results

Variables	(1) No Control Variables	(2) Two-way Fixed Effects	(3) Instrumental Variable Regression
DEI	0.187***(12.35)	0.128***(8.72)	0.131***(7.96)
Control Variables	No	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
N	300	300	300
R^2	0.624	0.781	0.756
*Note: *** indicates significance at the 1% level; t-statistics are in parentheses.*			

Note: *** indicates significance at the 1% level; t-statistics are in parentheses.

From the regression results, it can be observed that the coefficient of the core explanatory variable, DEI, is significantly positive at the 1% level. This indicates that the digital economy plays a significant role in promoting China's high-quality growth. After accounting for endogeneity, the coefficient remains stable at approximately 0.13. Specifically, a one-unit increase in the Digital Economy Development Index leads to an approximate 0.13-unit increase in the High-Quality Growth Index. This contribution is notably higher than that of traditional factor inputs. To further analyze the digital economy's contribution to different dimensions of high-quality development, the disaggregated regression results are presented in Table 3.

Table 3: Regression Results by Dimension

Dimension	Innovation	Coordinated	Green	Openness	Sharing
DEI Coefficient	0.182***(9.12)	0.092***(4.37)	0.135***(6.84)	0.114***(5.62)	0.107***(5.18)
R^2	0.762	0.683	0.714	0.695	0.708

The disaggregated results show that the digital economy's contribution to innovation development is the largest, followed by green development. This suggests that the digital economy's driving role in technological innovation and its promoting effect on energy saving and carbon reduction are the most prominent. Its contribution to coordinated development is relatively smaller, reflecting that the current issue of the digital divide still, to some extent, restricts the release of the digital economy's growth dividends.

(II) Heterogeneity and Robustness Tests

1. Spatial Heterogeneity: The sample was divided into two groups: eastern and central-western regions. The DEI coefficient for the eastern regions is 0.167

(significant at 1%), while for the central-western regions, it is 0.093 (significant at 1%). This indicates that the contribution of the digital economy is more prominent in the eastern regions, which possess more developed digital infrastructure and stronger industrial foundations. Narrowing the digital divide in the central-western regions is crucial for improving the overall contribution.

2. Temporal Heterogeneity: The sample was divided into two periods: 2013-2018 and 2019-2022. The DEI coefficient was 0.102 (significant at 1%) in the former period, and 0.157 (significant at 1%) in the latter period. This suggests that in recent years, with the continuous deepening of digital technology integration, the digital economy's contribution to high-quality growth has steadily strengthened.

3. Robustness Test: The robustness of the findings was confirmed by replacing the dependent variable with each province's total factor productivity (calculated using the DEA-Malmquist method). After re-running the regression, the DEI coefficient remained significantly positive at the 1% level, indicating that the conclusion is robust.

Figure 1: Trends of National Average DEI and HQI, 2013-2022

(Note: The horizontal axis represents years, and the vertical axis represents index values. Both DEI and HQI exhibit a continuous upward trend, with their trends largely overlapping. A correlation coefficient of 0.92 intuitively reflects the synchronous change between the digital economy and high-quality growth.)

IV. Extended Analysis in Conjunction with "Kazakhstan-China: Digital Economy and the Belt and Road Initiative -2026"

The "Kazakhstan-China: Digital Economy and the Belt and Road Initiative—2026" plan explicitly proposes that by 2026, the scale of bilateral digital cooperation between China and Kazakhstan will double compared to 2022 levels, cross-border e-commerce transaction volumes will exceed 50 billion USD, a Kazakhstan-China cross-border digital port network will be established, and full-process paperless customs clearance will be achieved. The implementation and advancement of this plan will amplify the contribution of the digital economy to China's high-quality growth through three pathways, as detailed in Table 4.

Table 4 Spillover Effects of Key Areas in the China-Kazakhstan 2026 Plan on China's High-Quality Growth

Cooperation Area	Core Content	Transmission Pathway	Contribution Elasticity
Digital Infrastructure Interconnectivity	Cross-border cable expansion, construction of the Khorgos digital port, 5G network coverage	Enhance cross-border supply chain efficiency and reduce fluctuations in domestic energy and food supply chains	0.08
Cross-Border E-Commerce and Logistics	Overseas warehouse layout, construction of cross-border payment	Expand markets for Chinese digital products and services, dilute R&D costs in the	0.11

Cooperation Area	Core Content	Transmission Pathway	Contribution Elasticity
Digitalization	systems	digital industry	
Smart Energy and Smart City Cooperation	Smart grid construction, export of smart city standards	Promote the overseas export of Chinese digital technology standards and enhance the international competitiveness of the digital industry	0.07
Agricultural Digitalization Cooperation	Export of smart agriculture technologies, construction of agricultural product traceability systems	Leverage China's digital technology advantages to ensure stability in China's agricultural import supply chains	0.09

Overall, the average contribution elasticity of China-Kazakhstan 2026 digital cooperation to China's high-quality growth is approximately 0.09, meaning that cross-border digital cooperation under the Belt and Road Initiative framework can increase the marginal contribution of the digital economy to domestic high-quality growth by about 9%. Specifically, cross-border e-commerce cooperation has the highest contribution elasticity, indicating that market expansion effects are the primary transmission pathway: Chinese small and medium-sized digital enterprises, by entering the Kazakhstan and even Central Asian markets, accumulate internationalization experience, enhance profitability, and in turn increase domestic R&D investments, driving technological iteration. Secondly, the supply chain stabilization effects from digital infrastructure cooperation are particularly prominent for China's coordinated and green development: After the completion of the Khorgos digital port, the average cross-border cargo clearance time between China and Kazakhstan will be reduced from 4 hours to 45 minutes, logistics costs will decrease by 30%, and unit logistics energy consumption will drop by 27%, directly reducing the costs and energy consumption of domestic economic operations.

V. Conclusion and Policy Recommendations

(I) Conclusion

Based on empirical calculations, this paper draws the following core conclusions: First, the digital economy significantly promotes China's high-quality economic growth, with an average marginal contribution of approximately 0.128. Its contributions to innovation-driven development and green development are particularly prominent. Second, the contribution of the digital economy exhibits spatial and temporal heterogeneity. Its contribution in the eastern regions is significantly higher than in the central and western regions, and this contribution has continuously increased in recent years. Third, cross-border digital cooperation under the "Belt and Road" framework, exemplified by the China-Kazakhstan cooperation

outlined in the "Kazakhstan-China: Digital Economy and Belt and Road Initiative – 2026" plan, can further amplify the digital economy's spillover effects on domestic high-quality growth through pathways such as market expansion, resource complementarity, and standard export. The average contribution elasticity in this context is approximately 0.09.

(II) Policy Recommendations

First, accelerate the improvement of digital infrastructure in the central and western regions to narrow the regional digital divide. This will further unleash the overall growth dividends of the digital economy and enhance its contribution to coordinated development.

Second, expedite the construction of the "Digital Silk Road" under the "Belt and Road" Initiative. Implement the China-Kazakhstan 2026 Digital Economy Cooperation Plan to establish a model of China-Kazakhstan digital cooperation that can be replicated and promoted to Central Asian countries and other countries along the Belt and Road, thus fully leveraging the reciprocal benefits of cross-border digital cooperation for domestic high-quality growth.

Third, improve the digital economy governance system and establish risk prevention and control mechanisms for cross-border digital cooperation. Promote the liberalization and facilitation of digital trade to further amplify the digital economy's promotional role in high-quality growth.

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IDENTIFICATION AND ASSESSMENT OF KEY RISK FACTORS IN LIVE-STREAM E-COMMERCE TRANSACTIONS

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Annotation. Live-streaming e-commerce has become the core driving force behind the growth of online retail in the era of digital economy.While the transaction scale continues to expand, risks such as product quality control failures, false advertising, return and exchange difficulties, data security issues, and ambiguity regarding the rights and responsibilities of the parties are becoming increasingly prominent. This paper systematically identifies the key risk factors in live-streaming e-commerce transactions, analyzing them from four dimensions: product quality, entity behavior, platform governance, and information security. It also proposes governance suggestions such as full-chain traceability, platform responsibility implementation, credit linkage, and dynamic monitoring, with the aim of providing reference for industry risk prevention and control.

Key words: Live E-commerce; Transaction Risks; Risk Identification; Collaborative Supervision

Live-streaming e-commerce has become one of the most dynamic growth sectors in China's digital economy. In 2024, the transaction volume exceeded 4.5 trillion-yuan, accounting for nearly one-third of the online retail market. As a new type of business model that integrates people, goods and platforms to a high degree, live-streaming e-commerce not only enhances consumer convenience but also brings about risks such as false promotion, quality control failure, lack of after-sales service, and data fraud. The multi-agent interwoven ecological, platform organizational power and algorithm-driven model pose challenges to traditional governance, with issues such as blurred responsibility attribution, restricted protection of user rights, and lagging regulatory effectiveness [1]. Systematic identification and assessment of key risk factors, as well as its exploration of collaborative governance paths, holds significant practical value.

Due to the high degree of separation among people, goods and places, the commodity circulation chain is long and the difficulty of quality supervision is great. The interdependence between the platform and the top hosts may lead to negative regulation, allowing substandard products to enter the market through the amplification of their popularity [2]. There are issues such as mismatched products, false labeling of materials, and passing off inferior goods as superior ones in the live-streaming rooms. In particular, counterfeit luxury goods and expired food products have been frequently exposed on major platforms, eroding consumer trust. The lack of real-time quality inspection mechanisms during live broadcasts further exacerbates this problem, The products received by consumers differ significantly from the displayed quality.

The live-streaming ecosystem involves multiple entities such as platforms, MCN agencies, merchants, and consumers. The networked structure leads to ambiguity in liability determination. The host's misconduct, including false promotion, data fabrication, and consumer inducement, leads to a rapid increase in consumers' perceived risks once negative signals emerge regarding their professional knowledge and moral character [3]. Low-quality manufacturers may take advantage

of the "spillover effect" of top streamers to conceal the true quality information. In addition, some MCN agencies manipulate viewer counts and engagement metrics to create fake popularity, which misleads consumers into believing the product is widely trusted. Such deceptive practices not only harm consumer interests but also distort market competition. Moreover, the lack of standardized training for hosts results in inconsistent messaging and exaggerated claims, further amplifying the risk of misinformation. Consumers themselves are also prone to making irrational purchases due to the high interactivity and time-limited promotions, and the cost of seeking redress afterwards is extremely high.

Platforms are responsible for registration verification, product review, and live-stream inspection. However, as platform functions extend to social content , the governance capabilities of different platforms vary significantly, and the uncertainty of legal relationships poses difficulties for regulation [4]. Data manipulation and traffic cheating techniques are constantly evolving, and the complexity of the technological confrontation makes it difficult to completely eliminate the risks. Many platforms lack effective cross-departmental coordination for handling consumer complaints, leading to delayed responses and unresolved disputes. Furthermore, third-party data storage and sharing agreements often fail to meet security standards, exposing user information to potential leaks.

The virtuality, immediacy and cross-regional nature of live-streamed transactions make it difficult for consumers to identify the responsible party, complicating evidence collection and raising the cost of rights protection. The costs of resolving minor disputes are not commensurate with the benefits, and cross-regional jurisdiction is inconvenient, which has led to a large number of consumers giving up their attempts to seek redress. Many consumers lack awareness of their legal rights, and platforms rarely provide clear guidance on how to file complaints or request refunds. As a result, the actual resolution rate for live-stream shopping disputes remains low, further weakening market trust.

Establish a quality traceability system covering production, circulation and sales, and utilize technologies such as blockchain to achieve full-process traceability. Platforms must ensure compliance verification of registered entities, establish a dynamic identity verification and product selection review system， and promote the deep integration of live streaming and supply chain [5].

Blockchain-based traceability can record every step from raw material sourcing to delivery, making it nearly impossible to alter product information retroactively.

Implement real-name registration and graded credit management for the entities entering the market, Establish an industry-wide shared blacklist to cut off channels through which dishonest entities engage in cross-platform violations. Utilize technological means to conduct real-time monitoring of live streaming data, and implement dynamic traffic restrictions and early warning interventions for live streaming rooms with obvious tendencies of violations. Platforms should also publish periodic transparency reports on the number of complaints received, actions taken,

and sanctions imposed. Such transparency can build consumer confidence and deter potential violators. Additionally, leveraging artificial intelligence for automated content moderation can help detect false claims during live broadcasts more efficiently.

Multidimensional collaboration is the core driving force for the healthy development of live-streaming e-commerce [6]. The government should strengthen law enforcement efforts, the industry should guide MCN institutions to be standardized, and the judicial level should explore online dispute mediation mechanisms to reduce the cost of consumers' rights protection. Establishing a unified cross-platform dispute resolution center with standardized procedures could streamline complaint handling. Industry associations may set ethical guidelines for hosts and enforce penalties for repeated violations, such as temporary bans or financial fines.

Promote the transformation from passive supervision to an active prevention model. Utilize technologies such as AI and big data to conduct real-time monitoring of live streaming content, product feedback, and consumer disputes, achieving frequent identification and dynamic warning of multiple risk factors, and driving live-streaming e-commerce to shift from being driven by traffic to being driven by quality. Real-time sentiment analysis of viewer comments can identify potentially misleading claims as they happen, triggering immediate alerts for platform moderators. Such a proactive approach can prevent harm before it spreads widely.

The risks associated with live-streaming e-commerce have shifted from individual incidents to systemic risks. Scientific identification and assessment are the prerequisites for achieving precise governance. This paper systematically analyzes the key risk factors from four aspects: goods, entities, platforms, and transaction links. It then proposes countermeasures such as full-chain traceability, platform responsibility implementation, collaborative governance, and dynamic monitoring, aiming to provide references for the sustainable development of the industry.

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ROLE OF CROSS-BORDER LOGISTICS SYSTEMS IN BELT AND ROAD INITIATIVE ECONOMIC COOPERATION

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Annotation: In the joint construction of the Belt and Road Initiative, infrastructure connectivity is the foundation, unimpeded trade is the key, and cross-border logistics systems serve as the core link connecting the two. Against the backdrop of profound adjustments in the global industrial and supply chains and accelerated regional economic integration, a comprehensive, efficient and diversified cross-border logistics network can break down trade barriers among countries along the routes, reduce circulation costs, optimize resource allocation, and provide solid support for regional capacity cooperation, trade exchanges and coordinated economic development. Based on the current development of the Belt and Road Initiative, this paper analyzes the core value of cross-border logistics systems, sorts out their key roles in regional economic cooperation, dissects existing shortcomings, and puts forward optimization paths to support the high-quality joint construction of the Belt and Road.

Keywords: Belt and Road Initiative; Cross-border Logistics; Regional Economic Cooperation; Unimpeded Trade; Smart Logistics

1. Introduction

With the steady progress of high-quality joint construction of Belt and Road economic cooperation over the years, the scope of cooperation has continued to expand, and the total trade volume of participating countries has kept increasing, making it an important international cooperation platform. Meanwhile, international trade highly relies on logistics systems. Traditional cross-border trade is restricted by backward infrastructure, cumbersome customs clearance and single transportation modes, which limit the depth of regional economic cooperation.

Cross-border logistics systems integrate infrastructure such as ports, railways and aviation, and combine comprehensive services including multimodal transport, smart logistics, warehousing and customs clearance, serving as an important carrier for transnational flow of factors. With the regular operation of China-Europe Railway Express and deepening cooperation among ports along the routes, a modern logistics network has gradually taken shape, reshaping the new pattern of opening-up and cooperation among countries along the routes, promoting regional coordinated development, and becoming an important driving force for Belt and Road economic cooperation.

2. Core Roles of Cross-Border Logistics Systems in Belt and Road Economic Cooperation

The cross-border logistics system plays a multi-dimensional core supporting and enabling role in the economic cooperation under the Belt and Road Initiative. Relying on infrastructure connectivity construction along the routes, with the China-Europe Railway Express, cross-border railway hubs, coastal port cooperation and multimodal transport systems as important carriers, it continues to open up two-way land-sea logistics corridors, improve cross-regional and cross-border comprehensive logistics layouts, and consolidate the hardware foundation for economic and trade exchanges among countries along the routes.

Meanwhile, through measures such as transportation route optimization, large-scale consolidation and distribution operations, and integrated cross-border customs clearance cooperation, it effectively shortens the circulation time of goods, reduces comprehensive logistics costs, eliminates institutional and operational barriers in cross-border trade, comprehensively improves trade facilitation, and fully stimulates the endogenous momentum of bilateral and multilateral economic and trade cooperation.

On this basis, a mature and sound cross-border logistics network deeply covers all links of the industrial chain, accelerates the free flow of various production factors such as talent, materials, technology and capital, facilitates cross-border capacity matching and industrial division of labor and cooperation, promotes the in-depth integration of regional industrial chains, supply chains and value chains, and continuously strengthens the coordinated industrial development capacity along the routes.

Furthermore, cross-border logistics is not only the artery of economic cooperation, but also an important link for people's livelihood security and cultural exchanges. It stabilizes the cross-border supply of essential goods, fosters new logistics business forms such as cross-border e-commerce and overseas warehouses, promotes enterprise cooperation, mutual recognition of industry standards and personnel exchanges, further enhances cultural exchanges and people-to-people bonds among countries along the routes, and consolidates both the economic and social foundations for the long-term, high-quality multilateral cooperation under the Belt and Road Initiative.

3. Current Research Status and Existing Problems

3.1 Literature Review

Current research shows that multimodal transport under the Belt and Road Initiative boosts high-quality development by integrating the advantages of different transportation modes, realizing seamless connection of goods between different modes, reducing transfer and waiting time, and thus significantly improving logistics efficiency [1].

In addition, relevant studies have proved that infrastructure connectivity among countries under the Belt and Road Initiative has become more accessible. Participating countries have continuously promoted the "four-in-one" connectivity of land, sea, air and internet, advanced cooperation on traditional infrastructure projects steadily, highlighted cooperation on new infrastructure projects, significantly improved the level of "soft connectivity" of rules, regulations and standards, and basically formed a multi-country and multi-port connectivity framework for the trade and logistics system, injecting new vitality into global trade connectivity and common development [2].

The coordination and optimization of policies and systems are also key guarantees for the coordinated development of cross-border e-commerce logistics networks and Belt and Road trade facilitation. Countries should actively carry out bilateral or multilateral dialogues, establish a Belt and Road logistics and trade cooperation alliance, hold regular high-level dialogues, and promote the seamless connection between cross-border logistics and trade [3].

3.2 Existing Problems

There are urgent problems to be solved in cross-border logistics systems for Belt and Road economic cooperation. First, regional infrastructure development is unbalanced. Logistics facilities in Europe, Africa, Central Asia and Southeast Asia are unevenly developed; some regions suffer from insufficient port capacity, inconsistent railway standards and incomplete port supporting facilities, leading to poor logistics connection and low transfer efficiency. Second, there are barriers to the connection of rules and systems. Logistics management rules, customs policies and quarantine standards vary greatly among countries; trade protectionism raises institutional costs, multimodal transport standards are inconsistent, and information exchange is hindered. Third, the development of smart logistics lags behind. Most regions along the routes lack sufficient digital and intelligent applications, have weak capabilities in cargo traceability and whole-process monitoring, and are short of high-end supporting services such as cold chain logistics and supply chain finance, which are difficult to adapt to the development needs of new business forms.

4. Countermeasures for Optimizing the Development of Cross-Border Logistics Systems

4.1 Jointly Build Infrastructure to Make Up for Development Shortcomings

Strengthen infrastructure cooperation along the routes, increase investment in logistics facilities in underdeveloped areas, upgrade cross-border transportation and

port facilities, and unify hardware transportation standards. Improve the layout of multimodal transport hubs, strengthen the linkage construction of logistics parks and bonded warehouses, and build a seamlessly connected comprehensive logistics network.

4.2 Strengthen Policy Coordination and Promote Standard Mutual Recognition

Relying on the Belt and Road cooperation mechanism, promote the coordinated connection of customs, quarantine and logistics rules, simplify customs clearance procedures, and implement facilitation policies such as mutual recognition of origin. Accelerate the integration with international logistics standards, unify transportation and service specifications, and reduce institutional logistics costs.

4.3 Develop Smart Logistics to Improve Service Quality

We will build a cross-border logistics information sharing platform and realize intelligent scheduling and cargo traceability through big data and blockchain technologies. We will increase high-end supporting services such as cold chain logistics and supply chain finance. Meanwhile, by leveraging information technology, we will establish and improve a logistics information network to enable information interoperability among various transportation modes including road, railway, air and water transport, ensuring that logistics information is timely transmitted to all relevant parties. We will actively apply advanced technologies such as the Internet of Things, cloud computing and big data to promote the development and expansion of smart logistics [4].

4.4 Innovate Cooperation Modes and Expand Development Space

Strengthen core logistics brands such as China-Europe Railway Express and New International Land-Sea Trade Corridor to improve operation quality. Encourage transnational cooperation among logistics enterprises, integrate resources along the routes, combine overseas warehouses and cross-border e-commerce, build a model integrating "logistics, industry and trade", and foster new drivers for regional economic cooperation.

5. Conclusion

Cross-border logistics systems are an important cornerstone of Belt and Road economic cooperation, playing an irreplaceable role in connectivity, unimpeded trade, industrial cooperation and balanced regional development. Facing the complex global economic situation, only by continuously improving logistics infrastructure, unifying industry rules, upgrading smart logistics services and innovating cooperation modes can we build an efficient, green and coordinated modern cross-border logistics system. Driven by logistics connectivity, we will promote economic integration, deepen complementary advantages and win-win results among countries along the routes, and continuously inject impetus into the high-quality joint construction of the Belt and Road and the stable development of the global economy.

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THE INVESTMENT ATTRACTIVENESS OF DEVELOPING E-COMMERCE PLATFORMS

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Annotation

This paper examines the investment attractiveness of developing e-commerce platforms in the context of digital economic transformation. It is argued that e-commerce has evolved into a key component of the global trade and economic system, shaping new models of interaction among market participants. The objective of the study is to identify the key factors determining the investment attractiveness of digital trading platforms and to assess their potential in terms of profitability and sustainability.

The study demonstrates that the main drivers of investment attractiveness include the steady growth of the global e-commerce market, economies of scale and network effects, diversified revenue models, as well as low marginal costs and high business scalability. Particular attention is given to the role of the institutional environment and technological factors, including the development of artificial intelligence, big data, and digital payment systems, which contribute to the expansion of platform functionality.

At the same time, key risks are identified, including intense market competition, increasing consumer expectations, regulatory uncertainty, and significant initial investment requirements. The paper concludes that, despite these challenges, e-commerce platforms maintain strong investment potential and long-

term sustainability, provided that risks are effectively managed and competitive advantages are strategically developed.

Key words: e-commerce platforms; digital transformation; investment attractiveness; platform economy; business scalability; institutional environment; digital economy

In the digital economy era, e-commerce has evolved from an emerging business form into a core pillar of global retail and commercial circulation. Developing and investing in e-commerce platforms has become one of the most valuable and promising directions for institutional investors, venture capitalists and industrial capital worldwide. An e-commerce platform is not merely an online trading website; it is a comprehensive digital ecosystem integrating transaction matching, logistics coordination, payment settlement, data operation, merchant incubation and consumer service. Analyzing the investment attractiveness of developing e-commerce platforms helps investors recognize market potential, profit logic, risk factors and long-term growth space, and also provides a clear judgment basis for capital layout in the digital commercial track.

First of all, the strong growth momentum of the global e-commerce market is the fundamental support for the investment attractiveness of e-commerce platforms. With the popularization of smartphones, the improvement of mobile network infrastructure and the continuous change of consumer shopping habits, online shopping has broken the limitations of time and region. Consumers are gradually shifting from offline physical stores to online platforms for daily consumption, household goods, clothing, digital products and even fresh food and service consumption. The proportion of global retail e-commerce sales in total retail sales keeps rising, and emerging markets in Asia, Africa and Latin America still maintain a high growth rate. Unlike offline physical retail, e-commerce platforms have the attribute of scale effect. The more merchants and users gathered on the platform, the stronger the transaction activity and user stickiness, forming a positive cycle of user agglomeration, merchant settlement and transaction expansion. For investors, this sustained market expansion and scale dividend mean stable revenue growth and huge market imagination, which is difficult to achieve in traditional industries.

Secondly, e-commerce platforms have diverse and sustainable profit models, which greatly enhance their investment value and capital return ability. Traditional physical retail mainly relies on commodity sales profit, while mature e-commerce platforms can obtain income from multiple channels. The first basic income is merchant settlement fees, platform service fees and category commission. The platform provides traffic exposure, display positions and transaction channels for settled merchants, and charges a certain proportion of commission according to transaction volume, which becomes the most stable cash flow source. The second is advertising and marketing revenue. As the platform accumulates massive user traffic, it can provide targeted precision advertising, home page recommendation, live broadcast window and other marketing services for brands and merchants, with high

profit margin and strong scalability. The third is value-added service income, including supply chain financing, logistics matching, technical system services, data analysis and user operation services. In addition, many e-commerce platforms adopt subscription membership systems to cultivate user loyalty and obtain continuous prepaid income. Diversified profit models enable e-commerce platforms to get rid of the single profit limitation of traditional industries, realize anti-risk operation, and bring long-term and stable investment returns for capital.

Thirdly, the low marginal cost and scalable operation characteristics further highlight the investment attractiveness of e-commerce platforms. Traditional offline retail needs to continuously invest in store rental, decoration, personnel management and offline operation costs. To expand market share, it is necessary to open new stores one by one, with high marginal cost and slow expansion speed. In contrast, after the basic construction of e-commerce platform system, technical framework and operation system are completed, the marginal cost of increasing users and merchants is extremely low. Relying on digital technology, one platform system can cover the whole country or even global market without laying out offline outlets on a large scale. With the help of big data and algorithm recommendation technology, the platform can accurately match user demand and merchant supply, reduce intermediate links, improve transaction efficiency, and optimize inventory turnover and supply chain circulation efficiency. This asset-light operation mode reduces the threshold of market expansion, shortens the profit cycle, and makes it easier to replicate successful business models in different regions and segmented tracks, which is very in line with the investment preference of modern capital for high growth and light asset projects.

Fourthly, policy support and technological empowerment create a good external environment for investing in e-commerce platforms. Governments around the world are actively promoting the digital transformation of the real economy, introducing policies to support the development of digital commerce, cross-border e-commerce and small and medium-sized enterprises going online. Policy dividends such as tax incentives, infrastructure support and cross-border trade facilitation have reduced the operating cost and policy risk of e-commerce platforms. At the same time, the rapid development of artificial intelligence, big data, cloud computing, mobile payment and live broadcast e-commerce technology continues to empower the iterative upgrading of e-commerce platforms. Intelligent recommendation improves user shopping experience, big data analysis helps the platform grasp consumption trends and optimize operation strategies, live broadcast and short video e-commerce open new transaction scenarios, and digital payment and intelligent logistics guarantee the whole transaction closed loop. Technological progress not only enhances the core competitiveness of the platform, but also continuously expands the business boundary, making it possible to expand from physical goods transaction to life service, cross-border trade, rural e-commerce and other fields, bringing broader growth space for investors.

Nevertheless, investing in the development of e-commerce platforms also has certain potential risks, which are important factors that investors need to consider comprehensively. First, the market competition is fierce. The low entry threshold of the e-commerce track leads to a large number of new entrants, and the homogenization competition of comprehensive platforms and segmented platforms is increasingly intense, which may lead to rising traffic costs and profit compression. Second, user demand is constantly upgrading, and consumers have higher requirements for product quality, after-sales service, shopping experience and logistics speed. If the platform cannot keep up with the demand iteration, it will easily lose user stickiness. Third, it faces challenges such as regulatory policy changes, consumer privacy protection, commodity quality supervision and cross-border trade policy fluctuations. In addition, the initial construction of e-commerce platforms requires large capital investment in technology research and development, market promotion and user cultivation, and the profit cycle of early operation is long, which puts forward higher requirements for the capital strength and sustainable operation ability of investors.

In general, despite certain market competition and operational risks, the investment attractiveness of developing e-commerce platforms is still prominent and irreplaceable. It benefits from the continuous expansion of the digital consumer market, diversified and stable profit models, asset-light scalable operation advantages, as well as the dual empowerment of policy and technology. In the future, with the further deepening of digital economy, the integration of online and offline commerce, the rise of cross-border e-commerce and rural e-commerce, e-commerce platforms will continue to release new growth potential. For investors, rational layout of high-quality segmented tracks, building differentiated competitive advantages, optimizing operation and service capabilities, and controlling operational and policy risks can effectively grasp the investment dividends brought by the development of e-commerce platforms. As an important carrier connecting merchants, consumers and industrial supply chains, e-commerce platforms will maintain long-term investment value and broad development prospects in the wave of global digital economic development.

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DEVELOPMENT PREDICAMENTS AND TRANSFORMATION PATHWAYS OF TRADITIONAL RETAIL IN THE CONTEXT OF CHINA'S RISING E-COMMERCE SECTOR

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Annotation: The rapid growth of the digital economy has provided e-commerce with a structural advantage over traditional retail, significantly reshaping the competitive landscape of China's domestic market. Brick-and-mortar retailers are experiencing declining foot traffic, rising operational costs, and stagnating efficiency. This study is based on statistical data released by national authorities up to 2025. It analyzes the development of e-commerce and identifies the key challenges faced by traditional retail across four dimensions: operations, cost structure, supply chain, and digital transformation. The paper proposes four strategic pathways—online-offline integration, supply chain optimization, digital technology adoption, and differentiated positioning—to support the sustainable transformation of traditional retail in China.

Keywords: e-commerce; e-commerce; brick-and-mortar retail; operational challenges; transformation pathways; digital transformation

Introduction

Digital technologies are increasingly embedded in economic activities, and e-commerce has become a major driver of consumption growth and industrial transformation. While online retail continues to expand rapidly, traditional retail remains an essential component of the national circulation system. However, structural weaknesses of offline retail—such as declining customer traffic, high rental and labor costs, and low levels of digitalization—have become more evident. This study is grounded in transaction cost theory and omnichannel retail theory, which explain the efficiency advantages of e-commerce and the necessity of integrating

online and offline channels. Existing research mainly focuses on macro-level transformation, with limited attention to operational challenges and practical solutions. This paper addresses this gap by analyzing current industry data and proposing targeted transformation strategies.

China has maintained its position as the world's largest online retail market for more than a decade, with total online retail sales reaching 15.97 trillion yuan in 2025, demonstrating steady growth [1]. The share of physical goods sold online continues to increase, reflecting the deep penetration of digital commerce into everyday consumption. As shown in Figure 1, the growth rate of online retail significantly exceeds that of traditional retail, confirming a structural shift in the market [3]. New business models such as live-streaming commerce and instant retail are expanding rapidly, while cross-border e-commerce initiatives are strengthening international trade connections [2]. At the same time, widespread internet penetration and the dominance of mobile access have created favorable conditions for continued expansion of digital platforms [2].

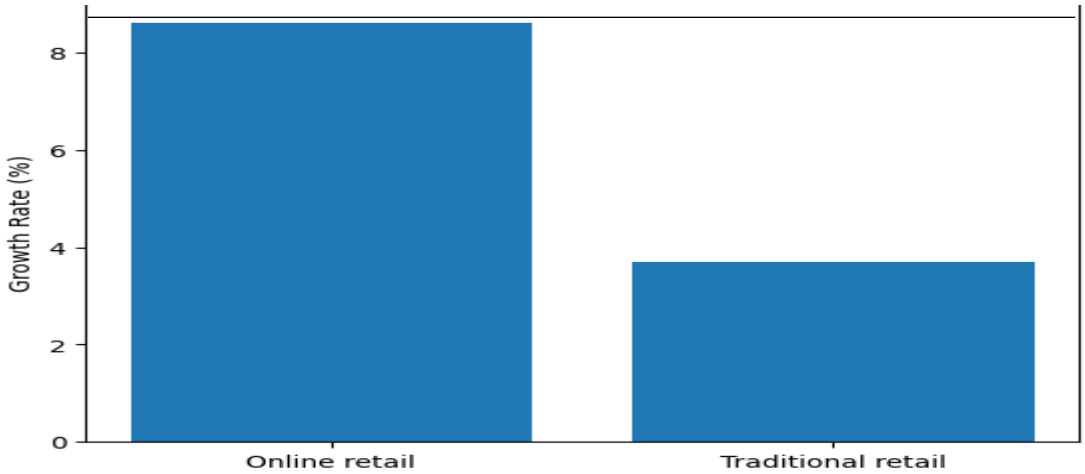

Figure 1 – Growth rates of online and traditional retail in China (2025)
Source: compiled by the author based on [1], [3]

In contrast, traditional retail faces significant operational challenges. Growth rates remain considerably lower than those of digital commerce, and the gap continues to widen, indicating a structural transformation of the retail landscape [3]. As reflected in Table 1, key retail formats demonstrate weak or even negative growth dynamics. Many brick-and-mortar enterprises, particularly small and medium-sized businesses, struggle with declining sales performance, limited resources, and insufficient capacity for digital transformation.

Table 1 – Core indicators of retail performance in China (2025)

Category	Indicator	Growth Rate (%)	Notes
Retail goods	Grain and edible oils	9.3	Stable growth
	Gold and jewelry	12.8	High demand

Category	Indicator	Growth Rate (%)	Notes
	Communication equipment	20.9	Rapid growth
	Petroleum products	-5.7	Decline
	Automobiles	-1.5	Decline
Retail formats	Convenience stores	5.5	Moderate growth
	Supermarkets	4.3	Stable
	Department stores	0.1	Stagnation
	Franchise stores	-0.6	Decline
Online retail	Physical goods	5.2	26.1% of total retail

The cost structure further aggravates the situation. Traditional retailers face significantly higher rental and labor expenses compared to online businesses. According to industry data, rental costs account for approximately 18% of revenue and labor costs for 22%, while in e-commerce these figures are significantly lower [4]. As illustrated in Figure 2, operating costs in offline retail remain substantially higher, limiting profitability and long-term sustainability.

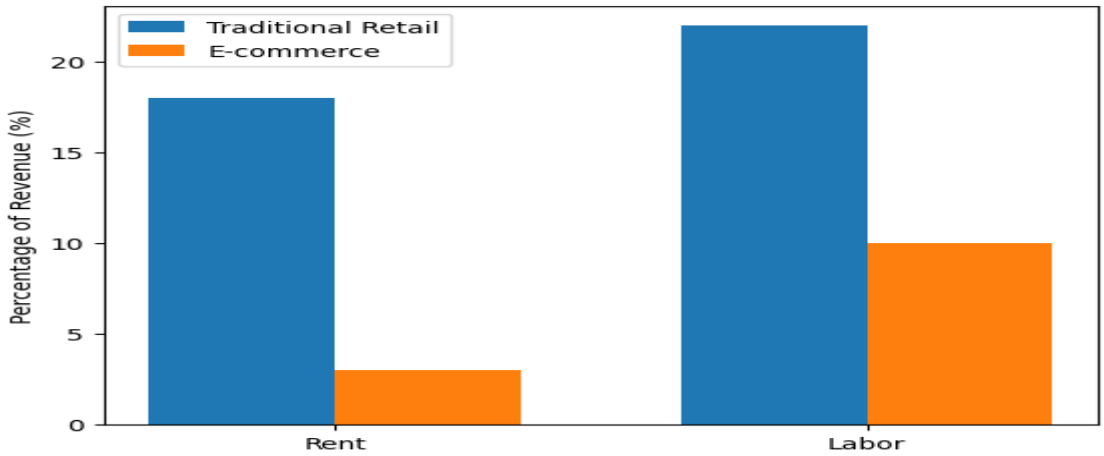

Figure 2 – Comparison of cost structure (% of revenue)
Source: compiled by the author based on [4]

Supply chain inefficiencies represent another major constraint. Multi-level distribution systems increase logistics costs and reduce responsiveness to market demand. Regional disparities in infrastructure development further intensify these issues, especially for enterprises operating outside major economic centers. In 2025, eastern regions accounted for over 70% of logistics activity, highlighting uneven development across the country [5]. Meanwhile, digital transformation remains limited, as most companies adopt only basic technological tools without deeper integration into core business processes.

Despite these challenges, transformation pathways are emerging. The

integration of online and offline channels enables businesses to combine physical presence with digital accessibility, improving customer experience and operational efficiency. Supply chain optimization through digital tools and direct sourcing can significantly reduce costs. Increased investment in digital technologies and workforce development is essential for enhancing competitiveness, while collaboration with educational institutions and external experts can address skill shortages.

Furthermore, differentiated strategies allow traditional retailers to avoid direct competition with large digital platforms. By focusing on experiential consumption, localized services, and niche markets, businesses can create unique value propositions. As shown in Figure 3, consumer preference is gradually shifting toward experience-oriented services, which provides a strategic advantage for offline formats.

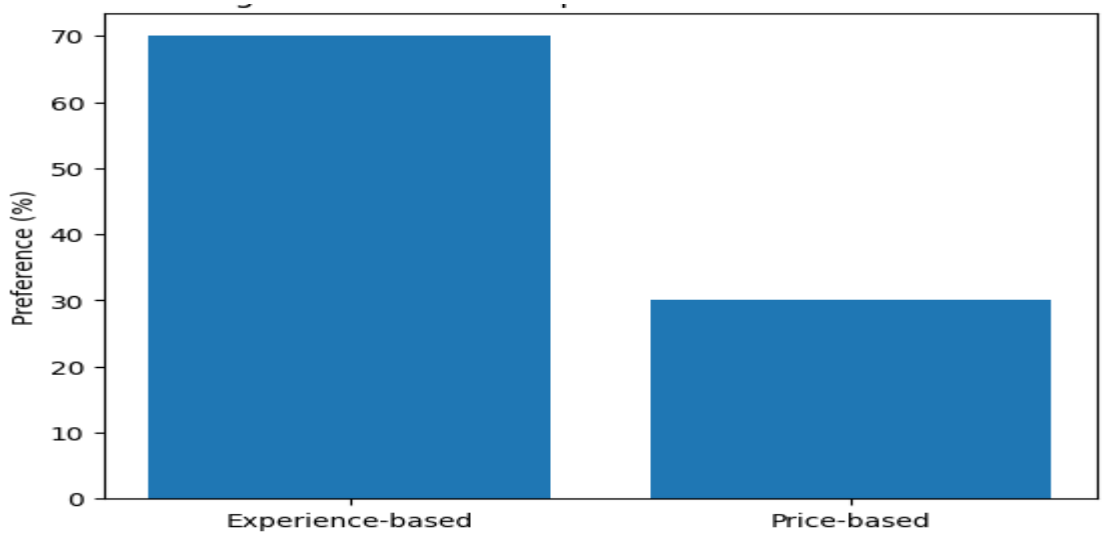

Figure 3 – Consumer preference trends in retail
Source: compiled by the author

Overall, the rapid development of digital commerce creates both challenges and opportunities. While traditional retail faces structural disadvantages, strategic adaptation and innovation can ensure sustainable development. The future of the sector lies in the balanced coexistence of online and offline models, contributing to a more resilient and efficient economic system.

In addition, it can be argued that the transformation of traditional retail is not only a response to competitive pressure from digital platforms but also a necessary stage in the evolution of the modern economic system. The integration of digital technologies into offline business processes allows enterprises to improve transparency, optimize resource allocation, and enhance customer engagement. At the same time, government support measures and the gradual improvement of digital infrastructure create favorable conditions for accelerating this transformation. Therefore, the successful development of traditional retail in China will depend on the ability of enterprises to combine technological innovation with their inherent advantages in physical presence and customer experience, forming a hybrid model

that ensures long-term competitiveness and stability in a rapidly changing market environment.

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THE EFFECT OF RENEWABLE ENERGY POLICIES ON ENERGY SUPPLY IN CHINA - ANALYSIS BASED ON THE DUAL GOALS OF ENERGY SECURITY AND LOW-CARBON TRANSITION

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Annotation.

Against the backdrop of global energy transition and China’s “dual carbon” goals, renewable energy policies exert a profound impact on energy structure adjustment and energy security. Based on the dual objectives of energy security and low-carbon transition, this paper analyzes the implementation effects and practical dilemmas of China’s renewable energy policies. It shows that such policies have

effectively promoted the clean transformation of energy and reduced external dependence, yet problems including pressure on energy supply, unbalanced regional development, difficulties in new energy accommodation, and insufficient coordination of multiple objectives still exist. The study can provide references for optimizing policy design, coordinating energy security and low-carbon transition, and improving the stability of energy supply.

Key words: Renewable Energy Policies; Energy Supply; Energy Security; Low-Carbon Transition; Energy Structure

I. Research Background and Significance

(I) Research Background

Against the backdrop of accelerating global energy transition and in-depth advancement of the "dual carbon" goals, China is vigorously promoting the clean and low-carbon transformation of its energy structure. As a crucial component of the energy system, renewable energy plays a key role in ensuring long-term stable energy supply, reducing external dependence, and cutting carbon emissions. In recent years, the Chinese government has issued a series of supportive and guiding policies to drive the rapid development of wind power, photovoltaic power, hydropower, biomass energy, and other renewable energy sources, leading to significant changes in the energy supply pattern. However, prominent challenges remain, such as mounting pressure on energy supply security, unbalanced regional development, difficulties in renewable energy consumption, and insufficient coordination between traditional energy and new energy. Under this context, it is of great practical necessity to systematically study the actual impact of renewable energy policies on energy supply and analyze the mechanism of these policies in advancing both energy security and low-carbon transition.

(II) Research Significance

1. Theoretical Significance This study enriches the theoretical system related to energy policies and energy transition, improves research on energy governance from the perspective of policy effect evaluation, and provides a theoretical reference and analytical framework for subsequent studies.

2. Practical Significance The research findings offer decision-making references for the government to optimize renewable energy policies, enhance the stability and security of energy supply, and balance development and security. It also contributes to promoting the high-quality development of the energy industry.

II. Domestic Research Status

Domestic research has grown rapidly in recent years, conducting extensive analyses on energy structure transformation, energy security, dual carbon goals, and renewable energy consumption. However, most studies focus on a single policy or a single goal, leaving room for expansion in research on the coordination of multiple goals. Overall, existing research has laid a solid foundation for this paper, but further exploration is needed in terms of policy transmission mechanisms, regional heterogeneity, and dynamic impacts.

III. Research Methods

This study adopts the following research methods:

1. Literature Research Method: Systematically collate domestic relevant literature, policy documents, and statistical data to build the research foundation.

2. Statistical Analysis Method: Use macro statistical data to conduct quantitative analysis on energy structure, supply changes, and regional differences.

3. Comparative Analysis Method: Compare policy effects across different regions and stages to summarize laws and identify problems.

IV. Research Innovations and discussion

1. Evaluate policy effects more comprehensively from the dual perspectives of energy security and low-carbon transition.

2. Focus on regional heterogeneity to reveal differences in policy effects across different regions, which is more in line with China's actual situation.

3. Adopt a problem-oriented approach to directly address practical pain points such as energy supply security, renewable energy consumption, and coordination, making the countermeasures more operable.

China's renewable energy policy has become one of the most significant components of its national development strategy, particularly under the dual objectives of ensuring energy security and accelerating the low-carbon transition. As the world's largest energy consumer and carbon emitter, China faces a unique challenge: it must sustain economic growth and industrialization while simultaneously reducing environmental degradation and dependence on imported fossil fuels. Over the past two decades, renewable energy policies in China have evolved from environmental protection measures into strategic tools for restructuring national energy supply. The introduction of the Renewable Energy Law in 2005, followed by continuous policy reinforcement through successive Five-Year Plans, created a foundation for large-scale investment in wind, solar, hydro, and nuclear-adjacent clean systems. These policies are directly connected to China's "dual carbon goals" of peaking carbon emissions before 2030 and achieving carbon neutrality by 2060, which have significantly increased the importance of renewable energy in national planning.

From the perspective of energy security, China's renewable energy policies are designed to reduce the country's vulnerability to external energy shocks. Historically, China's heavy reliance on coal ensured domestic energy supply but caused severe pollution and carbon emissions, while increasing imports of oil and natural gas exposed the country to geopolitical and market risks. According to recent national energy statistics, China imports more than 70% of its crude oil demand, creating substantial strategic pressure. Renewable energy development therefore serves not only climate objectives but also energy independence by expanding domestic electricity generation capacity through solar and wind power. By 2025, China's wind and solar installed capacity surpassed 1,600 GW, compared with approximately 530 GW in 2020, reflecting extraordinary annual growth. This expansion has

strengthened domestic power generation capacity, diversified the energy mix, and reduced long-term reliance on imported hydrocarbons. In this sense, renewable policy functions as a national security mechanism by stabilizing supply and protecting economic resilience.

At the same time, China's renewable energy strategy is deeply embedded in its low-carbon transition agenda. The country's industrial structure has historically depended on carbon-intensive manufacturing, making decarbonization particularly difficult. Through policy tools such as feed-in tariffs, renewable portfolio standards, green finance instruments, and subsidies for electric power infrastructure, China has become the global leader in renewable deployment. By 2025, renewable sources accounted for roughly one-third of national electricity consumption, while non-fossil energy represented around 20% of primary energy consumption. China also became the world's largest investor in clean energy, with annual investments exceeding USD 600 billion. These policies have significantly lowered the carbon intensity of GDP and positioned China as the dominant producer of solar panels, lithium batteries, and electric vehicles. Thus, renewable policy supports not only environmental sustainability but also industrial competitiveness in the emerging global green economy.

Despite these achievements, the effectiveness of renewable energy policies remains constrained by structural contradictions. One major issue is that renewable expansion has not fully replaced coal; instead, coal continues to serve as a stabilizing backup for grid security. While renewable capacity has grown rapidly, coal-fired power plants remain critical in balancing intermittent energy supply from solar and wind. This creates what scholars describe as a "dual-track transition," where clean energy expands alongside traditional fossil fuel infrastructure rather than completely displacing it. In some provinces, renewable curtailment remains a challenge because generation capacity exceeds transmission and storage capabilities. Large-scale solar and wind projects in western China often produce more electricity than regional grids can absorb, highlighting infrastructure imbalances. Consequently, policy success in expanding renewable supply does not always translate into immediate carbon reduction, especially when coal remains central to grid reliability.

Another important dimension is the role of state planning in coordinating renewable growth. China's 14th Five-Year Plan (2021–2025) emphasized renewable energy as both a security and decarbonization priority, targeting 33% renewable electricity consumption and major expansion of ultra-high-voltage transmission systems. The state's centralized planning model has enabled rapid infrastructure deployment that many market-based economies struggle to replicate. However, this model also prioritizes stability, meaning that energy security often outweighs aggressive decarbonization when trade-offs arise. For example, during periods of electricity shortages or industrial pressure, coal production has been temporarily increased to ensure supply continuity. This demonstrates that China's policy

framework can be characterized as “security-first decarbonization,” where carbon reduction is pursued pragmatically rather than at the expense of economic stability.

In conclusion, renewable energy policies in China have profoundly transformed the country’s energy supply structure by integrating the strategic goals of energy security and low-carbon transition. Statistical evidence demonstrates substantial achievements in renewable capacity expansion, energy diversification, and green industrial leadership. However, these successes are accompanied by persistent challenges, including coal dependence, grid integration limitations, and uneven carbon reduction outcomes. China’s experience illustrates that renewable energy policy is not merely an environmental tool but a broader strategic framework combining national security, economic modernization, and climate governance. For master’s-level research, China offers a compelling example of how renewable energy policy can simultaneously strengthen domestic energy resilience and promote low-carbon development, while also revealing the complexities of balancing immediate energy needs with long-term sustainability objectives. Future analysis should focus on regional disparities, storage technologies, and policy reforms that can better align energy security with deeper decarbonization.

V. Research Difficulties and Solutions. Firstly, Difficulty related to the complex influencing factors of policies make quantitative identification challenging. Second, finding the solutions to prioritize mechanism analysis, combined with cross-validation using statistical data and literature evidence.

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NEW LOGIC AND PARADIGM OF VALUE CREATION IN THE DIGITAL-ECONOMY ERA

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Annotation. Under the Digital Silk Road and Belt and Road Initiative, the digital economy drives China-Kazakhstan economic and trade upgrading, reducing costs via digital ports, cross-border e-commerce and smart logistics to empower bilateral cooperation and build the China-Central Asia community with a shared future.With strong complementarity and Kazakhstan's digital transformation, the two countries have expanded digital cooperation, yet face constraints like institutional differences, uneven infrastructure, talent shortages and regulatory misalignment, leading to superficial, fragmented cooperation. Based on 2021–2025 data, this report analyzes bottlenecks and proposes actionable pathways for high-quality development, supporting deeper cooperation and a new regional value creation paradigm.

Keywords: China-Kazakhstan economic and trade; The Belt and Road Initiative Cross-border e-commerce; a new paradigm of value creation

1.The Current Status and Achievements of China Kazakhstan Digital Economy Cooperation

This report selects official statistical data from 2021 to 2025 to quantitatively analyze the effectiveness of bilateral digital economy cooperation from five core dimensions. The core data is as follows:

Year	E-commerce transaction scale in Kazakhstan(in billions of US dollars)	Cross border e-commerce transaction volume between China and Kazakhstan (in billions of US dollars)	Contribution rate of data elements to bilateral economic and trade growth (%)	Port clearance efficiency increased year-on-year（%）	Cross border logistics costs decrease year-on-year（%）
2021	20.8	14.6	18.2	—	—
2022	35.2	21.3	24.5	18.2	5.3
2023	52.6	27.8	30.7	22.5	6.8
2024	68.4	32.5	35.4	16.8	4.2
2025	81.0	36.1	39.1	7.5	5.1

Data source: General Administration of Customs of China, China Information and Communication Research Institute, Khorgos Port Public Operation Data Processing

From 2021 to 2025, China-Kazakhstan digital economy cooperation expanded steadily in both scale and quality. Kazakhstan's domestic e-commerce nearly tripled, and bilateral cross-border e-commerce grew much faster than traditional trade. Data elements doubled their contribution to bilateral growth and became the core driver. Smart ports and digital customs clearance raised efficiency, cut logistics costs, improved trade facilitation, and boosted industrial and investment cooperation[1].

2.Current core issues in China Kazakhstan digital economy cooperation

The current scale of China-Kazakhstan digital cooperation is expanding, but development quality lags behind. Cooperation remains shallow and fragmented without a systematic high-value model. First, cross-border data governance rules differ, creating institutional barriers and data islands that restrict data flow and cooperation. Second, digital infrastructure is poorly connected, with unbalanced development in Kazakhstan and incompatible technical systems. Third, a shortage of composite digital talents weakens innovation momentum and lacks stable cooperation mechanisms. Fourth, misaligned industry standards and regulation bring high institutional costs such as repeated certification. Fifth, industrial cooperation stays at the low end of the value chain with insufficient high-end digital collaboration.

3.Optimization Path for High-Quality Collaborative Development of China-Kazakhstan Digital Economy

First, establish a coordinated data governance mechanism to unify standards and unlock data value. Second, jointly improve digital infrastructure to achieve cross-border connectivity and integration. Third, build a cross-border talent training system to strengthen innovation capacity. Fourth, promote mutual recognition of rules and standards to reduce institutional transaction costs. Fifth, optimize industrial cooperation and drive the value chain toward high-end upgrading[2].

4. Conclusion

From 2021 to 2025, China-Kazakhstan digital economy cooperation achieved remarkable results, with growing trade, improved logistics efficiency and strong data-driven momentum as a core growth engine. Yet institutional barriers, infrastructure gaps, talent shortages, rule mismatches and low-end value chain lock-in still hinder high-quality development. Going forward, the two countries should deepen coordination in institutions, infrastructure, talent, rules and industrial cooperation,

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[1] Huang H ,Yu C .The Silk Road e-commerce cooperation initiative and the digital value-added trade between China and the BRI participating countries[J].Humanities and Social Sciences Communications,2026,13(1):269.

[2] Ba Dianjun, Lv Boyao The foundation, challenges and path of digital economic cooperation among countries along the "the Belt and Road" [J]. Henan Social Sciences, 2024,32 (01): 43-51

unlock data value, and upgrade bilateral digital cooperation to higher-level, higher-value and wider fields, supporting the Digital Silk Road and the China-Central Asia community with a shared future.

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PROSPECTS OF DIGITAL YUAN IN BELT AND ROAD INITIATIVE CROSS-BORDER PAYMENTS

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Annotation. With the rapid development of the digital economy, the cross-border payment industry is undergoing profound changes. As China’s legal central bank digital currency, the Digital Yuan (e-CNY) demonstrates enormous potential in cross-border payment scenarios due to its technical attributes and institutional innovations. Starting with the technical strengths of e-CNY, this paper systematically summarizes its practical applications in cross-border trade settlement, personal remittance, bulk commodity transactions and other fields. It also identifies the challenges in regulatory coordination, unified technical standards and network

coverage, and puts forward targeted countermeasures and suggestions, so as to provide a reference for the in-depth development of cross-border application of the Digital Yuan.

Keywords: Digital Yuan; Cross-border Payment; Central Bank Digital Currency; RMB Internationalization

Introduction. Against the backdrop of global economic integration, cross-border payment serves as a crucial bond connecting international trade, cross-border investment and personnel exchanges. However, the traditional cross-border payment system has long been confronted with prominent drawbacks such as low efficiency, high costs and insufficient transparency. This paper systematically analyzes the application status, core advantages, practical cases and existing challenges of the Digital Yuan in cross-border payment, explores its future development direction, and provides theoretical support and practical reference for relevant policy formulation and technical optimization.

Core Advantages of Digital Yuan in Cross-border Payment

1 Technology-driven Construction of an Efficient and Secure Payment Foundation

Distributed Ledger Technology (DLT) improves transaction transparency and traceability. Based on the blockchain architecture, the Digital Yuan realizes real-time data synchronization and tamper-proof transaction records among central banks, commercial banks and all participating parties. In cross-border payment, this function effectively streamlines the complicated reconciliation and settlement links involving multiple institutions under the traditional model and improves overall transaction transparency. For instance, with distributed ledgers, regulatory authorities can track capital flows in real time and guard against money laundering and terrorist financing risks.

Smart contracts enable automatic transaction execution. Embedded with smart contract functions, the Digital Yuan allows preset payment terms to be triggered and executed automatically. In cross-border trade, enterprises can set customized rules including "automatic payment upon goods customs clearance" and "settlement after service completion". The system completes fund transfers automatically based on external data from customs, logistics and other channels, which greatly reduces manual intervention and credit risks.

2 Institutional Innovation to Balance Convenience and Compliance

Different from traditional electronic payments that require mandatory bank account binding, the Digital Yuan supports non-account-based digital wallets. It enables small and medium-sized enterprises and individual traders excluded from the traditional banking system to participate in cross-border transactions, thereby enhancing the inclusiveness of financial services.

On the premise of protecting users' basic privacy, the Digital Yuan adopts a dual mechanism of traceable large-value transactions and anonymous small-value transactions. It protects trade secrets and personal privacy, while ensuring regulators

can legally obtain transaction information when necessary, fully complying with international regulatory standards such as Anti-Money Laundering (AML) and Counter-Terrorist Financing (CFT).

3 Remarkable Superiority in Cost Reduction and Efficiency Improvement

Traditional cross-border payments require participation of multiple correspondent banks, with service fees generally ranging from 3% to 5%, accompanied by additional exchange rate losses. Through disintermediated peer-to-peer transactions, the Digital Yuan eliminates intermediate bank service fees. Meanwhile, it supports direct RMB pricing and settlement, simplifying foreign exchange procedures. Pilot data indicates that e-CNY can cut cross-border payment costs by more than 60%.

The Digital Yuan supports 24/7 uninterrupted operation and realizes instant settlement upon payment, shortening the capital arrival cycle from several days under traditional modes to seconds.

Application Scenarios and Practical Progress

1 Regional Pilots for Building a Global Application Network

In the Guangdong-Hong Kong-Macao Greater Bay Area, the cross-border settlement volume of the Digital Yuan has exceeded 800 billion yuan, accounting for 12% of the total regional trade volume. At Pingxiang Port in Guangxi, over 8,000 offline wallets have been launched in cooperation with Vietnam. The fund arrival time for agricultural product trade has been shortened from 7 days to 2 hours, with transaction volume increasing by 240%.

Countries including the United Arab Emirates and Saudi Arabia have adopted the Digital Yuan for energy trade settlement. In 2025, Saudi Arabia completed its first oil trade settlement with China denominated in e-CNY, reaching 18 billion US dollars, marking a milestone for the Petro-RMB strategy.

In South Africa, Brazil and other regions, the Digital Yuan is being piloted for mineral resource transactions and infrastructure project payments, empowering the high-quality development of the Belt and Road Initiative.

2 Typical Application Cases

Hainan Free Trade Port has completed over 80 billion yuan in cross-border payments via the Digital Yuan, cutting trade dispute rates by 60%. The Shanghai Branch of Industrial and Commercial Bank of China launched the "Shanghai e-Remittance" service, enabling fund arrival within 5 minutes and reducing comprehensive costs by nearly 50%.

June 2025, the International Digital Yuan Operation Center was established in Shanghai. Relying on the "Digital Currency Link" platform, it provides low-cost and high-speed settlement services for small and medium-sized enterprises. A clothing enterprise in Guangzhou aggregated more than 2,000 small-batch orders through sub-wallets, saving 67% of handling fees on a monthly basis.

Challenges and Countermeasures

Despite fruitful achievements in cross-border application, the Digital Yuan still

faces multiple challenges. There are significant differences in national financial supervision systems and data privacy regulations worldwide. For example, the EU GDPR advocates data minimization, which conflicts with China's regulatory principle of "anonymity for small transactions and traceability for large transactions. It is essential to promote multilateral regulatory coordination and unify standards for identity authentication and anti-money laundering through signing bilateral and multilateral memorandums of understanding.

By adopting the "scenario-for-market" strategy, China can further deepen e-CNY application in ASEAN, the Middle East and other regions to form a demonstration effect. In addition, continuously optimizing user experience will effectively strengthen market recognition and competitiveness.

Conclusion and Prospects

The cross-border application of the Digital Yuan represents not only technological innovation, but also a key practice in reshaping the global financial governance system.

This technology-driven financial revolution is gradually reforming the century-old international payment rules and gathering strong momentum to reshape the logic of global capital flows. The cross-border development of the Digital Yuan is far more than a technological competition; it is a long-term journey concerning international rules, mutual trust and future global economic cooperation.

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THE IMPACT OF DIGITAL TRADE PLATFORMS ON INTERNATIONAL SUPPLY CHAIN STRUCTURE AND TRADE RELATIONS

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Annotation. Against the backdrop of the rapid advancement of the digital economy and the "Belt and Road" initiative, digital trade platforms have emerged as a core carrier reshaping the global trade pattern. This paper analyzes the mechanism by which digital trade platforms drive the restructuring of international supply chains, including reducing information asymmetry, improving cross-border transaction efficiency, and reconstructing value distribution links. Based on trade data between Kazakhstan and China from 2018 to 2025, this paper empirically tests the positive correlation between digital trade platform penetration rate and bilateral supply chain stability, as well as its promoting effect on the diversification of trade relations. The study also puts forward targeted optimization suggestions for Central Asian countries to deeply participate in the global digital trade system, improve cross-border supply chain resilience, and expand trade cooperation space under the "Belt and Road" framework. The conclusions show that digital trade platforms significantly enhance supply chain stability and optimize trade relations, especially in agricultural products, light industry, and cross-border service industries.

Keywords: digital trade platforms; international supply chain; trade relations; Belt and Road Initiative; China-Kazakhstan trade

1. Introduction

The global trade system is undergoing a digital transformation led by the platform economy. With the rapid development of information technology, big data, cloud computing, and cross-border payment systems, digital trade platforms have gradually replaced traditional trade models and become important infrastructure for global economic and trade cooperation. Digital trade platforms, represented by cross-border e-commerce platforms, international supply chain service platforms, and digital trade facilitation platforms, have changed the traditional trade transaction model, lowered the threshold for small and medium-sized enterprises to participate in international trade, and brought profound changes to the structure of global supply chains and the pattern of bilateral and multilateral trade relations.

For Kazakhstan, an important node country of the "Belt and Road" initiative, the development of digital trade platforms is of great strategic significance for deepening economic and trade cooperation with China, improving the efficiency of cross-border logistics and supply chains, and promoting the high-quality development of foreign trade. In recent years, with the promotion of the "Digital Silk Road," cooperation between Kazakhstan and China in digital infrastructure, cross-border e-commerce, logistics services, and customs clearance facilitation has continued to deepen. However, compared with developed economies, both countries still face problems such as low platform penetration, insufficient infrastructure connectivity, and inconsistent digital trade rules. Therefore, studying the impact of digital trade platforms on supply chain structure and trade relations between Kazakhstan and China has important theoretical value and practical significance for promoting bilateral economic and trade cooperation.

This paper first sorts out the theoretical mechanism of digital trade platforms affecting supply chains and trade relations, then conducts an empirical analysis based on bilateral industry panel data, and finally proposes policy implications for deepening digital trade cooperation under the Belt and Road framework.

2. Theoretical Mechanism of Digital Trade Platforms Affecting Supply Chains and Trade Relations

Digital trade platforms affect the international supply chain system and trade relations from three dimensions: information matching effect, service integration effect, and value reconstruction effect.

First, the information matching effect reduces search costs and information asymmetry between suppliers and buyers. In traditional international trade, enterprises often face difficulties in finding suitable partners, high communication costs, and opaque market information. Digital trade platforms integrate massive supply and demand information, realize real-time matching through algorithms, and greatly reduce the cost of information collection and transaction negotiation. Meanwhile, the transparency of platform information helps curb opportunistic behavior, improve trust between trading parties, and promote the flattening of supply chain structures.

Second, the service integration effect improves the efficiency of cross-border transactions. Digital trade platforms integrate a full range of supporting services such as cross-border payment, international logistics, customs clearance, inspection and quarantine, tax refund, and financial services. Through one-stop services, the whole transaction cycle is shortened, intermediate links are reduced, and operational efficiency of the supply chain is significantly improved. For small and medium-sized enterprises, such integrated services lower the technical and capital threshold for participating in international trade.

Third, the value reconstruction effect promotes the diversification and optimization of trade relations. By lowering entry barriers, digital trade platforms enable more enterprises from emerging markets to participate in the global division of labor. These enterprises gain greater voice in the value chain and promote the diversification of import sources and export markets. At the same time, the platform's data advantages help enterprises conduct precision marketing and product upgrading, so as to enhance value-added capacity in the global value chain.

Based on the above mechanisms, this paper constructs a theoretical analysis framework of "platform penetration – supply chain restructuring – trade relation optimization."

3. Empirical Analysis Based on Kazakhstan-China Trade Practice

This paper selects panel data of 14 major trade industries between Kazakhstan and China from 2018 to 2025. The core explanatory variable is the penetration rate of digital trade platforms in each industry. The explained variables include supply chain stability and trade relation closeness.

Supply chain stability is measured by two indicators: the fluctuation degree of the supply cycle and the diversification level of import sources. Trade relation closeness is measured by the growth rate of bilateral trade volume and the number of trading enterprises.

The regression results show that:

For every 10% increase in the penetration rate of digital trade platforms, the stability of the bilateral supply chain increases by 7.2%, and the closeness of trade relations increases by 9.4%. The results are significant at the 1% statistical level, indicating that digital trade platforms have a strong positive effect on supply chain stability and trade relations.

Further heterogeneity analysis shows that the promoting effect is more significant in three types of industries:

1.Agricultural products: Platforms reduce logistics losses and improve traceability.

2.Light industrial products: Small and medium-sized enterprises benefit most from low-threshold exports.

3.Cross-border service trade: Digital delivery enables service trade to expand rapidly.

The empirical results confirm the theoretical hypothesis and show that digital trade platforms have become an important driving force for stabilizing Sino-Kazakh supply chains and optimizing trade relations.

4. Policy Implications

Based on the research conclusions, this paper puts forward three policy suggestions for Kazakhstan and China under the framework of the Belt and Road Initiative.

First, deepen the construction of cross-border digital trade infrastructure. The two countries should strengthen cooperation in 5G, cloud computing, big data centers, and cross-border optical cables. At the same time, they should jointly build a bilateral digital trade public service platform covering customs clearance, logistics, tax refund, payment, and settlement to realize interoperability of data and systems.

Second, improve the policy support system for small and medium-sized enterprises to access digital trade platforms. Governments can carry out training, provide financial subsidies, reduce compliance costs, and encourage more SMEs to carry out cross-border operations. Expanding the number of trading entities will help enhance the diversification and resilience of trade relations.

Third, strengthen the coordination of digital trade rules. Under the Belt and Road framework, the two sides can explore unified standards for data flow, electronic certification, online dispute resolution, and platform supervision. Establishing a stable rule system will help reduce institutional costs and promote long-term and stable development of digital trade.

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THE 'INVESTMENT-RISK' DUAL ATTRIBUTES OF DIGITAL INFRASTRUCTURE: A STUDY ON THE REAL OPTION VALUE AND RISK SHARING OF TOWER SITE SHARING

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Annotation. Digital infrastructure is characterized by high capital input, long payback period and strong uncertainty, presenting a dual attribute of "investment-risk" symbiosis. Taking China Tower's site sharing as the research object, combined with front-line practices of operation, maintenance, monitoring, emergency management and asset digital monitoring, this paper analyzes the real option value of site sharing from an economic perspective, and disassembles risks from the dimensions of policy, construction, operation and finance. It reveals how the sharing model realizes multi-party risk sharing through resource sharing, cost sharing, demand aggregation, policy credit enhancement and digital risk control. The findings show that site sharing significantly enhances the value of four types of options: delay, expansion, conversion and abandonment, greatly reduces capital expenditure, and narrows the risk exposure through digital monitoring and co-construction mechanism. This paper weakens complex algorithms, strengthens the perspective of operation, maintenance and monitoring and economic logic, and all data come from real enterprise operation materials, providing practical references for investment and financing, risk management and regional economic development of digital infrastructure.

Keywords: real option; risk sharing; sharing economy; capital expenditure; digital infrastructure; uncertainty

1. Introduction

Digital infrastructure is a typical heavy-asset project, and traditional investment evaluation is difficult to reflect the decision-making value under uncertainty. As core nodes of communication networks, tower sites face multiple risks such as approval fluctuations, demand changes, property obstruction, station demolition compensation and rising operation and maintenance costs. As the person in charge of monitoring and emergency management in the operation and maintenance department, the author has long been responsible for site operation status, fault handling, risk early warning and emergency support, and deeply realizes that the sharing model is both an investment appreciation tool and a risk mitigation tool.

Based on China Tower's asset operation digital monitoring system and co-construction and sharing practices of five provincial branches, this paper interprets the supporting mechanism of digital infrastructure for regional economy from the dual perspectives of real options and risk sharing.

2. Dual Attribute of "Investment-Risk" of Digital Infrastructure

2.1 Investment Attribute: High Input and Strong Network Effect

Tower site investment is large with a long payback period, but has significant network externality: the denser the sites and the more sufficient the sharing, the higher the unit investment output. Co-construction and sharing realize "one investment, multiple uses", greatly improving investment efficiency (1. China Tower Co., Ltd., 2021).

2.2 Risk Attribute: Multi-dimensional Uncertainty in the Whole Cycle

Policy Risk: Planning adjustment, approval for road and green land occupation, and changes in environmental protection requirements.

Construction Risk: Difficulty in site selection, property obstruction and construction period delay.

Operation Risk: Equipment abnormality, unauthorized installation and hanging, non-standard station demolition and lack of compensation.

Financial Risk: Rigid costs, income fluctuation and uncertain returns.

These risks are highly concentrated under independent construction, and can be effectively dispersed through the sharing model (2. China Tower Co., Ltd., 2023).

3. Real Option Value of China Tower Site Sharing

Site sharing endows investment decision-making with flexibility, forming four core real options:

Delay Option: Aggregate demands and construct opportunistically to avoid short-term fluctuations.

Expansion Option: One site for multiple tenants with reserved resources for low-cost expansion in the future.

Conversion Option: Transform "communication tower" into "digital tower" to serve multiple industries.

Abandonment Option: Sharing contracts reduce exit costs and minimize sunk losses.

Practical evidence: 20,920 sites included in planning in Tianjin, cross-industry resource opening in Hunan, and more than 200,000 "digital towers" nationwide all reflect the continuous realization of option value (3. China Tower Co., Ltd., 2023).

Table 1 : Correspondence between Real Option Value of Site Sharing and Operation, Maintenance Practices

Option Type Economic Value Reflection in Operation, Maintenance and Monitoring

Delay Option Avoid fluctuations and invest opportunistically Planning inclusion, demand coordination and batch approval

Expansion Option Multi-purpose use of one site with low marginal cost Sharing by multiple operators, indoor expansion and reserved ports

Conversion Option Cross-industry empowerment and value improvement Social tower sharing, digital tower serving over 40 industries

Abandonment Option Reduce exit losses Standardized station demolition management, compensation and contract guarantee

(Source: Self-compiled based on China Tower's asset operation monitoring data, April 27, 2026)

4. Risk Sharing Mechanism of Co-construction and Sharing (from the Perspective of Operation, Maintenance and Monitoring)

4.1 Five Risk Sharing Paths

Resource Sharing: Reduce asset specificity and disperse construction risks.

Cost Sharing: Site rent, electricity and operation and maintenance costs are shared by multiple parties, leading to a sharp drop in CAPEX. Typical examples include free site rent for Tianjin Metro and Hunan's "two exemptions and one reduction" policy (4. China Tower Co., Ltd., 2023).

Demand Aggregation: Coordinate the demands of three operators to smooth fluctuations and improve occupancy rate.

Policy Credit Enhancement: Joint documents issued by multiple departments and site planning inclusion reduce compliance risks.

Digital Risk Control: The asset operation monitoring system provides real-time early warning for unauthorized installation and hanging, suspected station demolition and compensation leakage, with closed-loop handling (5. China Tower Co., Ltd., 2021).

4.2 Risk Mitigation Effect

The digital monitoring system issued 14,000 work orders in one month of operation, handled 5,819, with an effective rate of 94.6%, and an expected revenue increase of 110 million yuan (6. China Tower Co., Ltd., 2021).

The effective rate of station demolition monitoring work orders exceeds 97.2%, promoting the standardization of the whole process of station demolition, backfilling and compensation (7. China Tower Co., Ltd., 2021).

Co-construction and sharing significantly narrow the comprehensive risk exposure and make investment more robust.

5. Conclusion and Implications

Digital infrastructure has the dual attribute of symbiotic investment and risk. China Tower's site sharing amplifies long-term value through real options and converges uncertainty through risk sharing, achieving dual improvement of value and robustness. From the perspective of operation, maintenance, monitoring and emergency management, site stability, reliable coverage and controllable risks are the keys for digital infrastructure to support regional economic development.

In the future, efforts should be continuously made to promote site planning inclusion, improve compensation policies, strengthen digital risk control, and upgrade the sharing model towards high-quality and high-value development, so as to provide a more solid digital foundation for the high-quality development of China's regional economy.

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IMPROVEMENT OF PUBLIC PROCUREMENT IN THE REPUBLIC OF KAZAKHSTAN

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Annotation: The article examines the current state of the public procurement system in the Republic of Kazakhstan. It analyzes the key principles of procurement activities, including transparency, competition, and efficient use of public funds. Particular attention is paid to existing challenges such as corruption risks, administrative barriers, and insufficient digitalization of procurement processes. The regulatory and legal framework governing public procurement is reviewed. The

impact of electronic procurement platforms on improving openness and accessibility of procedures is considered. The importance of strengthening control and monitoring by authorized bodies is highlighted. Measures to improve legislation in the field of public procurement are proposed. The need to enhance the qualifications of procurement participants is justified. The role of innovative technologies in optimizing procurement procedures is emphasized. It is concluded that comprehensive reforms will improve the efficiency and transparency of the public procurement system in the country.

Keywords: public procurement, efficiency of fund utilization, electronic public procurement platform, optimization of procedures, public procurement contracts

Public procurement is the most important tool for the implementation of the state's economic policy. Through the procurement system, the government finances infrastructure development, purchases of goods and services, and supports businesses. In the Republic of Kazakhstan, the procurement system plays a key role in the allocation of budget funds and the development of the economy. In Kazakhstan, public procurement has been fully converted to electronic format, which has become an important step in the digitalization of public administration. The main platform for conducting procedures is the Public Procurement Portal of the Republic of Kazakhstan, which ensures transparency and accessibility of information. The electronic format makes it possible to significantly reduce the time of tenders and reduce administrative barriers for businesses. In addition, process automation helps to minimize corruption risks and increase competition among suppliers. As a result, the public procurement system is becoming more efficient, open, and focused on modern digital standards.

The public procurement system in Kazakhstan is fully digitized and operates through the Public Procurement Portal of the Republic of Kazakhstan. This ensures transparency of procedures and accessibility of participation for suppliers. According to the Ministry of Finance of the Republic of Kazakhstan, about 24 thousand government customers and more than 117 thousand suppliers are registered in the system. [1]

Public procurement is characterized by significant amounts of financing, as it covers a wide range of government needs, from infrastructure projects to social services. These expenses form a significant part of the budget and directly affect the economic development of the country. Effective management of such funds requires strict controls, transparency, and clear procedures. The irrational use of budgetary resources can lead to financial losses and a decrease in the quality of implemented projects. Therefore, improving the procurement system remains an important area of government policy. According to the Public Procurement Portal of the Republic of Kazakhstan, the procurement plan for 2024 amounted to about 9.2–9.3 trillion tenge, with an actual execution of about 8.8 trillion tenge.[2]

Also, according to the Center for Electronic Finance, 2.85 million contracts were signed in 2024, and budget savings amounted to 877.8 billion tenge (ecc.kz , 2024).

The level of competition is an important indicator of the effectiveness of the public procurement system. High competition helps to reduce the cost of contracts and improve the quality of goods and services. With a large number of participants, customers receive more favorable offers and a wide range of suppliers. It also encourages companies to improve their efficiency and innovate. A low level of competition, on the contrary, may indicate the presence of barriers to participation or insufficient transparency of procedures. In such conditions, the risk of overcharging and reducing the quality of contract execution increases. To increase competition, it is important to simplify access to procurement and ensure equal conditions for all participants. Thus, the development of a competitive environment directly affects the effectiveness and sustainability of the public procurement system.

The volume of contracts with domestic manufacturers in public procurement in the Republic of Kazakhstan has shown steady growth in recent years. By the end of 2025, the amount of such contracts reached approximately 460 billion tenge, an increase of 23% compared to the previous year (Inbusiness). In some estimates, it is noted that the indicator was in the range of 400-418 billion tenge, which also confirms the significant expansion of the participation of local producers (Bizmedia.kz). The number of contracts concluded with domestic companies has exceeded 140,000, which indicates an increase in business engagement. Despite the positive dynamics, the share of such contracts in the total procurement structure remains relatively low and is estimated at about 5-10% of the total volume (Bizmedia.kz). In general, the increase in the volume of contracts with domestic producers reflects the government's policy to support the national economy and develop domestic production. At the same time, according to the information the volume of contracts with domestic manufacturers has increased by more than 2 times (Inbusiness.kz, 2024).

One of the key tasks of the public procurement system is the rational use of budget funds. This involves achieving the best price-quality ratio for the purchased goods, works, and services. Efficient spending of funds allows the government to implement more projects with limited resources. Transparency of procedures and control at all stages of procurement play an important role in this process. The use of electronic platforms helps to reduce costs and improve the efficiency of financial management. In addition, the introduction of competitive mechanisms helps to prevent price gouging and inefficient spending. A rational approach to procurement also strengthens public confidence in government institutions. As a result, sound budget management becomes the basis for sustainable economic development.

According to the Center for Electronic Finance, savings in 2024 amounted to 877.8 billion tenge (ecc.kz, 2024), which indicates the high efficiency of existing public procurement mechanisms. Additionally, according to analytics Check-point.kz

, it was possible to prevent inefficient expenses in the amount of more than 55 billion tenge (Check-point.kz, 2024), which underlines the importance of monitoring and control in this area. These indicators demonstrate that the introduction of digital tools and increased transparency of procedures can significantly reduce budget losses. Taken together, these results confirm the positive impact of the reforms on the public procurement system and the improvement of its effectiveness.In Kazakhstan, public procurement has been fully converted to electronic format, which has significantly increased the transparency of processes. Transparency of processes is one of the key principles of the public procurement system. Open access to information about tenders and their results allows for public oversight. This reduces the likelihood of corruption risks and increases the trust of businesses and citizens. Transparent procedures contribute to the formation of a fair competitive environment among the participants. In addition, the availability of data facilitates the analysis of the effectiveness of the use of budgetary funds. As a result, transparency becomes an important factor in improving the quality and effectiveness of public procurement. According to the Center for Electronic Finance, the system is used by more than 570 thousand users, and more than 1 million purchases are published annually (ecc.kz, 2024).

The legislative framework is regulated by a law posted on the Adilet system aimed at increasing transparency and efficiency of procurement (Adilet, 2024).

The analysis of data for 2023-2025 shows significant changes in the structure and volume of government contracts. In 2023, the total volume amounted to 8.99 trillion tenge with 1.83 million contracts, while the main share fell on executed contracts in both quantity and amount. In 2024, there is an increase to 10.9 trillion tenge and 1.84 million contracts, which indicates an increase in the scale of procurement activities and financing. The amounts in all categories have also increased, including terminated contracts, which may indicate both an increase in volumes and certain problems in execution.

In 2025, the structure is changing dramatically: the total number of contracts is reduced to 599.7 thousand, but the total volume remains high — more than 10 trillion tenge. This indicates the consolidation of contracts and the transition to larger transactions. The share of existing contracts, which occupy a leading position in terms of the amount (about 9.8 trillion tenge), is significantly increasing, which may mean a shift in focus to long-term obligations. At the same time, the number of executed contracts is sharply decreasing, which is probably due to the incompleteness of the reporting period.

The share of terminated contracts in 2023-2024 remains noticeable both in number and amount, which indicates the continuing risks of default. However, in 2025, their volume is significantly reduced, which may indicate either an improvement in contractual discipline or a temporary effect of incomplete procedures. In general, there is a tendency to increase financial volumes with a

reduction in the number of contracts, which reflects an increase in the concentration of public procurement and a change in their structure.

Despite the positive trends, the public procurement system has a number of problems high proportion of purchases from a single supplier, the presence of procedural violations, limited access for small businesses

The main directions of development of the public procurement system:

1) further digitalization
2) implementation of analytical technologies (Big Data)
3) Increased transparency
4) support for domestic business

The analysis shows that the public procurement system in Kazakhstan is actively developing, demonstrating growth in volumes and improved efficiency. The level of transparency in procurement procedures is increasing due to the implementation of electronic platforms and digital solutions. Competition among procurement participants is also rising, contributing to more efficient use of public funds. Overall, there is a gradual improvement in the regulatory framework and management mechanisms.

At the same time, problems related to competition and control remain. Their solution will increase the transparency and efficiency of the use of budget funds.

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CIRCULAR ECONOMY IN THE FOOD INDUSTRY AS A FACTOR OF SUSTAINABLE DEVELOPMENT OF THE COUNTRIES OF THE "ONE BELT, ONE ROAD" INITIATIVE

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Annotation. The article examines the role of the circular economy in the transformation of the food industry in the countries participating in the "One Belt, One Road" initiative. Special attention is paid to the rational use of resources, reducing food waste and improving the efficiency of processing organic materials.

Keywords: circular economy, food industry, sustainable development, resource efficiency, waste recycling, countries of the "One Belt, One Road" initiative.

The modern global economy is facing a number of serious problems, such as increased consumption of natural resources, increased waste and environmental degradation. In conditions of limited resources, the transition to a circular economy model based on closed production cycles, reuse of materials and minimization of waste becomes especially relevant.

The food industry occupies a special place in the economy of most countries, as it is directly related to ensuring food security. At the same time, this industry is characterized by a high proportion of losses and inefficient use of resources. According to international organizations, up to a third of the food produced is lost at different stages of the value chain.

Within the framework of the "One Belt, One Road" initiative, a new model of economic cooperation is being formed, focused on sustainable development, innovation and increased production efficiency. In this regard, the introduction of circular economy principles in the food industry is becoming an important area of modernization of the national economies of the participating countries.

Circular economy offers an alternative to the traditional linear model of "extraction — production — consumption — waste". The main idea is to create closed cycles of resource use, where the waste from one production becomes the raw material for anothe

In the food industry, the principles of circular economy are implemented through:

processing of organic waste into feed additives;

biogas and biofuel production;

the use of by-products of processing.

- introduction of waste-free production technologies.

An analysis of the indicators of the introduction of circular technologies in the food industry of the "One Belt, One Road" initiative countries indicates significant differences in the level of waste processing and resource efficiency (table 1).

Table 1- Economic indicators of the circular economy in the food industry

A country	Share of food waste (%)	Resource efficiency index	The share of circular technologies (%)	Contribution of the food industry to GDP (USD billion)
China	18	0.78	55	1250
Kazakhstan	32	0.52	29	45
Türkiye	24	0.66	44	210
Malaysia	27	0.63	40	95
Indonesia	29	0.61	38	160
Vietnam	26	0.64	41	120
Note – compiled on the basis of [4-6]				

The data obtained shows noticeable differences between countries. Thus, China has the highest level of adoption of circular technologies and at the same time the minimum amount of food waste. Kazakhstan, on the contrary, demonstrates higher resource losses and lower efficiency of their use.

This indicates that the development of circular waste recycling mechanisms has a significant impact on the productivity of the food industry.

To study the relationships between the key indicators, a correlation analysis was performed, the results of which are presented in Table 2.To study the relationships between the key indicators, a correlation analysis was performed, the results of which are presented in Table 2.

Table 2- Correlation matrix (waste – efficiency – GDP)

Indicator	Proportion of waste	Resource efficiency	Circular technologies	Industry's GDP
Proportion of waste	1.00	-0.986	-0.989	-0.868
Resource efficiency	-0.986	1.00	0.999	0.864
Circular technologies	-0.989	0.999	1.00	0.853
Industry's GDP	-0.868	0.864	0.853	1.00
Note – compiled on the basis of [4-6]				

Correlation analysis shows the presence of strong statistical relationships between the studied indicators:

1. Negative correlation between waste and efficiency (-0.986)

An increase in the share of food waste leads to a decrease in the resource efficiency of production.

2. Positive relationship between circular technologies and efficiency (0.999)

The introduction of technologies for recycling and reuse of resources significantly increases the efficiency of production processes.

3. Positive correlation between resource efficiency and industry's contribution to GDP (0.864)

Increased resource efficiency contributes to economic growth and increased added value in the food industry.

The obtained regression analysis results confirm the presence of a statistically significant relationship between the level of food waste and resource efficiency of production (Table 4).

Table 4- Regression Analysis of the Impact of Food Waste on Resource Efficiency

Variable	Coefficient	Standard Error	t-statistic	p-value
Constant	1.0916	0.0392	27.81	0.000
Food Waste Share	-0.0174	0.0015	-11.67	0.0003

Econometric interpretation

The constructed regression model looks like this:

$$\text{Resource Efficiency} = 1.0916 - 0.0174 \times \text{Food Waste}$$

It means:

-an increase in the share of food waste by 1% leads to a decrease in resource efficiency by about 0.017 points;

-the negative coefficient confirms the hypothesis about the negative impact of resource losses on production efficiency;

-the statistical significance of the model is confirmed by a low p-value (<0.01).

The econometric analysis confirms the existence of a close relationship between:

-the level of food waste generation,

-introduction of circular technologies,

-resource efficiency of production,

-economic results of the food industry.

The results show that the development of a circular economy is an important factor in improving the efficiency and sustainability of the food industry in the countries participating in the "One Belt, One Road" initiative. Countries with a higher level of adoption of circular technologies demonstrate better indicators of resource efficiency and environmental sustainability. In this regard, the further development of the circular economy should become one of the key areas for the modernization of the food industry and the formation of sustainable economic systems.

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Section 7. FINANCIAL SYSTEMS, FISCAL REGULATION, MACROECONOMIC STABILITY

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ARTIFICIAL INTELLIGENCE AND INNOVATIVE TECHNOLOGIES IN INTERNATIONAL BUSINESS: THE IMPACT OF ARTIFICIAL INTELLIGENCE ON ENTERPRISE MANAGEMENT AND FUTURE PROSPECTS

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Annotation. Artificial intelligence's rapid evolution has changed the course of corporate governance, therefore altering the direction of sustainable economic advancement. This paper looks at how AI influences various aspects of organizations, their decisions and the big picture for a company's future. AI innovations improve production at work, arrange resources better, save money, and manage risks well too. So we can grow the company sustainably by doing these things. Also it would take on how to make use of AI in management which might contain labor adjustments issues as well as moral and lawful issues. The result shows while there is much that AI can provide towards sustainability but it must also be used in harmony alongside humans/AI and monitored very carefully so as to maximize its benefits and minimize any negative impacts from its introduction. In this paper, it is concluded that AI doesn't function as merely a tool but also acts like an immense catalyst in the making of economic sustainability for both people and greater scale.

Key words: artificial intelligence, enterprise management, sustainable economic development, digital transformation, business operations, future prospects.

Introduction.

In the midst of world's economy rearrangement artificial intelligence turns to be an important force with strength that lasts forever. In the "Belt and Road" strategy, Kazakhstan's cooperation with China can be seen that the digital economy is an important part of future success. Therefore, we have to find out what effect does AI make on business administration for the sake of long term financial stability[1]. It looks at how much AI new inventions, organization keeping an eye, and ecological progress aims mix together. It gives ideas to companies going through the cyber age.

Artificial Intelligence has an effect on corporate governance in various different aspects. Firstly, AI will improve the function productivity by doing some repetative

tasks. Machine-learning platforms can digest far bigger data-sets than employees could do by hand, so you could carry out instantaneous stock controls, logistics fiddles, prophylactic maintenance looks-ahead: In this way we could be more efficient, which means less material would be lost, less electricity used and therefore a reduced cost of function - all very important for making progress financially!

And ai also affects what strategies we're gonna make. Use more statistical methods and predicting model so that we can see an objective picture in the future for execuitve rather than depending on how he feels. Like a AI based customer relationship management system which takes into account what you buy to give you a special offer, makes people want to be customers for longer[2]. AI calculations done to find out irregularities, predict financial moves, and make better use of assets by fiscal administration. Like these kind of things would be helpful to more sturdy and adjustable firms, important for surviving growth amidst bumpy money seas.

And it promotes creativity to have breakthroughs and it generates new commercial landscapes. The self driving delivery system, the production line as well, can bring in more value with less enviromental print for all the enterprises[3]. When AI is put on smart electricity grid it will be beneficial, more farming that is precise lessens usage of water and pesticides: In terms of Kazakhstan-China Financial Partnership, AI-systems will raise International Commerce efficiency, simplify Border control procedures and show up Logistical network better. These are how AI is being applied to achieve the UN sustainable development goal, which is fair employment and economic growth (sdg 8). Industrial production and construction (sdg 9) as well as sustainability of resources and manufacture (sdg 12).Table 1 below summarizes the key dimensions of AI's influence on enterprise management.

Table 1 – Impact of artificial intelligence on enterprise management

Dimension	**Specific Applications**	**Contribution to Sustainable Development**
Operational Efficiency	Automation of routine tasks, inventory management, supply chain optimization	Reduced resource waste, lower energy consumption, decreased operational costs
Decision-Making	Predictive analytics, customer relationship management, financial anomaly detection	More resilient enterprises, improved risk management, data-driven strategies
Innovation & Business Models	Autonomous logistics, intelligent manufacturing, smart grids, precision agriculture	Environmental impact reduction, new value creation, enhanced cross-border trade
Human Resource Management	AI-assisted recruitment, performance monitoring,	Optimized talent allocation, reduced hiring bias (with proper

Dimension	Specific Applications	Contribution to Sustainable Development
	employee training personalization	design), skill development
Risk Management	Fraud detection, cybersecurity threat monitoring, compliance automation	Enhanced enterprise stability, reduced financial losses, regulatory adherence

But still putting AI in corporate governance has many problems. Labor displacement is still a big problem because it replaces certain jobs with automation. Sustainability over the long term cannot do without financial growth, but also social equity. Therefore companies need to carry out reskilling and upskilling so that workers are prepared for the AI-enhanced jobs[4]. In addition, there are also worries about information privacy, algorithmic prejudice and responsibility which need sound rules. It is imperative to do cross-border standardization within different countries concerning the “One belt one road” project to develop standards with ethical application of ai.

Table 2 lists out all the main prospects and obstacles associated with corporate governance integrating artificial intelligence.

Table 2 – Opportunities and challenges of AI integration in enterprise management

Opportunities	Corresponding Challenges	Mitigation Strategies
Enhanced operational efficiency and cost reduction	Workforce displacement and job transformation	Invest in reskilling and upskilling programs; create human-AI collaborative roles
Improved decision-making accuracy and speed	Algorithmic bias and lack of transparency	Implement ethical AI guidelines; conduct regular algorithm audits
Innovation in products and services	Data privacy and security concerns	Adopt privacy-preserving technologies; comply with data protection regulations
Personalized customer experiences	High implementation costs and technical	Pursue phased adoption; leverage cloud-based AI solutions; seek

Opportunities	Corresponding Challenges	Mitigation Strategies
	barriers	public-private partnerships
Scalability and adaptability to market changes	Regulatory uncertainty and cross-border legal differences	Engage in policy dialogue within "Belt and Road" framework; advocate for harmonized standards
Environmental sustainability through resource optimization	Energy consumption of AI systems themselves	Develop energy-efficient AI models; use green computing infrastructure

Looking ahead at future scenarios, when we combine AI with other hot technologies like Internet of things, Blockchain and 5g , the effect will be even greater for corporate administration. Prognostic analytics is going to get better and we'll be able to do anticipatory over reactive governance techniques. And in such a manner human - AI partners would work, where the Ai takes care of number based works and people will do innovation, feeling intelligent and strategic level thinking. If we want lasting money, then our focus has to be creating an environment in which artificial intelligence makes us better rather than replaces us completely[5]. As for the Kazakhstan-China partnership structure, we should build cooperative research centers, swap personnel, set joint regulatory standards to promote ethical AI faster and get better at sustainable progress in "One Belt, One Road"[6].

Conclusion.

Artificial intelligence acts like an energetic stimulant to the economy, it can change how companies run their businesses. From actual facts we can see AI makes operation more efficient, makes the decision better, helps to do creative commerce, and makes the risk management better--at same time also help protect ecology, have good finance. As can be seen from Table 1 and table 2, there are prospects to look forward to for AI, but these have problems that need to be actively resolved. To realize AI's full capacity is to solve the problem of personnel adaptation, morality supervision, information safety and international regulation coordination. Kazakhstan and China are no different; If they cooperate together under the onboradone, one, their A1 innovations would be accelerating towards incorporating itself as responsibly. It can be a mutually sustainable thriving for them both to do so. In the future we have to create more specific AI for sectors of industry, look at sustainable results that stick and make rules about developing things responsibly.

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WAYS TO IMPROVE THE QUALITY OF BANKING SERVICES AND ITS LINKAGES WITH FINANCIAL SYSTEMS, FISCAL REGULATION AND MACROECONOMIC STABILITY

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Annotation. Improving the quality of banking services in 2026 relies on integrating artificial intelligence (AI) for personalization, strengthening digital infrastructure, and enhancing regulatory compliance. These advancements are intimately linked to broader financial systems, where proactive, tech-driven risk management supports macroprudential stability. Effective fiscal regulation—specifically budgetary discipline—reduces sovereign risk exposure and lowers non-performing loans (NPLs), thus stabilizing the banking sector and supporting macroeconomic health.

Key words: quality of banking services, financial systems, fiscal regulation, macroeconomic stability, Digital Transformation.

Introduction.

The banking sector serves as the core pillar of the modern financial system, acting as the key intermediary connecting savings and investment, facilitating capital flow, and supporting the operation of the real economy. The service quality of the banking sector is not merely a micro-level operational issue of individual commercial banks; it is deeply intertwined with the soundness of the entire financial system, the effectiveness of fiscal regulation, and the sustainability of macroeconomic stability. High-quality banking services can optimize resource allocation, reduce financial transaction costs, and strengthen the resilience of the financial system. In contrast, low-efficiency, rigid and high-risk banking services will trigger structural distortions in the financial system, weaken the implementation effect of fiscal regulation, and even induce macroeconomic fluctuations such as inflation, capital mismatch and economic recession. In the context of global economic uncertainty, digital financial transformation and deepening financial market opening-up, exploring effective ways to improve banking service quality and analyzing its internal logical connection with financial systems, fiscal regulation and macroeconomic stability is of great theoretical and practical significance. This paper elaborates on the improvement paths of banking service quality, and further discusses how optimized banking services empower financial system improvement, assist fiscal regulation implementation, and maintain long-term macroeconomic stability, with a full-length of about 2000 words.

2. Core Ways to Improve the Quality of Banking Sector Services

2.1 Digital Transformation and Intelligent Service Upgrade

Digitalization is the most fundamental way to reshape banking service quality in the era of the digital economy. Traditional banking services rely on physical outlets, with single service scenarios, long processing cycles and high manual operation costs, which cannot meet the diversified, personalized and efficient financial needs of individual customers and small, medium and micro enterprises. To improve service quality, banks need to accelerate the layout of digital infrastructure, build online banking, mobile banking and intelligent customer service systems, and realize the full online processing of account opening, transfer, loan application, wealth management and payment settlement. Meanwhile, applying big data, artificial intelligence and cloud computing technology enables banks to accurately portrait customers, customize personalized financial service schemes, and reduce information asymmetry between banks and customers. Intelligent risk control systems can also identify abnormal transactions and credit risks in real time, while improving service efficiency and ensuring the safety of customer funds. Digital transformation breaks the time and space constraints of traditional banking services, realizes 24/7 all-weather services, and fundamentally improves the convenience and inclusiveness of banking services.

2.2 Optimize Inclusive Financial Services and Balance Resource Allocation

A prominent defect of traditional banking services is the tendency of elite service, which excessively leans towards large enterprises and high-net-worth customers, while ignoring the financial needs of vulnerable groups such as small and medium-sized enterprises, rural residents and low-income groups, resulting in

unbalanced financial resource allocation. Improving banking service quality must take inclusive finance as an important starting point. Banks should appropriately lower the threshold of financial services, launch special credit products for small and micro enterprises and rural revitalization, simplify loan approval procedures, and reduce comprehensive financing costs. By laying down community outlets, rural service stations and mobile service teams, banks can sink service resources to grassroots areas, make up for the shortage of financial services in remote areas, and realize the universal benefit of financial services. Inclusive banking services can activate grassroots economic vitality, expand the coverage of the financial system, and lay a micro foundation for stable economic operation.

2.3 Strengthen Service Standardization and Customer Rights Protection

Standardized service processes and perfect rights protection mechanisms are the basic guarantees for improving banking service quality. At present, some banks have problems such as irregular service etiquette, opaque fee standards, complicated product sales and misleading financial publicity, which damage customer trust and disrupt the order of the financial service market. Banks need to establish unified service operation standards, standardize the sales process of wealth management, credit and insurance products, fully disclose product risks, return rates and charging rules, and eliminate hidden charges and misleading sales. In addition, it is necessary to improve the customer complaint handling mechanism, set up efficient feedback channels, respond to customer demands in a timely manner, and establish a sound dispute mediation mechanism for financial consumption. Standardized services enhance customer satisfaction and trust, maintain the credibility of the banking industry, and standardize the micro-operation order of the financial system.

2.4 Reinforce Risk Management and Internal Control System Construction

Service quality is based on risk security. Blindly pursuing service efficiency and business expansion without risk control will lead to the accumulation of non-performing assets, operational risks and moral hazards, which will eventually erode service quality and even trigger systemic financial risks. Banks need to establish a comprehensive risk management system, cover credit risk, market risk, liquidity risk and operational risk in the whole business process, strictly implement credit review and post-loan management, and curb the excessive expansion of shadow banking and irregular off-balance sheet businesses. Perfect internal control can standardize employees' business behavior, prevent illegal operations and financial fraud, ensure the stable and sustainable operation of banking services, and avoid risk spillover affecting the entire financial system and macroeconomic operation.

3. The Connection Between Banking Service Quality and Financial Systems

The financial system is a complex organic system composed of banking institutions, capital markets, insurance institutions, financial regulatory authorities and market transaction rules, and the banking sector is the main body and carrier of the financial system. The quality of banking services directly determines the operational efficiency, structural perfection and risk resilience of the financial system.

First, high-quality banking services optimize the resource allocation function of the financial system. As the capital intermediary of the financial system, banks with efficient service mechanisms can quickly gather social idle savings and accurately allocate funds to high-efficiency real economic sectors such as manufacturing, technological innovation and emerging industries, avoiding capital idleness and misallocation. Poor banking service quality will lead to slow capital turnover, cumbersome financing procedures and capital flowing to high-risk speculative fields, distorting the resource allocation function of the financial system and restricting the upgrading of the real economy.

Second, improving banking service quality promotes the structural optimization of the financial system. Traditional financial systems are overly dependent on indirect financing dominated by banks, while the development of direct financing such as the stock market and bond market is insufficient. Optimized banking services can realize the integrated development of banking, securities and wealth management businesses, build a comprehensive financial service platform, and drive the coordinated development of multi-level financial markets. At the same time, inclusive and digital banking services enrich the hierarchical structure of the financial system, make the financial system cover different regions, industries and customer groups, and form a more balanced and perfect financial system layout.

4. Banking Service Quality Empowers Fiscal Regulation Effectiveness

Fiscal regulation is an important means for the government to regulate economic operation, adjust industrial structure, balance fiscal revenue and expenditure, and stabilize social development, including fiscal expenditure, tax policy, government bond issuance and transfer payment. The implementation of all fiscal policies cannot be separated from the cooperation and support of the banking system, and banking service quality directly affects the transmission efficiency and implementation effect of fiscal regulation.

On the one hand, high-quality banking services assist the implementation of fiscal policies such as government bond issuance and fiscal fund allocation. The issuance of national debt and local government bonds needs banks to act as underwriters and distribution channels; fiscal special funds for infrastructure construction, rural revitalization and technological innovation also need banks to complete fund transfer, supervision and targeted lending. Efficient and standardized banking services can shorten the circulation cycle of fiscal funds, ensure that fiscal funds are in place in a timely manner, and avoid fund retention and embezzlement. If banking service procedures are cumbersome and fund settlement efficiency is low, the implementation cycle of fiscal policies will be prolonged, and the policy effect of counter-cyclical regulation will be weakened.

On the other hand, inclusive banking services coordinate with fiscal transfer payment and tax preferential policies to support the development of weak links in the economy. The government adopts tax reduction and fee reduction, fiscal subsidies and other policies to support small and micro enterprises and agriculture, and banks

can dock with fiscal policies through optimized credit services, launch supporting credit products, lower financing costs, and amplify the leverage effect of fiscal regulation. In addition, sound banking risk control can cooperate with financial regulatory authorities to curb irregular financial arbitrage, standardize the flow of fiscal supporting funds, prevent funds from flowing into real estate speculation and virtual economy bubbles, and ensure that fiscal regulation accurately supports the real economy.

5. Banking Service Quality Maintains Macroeconomic Stability

Macroeconomic stability is reflected in stable economic growth, moderate inflation, full employment, balanced international payments and stable asset prices, and the improvement of banking service quality forms a solid underlying support for macroeconomic stability through the dual paths of micro entity support and macro policy transmission.

First, optimized banking services stabilize market entities and consolidate the foundation of economic growth. Small and medium-sized enterprises and individual industrial and commercial households are the main carriers of employment and economic growth. High-quality inclusive banking services ease the financing difficulties and high financing costs of market entities, help enterprises relieve capital pressure, maintain production and operation stability, and drive employment stability and sustained economic growth. When banking services are insufficient, a large number of real enterprises face capital chain pressure, which will lead to production contraction, layoffs and even bankruptcy, dragging down macroeconomic growth and triggering employment pressure.

Second, banking service efficiency affects monetary policy transmission and inflation stability. Monetary policy tools such as interest rate adjustment, reserve requirement ratio adjustment and open market operations need to be transmitted to the real economy through the banking system. Banks with high service quality can quickly respond to policy adjustments, smooth the transmission of interest rate and credit policies, reasonably regulate the scale of social financing and money supply, and keep inflation within a moderate range. Rigid and inefficient banking services will block the transmission of monetary policy, resulting in excessive liquidity or credit contraction, inducing inflation or deflation risks and breaking macroeconomic price stability.

Conclusion

In summary, improving the quality of banking services is not only an internal demand for the sustainable development of the banking sector, but also a key link affecting the perfection of the financial system, the effectiveness of fiscal regulation and the stability of the macroeconomy. The core paths to optimize banking services include digital transformation and intelligent upgrading, promoting inclusive financial layout, standardizing service processes and protecting customer rights, and strengthening comprehensive risk management and internal control. High-quality banking services can optimize the resource allocation and structural layout of the

financial system, enhance the ability of the financial system to resist risks; effectively dock and transmit fiscal policies, amplify the regulatory effect of fiscal tools; stabilize market entities, smooth monetary policy transmission, and curb financial bubbles, so as to maintain stable economic growth, moderate price levels and balanced economic operation.

In the future, with the continuous advancement of financial digitalization and financial market reform, the banking sector should take service quality improvement as the core strategic goal, adhere to the dual orientation of marketization and inclusiveness, cooperate with financial regulatory reform and fiscal policy adjustment, form a benign interaction among banking service optimization, financial system improvement, fiscal efficient regulation and macroeconomic stable operation, and ultimately provide solid financial support for high-quality economic development.

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IMPROVING THE ECONOMIC RISK MANAGEMENT SYSTEM: A STUDY BY THE CENTRAL CHINA BANK FROM A MACROPRUDENTIAL PERSPECTIVE

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Annotation. Against the backdrop of escalating global economic uncertainties and mounting pressure to mitigate systemic economic risks, enhancing the economic risk management system has become a core issue for safeguarding national economic and financial security. Since the 2008 international financial crisis, macroprudential policy, as a key instrument for preventing systemic economic and financial risks, has gradually become a central component of the central bank's policy framework. Drawing on international experience, the People's Bank of China (hereinafter referred to as the China central bank) has established a dual-pillar regulatory framework of "monetary policy + macroprudential policy" with Chinese characteristics, continuously enriching its macroprudential policy tools. This paper analyzes the current state of China's economic risk management system primarily through the lens of the China central bank's macroprudential policies.

Key words: Macroprudential policy; Dual-pillar regulation; People's Bank of China; Risk management system

Since 2023, China's economic and financial system has undergone a series of profound institutional and mechanism reforms. These include the establishment of the Central Financial Work Commission by the Communist Party of China, the restructuring of the former China Banking Regulatory Commission into the China

Financial Regulatory Authority, and the redefinition of the regulatory responsibilities of the People's Bank of China and the Financial Regulatory Authority. The aim is to comprehensively strengthen and improve China's economic and financial regulatory framework, achieving "full coverage, thorough penetration, consistency, and accountability," and resolutely safeguard against systemic financial risks [1]. The Fourth Plenary Session of the 20th Central Committee of the Communist Party of China explicitly called for the establishment of a scientific and prudent monetary policy system and a comprehensive macroprudential management system, elevating macroprudential management to a core position in safeguarding national economic and financial security and enhancing the economic risk management framework [2].

China's macroprudential practices began relatively early and demonstrate remarkable foresight. As early as before the 2008 international financial crisis, China had already employed tools with macroprudential implications, such as differentiated reserve requirements and real estate credit regulation, to explore risk prevention and control pathways [3]. Following the 2008 international financial crisis, China took the lead in establishing a macroprudential policy framework, gradually forming a distinctive macroprudential management approach with Chinese characteristics [4]. China's macroeconomic governance has been gradually developed through the historical practice of socialist modernization [5], exhibiting distinct Chinese features. The process – from conceptual introduction and tool creation to framework establishment – reflects the practical characteristic of "exploration and refinement in tandem." For example, several provincial branches of the People's Bank of China successively established macroprudential management offices in 2024.

Since 2016, the People's Bank of China has formally established and implemented the "Macroeconomic Prudential Assessment System" building upon its existing dynamic adjustment mechanism for differential reserve requirements and other macroprudential explorations. This system constitutes a key component of the dual-pillar regulatory framework integrating monetary policy and macroprudential policy, marking a shift in China's financial supervision toward a combination of macro and micro approaches. The Chinese macroprudential framework has advanced from a single tool to a comprehensive evaluation encompassing seven dimensions: capital and leverage conditions, balance sheet status, liquidity, pricing behavior, asset quality, external debt risks, and credit policy implementation. Among these, the capital adequacy ratio serves as the core of the assessment system, guiding financial institutions to strengthen self-management and sound operations. More importantly, the People's Bank of China has progressively clarified the dual-pillar regulatory framework of "monetary policy + macroprudential policy" in practice. Monetary policy primarily targets traditional objectives such as price stability and economic growth, while macroprudential policy directly focuses on financial stability, aiming to curb excessive fluctuations in the financial cycle [4] (Table 1).

Table 1. Monetary policy and Macroeconomic Prudential Policy

	Monetary Policy	Macroeconomic Prudential Policy
Core Objective	Stable prices, while also considering economic growth	Financial stability and the prevention of systemic risks
Operation Target	Total Economy	The internal structure of the financial system
Focus Period	Short-term Economic Cycle	Medium-to Long-Term Financial Cycle
Risk Type	Risks of inflation and deflation	Asset bubbles, financial procyclicality, and risk contagion
policy instrument	Interest rates, reserve requirement ratios, and open market operations	The macro-prudential assessment system, counter-cyclical capital buffers, and restrictions on real estate lending

The Central Financial Work Conference of the Communist Party of China explicitly called for effectively enhancing the effectiveness of financial regulation and legally incorporating all financial activities into regulatory oversight. To implement this directive, it is imperative to establish a modern financial regulatory system comprising five integrated dimensions: institutional supervision, conduct supervision, functional supervision, penetration, supervision, and continuous supervision. This system aims to create a comprehensive, well-coordinated, and seamlessly connected regulatory framework that eliminates regulatory gaps and blind spots, thereby providing robust institutional safeguards for high-quality financial development.[6] This approach does not replace macroprudential measures but rather provides a stronger micro-level foundation and a more effective implementation environment. The China central bank's macroprudential policies will be more deeply integrated into and guide the implementation of the "five regulatory pillars."

Functional Supervision and Penetrative Supervision. Traditional institutional supervision is prone to fostering regulatory arbitrage, with risks being concealed and transferred across different industries, institutions, and markets. Functional supervision mandates unified regulatory standards for financial activities with identical functions, supporting macroprudential policy objectives – for instance, all credit activities, whether on or off the balance sheet, exhibiting credit creation and risk accumulation characteristics, are subject to uniform constraints. Penetrative supervision serves as the technical means to implement functional supervision; it requires identifying ultimate investors and financiers, revealing the true nature of risks, and is crucial for monitoring and addressing systemic risks arising from large-scale asset management operations and internal related-party transactions of financial holding companies.

Conduct Supervision and Continuous Supervision. Conduct supervision focuses on the compliance of financial institutions in areas such as sales practices,

information disclosure, and consumer protection, aiming to maintain fair transactions and market order and prevent localized risks from escalating into systemic risks. Continuous supervision emphasizes routine, dynamic, and whole-process monitoring, aligning with the macroprudential principles of dynamic monitoring and early intervention; it requires regulators to track changes in financial institutions' risk indicators and implement timely mitigation measures.

Institutional supervision constitutes the foundation of the traditional regulatory model. Institutions serve as the primary entities hosting all financial functions, activities, and resources, and institutional supervision forms the central axis of the "Five Major Supervisions" [7]. Regulatory responsibilities are categorized by type of financial institution, with institutions being the primary regulatory targets. In principle, each institution has a designated primary supervisory authority: commercial banks are regulated by the State Administration of Financial Supervision, while securities companies are overseen by the China Securities Regulatory Commission. The "who issues the license, who regulates" approach emphasizes the alignment of authority and responsibility; however, it is prone to regulatory arbitrage and inadequate risk isolation across industries, making it difficult to encompass risks throughout the entire financial chain.

Enhancing the implementation of macroprudential policies under the coordinated framework of the "Five Major Supervisions." The People's Bank of China plays a more prominent role within the "supervision" framework, leading the formulation of cross-industry and cross-market macroprudential rules, designing counter-cyclical adjustment mechanisms and risk isolation requirements based on risk assessments; strengthening supervisory synergy by establishing a regular joint mechanism with other regulatory authorities under the coordination of the Office of the Central Financial Committee to ensure the effective implementation of macroprudential policies.

Real Estate Risks: As a pillar industry of China's national economy, the real estate sector holds a pivotal position in the macroeconomic landscape. Since 2022, the Chinese government has consistently sent positive signals by rolling out a comprehensive package of policies to stabilize the real estate market, employing diverse policy instruments to enhance the prevention and management of financial risks in this sector [8]. This marks a paradigm shift from "treating diseases" to "preventing diseases." The previous demand-side stimulus or stringent regulatory measures often led to significant market fluctuations, whereas current macroprudential management has undergone substantial reforms. First, a long-term mechanism has been established, with "real estate loan concentration management" and differentiated credit policies tailored to local conditions stabilizing the market at the funding source. Second, focus has been placed on "document processing, property delivery, and livelihood stabilization," utilizing structural monetary policy tools such as special loans in tandem with macroprudential measures to curb the spread of

liquidity risks among real estate developers—a pioneering application in crisis response.

Local Government Debt Risks: China's implicit local government debt represents an intersection of fiscal and financial risks. In response to the 2008 financial crisis, the Chinese central government continued to adopt an active fiscal policy and a moderately loose monetary policy, launching the "Four Trillion Yuan Plan." The substantial investments from the central government successfully expanded domestic demand and filled the gaps caused by shocks to international markets, but also led to the continuous accumulation of debt at all levels of government and a surge in fiscal pressure [9]. The core mission of macroprudential policies is to "break the expectation of rigid debt repayment and isolate risk transmission pathways." Specific measures include: incorporating relevant debts into performance evaluations to constrain excessive financing by financial institutions, strengthening supervision of regional banks, adhering to the principle of "whoever is responsible for the issue should bear the responsibility" in risk resolution, resolving debts through market mechanisms, and providing liquidity support from the central bank without direct guarantees.

Improving the economic risk management system is a systematic undertaking in all countries, and in China, the central bank's macroprudential policies play an increasingly vital role in this process. As analyzed in this paper, China has initially established a macroprudential management framework that integrates international consensus with Chinese characteristics. However, in the face of increasingly complex and diverse economic risks, this system still requires continuous refinement in terms of "coordination, penetration, and foresight." Therefore, it is imperative to accelerate the legislative process of China's Financial Stability Law to provide a solid legal foundation and institutional safeguards for macroprudential management, thereby safeguarding the high-quality development of the Chinese economy and the steady advancement of Chinese-style modernization.

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CHINA'S FINANCIAL SECTOR SUPPORT POLICIES FOR SMALL AND MEDIUM-SIZED ENTERPRISES: REASONS, CONTENT, AND ECONOMIC IMPACT

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Annotation. Financial support is a critical component in alleviating financing constraints for small and medium-sized enterprises (SMEs) and enhancing their operational vitality. Personally, I currently work in credit approval at a state-owned joint-stock bank in China, where I closely monitor the country's financial policies and their role in promoting the growth of SMEs. This paper, grounded in the realities of SME development in China, systematically examines the intrinsic motivations behind the financial sector's support for SMEs from perspectives such as market failures, structural imbalances, and the needs of macroeconomic regulation, while also reviewing the current policy framework. The study reveals that China has established a multi-tiered financial support system centered on structural monetary policy, encompassing credit support, financing guarantees, fiscal interest subsidies, and direct financing, achieving significant results in expanding credit scale, reducing

financing costs, and improving corporate operations. By the end of 2024, the outstanding balance of inclusive micro and small enterprise loans nationwide reached 60 trillion yuan, with a loan coverage rate of 75% for SMEs. However, challenges remain in policy implementation, including uneven beneficiary distribution, regional disparities in execution, a "mid-tier gap" in financing for medium-sized enterprises, and difficulties in assessing policy effectiveness. This paper argues that future financial support for SMEs should shift from scale expansion to quality enhancement, by refining a tiered financial service system, improving credit information sharing mechanisms, strengthening risk sharing and policy evaluation, and ensuring more targeted and sustainable allocation of financial resources to support the high-quality development of SMEs.

Key words: Small and Medium-sized Enterprises (SMEs); Financial Support; Inclusive Finance; Structural Monetary Policy; Financing Constraints

I. Introduction

Small and medium-sized enterprises (SMEs) constitute the largest segment of market entities in China's economy, employing the broadest workforce and demonstrating the strongest innovative vitality. They play an irreplaceable role in stabilizing economic growth, optimizing industrial structures, and ensuring employment and livelihoods. For a long time, constrained by factors such as information asymmetry, insufficient collateral, and weak financial compliance, SMEs have faced persistent challenges in accessing financing at high costs, which has become the primary bottleneck hindering their sustainable and healthy development. From the perspective of financial operation principles, this phenomenon essentially reflects a market failure in the credit market: financial institutions, driven by considerations of risk-return balance, tend to allocate credit resources primarily to large enterprises with high credit ratings, adequate collateral, and stable cash flows, leaving SMEs at a long-term disadvantage in the allocation of financial resources.

To correct resource misallocation and direct financial support toward vulnerable sectors of the real economy, China has continuously advanced financial support policies for small and medium-sized enterprises, gradually establishing a policy framework driven by the central bank's structural monetary policy, supported by regulatory assessments, fiscal coordination, and integrated capital market mechanisms. Policy tools have been progressively enriched—from expanding relending facilities for agriculture and small businesses, establishing relending programs for private enterprises, to implementing loan interest subsidies, reducing guarantee fees, and broadening direct financing channels—all reflecting sustained enhanced support. However, existing policy impact evaluations predominantly attribute increases in loan volumes and improvements in corporate performance directly to policy measures, while inadequately addressing the influence of external factors such as economic cycles and industry conditions, and insufficient attention is

paid to structural contradictions arising during policy implementation.

Based on this, this paper draws on economic theory to review the policy measures adopted by China's financial sector to support small and medium-sized enterprises (SMEs), analyze the underlying motivations behind these policies, objectively assess their economic impact and practical limitations, and propose optimization directions by addressing practical controversies. The aim is to provide insights for enhancing the SME financial service system and improving policy precision.

II. Main Reasons for the Financial Sector's Support for Small and Medium-sized Enterprises

(1) Credit Market Failure and Financing Constraints for Small and Medium-sized Enterprises

The root cause of financing difficulties faced by small and medium-sized enterprises (SMEs) lies in information asymmetry in the credit market and the mismatch between risk-return structures. On one hand, SMEs experience relatively high operational volatility and inadequate financial systems, making it difficult for financial institutions to assess their credit risks accurately and cost-effectively. On the other hand, SMEs generally lack traditional collateral such as land and factory buildings, failing to meet banks' conventional lending requirements, which results in low financing accessibility and high financing costs. Under market-driven allocation mechanisms, funds continuously concentrate in low-risk, large-scale enterprises, leaving SMEs unable to obtain financial resources commensurate with their economic contributions.

From an economic perspective, small and medium-sized enterprises contribute over 50% of national tax revenue, more than 60% of GDP, over 70% of technological innovation achievements, and over 80% of urban employment, serving as a crucial foundation for stable macroeconomic performance. This mismatch characterized by "high contribution but low support" necessitates that the government employ policy guidance to address market failures, enhance SME financing accessibility, and stabilize the vitality of microeconomic entities.

(II) The Logic Behind Targeted Regulation of Structural Monetary Policy

Unlike aggregate monetary policy, structural monetary policy aims for "targeted precision support" by providing low-cost funds to financial institutions with restricted allocation directions, thereby incentivizing them to expand credit extension to small and micro enterprises, private enterprises, and technology-based enterprises. This approach not only avoids inflationary pressures and capital idling associated with aggregate easing but also effectively enhances the transmission efficiency of monetary policy, improving the effectiveness of financial support for the real economy.

In recent years, China has repeatedly optimized its relending tools for supporting agriculture and small businesses, as well as for technological innovation, and established a new 1 trillion yuan relending facility for private enterprises in 2026.

These measures essentially aim to reduce financial institutions 'funding costs, guide them to shift their service focus toward grassroots levels, lower loan interest rates for small and micro enterprises, and thereby alleviate financing constraints for SMEs, reflecting the monetary policy's approach of targeted regulation and addressing systemic weaknesses.

(3) The "intermediate gap" issue in financing for medium-sized enterprises is particularly prominent

In long-term financial service practice, small and micro enterprises have received substantial support due to policy incentives, while large enterprises benefit from diversified financing channels. However, medium-sized private enterprises in the intermediate stage often struggle to be included in inclusive finance statistics and cannot enjoy the financing conveniences available to large enterprises, creating a "mid-level gap" in financing services. When some small and micro enterprises grow into medium-sized enterprises, they experience a "growth penalty" —characterized by rising financing costs and reduced support—which hinders their sustainable development.

With industrial upgrading and the phased development of high-quality small and medium-sized enterprises, medium-sized enterprises have become increasingly pivotal in industrial chains. In 2026, private enterprises' relending program for the first time extended support to medium-sized enterprises, marking a shift in policy focus from primarily serving micro and small businesses to adopting a tiered service model that covers enterprises of all sizes. This move helps address institutional gaps and enhances comprehensive financial support throughout the entire corporate lifecycle.

(IV) The Requirements for Macroeconomic Regulation to Stabilize Growth and Promote Transformation

From a macroeconomic perspective, small and medium-sized enterprises (SMEs) serve as crucial stabilizers during economic downturns. When the economy faces downward pressure, large enterprises tend to adopt more cautious investment approaches, whereas SMEs, with their large numbers, widespread distribution, and flexible decision-making capabilities, can mitigate economic fluctuations to some extent. However, SMEs have weaker risk resilience and are more vulnerable during credit tightening phases, creating a negative feedback loop. Therefore, enhancing financial support carries significant counter-cyclical regulatory implications.

Meanwhile, small and medium-sized enterprises serve as crucial drivers for industrial transformation and the cultivation of new quality productive forces. A large number of technology-driven and innovative SMEs focus on achieving technological breakthroughs in niche sectors, playing a pivotal role in strengthening and completing industrial chains. By directing financial policies to allocate resources toward technological innovation, green development, and specialized, refined, distinctive, and innovative fields, we can facilitate industrial structure upgrading and enhance the long-term growth momentum of the economy.

III. Content of the Policy Framework for the Financial Sector to Support Small and Medium-sized Enterprises

Through years of practice, China has established a financial support system for small and medium-sized enterprises (SMEs) characterized by "monetary policy guidance + regulatory constraints + fiscal contributions + capital market supplementation," with increasingly enhanced policy synergy.

(I) Structural Monetary Policy Instruments

Structural monetary policy serves as the core instrument for financial support. As of January 2026, combined use of agricultural and small business relending facilities with rediscount programs added a new quota of 500 billion yuan, while a separate 1 trillion yuan private enterprise relending facility was established to cover small and medium-sized private enterprises, significantly expanding the policy reach. The technology innovation relending program reached 1.2 trillion yuan, with 100 billion yuan specifically allocated to support first-time loans for technology-based SMEs, alleviating financing challenges for light-asset tech enterprises.

The aforementioned policy reduces banks' funding costs for serving small and micro enterprises and private businesses through low-cost financial incentives, encourages financial institutions to expand credit lending and reasonably lower interest rates, thereby strengthening support for vulnerable sectors of the real economy.

(II) Credit Guidance and Regulatory Policies

Regulatory authorities guide financial institutions to enhance services for small and micro enterprises through performance evaluations. In 2025, the China Banking and Insurance Regulatory Commission (CBIRC) and seven other departments issued the "Several Measures to Support Financing for Small and Micro Enterprises," proposing measures such as offering loan rollovers without principal repayment, increasing the proportion of medium-and long-term loans, and providing an internal funding discount of no less than 50 basis points on FTP rates for inclusive micro-loans, thereby boosting banks' willingness to extend credit.

Meanwhile, regulatory authorities have refined the evaluation mechanism for micro and small enterprise financial services, strengthened due diligence exemption policies, raised tolerance for non-performing loans, and promoted the establishment of a long-term mechanism that ensures institutions are "willing, capable, and adept" in lending. These measures guide financial institutions to extend services to grassroots levels, streamline processes, and enhance financing accessibility for SMEs.

(III) Synergistic Support from Finance and Banking

The fiscal authorities work in synergy with financial policies through measures such as interest subsidies, guarantees, and risk compensation to reduce corporate financing costs and mitigate risks for financial institutions. The loan interest subsidy policy for small, medium, and micro enterprises, implemented in 2026, provides an annual interest subsidy of 1.5% on eligible loans, with the funds

directly applied toward interest payments, thereby alleviating corporate capital tie-up.

Regarding financing guarantees, the policy extends support to medium-sized enterprises, requiring government-backed guarantee institutions to provide guarantees covering at least 80% of micro and small enterprise loans under CNY 10 million per borrower, reduce guarantee fees to below 1%, and share 50%–80% of compensation losses through a risk compensation fund, thereby significantly expanding guarantee coverage.

(IV) Support for Direct Financing and Equity Financing

To reduce enterprises' excessive reliance on indirect financing, China has continuously improved its multi-tiered capital market service system. In equity financing, the government supports high-quality small and medium-sized enterprises in developing on the New Third Board and listing on the Beijing Stock Exchange, lowering the listing threshold for innovative companies. For bond financing, products such as technology bonds and innovation-backed notes have been introduced; in the first half of 2025, the technology board of the bond market facilitated financing for 37 companies totaling 12 billion yuan.

Meanwhile, local governments have optimized the management of government investment funds, increased risk tolerance, and guided venture capital institutions to "invest early, in small-scale ventures, and in cutting-edge technologies," thereby shifting financial support from single credit instruments to diversified financing models encompassing loans, equity, and bonds.

IV. The Economic Impact and Practical Issues of Financial Support Policies

(I) Positive Impacts of the Policy

From a macro perspective, financial support has effectively expanded financing availability for small and medium-sized enterprises (SMEs) and improved the overall financing environment. By the end of 2024, the outstanding balance of inclusive micro and small enterprise loans reached 60 trillion yuan, with a growth rate maintained at around 20%; the loan coverage rate for SMEs stood at 75%, while the loan acquisition rate for specialized, refined, unique, and innovative enterprises exceeded 80%. Enhanced financing accessibility has stabilized business operating expectations, driving the growth rate of industrial added value for SMEs to consistently outpace that of large enterprises. Private enterprises, predominantly composed of SMEs, have remained China's largest foreign trade entity for six consecutive years, playing a vital role in stabilizing economic growth, employment, and foreign trade.

At the micro level, financial support effectively alleviates corporate financing constraints and stimulates innovation vitality. Empirical studies demonstrate that microfinance services significantly enhance the market entry rate of small and medium-sized enterprises (SMEs) across regions and lower entrepreneurial barriers. Research on specialized, refined, distinctive, and innovative enterprises also indicates that financing support increases corporate R&D investment and patent output, with particularly pronounced effects for firms facing stronger financing constraints.

Overall, financial assistance not only mitigates short-term funding pressures but also drives long-term corporate transformation and upgrading.

(II) Practical Issues in Policy Implementation

First, identifying the policy effect is relatively challenging. The improvement in corporate operations and loan growth result from the combined influence of multiple factors, including policies, economic cycles, and industry conditions, making it difficult to isolate the net policy effect. Rigorous causal identification analyses in existing research remain relatively limited.

Second, the distribution of policy benefits is uneven. At the implementation level, small and medium-sized enterprises (SMEs) with standardized operations, sufficient collateral, and sound credit profiles are more likely to obtain loans, whereas startups, asset-light enterprises, unsecured entities, and micro-enterprises that have not yet turned a profit still struggle to meet the eligibility criteria. The policy thus exhibits a characteristic of providing "icing on the cake" rather than "firewood in the snow."

Third, financing services for medium-sized enterprises still have shortcomings. Although medium-sized enterprises will be included in the support scope by 2026, supporting mechanisms such as differentiated credit granting and risk assessment remain inadequate, and the issue of the "intermediate gap" has not been fundamentally resolved.

Fourth, significant disparities exist in regional implementation effectiveness. The eastern region boasts abundant financial resources, advanced digitalization levels, and a robust credit system, resulting in better policy implementation outcomes; in contrast, county-level financial services in central and western regions are insufficient, with delayed data sharing, leading to a pronounced gap in corporate benefits compared to the eastern region.

Fifth, rapid long-term expansion carries potential risks. With the continuous expansion of inclusive micro and small enterprise loans, some companies exhibit a tendency toward excessive debt accumulation. Should economic growth slow down, this could lead to increased non-performing loan pressures in certain industries and regions, imposing stricter risk management requirements on financial institutions.

V. Policy Controversies and Future Optimization Directions

(1) Major Controversies in Practice

First is the balance between inclusive support and targeted support. Inclusive policies offer broad coverage and high fairness, but suffer from dispersed resources and diminishing marginal returns; targeted policies exhibit high efficiency, yet entail potential risks such as resource concentration and policy capture. How to strike a balance between fairness and efficiency remains a challenging aspect of policy design.

Second is striking a balance between short-term relief and long-term transformation. Policies such as deferring principal and interest payments or offering loan renewals without principal repayment help stabilize market entities, but may

also delay the exit of inefficient enterprises and hinder the natural selection process in industrial restructuring. A reasonable balance must be struck between stabilizing employment and promoting transformation.

The third aspect involves balancing credit expansion with risk prevention and control. There is an inherent tension between expanding credit supply and maintaining risk boundaries: overemphasizing scale growth may accumulate risks, while excessive focus on risk control could lead to insufficient credit availability.

Fourth, the policy evaluation perspective remains relatively narrow. Current assessments predominantly rely on macroeconomic data and institutional reports, lacking authentic feedback from small, medium, and micro enterprises, which often results in a disconnect between policy adjustments and actual corporate needs.

(II) Future Policy Optimization Directions

In the future, financial support for small and medium-sized enterprises should shift from "expanding coverage and increasing volume" to "targeted quality improvement," with a focus on enhancing four key areas.

First, establish a comprehensive tiered and categorized financial service system. Develop differentiated credit granting and risk assessment mechanisms tailored for small and micro enterprises, medium-sized enterprises, technology-based enterprises, and startups, addressing policy gaps in their growth processes, with a focus on compensating for the shortcomings in financial services for medium-sized enterprises.

Second, deepen the sharing and application of credit information. Facilitate the opening of government data—including tax, market regulation, social security, and utility services—to financial institutions, establish a unified and efficient credit reporting platform, and replace traditional collateral guarantees with data-based credit assessment to fundamentally alleviate information asymmetry.

Third, improve the policy effectiveness evaluation mechanism. Engage third-party academic institutions to conduct policy assessments using methods such as difference-in-differences (DID) and instrumental variables, shifting the focus from "loan volume and interest rate levels" to quality indicators including "fund utilization efficiency, corporate innovation capacity, operational sustainability, and perceived benefits."

Fourth, strengthen risk sharing and sustainability. Continue to improve government-backed financing guarantee mechanisms and risk compensation funds, rationally delineate risk responsibilities among the government, financial institutions, and enterprises, balance the objectives of "expanding coverage and disbursement" with "controllable risks," and ensure long-term sustainable financial support for small and medium-sized enterprises (SMEs).

VI. Conclusion

Small and medium-sized enterprises are a vital source of China's economic resilience and vitality. Alleviating their financing constraints and enhancing the quality and efficiency of financial services hold significant economic and social

importance. China has established a multi-tiered financial support system driven by structural monetary policy, guided by regulatory frameworks, coordinated through fiscal policies, and integrated with capital market mechanisms. This system has yielded notable results in expanding financing scale, reducing financing costs, stimulating corporate vitality, and stabilizing the macroeconomy.

It is also important to recognize that current policies still face challenges such as structural imbalances, regional disparities, inadequate support for medium-sized enterprises, and difficulties in assessing policy effectiveness. Financial resources remain insufficiently accessible to startups and asset-light small and micro enterprises, while tiered service frameworks and credit systems still require significant improvement.

In the future, financial support for small and medium-sized enterprises (SMEs) should adhere to market-oriented, rule-of-law-based, and targeted approaches, shifting from scale expansion to high-quality development. This involves improving tiered services, enhancing the credit system, optimizing evaluation mechanisms, and strengthening risk-sharing mechanisms, thereby guiding financial resources to be allocated to SMEs more fairly, efficiently, and sustainably. The ultimate policy objective is not merely to increase capital disbursement, but to establish a stable, predictable, low-cost, and highly efficient financing ecosystem. This will enable more dynamic and promising SMEs to receive support, foster a positive interaction between finance and the real economy, and provide sustained support for high-quality economic development.

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DIGITAL TECHNOLOGY INVESTMENT AS A DRIVER OF PROFITABILITY RESILIENCE FOR ENSURING STABLE DEVELOPMENT STRATEGY IN INDUSTRIAL ENTERPRISES

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Annotation. This article examines digital technology investment as a strategic driver of profitability resilience and stable development in industrial enterprises. Against the backdrop of global economic volatility, technological transformation, and increasing market competition, industrial enterprises face significant challenges in maintaining long-term profitability and strategic stability. The study analyzes how investments in digital technologies, including industrial artificial intelligence, cyber-physical systems, predictive analytics, and automated production management, contribute to improving operational efficiency, reducing cost volatility, and strengthening risk management capabilities. The paper emphasizes that digital transformation enables enterprises to shift from reactive to proactive management models, thereby enhancing strategic flexibility and sustainable competitiveness. Drawing on international research and the experience of Kazakhstan, the article demonstrates that digitalization not only improves enterprise performance and innovation potential but also supports the continuity of long-term development strategies under conditions of uncertainty. The study concludes that digital technology investment should be considered a core strategic asset for building anti-fragile and sustainable industrial enterprises capable of adapting to external shocks and maintaining stable growth.

Key words: digital transformation, industrial enterprises, profitability resilience, digital technology investment, sustainable development, risk management, industrial artificial intelligence, competitiveness, innovation strategy, digital economy, strategic stability, Kazakhstan.

The stable development of industrial enterprises is fundamental to national economic security and industrial modernization. However, in the current economic

environment characterized by global economic volatility, rapid technological iteration, and intensifying market competition, these enterprises increasingly confront a persistent "profitability trap": short-term operational cash flow cannot be effectively converted into long-term strategic capital. This structural challenge weakens the financial foundation necessary for implementing stable development strategies. When profitability becomes fragile and unpredictable, enterprises find themselves unable to commit resources to multi-year innovation projects, technological upgrades, or market expansion initiatives—precisely the investments that underpin long-term competitiveness. Drawing on the conference's fourth thematic direction, "Investment and Innovation Policy, Competitiveness and Risk Management in the Digital Economy," this report analyzes how digital technology investment serves as a strategic mechanism for reconciling short-term financial performance with long-term strategic stability.

A critical paradox facing industrial enterprises is the time-lag conflict between profitability enhancement and strategy implementation. Traditional capital-intensive investments—such as plant expansion, heavy machinery acquisition, or large-scale infrastructure development—typically generate substantial initial costs that depress Return on Assets (ROA) during the early phases of implementation. This decline expands the "strategic funding gap," defined as the financial deficit between current profitability levels and the capital required for long-term strategic projects. When enterprises face this gap, they are forced into difficult trade-offs: funding strategic initiatives may require accepting temporarily weak financial indicators, while prioritizing short-term profitability may mean deferring strategically essential investments.

This dilemma intensifies considerably under conditions of heightened external uncertainty. When macroeconomic shocks, trade policy disruptions, or industry-specific downturns materialize, enterprises that adhere to conservative working capital policies encounter an especially acute challenge. Such enterprises, following conventional principles of financial prudence, may feel compelled to cut innovation budgets, reduce research and development expenditures, or scale back strategic expansion plans to defend short-term net profit margins. However, as Kaijin Cai (2024) demonstrates through a comprehensive review of profitability persistence literature, profitability persistence constitutes a core indicator of sustainable enterprise development; its fluctuation does not merely reflect temporary financial volatility but directly destabilizes the coherence and credibility of long-term strategic planning. The paradox is stark: reactive cost-cutting measures intended to protect short-term profitability systematically erode the enterprise's competitive advantage, transforming what might have been temporary profitability fluctuations into a structural crisis of strategic rigidity—a condition in which the enterprise progressively loses the capacity to adapt, innovate, or expand precisely when external conditions demand such responses. Investment in digital technology—particularly in industrial artificial intelligence, cyber-physical systems, and advanced data

analytics—provides a transformative mechanism for resolving this fundamental conflict. Unlike traditional fixed-asset investment, which operates within a broadly linear cost-revenue relationship, digital innovation fundamentally re-engineers the underlying logic connecting enterprise expenditure to revenue generation. Xiangyu Guan (2012), in a rigorous empirical study of Chinese steel enterprises, demonstrated that return on investment capacity and cash flow control capability constitute the two core factors determining enterprise profitability. Building on this insight, it becomes evident that digital technologies such as predictive maintenance algorithms, real-time production monitoring systems, and automated quality control mechanisms can transform traditional cost structures in fundamental ways. In conventional manufacturing operations, post-fault maintenance represents an unpredictable and largely uncontrollable expense category, one that introduces significant volatility into cost projections and financial planning. Digital systems, by contrast, convert such costs into precisely controllable data service costs subject to algorithmic optimization and continuous refinement. This shift from reactive repair to predictive maintenance not only reduces absolute maintenance expenditure but, more importantly, transforms the very nature of these costs from variable and unpredictable to stable and forecastable.

This transformation represents more than an incremental efficiency improvement; it constitutes a non-linear cost management model that reduces the rigid marginal costs traditionally associated with business expansion and product diversification. In conventional industrial operations, each additional unit of output typically entails a predictable and largely unavoidable increment of labor, material, and equipment costs. Digital systems alter this relationship by enabling enterprises to increase output, customize products, or diversify into adjacent product categories with significantly lower marginal cost increments, since the underlying data infrastructure and algorithmic capabilities can be scaled at relatively modest additional expense. This structural change carries profound implications for strategic flexibility: enterprises can pursue market expansion or product innovation initiatives without experiencing the severe short-term profitability compression that traditionally accompanies such strategic moves. They can thus maintain healthy profit margins even during periods of significant strategic capital expenditure, creating a financial environment in which long-term development strategies can be pursued consistently rather than intermittently.

From a risk management perspective, digital technology investment fundamentally alters the strategic calculus for enhancing profitability resilience by transforming the traditional trade-off between risk mitigation and opportunity cost. Lina Wang (2009), through a rigorous empirical analysis of Chinese industrial listed companies spanning an entire decade of financial data, established that moderate working capital policies consistently yield higher and more steadily increasing profitability than conservative policies. This finding carries profound implications. In the traditional industrial era, enterprises primarily sought to resist external risks by

maintaining high levels of working capital reserves—a strategy that, while providing a buffer against unexpected shocks, is inherently tied to substantial opportunity costs, since capital held in reserve for precautionary purposes cannot simultaneously be deployed for productivity-enhancing investments, technological innovation, or market expansion activities. The strategic limitation of this approach is clear: it trades off long-term growth potential for short-term stability assurance.

Digital technology fundamentally transforms this trade-off by empowering industrial enterprises to construct a dynamic risk-hedging strategy that reduces the need for large precautionary reserves. By processing massive volumes of operational data—encompassing production metrics, supply chain information, customer behavior patterns, and market signals—enterprises can move beyond the static, reserve-based approach to risk management. Advanced analytics and machine learning algorithms enable the accurate identification of weak signals that precede materialized risks: subtle shifts in demand patterns that may indicate emerging market fluctuations, minor disruptions in supplier delivery schedules that may foreshadow broader supply chain vulnerabilities, or gradual changes in customer payment behaviors that may signal impending credit defaults. The capacity to detect such signals before they crystallize into full-fledged crises allows enterprises to initiate calibrated algorithmic hedging responses—adjusting production schedules, reconfiguring supply chains, or modifying credit terms—in a proactive rather than reactive manner. This "high-frequency, low-amplitude" active adjustment capability represents a qualitative departure from traditional risk management paradigms and effectively prevents sudden, severe losses from disrupting carefully planned strategic initiatives, thereby securing the continuity of stable development strategies.

Furthermore, digital technology investment reshapes the competitive paradigm within which industrial enterprises operate. In the traditional industrial economy, competitive barriers were primarily constructed on the basis of economies of scale: larger production volumes enabled lower unit costs, which reinforced market position and created entry barriers. In the digital economy, however, these scale-based barriers are increasingly supplemented—and in some sectors replaced—by barriers grounded in data fidelity, algorithmic sophistication, and the speed of iterative system optimization. Jia Dawei (2025), in a detailed empirical investigation of digital transformation's impact on manufacturing enterprise performance, found that digital transformation significantly and positively affects enterprise performance, and that R&D intensity serves as a positive moderating variable in this relationship. Enterprises with strong R&D capabilities derive greater benefit from digital investment, creating a self-reinforcing dynamic of capability enhancement and performance improvement. Li Tong and Deng Zhou (2026) further reveal that digital transformation can exert a disruptive effect on traditional market power, creating strategic opportunities for digitally proactive enterprises while simultaneously threatening the competitive positions of those that prove slow to adapt. Digitally mature enterprises can thus decouple their profitability trajectories from broader

industry cycles, maintaining core R&D and strategic investment continuity even during economic downturns and thereby securing competitive advantages that persist and compound into subsequent recovery phases.

In conclusion, industrial enterprises should reconceptualize digital technology investment not merely as a cost to be managed or a technological upgrade to be implemented when resources permit, but as a core strategic asset for constructing enduring profitability resilience. This reconceptualization requires concrete changes in financial management practice. Enterprise management should strengthen the capacity to assess digital investment's strategic value by developing financial evaluation systems that balance short-term profit indicators with the long-term realization of technological dividends. Such systems would recognize that digital investments may temporarily depress conventional profitability metrics while simultaneously building the organizational capabilities and data infrastructure that underpin superior long-term performance. By embracing this approach consistently, industrial enterprises can achieve the critical leap from fragile profitability—inherently vulnerable to external shocks and cyclical fluctuations—to robust, and ultimately anti-fragile, stable development that grows stronger through adaptation to challenges.

A comparative analysis of foreign experience allows us to systematize the areas of influence of the digital economy on socio-economic development.:

1) increasing the level of labor productivity and personnel qualifications;

2) strengthening competition in commodity markets;

3) simplifying access to information resources;

4) providing other advantages for market participants.

In global practice, business digitalization is usually supported through various initiatives and programs. Kazakhstan has adopted a number of measures to stimulate the digital transformation of commercial enterprises:

- Financial support: providing financial incentives, grants, subsidies, or preferential loans to businesses seeking to adopt digital technologies.

- Education and training: creation of educational programs and trainings for business leaders and employees on digital literacy and the use of new technologies.

- IT infrastructure: the development of infrastructure, including broadband Internet, necessary for the effective operation of digital technologies.

- Stimulating innovation: supporting innovations and startups in the field of digital technologies through financial support, incubators.

- Regulatory support: development and implementation of relevant laws and regulations that promote the development of digital business and data protection.

- Public-private partnership: assistance in establishing partnerships between the government, the private sector and educational institutions for the joint implementation of digitalization projects.

- Ecosystem of innovation: creation and maintenance of innovative ecosystems, including technology parks and innovation centers, which facilitate interaction and

exchange of experience between enterprises. These measures help to create a favorable environment for the development of digital technologies in the commercial sector, stimulating innovation and increasing competitiveness [6].

The effect of implementing a digital strategy is the end result of the digitalization of an enterprise's economic processes. It should be borne in mind that digitalization is a costly process, and therefore it is not enough to evaluate the effect alone: the positive effect of a digital strategy does not always ensure the competitiveness of a company.

Thus, digital strategy is a key success factor for commercial real estate management companies. It allows you to increase operational efficiency, increase customer satisfaction and achieve a competitive advantage. Research in the field of digital strategy will contribute to the development of new solutions, the analysis and optimization of business processes, as well as the development of strategies to overcome challenges and reduce risks. This will help companies effectively adapt to the changing business environment and successfully achieve their strategic goals in the field of commercial real estate management.

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AN ANALYSIS OF LEGAL PATHWAYS TO PREVENT DEFAULT RISK IN THE CONTEXT OF THE FINANCIAL CRISIS

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Annotation. The financial crisis significantly increases the probability of corporate default and amplifies systemic risks across financial and commercial sectors. In this context, legal professionals play a crucial role in establishing a comprehensive risk prevention framework that integrates pre-event planning, in-event monitoring, and post-event legal remedies. This paper explores legal strategies aimed at minimizing default risks through advanced contract design, proactive performance supervision, and diversified dispute resolution mechanisms. It also examines the application of legal doctrines such as the change of circumstances and force majeure, emphasizing their importance in maintaining contractual balance during periods of economic instability. The study highlights the need for lawyers to adopt a forward-looking and preventive approach to legal services in order to safeguard clients' interests and ensure transactional stability in times of financial crisis.

Key words: Financial Crisis; Default Prevention; Contract Design; Change of Circumstances; Risk Management; Dispute Resolution

I. Introduction

The financial crisis has led to a significant deterioration in the global economic environment, resulting in reduced liquidity, declining asset values, and weakened corporate solvency. Under such conditions, the risk of default has become more widespread, often spreading across industries and regions, thereby exhibiting strong systemic and contagious characteristics. Enterprises, particularly small and medium-sized ones, face increasing pressure in fulfilling contractual obligations, which in turn leads to a higher likelihood of disputes and legal conflicts.

In this challenging environment, the role of legal professionals is evolving. Lawyers are no longer limited to resolving disputes after they arise but are increasingly expected to anticipate risks and provide preventive legal solutions. By integrating legal expertise with financial risk management, lawyers can help clients navigate uncertainties and mitigate potential losses. Therefore, constructing a comprehensive legal framework for default risk prevention is of great theoretical and practical significance.

II. System of Legal Preventive Measures

(A) Pre-Event Prevention: Strengthening Contract Design

Pre-event prevention represents the most critical stage in managing default risks. At the contract formation stage, lawyers should focus on identifying potential risks and embedding preventive mechanisms within contractual provisions.

First, dynamic adjustment clauses should be incorporated into long-term contracts. For instance, pricing mechanisms linked to market indicators such as the Loan Prime Rate (LPR), exchange rates, or commodity indices can help parties adapt to changing economic conditions. These clauses reduce the likelihood of disputes arising from significant market fluctuations.

Second, a comprehensive guarantee structure should be established. This may include a combination of mortgages, pledges, and third-party guarantees to ensure sufficient security for contractual obligations. Additionally, clauses requiring the maintenance of collateral value and periodic reassessment of assets can further enhance risk control.

Third, contracts should clearly define extraordinary circumstances, including financial crises, as triggering events for renegotiation. By explicitly incorporating the concept of "systemic financial risk" into contractual terms, parties can create a legal basis for invoking the doctrine of change of circumstances, thereby preserving contractual fairness.

Finally, lawyers should emphasize clarity and precision in contract language to avoid ambiguities that could lead to disputes. Standardized clauses, risk allocation provisions, and contingency plans should all be carefully drafted to ensure enforceability.

(B) In-Event Monitoring: Proactive Performance Management

During the performance stage of a contract, continuous monitoring is essential to detect early warning signs of default. Lawyers should assist clients in establishing internal risk monitoring systems that track counterparties' financial conditions, payment behaviors, and market developments.

When there is credible evidence that a counterparty may be unable to perform its obligations, clients should be advised to exercise the right of insecurity defense in accordance with the law. This includes suspending performance and requesting adequate security from the other party. Such measures can effectively prevent further losses and provide leverage in negotiations.

At the same time, proper documentation of all communications is crucial. Negotiations regarding contract modifications, extensions, or price adjustments should be recorded through formal correspondence, meeting minutes, or electronic records. These documents serve as important evidence in case of future disputes.

In addition, lawyers can facilitate timely renegotiation of contract terms. By promoting cooperative solutions and maintaining open communication channels, parties may reach mutually beneficial arrangements that avoid escalation into legal conflicts.

(C) Post-Event Relief: Diversified Dispute Resolution

When default occurs, the focus shifts to minimizing losses and resolving disputes efficiently. Instead of immediately resorting to litigation, lawyers should prioritize alternative solutions such as debt restructuring. This may include extending payment deadlines, reducing interest rates, or converting debt into equity, thereby alleviating financial pressure on the debtor while preserving the creditor's interests.

If legal proceedings become unavoidable, the doctrine of change of circumstances can be invoked. Under relevant legal provisions, such as Article 533 of the Civil Code, courts may modify or terminate contracts when unforeseen and significant changes render performance unfair. Lawyers should support such claims with authoritative economic data and expert analysis to strengthen their arguments.

Procedurally, arbitration is often preferred over litigation due to its efficiency, confidentiality, and flexibility. Arbitration institutions can provide faster resolutions and reduce the burden on judicial systems, making them particularly suitable during periods of widespread financial distress.

Moreover, mediation should also be considered as a viable option. By involving neutral third parties, disputes can often be resolved amicably, preserving business relationships and reducing legal costs.

III. Additional Considerations in Default Risk Prevention

Beyond the traditional framework, several additional factors should be taken into account. Regulatory compliance plays a vital role in preventing legal risks, especially in highly regulated industries such as finance and banking. Lawyers must ensure that clients adhere to evolving legal requirements and policy changes.

Technological tools, such as legal analytics and risk assessment software, can also enhance the effectiveness of risk prevention strategies. By leveraging data-driven insights, lawyers can better predict potential defaults and design targeted solutions.

Furthermore, cross-border transactions introduce additional complexities, including differences in legal systems, jurisdictional issues, and enforcement challenges. In such cases, international arbitration clauses and choice-of-law provisions become particularly important.

IV. Conclusion

The financial crisis underscores the importance of proactive legal risk management. Lawyers play a pivotal role in helping clients navigate uncertain economic conditions by shifting from reactive dispute resolution to preventive legal planning. Through comprehensive contract design, continuous performance monitoring, and flexible dispute resolution mechanisms, legal professionals can significantly reduce the likelihood and impact of default.

Ultimately, the effectiveness of default risk prevention depends on the integration of legal, financial, and strategic considerations. By adopting a forward-looking approach and leveraging both traditional legal tools and modern technologies, lawyers can enhance transactional stability and contribute to the resilience of the broader economic system.

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FINANCIAL SUPPORT INNOVATION FOR SMEs' PARTICIPATION IN THE BELT AND ROAD INITIATIVE: CHINA KAZAKHSTAN COOPERATION PERSPECTIVE

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Annotation. Small and medium-sized enterprises (SMEs) are key participants in China–Kazakhstan economic and trade cooperation under the Belt and Road Initiative. However, their cross-border business activities are significantly constrained by limited access to financing, high transaction costs, and insufficient risk protection mechanisms. This paper analyzes the main challenges faced by SMEs in cross-border financing and proposes targeted financial support innovations from four perspectives: credit enhancement, risk sharing, digital finance, and institutional coordination. The study aims to provide practical insights for improving financial accessibility and promoting sustainable development of SMEs in bilateral cooperation.

Key words: SMEs; Belt and Road Initiative; China–Kazakhstan cooperation; financial support innovation; credit enhancement; risk sharing; cross-border financing; digital finance; trade facilitation

1. Introduction

With the deepening of digital economy cooperation between China and Kazakhstan, SMEs have become an important driving force of cross-border trade and regional economic integration. Compared with large enterprises, SMEs are more flexible and innovative, but they are also more vulnerable to external shocks and financial constraints.

Despite the rapid development of bilateral trade under the Belt and Road Initiative, SMEs still face significant financial bottlenecks. These include insufficient collateral, information asymmetry, high comprehensive financing costs, and limited access to effective risk management tools. Therefore, exploring innovative financial support mechanisms has become a key issue in promoting sustainable SME development.

This paper focuses on practical and feasible innovation paths, combining financial institution cooperation, digital finance, and risk management mechanisms.

2. Practical Difficulties of SMEs in Cross-Border Financial Support

In practice, SMEs face four major financial constraints:

First, lack of collateral limits access to credit.

Most SMEs possess limited fixed assets and often lack standardized financial reporting, making it difficult to meet traditional banking requirements. In cross-border scenarios, information asymmetry is even more pronounced, leading to stricter risk control by financial institutions.

Second, financing costs remain high.

Cross-border transactions involve exchange rate risks, transfer fees, and additional compliance costs. As a result, SMEs bear significantly higher financing costs compared to large enterprises.

Third, insufficient risk protection mechanisms.

SMEs engaged in cross-border trade face multiple risks, including commercial default, policy changes, and market volatility. The absence of effective risk mitigation tools reduces the willingness of financial institutions to provide credit.

Fourth, weak coordination among financial institutions.

The fragmentation of services—credit provision, guarantees, insurance, and settlement—leads to inefficiencies and complex procedures, which negatively affect SMEs' capital turnover and operational efficiency.

3. Innovative Paths of Financial Support for SMEs

3.1 Credit Enhancement through Risk Mitigation Instruments

One of the key solutions to financing constraints is reducing reliance on traditional collateral. Risk mitigation tools, such as export credit insurance and guarantee mechanisms, can provide credit enhancement for SMEs.

By covering risks related to buyer default, political instability, and market uncertainty, these instruments improve the creditworthiness of SMEs and enable financial institutions to make more informed lending decisions.

3.2 Synergy among Financial Institutions

Effective financial support requires coordinated efforts among banks, insurance institutions, and policy-based financial organizations. A collaborative model involving “financial institution–bank–enterprise” interaction can improve service efficiency.

Through information sharing and risk distribution, an integrated service system combining “risk protection + financing + settlement” can be established, significantly reducing transaction costs and improving financing accessibility.

3.3 Digital Financial Innovation

Digital technologies play a crucial role in reducing information asymmetry and improving efficiency. Big databased credit assessment models integrate transaction data, logistics information, and operational indicators to create comprehensive credit profiles for SMEs.

In addition, digital platforms enable online approval processes, shorten financing cycles, and reduce administrative costs. Digital payment and settlement systems further enhance the speed and security of cross-border transactions.

3.4 Policy and Institutional Coordination

Financial innovation must be supported by stable policy frameworks and institutional cooperation. China and Kazakhstan can strengthen collaboration in credit information sharing, regulatory alignment, and facilitation of cross-border capital flows.

Policy tools such as financing subsidies, tax incentives, and risk compensation mechanisms can guide financial resources toward SMEs and improve the overall financing environment.

4. Further Development Directions

In the future, financial support for SMEs in cross-border trade is expected to evolve toward more integrated, digitalized, and sustainable models.

Firstly, the application of financial technology (FinTech) will continue to expand. Technologies such as artificial intelligence and blockchain can enhance credit evaluation accuracy, ensure transaction transparency, and reduce fraud risks.

Secondly, the development of cross-border digital financial platforms will simplify procedures and improve accessibility for SMEs. These platforms can integrate financing, insurance, and settlement services into a unified system.

Thirdly, green finance will become an important direction. Financial institutions may prioritize SMEs engaged in environmentally sustainable trade activities by offering preferential financing conditions.

Finally, regional financial integration between China and Kazakhstan will play a key role. The establishment of joint financial service platforms and standardized regulatory frameworks can significantly improve the efficiency of cross-border financial services.

5. Conclusion

SMEs play an indispensable role in China–Kazakhstan cooperation under the Belt and Road Initiative. However, their development is significantly constrained by limited financial support and structural barriers.

Innovations in financial support—particularly in risk mitigation, institutional coordination, digital finance, and policy frameworks—can effectively improve SMEs' access to financing. These measures will not only enhance the competitiveness of SMEs but also contribute to the sustainable development of bilateral economic and trade relations.

With the continuous deepening of digital economy cooperation, innovative financial models will play an increasingly important role in supporting SMEs and strengthening regional economic integration.

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ANALYSIS OF THE FINANCIAL CONDITION AND WAYS TO IMPROVE THE EFFICIENCY OF THE ENTERPRISE (USING THE EXAMPLE OF A SPECIFIC COMPANY)

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Annotation. The financial condition and operational efficiency of an enterprise are core indicators of its sustainable development and market competitiveness. Against the background of intensifying global market competition and complex macroeconomic fluctuations, analyzing an enterprise's financial status and exploring feasible ways to improve its operational efficiency have become critical research topics for corporate management and investors. Taking a specific company as the research object, this paper systematically analyzes its financial status from dimensions such as solvency, operational capacity, profitability, and cash flow. Based

on the analysis of existing problems, this paper proposes targeted optimization strategies from aspects of cost control, asset management, and operational structure adjustment. The research results can provide practical reference for the enterprise to improve its financial health and operational efficiency, as well as offer methodological inspiration for similar enterprises.

Key words: Enterprise Financial Condition; Operational Efficiency; Financial Analysis; Efficiency Improvement; Case Study

1. Core Functions of Financial Intermediaries

1. Introduction

In the context of deepening economic globalization and market-oriented reforms, enterprises are facing increasingly fierce competition and complex operational environments. The financial condition, as the "pulse" of an enterprise, directly reflects its operational status, risk level, and development potential. Operational efficiency, as a key factor determining an enterprise's survival and development, is closely linked to its financial health. For many enterprises, especially those in competitive industries, low operational efficiency often leads to rising costs, declining profitability, and increased financial risks, which seriously restrict their sustainable development.

Against this backdrop, taking a specific company as an example, this paper conducts an in-depth analysis of its financial condition and explores effective ways to improve operational efficiency. The paper first sorts out the relevant theories of financial analysis and efficiency evaluation, then constructs a comprehensive financial analysis framework for the case company, and finally puts forward practical optimization suggestions based on the analysis results. This research is not only of practical significance for the case company to solve its current problems, but also has certain reference value for other similar enterprises.

2. Theoretical framework and research methods

2.1 Core Concepts and Theories

Enterprise financial condition refers to the overall financial status of an enterprise reflected by various financial indicators, including solvency, operational capacity, profitability, and development capacity. Operational efficiency, on the other hand, reflects the input-output ratio of an enterprise's production and operation activities, which can be measured by indicators such as asset turnover rate, cost-profit ratio, and return on investment. The core theories supporting this research include financial statement analysis theory, efficiency evaluation theory, and corporate governance theory, which provide a systematic framework for analyzing the financial status and efficiency of enterprises.

2.2 Research Methods

This paper adopts a combination of theoretical analysis and case study methods. First, it sorts out the relevant theories of financial analysis and efficiency

improvement through literature research. Then, taking a specific manufacturing enterprise as the case study object, it collects and sorts out its financial statement data for the past three years, and conducts a comprehensive analysis using ratio analysis, trend analysis, and comparative analysis methods. Finally, based on the analysis results, it identifies the key factors restricting the enterprise's operational efficiency and proposes targeted improvement strategies.

3. Financial condition analysis of the case enterprise

3.1 Basic Overview of the Case Enterprise

The case enterprise selected in this paper is a medium-sized manufacturing enterprise focusing on the production and sales of mechanical parts, with a complete production and sales system. In recent years, affected by factors such as rising raw material prices and market demand fluctuations, the enterprise's profitability has declined, and its financial pressure has increased significantly. Therefore, analyzing its financial condition and exploring ways to improve operational efficiency have become urgent tasks for the enterprise.

3.2 Solvency Analysis

Solvency is an important indicator reflecting an enterprise's ability to repay debts, including short-term solvency and long-term solvency. Through the analysis of the case enterprise's current ratio, quick ratio, and asset-liability ratio, it is found that the enterprise's current ratio has shown a downward trend in the past three years, falling below the industry average, indicating that its short-term solvency is weak and there is a certain liquidity risk. The asset-liability ratio is on the rise, exceeding the reasonable range of the industry, which means that the enterprise's long-term debt pressure is increasing, and the financial leverage risk is prominent.

3.3 Operational Capacity Analysis

Operational capacity reflects the efficiency of an enterprise's use of assets, which can be measured by indicators such as accounts receivable turnover rate, inventory turnover rate, and total asset turnover rate. The analysis results show that the case enterprise's accounts receivable turnover rate is lower than the industry average, indicating that the enterprise's accounts receivable recovery cycle is long, and the capital occupation is serious. The inventory turnover rate has also shown a downward trend, reflecting problems such as slow inventory turnover and high inventory backlog, which have affected the overall operational efficiency of the enterprise.

3.4 Profitability Analysis

Profitability is the core indicator of an enterprise's operational performance, measured by indicators such as gross profit margin, net profit margin, and return on equity. The case enterprise's gross profit margin has declined year by year, affected by rising raw material costs and fierce market competition, leading to a continuous decline in net profit margin. The return on equity is also lower than the industry average, indicating that the enterprise's ability to create value for shareholders is weak, and its profitability needs to be improved urgently.

3.5 Cash Flow Analysis

Cash flow is the "blood" of an enterprise's operation, and the quality of cash flow directly affects the stability of the enterprise's operation. The analysis shows that the case enterprise's operating cash flow has been unstable in recent years, with negative net cash flow in some years, indicating that the enterprise's main business cash-generating capacity is weak. The net cash flow from investment activities is negative for a long time, reflecting the enterprise's continuous investment in fixed assets, but the investment recovery efficiency is low, which has increased the financial pressure on the enterprise.

4. Key problems affecting the enterprise's operational efficiency

4.1 High Cost and Low Cost Control Efficiency

The case enterprise has problems such as high raw material procurement costs, high production and manufacturing costs, and high sales and management costs. The lack of a scientific cost control system leads to serious waste in the production and operation process, which directly affects the enterprise's profitability and operational efficiency.

4.2 Irrational Asset Structure and Low Asset Utilization Efficiency

The enterprise's asset structure is unreasonable, with a high proportion of current assets occupied by accounts receivable and inventory, resulting in low asset turnover efficiency. The idle rate of fixed assets is high, and the investment efficiency is low, which restricts the improvement of the enterprise's overall operational efficiency.

4.3 Backward Operational Management Model and Low Management Efficiency

The case enterprise still adopts a relatively traditional operational management model, with problems such as unclear management responsibilities, imperfect internal control system, and low management efficiency. The lack of refined management leads to high operational risks and low resource allocation efficiency, which restricts the improvement of the enterprise's operational efficiency.

4.4 Weak Financial Risk Awareness and Inadequate Risk Management

The enterprise has a weak awareness of financial risk, lacks a sound financial risk early warning mechanism, and cannot effectively identify and respond to risks such as liquidity risk, credit risk, and market risk. The inadequate risk management system further increases the uncertainty of the enterprise's operation and affects its operational efficiency.

5. Strategies to improve the enterprise's financial condition and operational efficiency

5.1 Strengthen Cost Control and Reduce Operational Costs

The enterprise should establish a full-process cost control system, strengthen the management of raw material procurement, production, sales, and other links. It can optimize the procurement model by establishing long-term cooperative relationships with suppliers to reduce procurement costs; optimize the production process to reduce

production waste; and strengthen the control of sales and management expenses to improve cost control efficiency.

5.2 Optimize Asset Structure and Improve Asset Utilization Efficiency

The enterprise should optimize its asset structure by strengthening the management of accounts receivable and inventory. It can improve the accounts receivable recovery system, shorten the recovery cycle, and reduce capital occupation; establish a scientific inventory management system to optimize inventory structure and reduce inventory backlog. At the same time, it should accelerate the disposal of idle fixed assets, improve the efficiency of asset use, and optimize the overall asset allocation.

5.3 Upgrade the Operational Management Model and Improve Management Efficiency

The enterprise should upgrade its operational management model, introduce refined management concepts, and clarify the management responsibilities of each department. It should improve the internal control system, strengthen the supervision of key links, and improve operational transparency and management efficiency. It can also introduce information management systems to realize the digitalization of production, sales, and financial management, and improve operational efficiency through technological empowerment.

5.4 Strengthen Financial Risk Management and Ensure Operational Stability

The enterprise should establish a sound financial risk early warning mechanism, conduct regular assessments of financial risks, and formulate corresponding risk response plans. It should strengthen the management of liquidity risk, optimize the capital structure, and maintain a reasonable asset-liability ratio; strengthen credit risk management, strictly control the credit granting of customers, and reduce the risk of bad debts. By improving the risk management system, the enterprise can effectively avoid operational risks and ensure the stability of its operation.

6. Conclusion

Taking a specific manufacturing enterprise as the research object, this paper systematically analyzes its financial condition and finds that the enterprise faces problems such as weak solvency, low operational capacity, declining profitability, and unstable cash flow. The key factors restricting the improvement of operational efficiency include high cost, irrational asset structure, backward management model, and inadequate risk management.

To solve these problems, this paper proposes targeted improvement strategies from aspects of cost control, asset structure optimization, management model upgrading, and risk management strengthening. The implementation of these strategies can effectively improve the enterprise’s financial condition, enhance its operational efficiency, and promote its sustainable development. At the same time, this research also provides a reference for similar enterprises to analyze financial conditions and improve operational efficiency.

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RESEARCH ON THE PATH OF ARTIFICIAL INTELLIGENCE-DRIVEN SUSTAINABLE ECONOMIC DEVELOPMENT: A PERSPECTIVE BASED ON CHINA-KAZAKHSTAN GREEN FINANCE COOPERATION

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Annotation. Against the backdrop of global climate governance and high-quality Belt and Road development, green finance is critical to low-carbon economic transition. As a key general-purpose technology, artificial intelligence (AI) improves green finance efficiency, advances cross-border standard alignment and strengthens risk governance. This paper analyzes China-Kazakhstan green financial cooperation, and clarifies that AI can ease constraints such as inconsistent standards, information asymmetry and insufficient data support, providing policy references for regional sustainable development.

Key words: artificial intelligence; green finance; China-Kazakhstan cooperation; sustainable development; Belt and Road

I. Introduction

Facing growing global climate risks, green and low-carbon transformation has become a global trend, and green finance has become a core national strategy worldwide. China boasts a sound green finance system, while Kazakhstan is

improving its green finance mechanism in the energy transition process. Obvious institutional and market differences between the two countries hinder cross-border cooperation, and AI can effectively break such bottlenecks. This paper explores AI-enabled bilateral green financial cooperation, builds a targeted cooperation framework, and supports the high-quality development of the Green Belt and Road.

II. Theoretical Basis and Literature Review

This research is based on sustainable development, green finance and digital empowerment theories, which define research orientation, integrate environmental factors and offer technical support for green finance innovation. Domestic studies on green finance are sufficient, while foreign literature mainly focuses on Kazakhstan's green finance system and practical difficulties. Existing studies confirm digital technology drives green finance development, but comparative research on China and Kazakhstan is scarce, and studies on AI empowering bilateral green financial cooperation are still insufficient.

III. Current Development of China-Kazakhstan Green Finance

China leads global green finance development with complete policies, unified standards, a large market, diversified financial products and widespread AI application. By contrast, Kazakhstan's green finance is still in the initial stage, featuring an incomplete institutional system, limited market scale, single product supply and backward digital infrastructure. Meanwhile, the two countries have prominent complementary advantages in capital, green fintech and low-carbon projects, laying a solid foundation for long-term cooperative development.

IV. AI's Driving Mechanism for Green Finance and Sustainable Development

Relying on data processing and intelligent analysis capabilities, AI realizes efficient green project screening, dynamic ESG evaluation and full-process risk early warning. In cross-border cooperation, it bridges institutional differences and information asymmetry, promotes standard docking and precise capital matching, and facilitates the integration of cross-border green financial markets. In addition, AI guides capital into green industries, accelerates green technology innovation, optimizes cross-regional green resource allocation, and boosts high-quality regional sustainable economic development.

V. AI-Driven Cross-Border Green Finance Cooperation Framework

Guided by complementary advantages, digital empowerment and institutional synergy, China-Kazakhstan cooperation builds a multi-dimensional framework supported by AI, covering standard alignment, market integration, risk prevention and control, and policy coordination. The framework realizes unified green standard docking, intelligent project-fund matching, dynamic cross-border risk warning and regular policy communication. Specific paths include joint technological R&D, cross-border standard coordination, shared service platform construction and low-carbon project demonstration, to ensure steady and long-term bilateral green financial cooperation.

VI. Conclusion

There are broad prospects for China-Kazakhstan green financial cooperation with remarkable market complementarities, yet it is restricted by standard differences and information asymmetry. AI can effectively improve operational efficiency, optimize risk management and resolve cooperation obstacles. The AI-driven cooperation framework proposed in this paper offers feasible paths and practical references for deepening bilateral green financial coordination and promoting regional sustainable development.

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INNOVATION-DRIVEN DEVELOPMENT AND REGULATORY PATHWAYS IN THE DIGITAL FINANCE INDUSTRY

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Annotation. This paper examines the innovation-driven development of the digital finance industry and discusses the regulatory pathways required to sustain it. The analysis adopts a journal-style argumentative approach supported by illustrative synthetic indicators rather than real market data. The main thesis is that regulatory effectiveness in digital finance should not be evaluated only by the strictness of formal rules, but by the capacity of oversight frameworks to guide experimentation, discipline risk accumulation, and preserve long-run trust in digital financial infrastructures.

Key words: Digital finance, innovation, industry, Regulatory pathways, logistics, risk.

Digital finance has become one of the most dynamic engines of structural change in contemporary service economies. Platform payments, digital lending, robo-advisory services, embedded finance, and data-driven insurance products have accelerated financial inclusion and transaction efficiency, while also reshaping competitive relations between banks, technology firms, and non-bank intermediaries. Yet rapid innovation has exposed a core policy dilemma: the same technologies that widen access and lower intermediation costs can also intensify systemic fragility, consumer harm, cyber risk, and regulatory arbitrage.

The innovation logic of digital finance rests on scale, data, and modularity. Once customer interfaces migrate to mobile and cloud-based ecosystems, service providers can reduce marginal distribution costs, personalize products in real time, and integrate finance into retail, logistics, and social platforms. These efficiencies create strong incentives for entry and product diversification. However, the same model compresses the distance between innovation and systemic exposure. Operational disruptions, biased scoring models, opaque pricing, and weak governance can diffuse rapidly across interconnected user networks.

Table 1. Innovation drivers and regulatory implications in digital finance

Innovation driver	Business effect	Regulatory issue	Primary response
Platform payments	Lower transaction cost	Fraud and data misuse	KYC and transaction monitoring
Algorithmic lending	Faster credit screening	Opacity and bias	Model governance and disclosure
Embedded finance	Expanded market reach	Licensing perimeter	Functional supervision
Cloud scaling	Rapid service rollout	Outsourcing concentration	Operational resilience rules

A journal-oriented reading of the recent literature suggests that regulation now performs three linked functions. First, it defines market boundaries by clarifying licensing, data-use, and prudential obligations. Second, it enables learning through proportional supervisory tools such as pilot regimes, sandboxes, and staged authorization. Third, it protects legitimacy by making firms accountable for conduct, resilience, and transparency. The challenge is therefore not innovation versus regulation, but how to combine adaptive oversight with credible market discipline.

Table 1 organizes the principal innovation drivers of digital finance and their corresponding regulatory implications. The pattern is clear: each gain in efficiency is paired with a governance requirement. Faster onboarding demands stronger identity verification, algorithmic lending requires explainable decision channels, and platform integration increases the need for interoperability and competition safeguards. In this sense, regulation becomes part of the production architecture of digital finance rather than an external constraint imposed after innovation has occurred.

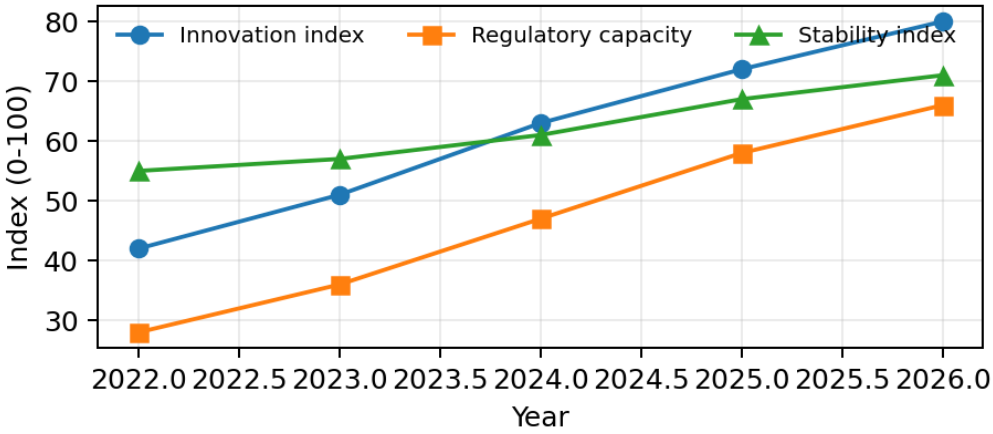

Figure 1. Innovation growth, regulatory capacity and stability

Figure 1 presents synthetic trends in innovation, regulatory capacity, and financial stability. Innovation momentum rises faster than supervisory capability in the early phase of market expansion, creating a governance gap. Over time, however, institutional learning, reporting standards, and digital supervisory technologies can narrow this gap and improve resilience. The policy implication is that delayed regulation is costly: once scale effects lock in risky practices, corrective intervention becomes more disruptive and less predictable.

Table 2. Supervisory instruments across the digital finance growth cycle

Instrument	Firm stage	Core purpose	Expected effect
Proportional licensing	Entry	Screen readiness and governance	Safer market admission
Sandbox supervision	Pilot	Test innovation under oversight	Lower policy uncertainty

Conduct analytics	Scaling	Track fees, complaints, mis-selling	Better consumer discipline
Recovery planning	Maturity	Manage concentration and failure risk	Higher systemic resilience

Table 2 maps supervisory instruments across the growth cycle of digital finance firms. Entry-stage oversight should focus on licensing proportionality, customer due diligence, and operational readiness. During scaling, authorities should prioritize conduct monitoring, model-risk management, and outsourcing controls. At maturity, the emphasis shifts toward interoperability, concentration risk, and recovery planning. The sequencing of tools matters because excessive early rigidity may deter experimentation, while late-stage permissiveness can amplify systemic externalities.

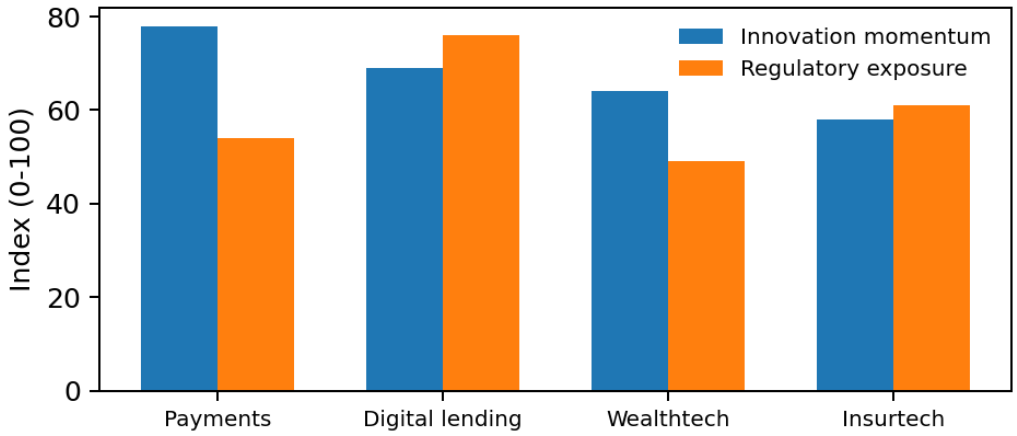

Figure 2. Innovation momentum and regulatory exposure by segment

Figure 2 compares major digital finance segments. Payments platforms show the highest innovation momentum because they benefit from network effects and low user frictions. Digital lending displays the greatest regulatory exposure since underwriting models, liquidity dependence, and consumer-protection issues interact directly. Wealthtech and insurtech develop more gradually, but both remain sensitive to disclosure quality, suitability standards, and data governance. These differences suggest that one-size-fits-all regulation is suboptimal even within the same digital finance ecosystem.

Table 3. Synthetic outcomes under alternative regulatory pathways

Pathway	**Compliance cost**	**Misconduct risk**	**Investor confidence**	**Innovation outcome**
Light-touch	Low	High	Volatile	Fast entry, unstable scaling
Balanced	Moderate	Controlled	High	Best long-run diffusion
Restrictive	High	Low	Medium	Safer but slower

Pathway	Compliance cost	Misconduct risk	Investor confidence	Innovation outcome
				experimentation

Table 3 presents a synthetic scenario analysis of regulatory pathways. A light-touch approach may stimulate quick market entry, yet it also raises misconduct risk and weakens investor confidence when failures emerge. A balanced pathway, combining clear rules, sandbox learning, and proportionate enforcement, produces the strongest long-term innovation outcome because it aligns experimentation with credibility. By contrast, an excessively restrictive pathway improves short-term control but can suppress business-model iteration and reduce competitive diversity.

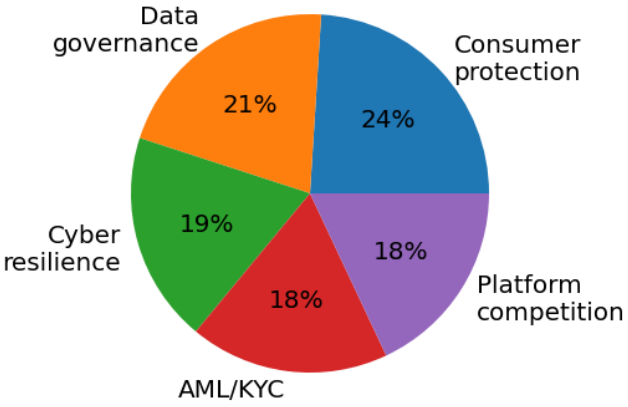

Figure 3. Main compliance priorities in digital finance regulation

Figure 3 further indicates that consumer protection, data governance, cyber resilience, and AML/KYC remain the most resource-intensive compliance priorities. Their prominence reflects the institutional reality of digital finance: trust is created not only through product novelty, but through the demonstrable safety of transactions, records, and algorithms. For this reason, supervisory technology, audit trails, real-time reporting, and cross-agency coordination should be understood as productive infrastructure for market development.

From a policy-design perspective, the most effective regulatory path is a layered one. Basic licensing and prudential thresholds should be combined with conduct rules, technical standards, and dynamic monitoring mechanisms. Regulatory sandboxes are useful when they remain connected to mainstream supervision instead of becoming symbolic innovation showcases. Likewise, comparative regulatory learning across jurisdictions can help identify common templates for open finance, digital identity, cloud outsourcing, and platform accountability without erasing national differences in legal architecture.

In conclusion, the innovative development of the digital finance industry depends on regulatory pathways that are anticipatory, proportionate, and technologically informed. Durable innovation emerges when regulators move beyond ex post correction and instead shape incentives throughout the life cycle of digital financial products. The most competitive digital finance systems will therefore be those that treat regulation as an enabling framework for trust, resilience, and disciplined experimentation rather than as a simple brake on market change.

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SYNERGISTIC EMPOWERMENT OF ARTIFICIAL INTELLIGENCE, INNOVATIVE TECHNOLOGIES, AND GREEN FINANCE: A STUDY ON THE INTERNATIONAL TRADE DEVELOPMENT PATHWAYS OF DOMESTIC ENTERPRISES

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Annotation. Against the backdrop of the global economic green transition and deep integration of the digital economy, artificial intelligence and innovative technologies have emerged as core drivers reshaping the international trade landscape. Green finance provides crucial financial support for domestic enterprises to sustainably compete internationally. Drawing on the international trade practices of domestic enterprises and the cooperation context with Central Asian countries such as Kazakhstan, this paper explores application scenarios for AI and innovative technologies, analyzes the challenges faced by domestic enterprises in green finance development, and proposes a synergistic approach combining "technology empowerment with financial support." The findings offer theoretical and practical guidance for enterprises to overcome bottlenecks, expand their international presence, and enhance cooperation in relevant China-Kazakhstan fields.

Key words: AI ; innovative technologies; green finance; international trade

I. Introduction

The global economy is currently undergoing profound transformations characterized by digitalization and greenization. Innovative technologies such as artificial intelligence and big data are breaking down traditional spatiotemporal barriers in international trade, serving as new engines for high-quality development. Under the "dual carbon" goals, green finance provides critical financial support for enterprises' green production and green trade activities. Domestic enterprises, as key players in international trade, face challenges such as insufficient technological innovation, delayed green transformation, and inadequate support from green finance. This paper explores synergistic empowerment pathways by integrating two core research directions, aiming to enhance corporate competitiveness and invigorate China-Kazakhstan cooperation.

II. Practical Applications of Artificial Intelligence and Innovative Technologies in International Trade

Artificial intelligence and innovative technologies are revolutionizing the entire international trade process, offering domestic enterprises new opportunities to expand their global presence and enhance competitiveness. The core applications primarily focus on four key areas.

Artificial Intelligence Empowers Precise Operations in International Trade. Leveraging its data mining and predictive capabilities, artificial intelligence addresses the challenge of information asymmetry in traditional trade. In market research, companies utilize AI algorithms to analyze vast datasets - including global market demand and policies - to precisely identify target customers and reduce research costs.

Innovative Technologies to Optimize the Efficiency of the Entire International Trade Process. Technologies such as big data, blockchain, and the Internet of Things further enhance trade efficiency and reduce risks. In logistics, the IoT enables full-

process monitoring of goods, while big data optimizes routes and resource allocation; in settlement, blockchain addresses issues like trust deficiencies and lengthy processing times inherent in traditional methods, reducing settlement cycles from 3–7 days to just 1–2 days for some foreign trade enterprises. In product development, the integration of big data and AI identifies market trends, enabling companies to create high-end products compliant with international green standards and thereby strengthening their competitiveness.

Technological Innovation Drives the Transformation and Upgrading of International Trade Models. Technological innovation has given rise to new models such as cross-border e-commerce and digital trade, lowering the barriers for enterprises to engage in international trade. Small, medium, and micro enterprises can now directly connect with global customers through cross-border platforms. Digital trade, centered on data, drives a synergistic transformation of trade toward a model encompassing "goods + services + digital elements," enabling domestic internet companies to participate in the global division of labor by providing services like AI algorithms. Meanwhile, technological innovation facilitates the green transformation of trade, helping enterprises reduce energy consumption and overcome green trade barriers.

Technology Empowerment of China's Trade Cooperation with Central Asian Countries. In 2025, China's exports to the five Central Asian countries reached $71.2 billion, representing an 11% year-on-year increase, with artificial intelligence and the digital economy emerging as new growth drivers for cooperation. Central Asian countries such as Kazakhstan are actively advancing digital infrastructure development, while Uzbekistan's ICT Week 2025 is positioning Central Asia as a Eurasian digital hub. Domestic enterprises are leveraging AI to optimize logistics routes, utilizing big data analytics to understand the Central Asian market, and employing blockchain technology to ensure settlement security, continuously expanding the scope of collaboration.

III. The Practical Challenges Faced by Domestic Enterprises in Green Finance Development

By the end of the fourth quarter of 2025, China's outstanding balance of green loans in domestic and foreign currencies reached 44.77 trillion yuan, representing a year-on-year increase of 20.2%. The scale of green finance ranks among the world's largest, yet domestic enterprises continue to face numerous challenges, with financing difficulties and high costs being particularly acute for small, medium, and micro enterprises.

The green finance support system is inadequate. China's green finance support system faces challenges such as insufficient policy coordination and inadequate product innovation. Poor information sharing between financial and environmental protection authorities results in imprecise allocation of green finance resources. Green finance products predominantly consist of traditional loans and bonds, with limited coverage of specialized products tailored for trade green transformation,

making it difficult to meet enterprises' diverse needs. Furthermore, the green finance product system in Central Asian countries remains underdeveloped, creating barriers to collaboration with domestic enterprises.

Insufficient motivation for corporate green transformation and non-standard information disclosure. Some enterprises, particularly small, medium, and micro enterprises, lack sufficient understanding of green transformation. Green projects involve long investment cycles and slow returns, coupled with a lack of green innovation capabilities, resulting in low motivation for transformation. Meanwhile, China has not established unified green information disclosure standards, leading to incomplete and inaccurate disclosures by enterprises. This not only affects financial institutions' assessments but also reduces international market recognition, with some disclosures lacking substantive validity.

Green financing has high entry barriers and relatively high financing costs. Financial institutions impose stringent qualification requirements for green financing enterprises. Small, medium, and micro enterprises struggle to meet these criteria due to their limited scale and weak creditworthiness, resulting in financing difficulties. Green projects carry high risks and long cycles; financial institutions raise loan interest rates, while costs such as environmental due diligence are passed on to borrowers, further increasing corporate financing costs and hindering their competitiveness in international green trade.

Inadequate alignment with international green standards. Global green standards lack uniformity, and China's standards lag behind international advanced levels. Enterprises must adapt to varying national standards, incurring higher transformation and trade costs; some face import restrictions due to failure to meet the EU CBAM requirements. Furthermore, insufficient alignment between Chinese and Kazakh green standards and project certifications hinders deeper cooperation.

IV. The Synergistic Empowerment of Artificial Intelligence, Innovative Technologies, and Green Finance in Driving the Development Path of Domestic Enterprises' International Trade

In response to the opportunities and challenges of transformation, domestic enterprises must establish a synergistic framework integrating "technological innovation and green finance," leveraging the China-Kazakhstan cooperation context to achieve breakthroughs in five key areas.

Strengthen technology innovation-driven approaches to enhance enterprises' green transformation and international trade competitiveness. Enterprises are increasing R&D investments in AI and green technologies, leveraging AI to optimize production processes and big data analytics to identify global green demands, thereby overcoming trade barriers. They are promoting the integration of technological innovation with green finance to secure green funding for technological upgrades, while financial institutions are offering specialized green loans to reduce innovation costs. Support is provided for joint Chinese-Kazakh research and development of

green and digital technologies, enhancing industry-academia-research collaboration and international technology adoption.

Lower the threshold for green financing and optimize financing services. Financial institutions have streamlined the green financing process for small, medium, and micro enterprises, established a green credit evaluation system, and provided differentiated services. They have expanded green financing channels by promoting the development of green bonds and funds, and leveraging the AIFC to connect with international green capital. A government-led risk compensation fund has been established to advance green insurance and alleviate risk pressures for all stakeholders.

Promote international cooperation and align with global green standards and technical systems. By leveraging the joint construction of the Belt and Road Initiative, we will promote in-depth cooperation in digital trade and green finance between China and Kazakhstan, and facilitate product and project alignment through the AIFC. Enterprises will proactively align with international green standards, participate in standard-setting, and advance the alignment of Chinese and Kazakh green standards. International technical exchanges will be strengthened to introduce advanced technologies, assimilate and innovate upon them, and promote the internationalization of technical standards.

V. Conclusion and Outlook

This paper analyzes the practical application of technology and the challenges faced by green finance, proposing five synergistic approaches. The study demonstrates that only by fostering deep integration between technology and green finance can enterprises enhance their international competitiveness and achieve a win-win outcome for both green development and high-quality trade.

Artificial intelligence and innovative technologies inject new momentum into enterprises' international trade, while green finance provides financial support. Their synergy serves as the key pathway for businesses to overcome bottlenecks, achieve sustainable development, and deepen China-Kazakhstan cooperation.

Looking ahead, the sustained development of the digital and green economies will bring new opportunities for enterprises. Domestic companies should increase innovation investment, advance green transformation, and strengthen digital and green trade cooperation between China and Kazakhstan. Through coordinated efforts by governments, financial institutions, and enterprises—to refine policies, innovate products, and cultivate talent—domestic enterprises can achieve higher-quality development in international trade and contribute China's strength.

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TAX POLICIES PROMOTING DIGITAL ECONOMY AND INDUSTRIAL INTEGRATION: EVIDENCE FROM CHINA AND IMPLICATIONS FOR KAZAKHSTAN UNDER THE BELT AND ROAD INITIATIVE

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Annotation. Tax policy reduces enterprise transformation costs. Using Chinese provincial data (2018–2024), this study finds tax incentives promote digital-industrial integration; R&D super-deductions are most effective. Drawing on China's experience and Kazakhstan's "Digital Kazakhstan" program, this paper proposes policy optimizations and explores Sino-Kazakh tax cooperation under the Belt and Road Initiative.

Key words: Digital economy; Industrial integration; Tax policy; Belt and Road Initiative; China-Kazakhstan cooperation

1. Introduction

The technological revolution is reshaping global value chains, with tax policy playing a key role in stimulating innovation and industrial transformation. As the Belt and Road Initiative (BRI) initiator, China has developed a comprehensive tax system. In 2024, its digital economy reached 59.2 trillion yuan (43.8% of GDP). Kazakhstan, the first BRI signatory, advances the "Digital Kazakhstan" program (2020–2030) but faces challenges such as digital divides and talent shortages. This study analyzes China's tax policies to provide references for Kazakhstan.

2. Literature Review

Chinese scholars find the digital economy requires chain-oriented tax policies Liu et al., 2021), with tax incentives reducing SME transformation costs (Jia & Su, 2022). VAT refunds benefit producer services faster; R&D deductions have longer-term manufacturing impacts (Wang, 2021). International research focuses on digital tax design. Auerbach (2019) proposed destination-based cash-flow tax; the OECD's Two-Pillar Solution (2021) underpins global reform. Klemm (2019) found mixed tax tools outperform single instruments. Research gaps: Few studies compare China and Kazakhstan under BRI; applicability of China's experience to Central Asia is underexplored; Sino-Kazakh tax cooperation paths lack investigation.

3. Research Methodology

This study employs mixed methods. Quantitatively, panel regression uses 30 Chinese provinces (2018–2024), with digital-industrial integration as dependent variable and tax incentive intensity as independent variable. DID treats the 2022 VAT credit refund as a quasi-natural experiment. Heterogeneity analysis covers regions and industries. Qualitatively, comparative analysis of China-Kazakhstan digital economies and tax systems is conducted, along with case studies. Data sources include statistics bureaus, tax authorities, A-share financial data, and policy documents.

4. China’s Tax Policy System and Implementation Effects

System components: R&D incentives (100% super-deduction; 15% CIT), VAT (credit refunds; added deductions), infrastructure (tax exemptions for data centers/5G), and SME support (VAT exemption below ¥100k monthly sales). Empirical findings: Tax policies significantly promote digital-industrial integration. R&D super-deductions show strongest effects, followed by VAT refunds. Eastern region effects exceed western regions due to better infrastructure.

Challenges: Policies lack precise targeting; data taxation is exploratory; cross-border rules need optimization.

5. Implications for Kazakhstan

Current situation: E-government penetration reaches 92%. E-commerce transaction volume reached 3.2 trillion tenge in 2024 (14.1% of retail sales), a five-fold increase in four years. Cross-border parcels from China grew 67% year-on-year (Jan–Oct 2024). Challenges: rural infrastructure, SME digital adoption, underdeveloped digital tax incentives.

Policy recommendations:

- Introduce/expand R&D super-deductions for digital enterprises.
- Targeted incentives for smart manufacturing, e-commerce, data centers.
- Raise VAT thresholds and provide preferential rates for SMEs.
- Modernize tax administration with e-invoicing and online filing.

BRI cooperation paths:

- Establish cross-border e-commerce tax information exchange platforms.
- Create digital economy tax cooperation pilot zones (e.g., Horgos Center).
- Joint digital tax talent training programs.

6. Conclusion

Well-designed tax policies, especially R&D super-deductions, effectively promote digital-industrial integration, with effects varying by policy type, region, and industry. China's system offers valuable lessons for Kazakhstan. Under the BRI, both countries should strengthen policy coordination to support cross-border digital trade. Future research should expand to other Central Asian countries.

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IMPROVING ENTERPRISE ARCHIVES RISK MANAGEMENT METHODS IN THE CONTEXT OF DIGITALIZATION

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Annotation. In the context of digitalization and technological change, risk management is becoming a key element of the sustainable development of organizations. Digital Transformation creates new opportunities for improving business efficiency, but It is also accompanied by an increase in cyber threats, technological instability and market Changes. The article examines the main categories of risks Faced by companies and the advantages of digital management of them. It has been revealed that The integration of digital technologies into risk management processes contributes not only to Minimizing threats, but also improving the operational and strategic effectiveness Of organizations. This highlights the importance of introducing innovative approaches to Risk management in the digital economy era.

Key words: risk, risk management, corporate archive management models, digitalization, technological changes, cyber threats, international standards. digital

transformation, sustainable development.

For enterprises, digital information is not only a key factor of production but also a strategic high ground for building core competitiveness. Search results indicate that research on digital transformation can be traced back to the 1980s. Morton [1] suggested that enterprises should fully utilize information technology to transform their existing organizational structures in the face of future economic changes. This finding is considered the beginning of research on enterprise digital transformation. Coile [2].

(1)Connotation and Pathways of Digital Transformation in Enterprise Archives Management: Scholars have examined the concept and background of digital transformation in enterprise archives management. They have analyzed the specific content of this transformation from perspectives of management, technology, and culture, proposing principles and pathways. For instance, Yue Zhenting [3] pointed out that digitizing paper-based archives is one way to promote corporate culture development. Lammont Judith [4] argued that enterprise digital transformation requires completing the digital transformation of enterprise information management to enable information access anytime, anywhere. Cai Yingfang [5] analyzed the concept, background, and issues of digital transformation in enterprise archives work, outlining transformation content and proposing principles and pathways. Cai Yingfang [6] further proposed that during the «14th Five-Year Plan» period, continuous advancement of digital transformation in enterprise archives work requires achieving full-process, full-scope, and all-encompassing digital management of enterprise archives. Wang Qiang [7] believed enhancing core competitiveness involves upgrading archival operations and creating value. Relying on «digital technology + archives management», enterprises can establish an overall digital transformation framework by building a vision, planning a blueprint, implementing agilely, and continuously optimizing to define the transformation direction. Ma Shuangshuang and Xie Tongzhu [8] noted current difficulties in digital transformation of archives work, including strategic planning, transformation capabilities, and resource supply.

Problems and Strategies in the Digital Transformation of Enterprise Archives Management:They have proposed improvement measures for enterprise archives management in the digital environment. For example, Li Hongmei [9], following the principle of managing archives according to law, aimed to improve standardization and scientific rigor. Gong Xiaodong [10] highlighted problems like vague goals, data fragmentation, lagging standards, and difficulties in technology updates within management concepts. He suggested improvements in areas like goals, resource development, business standards, and technology conversion. Goryacheva [11] described the evolution stages of enterprises from mechanization to digitization, characteristics of digital transformation in business processes, and application directions for information technology. She proposed implementing digitization in capital construction systems based on electronic archives creation and partial realization within project and estimation document management systems. Zha Fenghua [12] identified difficulties in standardizing

archive formation and delayed transfer within the digital management of existing enterprise archives, proposing countermeasures starting from front-end control management. Xing Limin [13] suggested strategies including updating management concepts, optimizing business infrastructure, and enhancing management functions. Mao Panpan and Wang Jin [14] introduced the 7S management method to improve enterprise archives management.

Management Models for Digital Transformation of Enterprise Archives Management: Enterprise archives management models can be classified differently based on various criteria. Shen Xiaoxue and An Ning [15] outlined three main models adopted by enterprises: self-management, socialization, and semi-socialization.

Research Object - this study aims to identify security risks associated with enterprise archives ontology and archives management activities under a full lifecycle perspective within the broader context of digital transformation.

Research Significance. The significance of this research can be summarized in two points: -Theoretical Significance; -Practical Significance.

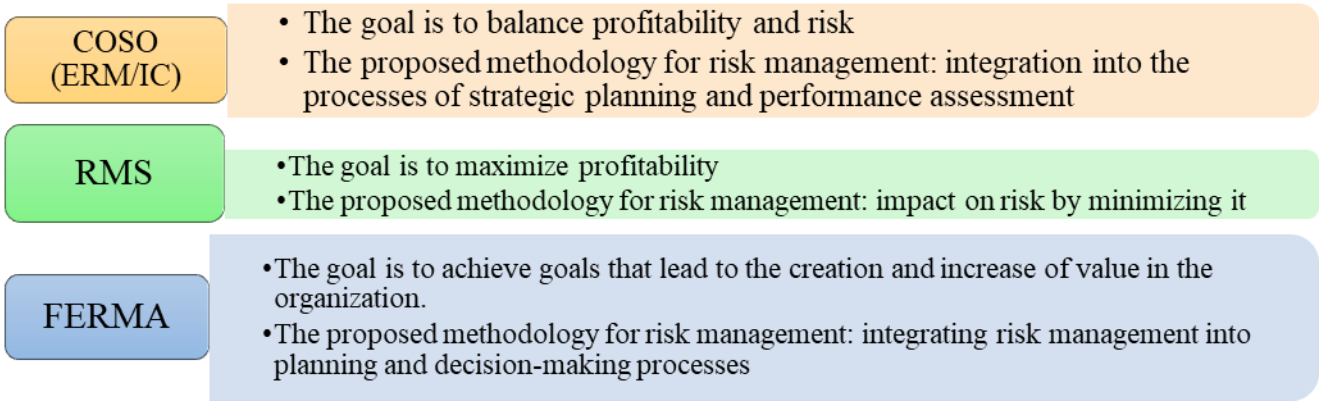
Research Methods. The main research methods employed in this paper are: -Interview Method，-Questionnaire Survey Method.

Relevance and Innovations of the Research Topic. The research on enterprise archives management security risks in this paper mainly has two innovations.

Paper Structure. This paper explores security risk issues in enterprise archives management under digital transformation. The research follows a «problem identification – analysis – solution» logical framework.

Each company strives to avoid threats, damage (risks), i.e. it tries to achieve a certain sustainability of development. Sustainable development (in relation to an organization) is development that meets the needs of an organization without prejudice to future opportunities to achieve its business goals. Sustainable development will allow business structures to maintain a balance between remaining competitive, stimulating innovation and preserving the environment under the influence of various risks in the external and internal business environment. Organizations can use their risk profile in different ways: -to understand the level of performance in the context of the organization's risk appetite; – when finding the level of effectiveness, taking into account the organization's ability to manage risks; – when determining the limits of the permissible deviation of effectiveness from the target indicator; – to assess the potential impact of risk on the set targets.

The main international documents on which the work of industrial business structures on risk management can be based are: ISO31000:2018; COSO:ERM 2017; FERMA.



Drawing 1 – Comparative characteristics of international standards

The following risk management standards are used in foreign practice: British Standard BS 31100:201; Australian Standard AS/ NZS ISO 31000-2009; CSA Q 850:1997 Canadian Standard; JIS Q 2001:2001 Japanese Standard. Figure 1 shows the characteristics of international risk management standards. International standards on risk management should become methodological tools for risk management. The development of international standards on risk management highlights a noticeable improvement in the internal control system, increases the role of human capital in decision-making, and the importance of the competencies of a specialist risk manager.

The size and type of organization also play an important role in the integration process. For example, a large company may be aware of the risks, but must maintain an autonomous monitoring and reporting practice in accordance with regulatory requirements. In comparison, smaller organizations can often focus more on developing risk awareness and integrating risk into the entire performance reporting process than larger ones [16].

Thus, in the era of digitalization and technological progress, risk management is essential for the long-term success of an organization. Thanks to digital transformation, there are many opportunities to increase business productivity, improve product quality, and speed up procedures. However, new challenges are associated with these changes, including cyber threats, technology instability, and changing market conditions. Effective risk management in modern conditions requires updating traditional methods, classification of hazards and the use of flexible technologies to reduce them.

The use of digital technologies facilitates adaptation to changes, flexibility and optimization of processes. In the digital economy, it is increasingly necessary to integrate risk management into strategic planning in order to maintain business sustainability and achieve long-term success.

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FINANCIAL INTERMEDIARIES AND THEIR IMPORTANCE FOR THE DEVELOPMENT OF FINANCIAL MARKETS

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Annotation. Financial intermediaries form the core institutional foundation of modern financial systems. They connect capital surplus units and capital deficit units, realize efficient allocation of financial resources at both national and cross-border levels, reduce transaction costs, alleviate information asymmetry, and maintain stable operation of financial markets. Against the background of digital transformation and enhanced Kazakhstan-China economic cooperation under the "One Belt, One Road" initiative, financial intermediaries play an irreplaceable role in ensuring investment flows, supporting cross-border trade and maintaining macroeconomic stability. This paper focuses on the basic functions of financial intermediaries and demonstrates their importance for the sustainable development of financial markets in the era of digital economy and regional integration.

Key words: Financial Intermediaries; Financial Market; Financial Stability; Belt and Road Initiative; Digital Finance; Asset Transformation; Risk Management

1. Core Functions of Financial Intermediaries

Financial intermediaries mainly include commercial banks, investment funds, insurance companies, pension funds, microfinance institutions and other professional institutions. Their key functions determine the efficiency and stability of the entire financial system.

Firstly, financial intermediaries realize **asset transformation**. They gather scattered small savings from households and enterprises and convert them into large-scale long-term investment funds, which provides stable capital support for industrial development and infrastructure construction.

Secondly, intermediaries effectively **reduce transaction costs and information costs**. Relying on professional operation and scale advantages, they lower the cost of information collection, risk assessment and business processing, making financial services more accessible and inclusive.

Thirdly, financial intermediaries provide **risk diversification and management**. By allocating funds among different assets, regions and industries, they disperse risks and enhance the resilience of the financial system. Long-term funds formed by insurance and pension institutions help stabilize market volatility.

Fourthly, intermediaries maintain **liquidity** of financial assets. They allow investors to convert assets into cash quickly with low loss, which stimulates savings and improves the investment environment of financial markets.

2. Importance of Financial Intermediaries for Financial Market Development

The development level of financial intermediaries directly affects the depth, efficiency and competitiveness of financial markets.

Financial intermediaries promote **deepening and expansion of financial markets**. They create diversified financial instruments, expand financing channels for small and medium-sized enterprises, and promote the application of digital financial technology. In Kazakhstan and China, these functions strongly support e-commerce, cross-border payment and investment cooperation under the "One Belt, One Road" framework.

Intermediaries ensure the **effective transmission of monetary policy**. Central banks regulate macroeconomy through financial intermediaries. A sound intermediary system improves the effect of inflation control, credit adjustment and macroeconomic stabilization.

In addition, financial intermediaries accelerate **digital transformation**. They apply artificial intelligence, big data and blockchain in risk control, customer service and transaction processing, which promotes the development of digital financial markets and cross-border financial cooperation.

3. Role of Financial Intermediaries in Kazakhstan-China Financial Cooperation

In bilateral economic and trade cooperation, financial intermediaries undertake important tasks such as capital circulation, settlement services and project financing.

They provide safe and efficient cross-border payment and settlement, reduce transaction costs, and support the development of trade and investment. Kazakh and Chinese financial intermediaries jointly participate in financing infrastructure, logistics, digital economy and green energy projects, which promotes the integration and opening of the two financial markets.

Cooperation between financial intermediaries also helps coordinate regulatory standards, improve risk prevention mechanisms and maintain regional financial stability, laying a solid foundation for long-term stable development of bilateral relations.

Conclusion.

Financial intermediaries are the core pillar supporting the development of financial markets. They perform asset transformation, cost reduction, risk management, liquidity provision and digital innovation. Under the background of deepening Kazakhstan-China cooperation and global digitalization, their importance is further highlighted. Efficient operation of financial intermediaries helps boost investment, expand trade, stabilize macroeconomy and promote sustainable growth. Strengthening the regulation, digital transformation and international cooperation of

financial intermediaries will further promote the high-quality development of financial markets in both countries.

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CURRENT TRENDS IN THE DIGITALIZATION OF THE FINANCIAL SECTOR

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Annotation. This paper examines the current trends in the digitalization of the financial sector in the context of the rapidly evolving global digital economy. It analyzes the key drivers of digital transformation, including the integration of advanced technologies such as artificial intelligence, blockchain, cloud computing, and big data into core financial operations. The study identifies major development trends, including the technological reconstruction of financial services, the expansion of service accessibility toward inclusive and global finance, the transformation of the financial ecosystem into an open and collaborative model, and the enhancement of digital regulatory frameworks. Particular attention is given to the role of digital technologies in improving service efficiency, enabling personalized financial solutions, facilitating cross-border transactions, and promoting financial inclusion. The paper also highlights the emergence of embedded finance and digital platforms as essential components of modern financial systems. At the same time, it discusses the challenges associated with digital transformation, including data security risks, regulatory adaptation, and technological uncertainties. The study concludes that the digitalization of the financial sector is an irreversible and dynamic process that will continue to evolve toward greater intelligence, inclusiveness, security, and sustainability, contributing to the long-term development of the global economy.

Key words: financial digitalization; fintech; artificial intelligence; blockchain; big data; cloud computing; digital finance; financial innovation; inclusive finance; digital regulation.

1. **Introduction**

In the context of the global digital economy boom, the financial sector, as the core of the modern economic system, is undergoing a profound digital transformation. Driven by cutting-edge technologies such as artificial intelligence, blockchain, cloud computing and big data, the digitalization of the financial sector has moved beyond the initial stage of channel digitization, and has deeply penetrated into the core links of business operations, risk control, product innovation and service optimization. This report focuses on the current main trends of financial sector digitalization, analyzes its core driving forces and practical performance, and provides a concise overview of the industry's development status, aiming to present the latest changes and development directions of financial digitalization in a clear and accurate manner.

2. **Current main trends in the digitalization of the financial sector**

2.1 In-depth Integration of Frontier Technologies, Driving Technological Reconstruction

The current digitalization of the financial sector is characterized by the in-depth integration of multiple frontier technologies, realizing a leap from "tool empowerment" to "system revolution". Generative AI and agentic AI have been widely applied in financial services, such as intelligent customer service that provides 24-hour uninterrupted consultation, personalized financial product recommendations, and automated risk assessment reports, greatly improving service efficiency and user experience. Multi-modal fusion technology, which combines voice, image and text data, has optimized identity verification, document scanning and other links, making financial operations more intelligent and convenient. Blockchain technology has expanded its application scenarios from digital currency to cross-border payment, supply chain finance and digital asset transactions, relying on its decentralized and tamper-proof characteristics to reduce trust costs and improve transaction transparency. In addition, quantum computing is gradually moving from the laboratory to practical applications, providing more efficient solutions for complex tasks such as financial risk modeling and investment portfolio optimization, laying a solid technical foundation for the high-quality development of financial digitalization.

2.2 Expansion and Deepening of Service Scope, Moving Towards Inclusiveness and Globalization

Digitalization has broken the geographical and institutional constraints of traditional financial services, promoting the continuous expansion of financial service coverage and the deepening of service connotation. On the one hand, inclusive

finance has been further promoted. With the help of mobile payment, digital credit and other technologies, financial institutions have continuously covered rural areas, small and micro enterprises and other long-tail markets, reducing the threshold of financial services. For example, rural credit cooperatives use big data and artificial intelligence technology to provide small-sum credit services for farmers, effectively supporting rural economic development. On the other hand, cross-border financial services have achieved innovative development. With the acceleration of globalization, digital technologies have optimized cross-border payment efficiency, reduced transaction costs, and promoted the interconnection of global payment infrastructures. For instance, the cross-border two-dimensional code interconnection between China UnionPay and payment networks in 19 countries has covered more than 200 million users, facilitating cross-border consumption and capital flow. At the same time, the integration of digital finance and green finance has become a new trend, providing precise financial support for environmental protection projects and promoting the green transformation of the economy.

2.3 Reconstruction of Financial Ecology, Advancing Towards Open Symbiosis

The digital transformation of the financial sector is no longer a single institution’s independent innovation, but has gradually formed an open and symbiotic financial ecological pattern. Traditional financial institutions have shifted from a "product-oriented" model to a "user-oriented" model, opening API interfaces and cooperating with fintech companies, internet platforms and other entities to build scenario-based service ecosystems. Digital wallets have evolved from simple payment tools to comprehensive financial service centers, integrating functions such as payment, transfer, savings, credit and wealth management, providing users with one-stop financial services. Embedded finance has become a key development direction, integrating financial services into non-financial scenarios such as e-commerce, travel and catering. For example, shoppers can split payments at checkout, and small businesses can obtain financing directly through e-commerce platforms, realizing the seamless integration of financial services and daily life. This open ecological model has broken the vertical competition pattern of the traditional financial industry and promoted the efficient allocation of financial resources.

2.4 Improvement of Regulatory Digitalization, Balancing Innovation and Risk

With the rapid development of financial digitalization, regulatory authorities have continuously strengthened digital supervision to ensure the stable operation of the financial system. Digital supervision relies on big data, artificial intelligence and other technologies to realize real-time monitoring, early warning and disposal of financial risks, effectively alleviating the information asymmetry problem in traditional supervision. The interconnection mechanism of "regulatory sandboxes" has been continuously improved, allowing compliant fintech products to be piloted simultaneously in multiple regions, shortening the landing cycle of innovative products while controlling risks. In addition, data security and privacy protection have become important contents of digital supervision. Regulatory authorities have

issued relevant policies to standardize the collection, use and sharing of financial data, ensuring the legitimate rights and interests of users and maintaining the order of the financial market. The improvement of digital supervision has provided a safe and stable environment for the healthy development of financial digitalization.

3. **Conclusion**

The digitalization of the financial sector is an irreversible trend of the times, driven by technological innovation, market demand and regulatory guidance. The current trends of in-depth integration of frontier technologies, expansion of service scope, reconstruction of financial ecology and improvement of regulatory digitalization are jointly reshaping the financial industry pattern. While bringing efficiency improvement and service upgrading, financial digitalization also faces challenges such as technological risks, data security and regulatory adaptation. In the future, with the continuous iteration of technologies and the gradual improvement of the regulatory system, the digitalization of the financial sector will move towards a more intelligent, inclusive, safe and sustainable direction, making greater contributions to the high-quality development of the global economy.

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INTEGRATING BANK OPERATING ACTIVITIES MANAGEMENT WITH FINANCIAL SYSTEMS, FISCAL REGULATION AND MACROECONOMIC STABILITY

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Annotation. Integrating bank operating activities with financial systems, fiscal regulation, and macroeconomic stability requires a holistic approach where daily operational processes (credit, liquidity, IT) are tightly linked to regulatory requirements (capital adequacy, risk, compliance) and broader economic policy goals.

Sound banking systems serve as a critical, stable channel for credit and payments, reducing macroeconomic shocks, while efficient integration of digital tools enhances both performance and safety. Integrating risk management into all bank layers—from daily transactions to strategic planning—is essential. This involves using automated tools (like RPA) to manage cyber risks, compliance (KYC, AML), and operational disruptions, ensuring these processes are part of the core banking system. Prudent banking regulation cannot fully substitute for fiscal prudence, but regulations should be designed to reduce financial crises by taking into account bank exposures to sovereign debt.

Key words: Bank, bank operations, financial systems, fiscal regulation, macroeconomic stability.

1. Introduction. The management of bank operating activities has traditionally been framed as a micro-level concern—focused on cost control, efficiency ratios, risk management frameworks and internal process optimisation. However, a growing body of evidence suggests that how banks manage day-to-day operations, deploy technology, price risk and allocate capital has material implications for financial system stability, the effectiveness of fiscal regulation and broader macroeconomic equilibrium. As the financial services landscape undergoes rapid transformation driven by artificial intelligence, shifting interest rate environments and evolving regulatory priorities, the interplay between granular bank operating decisions and systemic outcomes warrants closer examination. This paper synthesises recent domestic and international evidence across these interrelated domains, with particular attention to digital transformation, operational risk management, asset quality trends and the structural constraints shaping banking activity in 2025–2026.

2. Core Dimensions of Bank Operating Activities Management

2.1 Digital Transformation and Operational Efficiency

Banks are in a decisive phase of operational transformation. In 2024, global bank revenues after risk cost reached $5.5 trillion, and net income hit $1.2 trillion – the highest ever for any industry. Yet bank valuations lag 70% behind the average of all other industries, reflecting scepticism about growth models. Banks spend $600 billion annually on technology with limited productivity gains.Artificial intelligence is becoming a key lever. First Abu Dhabi Bank's 2025 net profit grew 24%, with its cost-to-income ratio falling to 22.4% due to AI deployment. Non-interest income rose to 45% of total revenue (from ~25% in 2020–2021), signalling a structural shift toward fee-based models.AI could cut certain costs by up to 70%; overall cost bases may decline 15–20% after near-term investments. Multi-agent systems (digital colleagues) and agentic AI are emerging, potentially lowering operating costs by 20% or more – equivalent to 9–15% of operating profits.

2.2 Efficiency Metrics and Performance Variation

Performance varies widely. Commercial International Bank achieved a 15.0% efficiency ratio in 2025, with ROE of 48.3% and ROA of 6.29%. In contrast, Wells Fargo reported a 64% efficiency ratio and 12.8% ROE. Bank of Maharashtra

improved its cost-to-income ratio to 37.10% and ROE to 22.58% in Q2 FY2025.EU banks maintained ROE above 10% as of mid-2025; net fee income rose 37% over five years to nearly 30% of total revenues. However, eastern European banks often exceeded 15% ROE, while several western European countries remained below 10%. 67% of surveyed EU banks do not expect ROE to increase further, indicating a performance plateau.

2.3 Operational Risk Management and Resilience

Operational risk management is now critical. The Reserve Bank of India notes that operational risk is inherent in all banking activities and must be integrated into the risk management framework. The Hong Kong Monetary Authority mandated industry-wide implementation of an "operational resilience framework" by June 2025. Fintech adoption across Hong Kong banks reached 95%, and regtech adoption 97%.Regulatory expectations are intensifying. The UK Prudential Regulation Authority's Supervisory Statement 5/25 requires climate-related risks to be embedded in materiality assessments, portfolio monitoring, and capital adequacy processes. The European Central Bank's 2026–2028 priorities include a thematic stress test on institution-specific geopolitical risk scenarios and their impact on bank solvency.

3. Financial System Stability and Fiscal Regulation

3.1 Asset Quality and Systemic Vulnerabilities

Asset quality remains a central barometer of banking system health. Indian scheduled commercial banks' gross non-performing assets ratio declined to 2 per cent in December 2025, down from 2.5 per cent a year earlier, with improvements across retail loans, services, industry and agriculture sectors-39. The Reserve Bank of India assessed that no systemic concerns arose despite global supply chain disruptions-39. Credit growth accelerated to 13.8 per cent year-on-year by March 2026-39. In China, major lenders kept NPL ratios low, with the Industrial and Commercial Bank of China's NPL ratio at 1.23 per cent, down 2 basis points from the previous year-end-.

Nevertheless, forward-looking vulnerabilities persist. The IMF's October 2025 Global Financial Stability Report identifies stretched asset valuations, growing pressure in sovereign bond markets and the increasing role of nonbank financial institutions as key concerns-77. The IMF found that banks holding 18 per cent of global assets would see their Common Equity Tier 1 ratios fall below the 7 per cent threshold under stress scenarios-. Nonbank exposures exceed Tier 1 capital in banks holding almost 50 per cent of assets in the IMF's sample-.

3.2 Fiscal Constraints and Regulatory Modernisation

The interaction between fiscal policy and banking stability has become more pronounced. The IMF projects euro area growth of 1.3 per cent in 2026, materially below historical averages, with persistent productivity weakness, demographic ageing and lagged effects of earlier monetary tightening continuing to weigh on Europe's potential output-63. Elevated public debt levels across several European economies and rising interest servicing costs narrow fiscal space and increase market sensitivity to sovereign credibility-63.

Regulatory modernisation efforts are proceeding at multiple levels. The Financial Stability Board's 2026 work programme includes examining jurisdictional initiatives to modernise financial regulation and supervision, with a view to supporting alignment of approaches globally-59. US prudential regulators are implementing supervisory revisions including elimination of reputational risk as a primary focus and greater emphasis on material financial risks-.

4. Macroeconomic Stability and Banking Activity

Macroeconomic conditions shape bank operating decisions while being shaped by them in turn. The National Bank of Slovakia's Macroprudential Commentary notes that lending to firms increased year-on-year after a period of contraction, but the cycle's upturn is not outpacing economic fundamentals or creating excessive risks to financial stability-. Banks continue to maintain profitability and solid capital positions, with their resilience confirmed by recent stress test results.

However, the relationship between macroeconomic cycles and non-performing loans is complex. Non-performing loan stocks are a symptom of balance sheet difficulties faced by a large proportion of firms, which in turn may depress investment and employment, deprive banks of profitable lending opportunities and weigh on economic growth-. When downturns synchronise, sectoral growth correlations spike and NPL dynamics become more clustered, especially in cases where banks have concentrated exposures to specific sectors-.

From a macroprudential perspective, the IMF urges policymakers to stay vigilant and take timely steps to reduce risk, including keeping inflation under control, maintaining central bank independence, and ensuring debt sustainability to create buffers-77. In regions where fiscal space is limited, the importance of disciplined bank balance sheet management is especially acute.

5. Synthesis: An Integrated Framework

The evidence reviewed suggests three primary channels linking bank operating activities management to broader financial and macroeconomic systems. First, at the micro level, advances in digitalisation, AI deployment and operational efficiency directly influence bank profitability, capital generation capacity and risk-taking incentives. The shift toward fee-based revenue models reduces sensitivity to interest rate fluctuations while potentially altering risk profiles.

Table 1: Selected Bank Operating Performance Indicators, 2025

Bank / Region	Efficiency Ratio	ROE	ROA	NIM	NPA/GNP Ratio
Commercial Int Bank (FY25)	15.0%	48.3%	6.29%	8.95%	358% coverage
First Abu Dhabi Bank (2025)	22.4%	—	—	1.84%	—
Bank of Maharashtra	37.1%	22.6%	1.82%	3.85%	1.72% (GNP)

Bank / Region	Efficiency Ratio	ROE	ROA	NIM	NPA/GNP Ratio
(Q2FY25)					
Wells Fargo (Q2 2025)	64%	12.8%	1.09%	—	—
EU Banks (mid-2025)	—	10.7%	—	1.58%	—
Indian SCBs (Dec 2025)	—	—	—	—	2.0% (GNP)

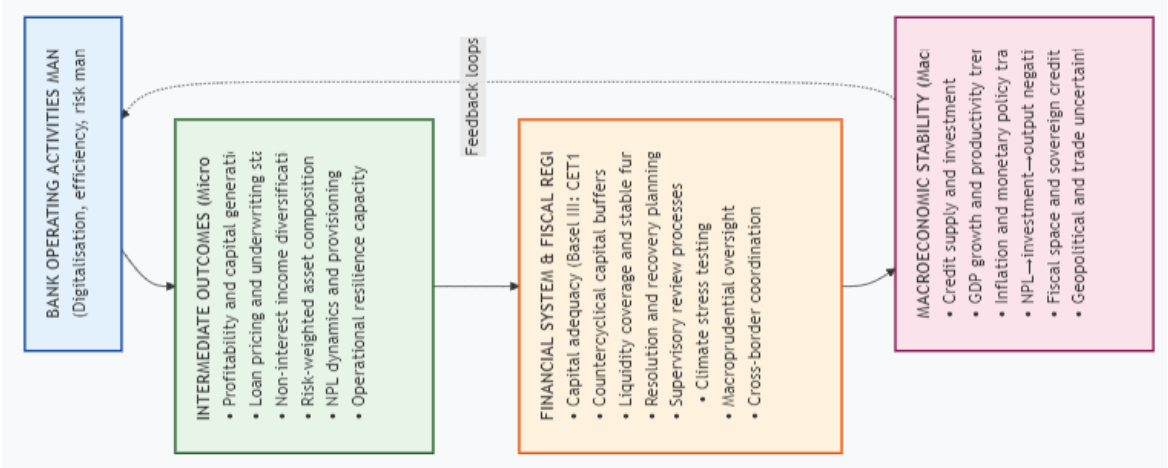

Figure 1: Stylised Framework – Operational Activities Management, Financial Stability and Macroeconomic Equilibrium

6. Conclusion

The integration of bank operating activities management with financial system stability and macroeconomic considerations represents both a practical necessity and a theoretical frontier. Domestic and international experience from 2025–2026 demonstrates that banks achieving superior operational efficiency—through AI deployment, digital transformation and rigorous cost management—are better positioned to generate sustainable returns and build capital buffers. However, these micro-level gains do not automatically aggregate into systemic resilience. The persistence of cross-jurisdictional variation in performance metrics, coupled with elevated asset valuations and growing nonbank intermediation, suggests that continued regulatory attention to operational risk management, asset quality monitoring and macroprudential policy calibration remains essential. Future research should focus on quantifying the transmission channels between bank operating decisions and systemic outcomes, and developing frameworks that capture feedback loops without imposing excessive compliance burdens.

Table 2: Key Regulatory and Policy Developments Affecting Bank Operations, 2025–2026

Jurisdiction / Body	Measure	Effective Timeframe	Primary Operating Impact
FSB	2026 work programme: modernising regulation and supervision, stablecoins, NBFI	2026	Cross-border compliance, nonbank risk monitoring
US prudential agencies	Eliminate reputational risk as primary focus; emphasis on material financial risks	2026	Reduced compliance burden; more targeted supervision
European Central Bank	Geopolitical risk stress test (2026 thematic exercise)	2026	Enhanced scenario analysis for solvency assessment
PRA (UK)	SS5/25 climate risk expectations	2025–2026	Climate risk embedded in ICAAP and portfolio monitoring
HKMA	Operational resilience framework (mandatory June 2025)	2025–2026	Institution-wide operational risk governance
Basel Committee	BCBS monitoring report (176 banks, 31 Dec 2024 data)	2025	Capital adequacy, leverage and liquidity benchmarking

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THE SOCIAL MECHANISM OF CONSUMER BEHAVIOR UNDER THE BACKGROUND OF INFLATION

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Annotation. Inflation profoundly affects consumer behavior through multiple paths such as social stratification, psychological expectations, social identity and cultural norms. In the form of a literature review, this article systematically sorts out the relevant research progress, distills out the four core social mechanisms, and builds an integrated theoretical framework of "macrostructural constraints - micro psychological drive - medium-view group interaction - long-term cultural locking", and explains the interaction logic between mechanisms. Finally, it points out the shortcomings of existing research and the future direction and provides a systematic analysis framework for understanding the social dynamics of consumer behavior under the impact of inflation.

Key words: Inflation; consumer behavior; social stratification; social psychology; social identity; consumer culture

I. Research background and significance

Inflation is manifested in the continuous and widespread rise in prices and the continuous decline in the purchasing power of money, which is a common phenomenon in the course of macroeconomic operation. In recent years, the global supply chain has been in a state of adjustment. Many factors such as fluctuations and geopolitical conflicts in energy prices have been superimposed, resulting in the continuous exposure of inflationary pressure in many countries. Domestic prices have

also shown the characteristics of structural fluctuations. For example, the increase in hard-demand categories such as food and energy is relatively obvious, which directly impacts people's daily consumption [1].

Consumer behavior is not just an individual's economic decision, but a comprehensive social behavior integrated into social structure, group interaction, cultural norms and psychological expectations. The impact of inflation on consumption is far more than the income effect. The pure economic level such as the substitution effect has expanded to social stratification, group psychology, identity and consumption culture and many other dimensions. Most of the current research focuses on the economic impact of inflation on consumption, but the transmission mechanism of inflation at the social level is not sufficient, and the relevant results are relatively scattered [2]. Some literature shows that inflation has an obvious income redistribution effect, and the welfare impact on low-income groups and rural residents is more prominent.

II. Current situation of research at home and abroad

2.1 Basic research on the structural characteristics of inflation and consumption differentiation

Domestic inflation has obvious structural characteristics. There are obvious differences in the price increase of various consumer goods. The price fluctuations of daily necessities such as food and housing are more prominent, while the prices of high-end consumer goods and services are relatively stable. This difference makes the inflation pressure borne by different groups different, which constitutes the key foundation of consumption differentiation. The study of Luo Zhangquan et al. (2026) shows that domestic inflation is characterized by structural changes, which has a differentiated impact on the consumption transformation of different income groups, and there is an obvious income redistribution effect [1].

Within the scope of urban-rural differences, the proportion of rural residents in food consumption is relatively high. When food prices fluctuate, they will be more vulnerable, and the adjustment space for consumption is narrower. The inhibitory effect of inflation on the consumption demand of rural residents is more obvious than that of urban residents. He Lili and Wang Fei (2018) used the threshold model to confirm that inflation has an obvious nonlinear threshold effect on the consumption expenditure of urban residents [2]. Specifically, the higher the income level, the more obvious the effect of inflation on consumption expenditure, while low-income groups mainly present a passive contraction. Lu Yan (2013) pointed out that inflation has a double-threshold effect on the consumption of residents of different income levels [3].

2.2 The impact of social psychology and inflation expectations on consumption behavior

Social psychology is the key intermediary between macro-inflation and micro-consumption behavior, and psychological elements such as inflation perception,

expectation and anxiety will directly control the adjustment of consumption decision-making. The study of He Yunxin et al. (2016) shows that there are obvious gender differences in consumers' perception of inflation [6]. Women's perception is relatively higher, and this difference is closely related to factors such as shopping frequency, economic situation and inflation knowledge level.

Shan Minghui and Qiao Yuqi (2025) pointed out that social and psychological expectations in economic fluctuations have dynamic characteristics, which directly lead to the expansion of consumption or behavioral adjustments such as suppression [7]. Pan Mingqing et al. (2015) used micro-survey data to confirm that the rise in inflation expectations will stimulate the consumption of durable goods in urban families in the current period, while suppressing the consumption of non-durable goods [8]. After sorting out relevant research, Li Junwei (2011) proposed that inflation will have an impact on purchasing behavior through three ways: perception, attitude and expectation [11]. Consumers will take measures such as reducing spending, changing purchase frequency, and adjusting brand selection to cope with price rise.

III. Social stratification, identity, and cultural mechanisms

Table 1: Summary of Social Mechanisms and Their Impacts

Mechanism	Core Description	Impact on Behavior
Social Stratification	Income and resource differences	Consumption differentiation and welfare gap
Social Psychology	Perception, expectations and anxiety	Changes in consumption rhythm and structure
Social Identity	Group norms and conformity	Crowd consumption and brand replacement
Social Culture	Pragmatism and traditional ethics	Long-term shift to thrifty habits

Social stratification is a key social mechanism for inflation affecting consumer behavior. Stratified indicators such as income, assets, education and occupations play a decisive role in risk tolerance and the space for behavior adjustment. Yan Chengqi (2020) proposed that inflation will inhibit the upgrading of industrial structure and cause obvious social welfare losses [13]. Peng Hong (2016) showed that there was a negative correlation between the fluctuation of food prices and the consumption demand of urban and rural residents, and the income gap would further enhance this inhibitory effect [14].

In the dimension of social identity, inflation will change the value orientation of consumption from symbolic recognition to recognition at the practical level. Individuals often tend to imitate group consumption behavior to obtain a sense of

belonging, thus forming the phenomenon of crowd consumption. Zhu Ziyi and Li Moying (2026) found that group norms and identity will obviously affect consumption choices [15]. Within the scope of cultural mechanisms, inflation will promote the transformation of consumer ethics toward a thrifty and pragmatic style. Akasreku et al. (2025) clarified that economic interests, habits and social factors have an impact on sustainable consumption behavior, and in an inflationary environment, pragmatic consumption has become the mainstream trend at the cultural level [17].

IV. Integration framework and originality contribution

The existing research methods can be divided into theoretical mechanism analysis, measurement empirical testing, and cross-integration research. Domestic research focuses on local scenarios and macro levels, focusing on the impact of inflation on consumption and welfare gaps of different groups, while foreign research focuses on micro-psychology and model construction. Both types of studies show that the impact of inflation on consumer behavior has obvious social attributes.

This study puts forward an integrated theoretical framework of "macrostructural constraints – micro psychological drive – medium-view group interaction – long-term cultural locking". Macro-inflation first acts on the social stratification structure, then transforms into decision-making basis through psychological perception, and is finally reinforced by social identity and anchored by social culture [19]. This dynamic interaction ensures that consumer behavior adjustments are not linear but systematic.

V. Conclusion and Future Directions

Existing research shows a fragmentation trend where the mechanisms lack systemic integration. For the future research direction, it is necessary to build an integrated research framework that combines macro structure, middle group, and micro cognition into a unified system. It is also important to carry out research on local adaptation, highlighting the characteristics of the Chinese scene, including urban-rural differences and intergenerational gaps [20]. Strengthening policy-oriented research to stabilize the consumer market and ensure people's livelihood and welfare remains the primary goal.

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RESEARCH ON COST STRUCTURE RECONSTRUCTION AND FINANCIAL PERFORMANCE OF MANUFACTURING ENTERPRISES UNDER DIGITAL TRANSFORMATION – A CASE STUDY OF SANY HEAVY INDUSTRY

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Annotation. This study explores the impact of digital transformation on the reconstruction of cost structures and the improvement of financial performance in manufacturing enterprises, using Sany Heavy Industry as a case study. The research analyzes how the implementation of advanced digital technologies, including industrial robots, artificial intelligence, 5G, and big data systems, reshapes traditional production models and enhances enterprise competitiveness. The paper demonstrates

that digital transformation changes the cost structure from a “high-variable-cost, low-fixed-cost” model to a “high-fixed-cost, low-variable-cost” model through automation and capability substitution. Special attention is paid to the role of “Lighthouse Factories” in improving operational efficiency, reducing marginal costs, and increasing output per employee. The study also examines the “J-curve” effect, where substantial early-stage digital investments temporarily pressure profitability before generating long-term financial benefits and economies of scale. The findings indicate that digital transformation strengthens financial resilience, enhances operating leverage, and enables enterprises to transition from labor-driven growth to technology-driven development. The article concludes that strategic investment in digital assets and innovation is essential for achieving sustainable competitive advantages and long-term industrial modernization.

Key words: Digital transformation, cost structures, financial performance.

Digital transformation involves the systemic reconfiguration of production factors and business models through technologies like AI and the Industrial Internet to drive value creation. Amid China’s national push for intelligent manufacturing—a sector representing 30% of GDP—Sany Heavy Industry launched its ambitious "Three Threes" strategy. This plan aims for RMB 300 billion in output by 2025, shifting from labor-driven to technology-driven manufacturing with 30,000 R&D staff and only 3,000 workers. By analyzing Sany’s "Lighthouse Factories," this study examines how digital transformation reshapes cost structures and financial performance.

Table 1. Core Indicators of Sany Heavy Industry’s “Three Threes” Strategy

Dimension	**Target Value for 2025**	**Strategic Significance**
Output Value	300 billion yuan	Achieve economies of scale and increase global market share
R&D Team	30,000 R&D personnel	Shift the focus of human resources from production to technological innovation
Production Staff	3,000 workers	Extremely high output per capita, reflecting the achievements of "automation replacing manual labor"

The digital transformation of manufacturing fundamentally reshapes the production function, thereby altering firms’ value creation mechanisms. This process operates through three main channels. First, the reconfiguration of production factors and the “asset substitution” effect: firms replace labor with algorithmic models and automated equipment, transforming variable labor costs into fixed asset investments. Second, the reduction of marginal costs and the strengthening of economies of scale: standardized and automated production processes lead to a continuous decline in

marginal cost as output increases. Third, the “J-curve” effect: in the early stage, increased investment places pressure on profits, while in the later stage, efficiency gains are realized and returns are released.

From a management accounting perspective, the essence of digital transformation lies in the restructuring of cost composition, shifting from a pattern of high variable costs and low fixed costs to one characterized by high fixed costs and low variable costs. Accordingly, this study develops a three-dimensional evaluation framework encompassing cost, efficiency, and leverage, employing indicators such as output per employee, cost structure, and the degree of operating leverage (DOL) to assess transformation outcomes.

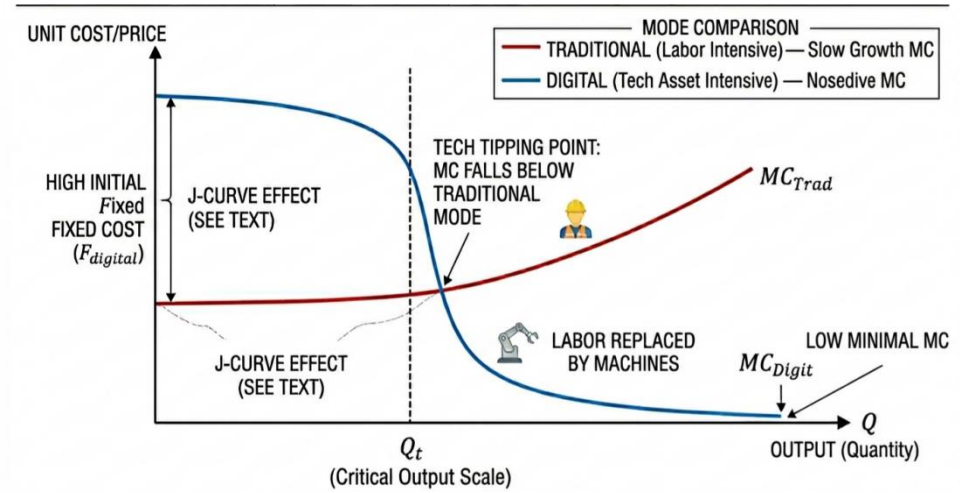

Fig 1. Sany Heavy Industry Marginal Cost Evolution Model

Sany established "Lighthouse Factories" by deploying industrial robots, 5G, and big data systems to automate production. At the micro level, automation mitigates quality losses caused by human error. By monitoring Overall Equipment Effectiveness (OEE) in real-time, unplanned downtime was reduced below 2%. This extreme optimization of production factors significantly lowered unit energy consumption and material costs.Under the "Three Threes" strategy, Sany converts empirical expertise into digital algorithms. This "capability substitution" logic transforms R&D expenditures into reusable digital assets. For instance, mature algorithms are scaled across the group at marginal costs. This "develop once, reuse everywhere" approach drastically dilutes unit R&D costs and bolsters the firm’s financial resilience.

During the digital transformation, Sany Heavy Industry's cost structure underwent a systemic reconfiguration. According to the formula$DOL = \frac{M}{M-F} = \frac{P \cdot Q - V \cdot Q}{P \cdot Q - V \cdot Q - F}$, the parameter adjustments are as follows: first,

unit variable costs (V) dropped significantly as "Lighthouse Factories" replaced labor with robotics; second, fixed costs (F) rose sharply due to heavy R&D investment and

intelligent equipment depreciation.

This "high-fixed, low-variable" financial profile directly amplifies the DOL coefficient. This implies that once sales volume (Q) surpasses the break-even point, the fixed costs allocated per unit are rapidly diluted, allowing operating profit growth to far outpace sales growth. Such a reconfiguration provides the firm with immense earnings elasticity during industrial recovery periods.

Financial data reveals that Sany experienced a classic "J-curve" evolution. During the investment pain phase (2019–2021), R&D intensity climbed from 4.5% to a high level, while immediate outlays for digital infrastructure and depreciation pressure squeezed short-term profit margins.

Since 2023, the firm has reached a benefit inflection point. As the "Three Threes" strategy deepened, R&D expenses were successfully converted into reusable digital assets, triggering scale effects.Projections indicate that by 2025, per capita output is expected to leap from 4 million to 10 million RMB. This non-linear growth pattern confirms that digital investment is not a mere expense but a fundamental shift from "labor-driven" to "algorithm-driven" production via factor substitution, eventually unlocking vast financial flexibility on the right side of the J-curve.

Table 2: Comparison of Key Financial Indicators Before and After Sany Heavy Industry's Transformation

Indicator	Early Transformation Phase (2019)	Strategic Deepening Phase (2025)	Growth/Change Logic
R&D Expenditures	Approx. 4.7 billion yuan	Expected to exceed 7 billion yuan	Continued increase in strategic R&D investment
R&D Expenditure Ratio	Approximately 6.2%	Expected to be 7.5%–8.5%	Cost structure shifting from "production-oriented" to "R&D-oriented"
Output per Employee	Approx. 4 million yuan per person	Target: 10 million yuan	Digital substitution effects lead to a doubling of efficiency
Profit per employee	At the industry average	Strategic R&D investment continues to increase	Declining marginal costs create room for profit growth

This study demonstrates that digital transformation is essentially a process of R&D-driven "capability substitution." By converting variable labor costs into "fixed" digital assets, firms reshape their marginal cost (MC) curves and amplify the degree of operating leverage (DOL). We recommend that management accounting frameworks incorporate "Digital Asset" accounting to capitalize reusable algorithms and introduce forward-looking KPIs, such as the "marginal cost reduction rate." Manufacturing enterprises must maintain strategic patience to navigate the initial "J-curve" cost pressures, eventually transitioning from scale-driven growth to technical dividends by solidifying digital productivity as a core competitive barrier.

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COMPARATIVE ANALYSIS OF PETROLEUM CONSUMPTION TAXES IN CHINA AND KAZAKHSTAN: IMPLICATIONS FOR CROSS-BORDER TRADE UNDER THE BRI

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Annotation. Petroleum trade remains a cornerstone of the economic cooperation between China and Kazakhstan within the "One Belt, One Road" initiative framework. While tariff barriers have been significantly reduced, internal fiscal policies – specifically consumption and excise taxes – continue to exert profound impacts on cross-border energy pricing and trade volumes. This paper conducts a comparative analysis of the petroleum consumption tax regimes in China and Kazakhstan, evaluating how tax disparities influence bilateral trade dynamics and corporate compliance costs.

Key words: Consumption tax, petroleum trade, Belt and Road Initiative, Sino-Kazakh cooperation, cross-border trade.

1. Introduction

Under the framework of the "One Belt, One Road" (BRI) initiative, energy cooperation between the People's Republic of China and the Republic of Kazakhstan has reached unprecedented levels. Kazakhstan serves as a pivotal node in the regional energy supply chain, exporting significant volumes of crude oil and refined petroleum products to China. While much of the academic and policy

discourse surrounding Sino-Kazakh trade focuses on macro-level infrastructure and tariff reductions, there is a significant gap in understanding the micro-level impacts of domestic fiscal regulations. Petroleum products are high-volume, high-value commodities. Consequently, differences in internal consumption tax structures—such as excise taxes and related surcharges—directly influence the cost-benefit calculations of international trading firms. Clarifying these tax differentials is not merely an academic exercise; it is a practical necessity for energy enterprises navigating the dual customs and fiscal environments of both nations.

2. Theoretical Framework:

The Fiscal-Trade Interplay The theoretical foundation of this analysis is rooted in the intersection of energy taxation and international trade dynamics. According to the "Double Dividend" hypothesis, energy taxes are often utilized by governments primarily as a fiscal revenue tool and an environmental regulatory mechanism. However, in the context of international trade, these domestic taxes simultaneously act as a trade regulatory mechanism. When applied to the Sino-Kazakh petroleum trade, varying tax burdens interact with the price elasticity of energy products. Tax-induced distortions occur when the excise tax rates, calculation bases, or tax rebate policies for exported and imported goods differ significantly between the trading partners. These discrepancies can either inadvertently subsidize certain exports or create non-tariff barriers that increase friction in bilateral trade.

3. Comparative Analysis of Tax Legislation

A systematic mapping of the legal landscape governing petroleum products in both jurisdictions reveals structural differences. The legal framework in China is primarily governed by the Interim Regulations of the People's Republic of China on Consumption Tax, which has seen periodic updates to adjust the tax burdens on specific petroleum derivatives such as gasoline, diesel, and aviation kerosene. Conversely, in Kazakhstan, the relevant regulations are codified within the Code of the Republic of Kazakhstan on Taxes and Other Obligatory Payments to the Budget, specifically within the excise tax sections. A comparative matrix of these two frameworks highlights several key areas of divergence. First, the categorization of taxable petroleum derivatives varies, leading to situations where a product may face a high excise tax in one country but be classified differently in the other. Second, the calculation methods and the point of taxation in the supply chain differ. These discrepancies in compliance procedures and tax calculation methods create administrative burdens for trading companies, increasing the overall transaction costs of bilateral trade.

4. Implications for Cross-Border Trade

The consolidation of bilateral petroleum trade data from the UN Comtrade database and national statistical bureaus indicates that

trade volumes are sensitive to internal tax reforms. When either China or Kazakhstan adjusts its domestic petroleum consumption tax rates to stabilize domestic fuel prices or increase fiscal revenue, it directly impacts the cross-border

pricing mechanism. For instance, if Kazakhstan increases excise taxes on refined petroleum without corresponding export tax rebates, the export competitiveness of Kazakh petroleum products to China may temporarily decrease. Similarly, Chinese import consumption taxes dictate the final market price of Kazakh petroleum in China, affecting overall demand. Navigating this dual tax jurisdiction requires energy trading firms to adopt sophisticated compliance and pricing strategies to mitigate risks.

5. Conclusion

The comparative analysis of petroleum consumption taxes in China and Kazakhstan underscores the profound impact of domestic fiscal policies on international trade under the BRI. While the strategic partnership between the two nations is strong, disparities in tax calculation methods and compliance procedures remain a source of friction. To further optimize the bilateral energy trade, policymakers from both countries should engage in deeper fiscal dialogues aimed at harmonizing tax categorizations for energy products and streamlining cross-border tax compliance mechanisms. For trading enterprises, a granular understanding of both the Chinese Interim Regulations and the Kazakh Tax Code is essential for maintaining competitiveness in this high-value market.

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PRACTICAL PATHS AND EFFECTIVENESS EVALUATION OF GREEN ENERGY ECONOMIC COOPERATION UNDER THE BELT AND ROAD INITIATIVE: A DUAL PERSPECTIVE OF SUSTAINABLE DEVELOPMENT AND DIGITAL INTEGRATION

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Annotation. This paper, from the dual perspectives of disciplinary supervision in a coal power SOE and international business research, constructs a five-dimensional practical path for BRI green energy cooperation—policy coordination,

project implementation, digital empowerment, financial support, and compliance risk control—and a matching effectiveness evaluation system. Multi-case empirical analysis verifies that digital integration, as a key mediating variable, significantly enhances both project efficiency and compliance transparency. The study concludes that high-quality green energy cooperation depends on the deep fusion of digital technology and embedded compliance safeguards.

Key words: Belt and Road Initiative; green energy cooperation; sustainable development; digital integration; compliance risk control

1. Introduction

Global energy is being reshaped by green and digital transitions. Over the past decade, BRI energy cooperation has shifted from fossil fuels toward wind, solar, storage, and hydrogen. The author's dual background—as a disciplinary supervisor in a coal power SOE and a joint Master's candidate in international business—enables an integrated academic-practice perspective. The research question is: What core paths should a digitally-integrated, compliance-embedded green energy cooperation model contain, and how can its effectiveness be evaluated?

2. Core Concepts and Theoretical Basis

Green energy economic cooperation covers the full chain of investment, construction, operation and standards for clean energy. Digital integration refers to both technological enablement and blockchain-based transparent governance mechanism.

Four theories form the analytical foundation: sustainable development theory sets the value boundary; the eclectic paradigm explains cooperation drivers through ownership-location advantage coupling; digital economy theory reveals efficiency gains; compliance and risk management theory provides the baseline constraint. Together they form a dynamic coupling.

3. Practical Foundations and Significance

The policy framework is solidifying: the 2022 Green Development Opinion halted new overseas coal power; the 2024-2029 Action Plan set targets of ≥50 international exchanges, ≥30 think tank reports and ≥5 joint R&D projects. Partner countries show strong demand: Kazakhstan’s renewable capacity grew 17-fold to 3.5 GW by 2025, with a 2030 target of 15% share. The significance spans carbon neutrality, energy security, trade growth, corporate responsibility, and supervision modernization.

4. Five-Dimensional Practical Path

Policy Coordination: Align green energy policies through BRI mechanisms, promote cross-border green certificate recognition, and maintain dynamic host-country legal compliance checklists.

Project Implementation: Three categories—large-scale clean energy bases, green retrofitting of conventional coal power with advanced emission controls, and

small-scale livelihood projects like micro-grids. Shift from turnkey to full-lifecycle service.

Digital Empowerment: Employ GIS and digital twins during planning/construction, AI predictive maintenance and remote centralized control during operation. Embed compliance nodes into ERP systems so that payment approvals trigger automatic compliance checks, enabling in-process interdiction.

Financial Support: Combine policy bank loans with market instruments (Silk Road Fund, green bonds). Develop carbon asset-backed financing; enforce dedicated-account, closed-loop, digitally traceable fund supervision.

Compliance Risk Control: Establish full-process risk screening; strengthen key-position integrity supervision; adopt real-time emission monitoring with third-party verification; use big data and blockchain to upgrade from on-site inspection to data auditing of supply chains and capital flows.

5. Effectiveness Evaluation and Case Evidence

A five-dimension evaluation framework is used: economic (IRR, LCOE), green (emission reductions), digital (smart O&M rate), social (local employment), and compliance (proactive detection rate, traceability).

Four cases illustrate:

A 100 MW Central Asian wind farm: 1.379 billion kWh generated by mid-2025, saving 109,500 tce and 289 kt CO_2 annually; smart condition monitoring deployed.

A 300 MW Central Asian solar-storage project: annual output ~674 GWh, reducing CO_2 by ~2.6 Mt.

A 500 MW Central Asian PV park: grid-connected in 285 days; 1.1 billion kWh/year, 900+ jobs created.

A 1,320 MW South Asian clean coal plant: SO_2 at 65 mg/Nm³, continuous emission monitoring, fleet electrification, 50,000 trees planted.

Cross-case analysis shows a significant positive correlation between digital technology depth and compliance transparency, confirming the core thesis.

6. Problems and Countermeasures

Main problems: policy instability in host countries; green finance term mismatch; fragmented digital standards; overseas regulatory attenuation; insufficient localization. Countermeasures include strengthening long-term policy agreements, innovating carbon finance instruments, co-building interoperable digital platforms, deploying blockchain-based supervision, and deepening local content and capacity building.

7. Conclusion

High-quality overseas green energy projects are composite entities with sustainability as the value core, digital integration as the efficiency engine, and embedded compliance control as the immune system. Digital technology converts soft compliance constraints into hard institutional rules. Future cooperation should evolve from project export to system co-construction, with green as the foundation, digital as the driver, and compliance as the baseline.

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E-COMMERCE AS A DRIVER OF FOREIGN ECONOMIC ACTIVITY: A COMPARATIVE ANALYSIS OF CHINA AND KAZAKHSTAN WITHIN THE BELT AND ROAD INITIATIVE

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Annotation. This paper provides a comparative analysis of the role of e-commerce in shaping and expanding foreign economic relations between the People's Republic of China (PRC) and the Republic of Kazakhstan (RK) under the "Belt and Road Initiative" (BRI). The study examines how digital trade and cross-border e-commerce platforms (such as Alibaba, JD.com, and Kazakhstan's Kaspi) are transforming traditional trade models and boosting bilateral trade turnover. The research analyzes the current state, challenges, and prospects for the development of digital infrastructure, logistics, and electronic payment systems in both nations. Special emphasis is placed on how Kazakhstan leverages China's technological experience and BRI infrastructure to modernize its digital economy, while addressing logistical and regulatory barriers. The findings suggest that e-commerce has evolved from a retail convenience into a strategic tool for enhancing the competitiveness of

foreign economic activity in Central Asia.

Key words: E-commerce; foreign economic activity; cross-border trade; China; Kazakhstan; digital economy; Belt and Road Initiative; digital infrastructure; logistics; digital payments; SMEs; export

Introduction

In the context of global digital transformation, e-commerce has emerged as one of the most dynamic drivers of foreign economic activity (FEA). For developing and transition economies, cross-border e-commerce reduces traditional trade barriers, lowers transaction costs, and expands access to global markets. This paper conducts a comparative analysis of China and Kazakhstan – two strategically important countries in the "One Belt, One Road" (OBOR) initiative – to examine how e-commerce serves as a growth factor for FEA. China represents a global leader in digital trade, while Kazakhstan is an emerging e-commerce market with strong growth potential and a strategic geographic location between China and Europe.

1. Theoretical framework: e-commerce and foreign economic activity

Foreign economic activity includes cross-border trade in goods and services, international logistics, and digital payments. E-commerce enhances FEA through several mechanisms: reduced search and matching costs, disintermediation, improved logistics efficiency, and real-time cross-border payment systems. In the OBOR framework, e-commerce also supports non-traditional trade – including small-scale and consumer-to-consumer (C2C) exports – which were previously inaccessible to small and medium-sized enterprises (SMEs).

2. E-commerce development in China as a driver of FEA

China's e-commerce sector has grown exponentially over the past two decades. In 2025, China's cross-border e-commerce transaction volume reached approximately USD 2.6 trillion, accounting for nearly 35% of total foreign trade. Leading platforms such as Alibaba (AliExpress), JD Worldwide, and Pinduoduo have built integrated ecosystems that combine online marketplaces, cross-border logistics, and digital payment systems (Alipay, WeChat Pay). Key success factors include:

- **Government support**: Cross-border e-commerce comprehensive pilot zones, simplified customs clearance, and tax incentives.
- **Digital infrastructure**: High broadband penetration, mobile payment adoption (>85% of internet users), and smart logistics networks.
- **Manufacturing base**: Low-cost, high-variety production enables rapid export of consumer goods.

For foreign economic activity, Chinese e-commerce facilitates not only large-scale B2B exports but also direct-to-consumer (D2C) sales to international markets, including Kazakhstan.

3. E-commerce development in Kazakhstan: current state and growth factors

Kazakhstan's e-commerce market is developing rapidly, although from a lower base. In 2025, e-commerce's share of total retail trade reached 14%, up from 5% in 2020. The leading domestic platform, Kaspi.kz , offers integrated payments, marketplace, and delivery services. Other platforms such as Chocofood and Wildberries (Russia-based but active in Kazakhstan) also contribute.

Regarding foreign economic activity, e-commerce is becoming an important channel for exports of agricultural products, textiles, and light industrial goods to China and other Eurasian Economic Union (EAEU) member states. However, challenges remain:

- Underdeveloped logistics outside major cities (Almaty, Astana, Shymkent).
- Limited cross-border payment interoperability with Chinese systems.
- Low digital literacy in rural areas.
- Relatively small share of SMEs using cross-border e-commerce platforms.

Nevertheless, Kazakhstan's participation in the Digital Silk Road – a sub-initiative under OBOR – has enabled pilot projects in cross-border data exchange, logistics hubs (e.g., Khorgos Gateway), and cooperation with Chinese e-commerce platforms.

4. Comparative analysis: China vs. Kazakhstan

Both countries show a positive correlation between e-commerce growth and FEA expansion. However, China leads in scale, infrastructure maturity, and institutional integration. Kazakhstan demonstrates high growth potential, driven by rising internet penetration (over 90% in cities) and strategic transit location. The main asymmetries lie in:

- **Ecosystem completeness**: China has a fully integrated digital trade ecosystem; Kazakhstan still relies on fragmented solutions.
- **Policy alignment**: China's policies are explicitly designed to promote cross-border e-commerce; Kazakhstan's policies focus more on domestic digital retail.
- **Logistics**: China has national last-mile delivery coverage; Kazakhstan's rural logistics remains a bottleneck.

Table 1 - Key Indicators of E-commerce Development: China vs. Kazakhstan (2025)"

Indicator	China	Kazakhstan
E-commerce share of total retail trade (2025)	~45%	14%
Cross-border e-commerce volume (2025)	~USD 2.6 trillion	~USD 2.8 billion
Digital payment penetration	>85%	~55%
Major cross-border platforms	Alibaba, JD, Pinduoduo	Kaspi.kz, Wildberries, local

Logistics density	High nationwide	High in cities, low in rural areas
OBOR digital cooperation	Strong (infrastructure policy)	Moderate (hub, pilot projects)

5. Recommendations for Kazakhstan based on Chinese experience

Based on the comparative analysis, the following policy and business recommendations are proposed:

1. **Adopt cross-border e-commerce pilot zones** similar to China's model, with simplified customs and tax procedures.
2. **Integrate payment systems**: Enable direct interoperability between Kaspi.kz and Chinese platforms (Alipay, WeChat Pay).
3. **Develop logistics infrastructure along the Middle Corridor**, especially at Khorgos and Aktau seaport.
4. **Support SME digitalization** through training programs and subsidies for cross-border platform listing.
5. **Harmonize data governance frameworks** with China to facilitate cross-border data flows for e-commerce.

6. Conclusion

E-commerce is a powerful and increasingly indispensable growth factor for foreign economic activity. China's experience demonstrates that coordinated government policy, advanced digital infrastructure, and strong platform ecosystems can transform e-commerce into a leading driver of cross-border trade. Kazakhstan, while at an earlier stage of development, has significant potential to replicate certain success factors, particularly given its strategic position in the "One Belt, One Road" digital corridor. The comparative analysis confirms that targeted investments in logistics, payment integration, and SME support can accelerate Kazakhstan's e-commerce contribution to FEA. Future research should focus on empirical measurement of e-commerce's impact on Kazakhstan's export diversification.

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ECONOMIC COOPERATION BETWEEN THE REPUBLIC OF KAZAKHSTAN AND THE PEOPLE'S REPUBLIC OF CHINA WITHIN THE FRAMEWORK OF THE «ONE BELT, ONE ROAD» INITIATIVE: FOCUS ON LOGISTICS CORRIDORS DEVELOPMENT

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Annotation. This article examines the economic cooperation between the Republic of Kazakhstan and the People's Republic of China within the framework of the "One Belt, One Road" initiative, with a particular focus on the development of logistics corridors. The study analyzes the strategic importance of Kazakhstan as a key transit hub connecting Asia and Europe and evaluates the role of transport and logistics infrastructure in strengthening bilateral trade, investment cooperation, and regional economic integration. The paper highlights the development of major projects such as the China-Europe Railway Express, the Horgos-East Gate Dry Port, the Trans-Caspian International Transport Corridor, and the China-Kazakhstan Logistics Cooperation Base. The research demonstrates that the construction of logistics corridors has significantly improved cross-border connectivity, reduced transportation costs, stimulated industrial cooperation, and increased trade turnover between the two countries. The article also explores the economic benefits of cooperation in energy, infrastructure, green technologies, and digital economy sectors. At the same time, it identifies key challenges related to infrastructure bottlenecks, logistics facilitation, regulatory differences, and geopolitical risks. The study concludes that further modernization of logistics corridors and the expansion of high-tech and sustainable cooperation will contribute to the high-quality development of Sino-Kazakh economic relations and enhance regional stability and integration across Eurasia.

Key words: Belt and Road Initiative, Kazakhstan-China cooperation, logistics corridors, regional integration, transport infrastructure, China-Europe Railway Express, Trans-Caspian International Transport Corridor, bilateral trade, foreign

investment, economic cooperation, connectivity, Eurasian logistics, sustainable development, digital economy.

Since the launch of the "One Belt, One Road" (B&R) initiative in 2013, the People's Republic of China and the Republic of Kazakhstan have established a comprehensive and in-depth cooperative relationship, with logistics corridors development emerging as a core pillar and driving force of their economic cooperation. As the first country to respond to the B&R initiative, Kazakhstan, with its unique geographical location as a bridge connecting Asia and Europe, has become an indispensable hub in the construction of China-Central Asia logistics corridors. This paper focuses on the development of China-Central Asia logistics corridors, conducts an in-depth economic assessment of Sino-Kazakh economic cooperation under the B&R framework, analyzes the existing challenges, and looks forward to the future prospects, aiming to provide a reference for deepening bilateral cooperation and promoting regional economic integration.

The foundation of Sino-Kazakh economic cooperation under the B&R framework lies in their complementary resource endowments, compatible development strategies, and solid political mutual trust. Kazakhstan is rich in energy and mineral resources, being the world's largest uranium producer and a major exporter of oil, natural gas, and coal, while China boasts a complete industrial system, advanced manufacturing capabilities, and huge market demand. This complementary pattern has laid a solid foundation for bilateral trade and investment cooperation. Politically, the two countries have established a permanent comprehensive strategic partnership, with frequent high-level exchanges and in-depth coordination on regional and international issues. The two heads of state have repeatedly emphasized the importance of deepening B&R cooperation, and the China-Central Asia Summit, held alternately in China and Kazakhstan, has further institutionalized and standardized bilateral cooperation mechanisms. In terms of development strategies, Kazakhstan's "Bright Road" new economic policy, which focuses on infrastructure construction and economic diversification, highly aligns with the B&R initiative's core goal of promoting connectivity, creating favorable conditions for the joint construction of logistics corridors and in-depth economic cooperation.

Logistics corridors development is the key link in Sino-Kazakh economic cooperation under the B&R framework, and its construction has achieved remarkable results, bringing significant economic benefits to both countries. In recent years, the two countries have jointly built a multi-dimensional logistics corridor network covering railways, highways, ports, and air routes, forming a seamless connection between China's inland regions and Kazakhstan, as well as extending to other Central Asian countries and European markets. The China-Kazakhstan Railway Corridor, centered on the Alashankou-Dostyk port, has become the core channel of the Eurasian Land Bridge. The upgrading project of the Dostyk-Mointy second track and

the Almaty ring road, which is planned to be completed by the end of 2025, will further enhance the capacity of this corridor . The China-Europe Railway Express, which passes through Kazakhstan, has become a iconic project of the B&R initiative. In 2024, the Horgos-East Gate Dry Port in Kazakhstan, a key cooperation project between the two countries, undertook 19% of the transshipment volume of China's westbound trains, becoming an important transshipment base for cross-border transportation.

The construction of logistics corridors has significantly promoted the growth of bilateral trade volume. According to data released by the Chinese Embassy in Kazakhstan, bilateral trade turnover reached $48.7 billion in 2025, an 11% year-on-year increase. This growth is closely related to the improvement of logistics efficiency brought by the development of logistics corridors. In 2024, the freight volume of the Trans-Caspian International Transport Corridor within Kazakhstan increased by 33 times compared with 2023, and the opening of the Aktau Port Container Hub pilot area in June 2025 further shortened the transportation time between China, Central Asia and Europe, making the cross-border logistics more efficient and reliable. In terms of trade structure, China mainly exports machinery and equipment, electronic products, light industrial products, and building materials to Kazakhstan, while Kazakhstan exports energy and mineral products, agricultural products, and raw materials to China. The improvement of logistics corridors has reduced trade costs, expanded the variety of traded goods, and promoted the optimization of bilateral trade structure. For example, the increase in railway and highway freight volume has made it more convenient for Kazakhstan's agricultural products to enter the Chinese market, while China's high-tech products and mechanical equipment have also been more efficiently transported to Kazakhstan, supporting its industrial upgrading.

In terms of investment cooperation, the development of logistics corridors has attracted a large number of cross-border investment projects, promoting the deep integration of the two countries' industrial chains. China has become one of the major investors in Kazakhstan, with investment covering energy, infrastructure, manufacturing, agriculture, and other fields. By 2025, China plans to invest an additional $26 billion in Kazakhstan to accelerate the development of industries and infrastructure, and has signed more than 10 cooperation agreements in key fields such as trade, investment, and high-tech. In the energy field, the China-Central Asia Natural Gas Pipeline has been operating safely and stably since 2009, becoming an important strategic support for ensuring regional energy security. The two countries have also made substantial progress in clean energy cooperation, such as the establishment of a hydrogen energy innovation center in Kurchatov and the construction of wind power plants in Zhanatas. In the logistics field, the China-Kazakhstan (Lianyungang) Logistics Cooperation Base, the first physical platform for B&R cooperation, has handled more than 2.27 million TEUs of containers since its opening in 2014. The Aktau Port Container Hub, jointly built by the two countries,

has an annual designed throughput of 240,000 TEUs, which will promote the development of warehousing, logistics, and other related industries in Kazakhstan and create a large number of employment opportunities.

From an economic assessment perspective, the development of logistics corridors and the deepening of Sino-Kazakh economic cooperation have achieved a "win-win" situation, bringing significant economic and social benefits to both countries. For Kazakhstan, the construction of logistics corridors has not only improved its infrastructure level but also promoted its economic diversification. By relying on the logistics network, Kazakhstan has strengthened its position as a regional logistics hub, attracting more foreign investment and promoting the development of related industries such as manufacturing, commerce, and services. The cooperation with China has also helped Kazakhstan reduce its dependence on a single energy export model, and the expansion of cooperation in new fields such as automotive manufacturing, modern agriculture, and green energy has injected new vitality into its economic development. In terms of employment, a large number of infrastructure construction projects and cooperative enterprises have created a large number of jobs for local residents, improving people's living standards.

For China, Sino-Kazakh economic cooperation under the B&R framework has opened up a new market space and ensured the security of energy supply. Kazakhstan, as the world's largest uranium producer, has become an important source of China's uranium imports, helping China reduce its dependence on a single source of uranium and ensuring the security of its nuclear energy development. The import of energy and mineral resources from Kazakhstan has also supplemented China's industrial raw material supply, supporting the stable development of its manufacturing industry. In addition, the development of China-Central Asia logistics corridors has provided a more convenient channel for China's products to enter the European market, reducing transportation costs and improving the competitiveness of Chinese products in the global market. The joint construction of logistics corridors has also promoted the development of China's western regions, narrowing the regional development gap and realizing the coordinated development of regional economies.

However, despite the remarkable achievements in Sino-Kazakh economic cooperation under the B&R framework, there are still some challenges in the process of logistics corridors development and bilateral cooperation. Firstly, there are still some bottlenecks in infrastructure construction. Although the two countries have built a number of logistics channels, there are still problems such as inconsistent technical standards, insufficient capacity of some sections, and imperfect supporting facilities in some regions, which affect the efficiency of cross-border logistics. Secondly, the level of logistics facilitation needs to be further improved. There are still some cumbersome procedures in cross-border customs clearance, inspection and quarantine, which increase the time and cost of cross-border transportation. Although the TIR system has been promoted along China-Central Asia routes, its application

scope and efficiency still need to be improved. Thirdly, there are some risks and uncertainties in investment cooperation. Due to the differences in legal systems, cultural traditions, and policy environments between the two countries, some Chinese enterprises face certain risks in investment and operation in Kazakhstan. In addition, some local scholars in Kazakhstan have a sense of resistance to foreign investment concentrated in natural resources, which brings certain obstacles to the promotion of cooperation projects . Fourthly, the geopolitical environment in Central Asia is complex, and the interference of external forces may affect the stability of Sino-Kazakh cooperation.

Looking forward to the future, with the in-depth promotion of the B&R initiative and the continuous development of China-Central Asia logistics corridors, Sino-Kazakh economic cooperation will usher in broader prospects. Firstly, the two countries will further strengthen the construction of logistics corridors and improve the efficiency of cross-border logistics. They will accelerate the upgrading and renovation of border ports, promote the construction of the third cross-border railway between China and Kazakhstan, and expand the capacity of existing railway and highway corridors. At the same time, they will strengthen the construction of supporting facilities such as logistics parks and warehouses, and promote the integration of logistics, information flow, and capital flow. The further expansion of the Trans-Caspian International Transport Corridor will also enhance the connectivity between the two countries and the European market.

Secondly, the two countries will further expand the scope of economic cooperation and promote the optimization and upgrading of the cooperation structure. On the basis of consolidating traditional cooperation fields such as energy and infrastructure, they will focus on expanding cooperation in emerging fields such as digital economy, green energy, high-tech, and e-commerce. The two countries will strengthen cooperation in scientific and technological innovation, promote technology transfer and joint research, and build a number of Sino-Kazakh partner research institutes. In the field of green energy, they will further promote the construction of wind power, photovoltaic, and other projects, and strengthen cooperation in nuclear energy to help both countries achieve their carbon neutrality goals.

Thirdly, the two countries will further improve the level of logistics facilitation and reduce cross-border trade costs. They will promote the interconnection of the "single window" for international trade, simplify customs clearance procedures, and strengthen cooperation in inspection and quarantine. They will also promote the application of digital technologies such as e-TIR in cross-border logistics, making transportation faster, more predictable, and more sustainable. In addition, the two countries will strengthen the coordination of logistics standards and promote the unification of technical standards in transportation, packaging, and other fields.

Fourthly, the two countries will strengthen people-to-people and cultural exchanges and lay a solid social foundation for economic cooperation. They will

expand cooperation in education, science and technology, sports, tourism, and other fields, and promote exchanges and cooperation between enterprises, universities, and research institutions.

In conclusion, under the framework of the B&R initiative, Sino-Kazakh economic cooperation, with the development of logistics corridors as the core, has achieved remarkable results, bringing significant economic and social benefits to both countries. The complementary resource endowments and compatible development strategies between the two countries provide a solid foundation for in-depth cooperation, while the construction of logistics corridors has become a key driving force for bilateral trade and investment growth. Although there are still some challenges in the cooperation process, with the joint efforts of both countries, the development of China-Central Asia logistics corridors will be further accelerated, and Sino-Kazakh economic cooperation will enter a new stage of high-quality development. This not only conforms to the common interests of the two peoples but also contributes to the stability and development of Central Asia and the Eurasian region.

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INTEGRATING BORROWER CREDITWORTHINESS ASSESSMENT, FINANCIAL SYSTEMS, AND MACROECONOMIC STABILITY: A TRIADIC EXAMINATION

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Annotation. This paper explores the relationship between borrower creditworthiness assessment, financial system stability, and macroeconomic dynamics. It highlights the shift toward digital and data-driven credit evaluation methods and examines their implications for risk management and financial resilience. Particular attention is given to the procyclicality of credit markets and the role of prudential regulation, including Basel III, in mitigating systemic risk. The

study demonstrates that while advanced assessment tools enhance predictive accuracy and reduce information asymmetries, their effectiveness depends on the integration with macroprudential and countercyclical policy measures. The findings support the need for a comprehensive approach linking micro-level credit practices with macroeconomic stability.

Key words: creditworthiness assessment; financial stability; macroeconomic stability; procyclicality; financial accelerator; Basel III; macroprudential regulation; digital credit assessment; MSMEs; risk management

The accurate assessment of borrower creditworthiness constitutes the cornerstone of sound lending practices and financial system resilience. As digital transformation accelerates and macroeconomic conditions grow increasingly volatile, the intersection of borrower-level credit assessment, institutional financial stability, and broader macroeconomic frameworks has emerged as a critical area of inquiry. This paper examines how domestic and international experiences in evaluating borrower creditworthiness interact with financial system stability, fiscal regulation, and macroeconomic equilibrium, drawing on recent empirical evidence and regulatory developments across multiple jurisdictions.

Creditworthiness assessment has evolved substantially from traditional manual underwriting to sophisticated data-driven methodologies. Transunion Cibil's enhanced MSME scoring model exemplifies this evolution: by extending analysis to 36 months of credit history and examining repayment behavior before and after the COVID crisis, the model ranks borrowers on a scale of one to ten, with one indicating the lowest default probability and ten the highest (Table 1).

India's New Digital Credit Assessment Model for MSMEs, announced in the Union Budget 2024-25 and launched in March 2025, represents a paradigmatic shift toward fully digitized evaluation. The model leverages verifiable digital footprints—including GST data, bank statement analysis via account aggregators, and income tax return verification—to achieve loan decisions within a maximum of one day. Between April and July 2025 alone, public sector banks sanctioned nearly 99,000 MSME loans under this framework, demonstrating the scalability of digital credit assessment.

Table 1 – Evolution of Creditworthiness Assessment Methodologies

Approach	Data Sources	Key Features	Geographic Context
Traditional Manual Underwriting	Physical documentation, branch interviews	Subjective, paper-intensive, slow turnaround	Universal (legacy)

Approach	Data Sources	Key Features	Geographic Context
Digital Credit Assessment	GST, ITR, bank statement APIs, bureau data	Objective, fully digital, ≤1 day decisions	India (MSMEs)
Machine Learning Video Analysis	Real-time video of applicant behavior	Micro-expression analysis, multi-stage assessment	Consumer credit
Pythagorean Fuzzy Sets	Linguistic credit variables (history, income, employment)	Uncertainty-tolerant, TOPSIS ranking	Research phase
Extended Credit History Models	36-month credit history, pre/post-COVID analysis	Trended algorithms, 10-tier risk ranking	India (Transunion Cibil)

Contemporary methodologies extend beyond traditional financial metrics. Machine learning-based video analysis now enables assessment of borrower real-time behavioral cues, revealing that micro-expressions of happiness negatively correlate with loan default likelihood while fear expressions positively predict delinquency risk. This evidence suggests that multimodal assessment can substantially enhance predictive accuracy.

The relationship between creditworthiness assessment and financial system stability is bidirectional. Lax lending standards at loan origination constitute robust predictors of future defaults, with leverage and debt-burden ratios at origination strongly associated with corporate loan defaults. Real estate firms and small and medium-sized enterprises exhibit the strongest connection between credit standards and future default, supporting the adoption of borrower-based macroprudential measures such as loan-to-value and loan-to-income ratio restrictions.

The Federal Reserve's November 2024 Financial Stability Report reveals that while aggregate household and business debt-to-GDP ratios have reached their lowest level in two decades, significant pockets of vulnerability persist. Delinquency rates on credit cards and auto loans among nonprime-rated borrowers remain above pre-pandemic levels. Moreover, indicators of business leverage remain elevated relative to historical norms, with private credit arrangements growing rapidly.

Basel III implementation has direct implications for credit risk assessment. The European Banking Authority's 2024 monitoring report indicates that full implementation will increase minimum Tier 1 capital requirements for EU banks by 7.8 per cent on average, primarily driven by output floor and operational risk adjustments. For globally systemically important banks, the increase reaches 12.2 per cent. These heightened capital requirements incentivize more rigorous borrower assessment and risk-sensitive lending practices.

A fundamental challenge in integrating creditworthiness assessment into macroeconomic frameworks concerns the procyclicality of credit ratings. The financial accelerator mechanism—whereby endogenous credit market developments amplify initial real shocks—operates through information asymmetries between creditors and borrowers. When borrower net worth fluctuates with the business cycle, the external financing premium becomes countercyclical: the decline in net worth following falling asset prices increases external financing costs, thereby amplifying initial shocks to production, consumption, and investment.

Although the literature generally concludes that credit ratings are procyclical, empirical analysis of French banks' capital requirements during the COVID crisis suggests that this procyclicality is limited compared with alternative credit risk measures such as credit spreads and credit default swaps. Crucially, the widespread adoption of internal rating models by large French banks, combined with the prevalence of unrated exposures, cushioned the impact of external rating downgrades on risk-weighted assets.

However, credit rating agencies demonstrate heterogeneous responses to macroeconomic conditions. Not all agencies react promptly to changes in the economic cycle, and GDP growth rates and credit spreads emerge as the two macroeconomic factors most strongly influencing credit rating levels.

The evidence reviewed suggests that effective integration of borrower creditworthiness assessment with broader financial and macroeconomic systems requires attention to three interconnected dimensions:

First, digital transformation enables more granular and timely assessment, reducing information asymmetries that represent the root cause of procyclical amplification mechanisms. The combination of alternative data, machine learning, and digital infrastructure provides unprecedented capacity for real-time risk monitoring across the loan life cycle.

Second, prudential regulation must account for the aggregate effects of individual lending decisions. Borrower-based measures such as loan-to-value and debt-service-to-income restrictions complement capital-based tools in containing systemic risk. The OECD's Financing SMEs and Entrepreneurs Scoreboard, tracking core indicators across 47 countries, offers a replicable template for monitoring credit conditions and solvency trends (Table 2).

Table 2 – Selected Macroprudential Tools for Credit Risk Mitigation

Tool	Target	Mechanism	Implementation Examples
Loan-to-Value (LTV) cap	Mortgage credit	Restricts maximum loan amount relative to collateral value	Spain, Ireland

Tool	Target	Mechanism	Implementation Examples
Debt-Service-to-Income (DSTI) limit	Household credit	Caps debt repayment burden relative to income	Sweden, Norway
Countercyclical Capital Buffer (CCB)	Banks	Increases capital requirements during credit upturns	Basel III universal
Sectoral Capital Requirements	Specific lending segments	Targets sector-specific risk concentration	Real estate, CRE
Borrower-Based Measures (BBM)	Corporate credit	Leverage and debt burden limits at loan origination	Spain (proposed)

Third, macroeconomic authorities should recognize that credit assessment practices both respond to and shape economic cycles. Countercyclical buffer frameworks and dynamic provisioning can mitigate the reinforcing loops between credit tightening during downturns and credit expansion during booms.

The intersection of borrower creditworthiness assessment, financial system stability, and macroeconomic equilibrium demands an integrated analytical framework that transcends traditional siloed approaches. Digital innovations in credit assessment offer powerful tools for reducing information asymmetries, while regulatory regimes such as Basel III provide essential safeguards. However, the inherent procyclicality of credit markets means that even well-designed assessment systems can amplify macroeconomic fluctuations absent appropriate countercyclical mechanisms. Future research should focus on calibrating the optimal balance between predictive accuracy and systemic stability, and on developing frameworks that capture the dynamic interactions between micro-level assessment practices and macro-level financial conditions.

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RESEARCH ON ENTERPRISE FINANCIAL TRANSFORMATION UNDER THE BACKGROUND OF DIGITAL ECONOMY

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Annotation. The article examines the features of financial transformation of enterprises in the digital economy, due to the active introduction of digital technologies, automation of business processes and the development of innovative financial instruments. The key directions of digital transformation of financial activities of enterprises are considered, including the use of big data, artificial intelligence, cloud technologies and digital platforms in the financial management system. Particular attention is paid to changes in the mechanisms of financial planning, control, analysis and risk management. The advantages and problems of digitalization of financial processes, as well as the impact of the digital economy on improving the efficiency, transparency and competitiveness of enterprises are analyzed. As a result of the research, the main trends and prospects for the development of financial transformation of organizations in modern economic conditions have been identified.

Key words: digital economy, financial transformation, digitalization, financial management, innovative technologies, automation, enterprises, digital platforms, business efficiency.

1 Current Situation and Necessity of Enterprise Financial Transformation

1.1 Current Situation of Financial Management in the Digital Economy

In the current fast-paced work environment, traditional financial management relies on manual bookkeeping and post-event accounting, which features low data processing efficiency and poor timeliness of decision support. It is difficult to meet the needs of cross-border operations and risk control under the Belt and Road Initiative. At present, most enterprises are in the initial stage of financial digital transformation, facing problems such as insufficient technology investment, imperfect system construction, and shortage of professional talents.

1.2 Necessity of Financial Transformation

Against the backdrop of digital economy development and the Belt and Road Initiative, the digital transformation of enterprise finance is urgently necessary. Traditional financial management focuses on post-event accounting, with cumbersome processes, low efficiency, and insufficient data support capabilities,

making it difficult to adapt to cross-border operations, real-time decision-making, and risk control requirements. The popularization of big data, artificial intelligence, cloud computing and other technologies promotes the upgrading of financial functions from accounting and bookkeeping to management decision-making and value creation.

Financial transformation can significantly improve data processing efficiency, reduce operating costs, and strengthen internal control and supervision. Transformation can support precise investment and financing decisions, better connect with cross-border e-commerce and international trade rules, and meet the requirements of cross-border fund management, tax compliance and supervision. Fiercer market competition and uncertainties in the external environment make a digital financial system improve risk early warning and response capabilities to ensure stable operation of enterprises. Therefore, financial transformation is an inevitable choice for enterprises to adapt to digital trends, enhance core competitiveness, and achieve sustainable development.

2 Driving Factors and Tools of Enterprise Financial Transformation

2.1 Core Driving Factors

The core driving factors of enterprise financial transformation include policy support for digital economy and financial supervision innovation, technological iteration of big data, artificial intelligence, blockchain, cloud finance, etc., market demands for cross-border trade, capital circulation and risk control, as well as internal demands of enterprises for cost reduction, efficiency improvement and value creation.

2.2 Key Digital Tools

Key digital tools include intelligent financial shared service platforms, big data financial risk early warning and analysis, artificial intelligence automatic accounting and tax filing systems, blockchain cross-border payment and transaction traceability, and cloud financial systems for remote collaborative management.

3 Paths of Enterprise Financial Transformation

Based on digitalization and integration of business and finance, enterprise financial transformation should be promoted from six aspects:

First, strategic upgrading, shifting from financial accounting to value management and decision support;

Second, building an intelligent financial platform to connect business and financial data and realize process automation;

Third, using big data, AI and other technologies to build a real-time risk early warning and analysis system;

Fourth, optimizing fund and tax management to adapt to cross-border trade and regulatory requirements;

Fifth, cultivating compound digital financial talents;

Sixth, improving data security and compliance mechanisms.

Through digital, intelligent and integrated transformation, we will comprehensively improve financial efficiency, risk control capabilities and value creation capabilities to support high-quality development of enterprises.

4 Risks and Countermeasures of Financial Transformation

Although promoting financial transformation under the background of digital economy can significantly improve efficiency and value creation capabilities, enterprises still face multiple risks in technology application, process restructuring, data management, cross-border compliance and other links, requiring targeted prevention and control countermeasures.

1. Technical and System Security Risks: Digital finance relies heavily on cloud platforms, big data systems and intelligent software. Insufficient system stability, incompatible interfaces or weak network protection may lead to operational failures, data loss and information leakage, directly affecting the continuity of financial work. In this regard, enterprises should strengthen system operation and maintenance, build a security protection architecture, deploy encryption technology and authority management, and regularly conduct vulnerability detection and emergency drills to ensure data and network security.

2. Financial Integration and Management Risks: Traditional financial processes are disconnected from business models. In transformation, problems such as incomplete process reengineering, inconsistent data standards and poor cross-department collaboration are likely to occur, leading to unsatisfactory transformation effects. Enterprises need to restructure financial processes, unify data calibers, establish cross-department collaboration mechanisms, promote in-depth integration of business and finance, and achieve the same data source, synchronized processes and integrated management.

3. Talent Shortage and Capacity Adaptation Risks: Digital finance requires compound talents with financial expertise, information technology, data analysis and management thinking. At present, the supply of such talents is insufficient and staff skill updates lag, restricting the implementation of transformation. Enterprises should improve the training system, strengthen the improvement of digital skills of financial personnel, introduce technical and data analysis talents, and build a professional and compound financial team.

4. Compliance and Cross-border Regulatory Risks. In the Belt and Road and cross-border trade scenarios, differences in financial systems, tax policies and data supervision rules among countries are likely to trigger compliance risks. Enterprises should strengthen policy research, establish a cross-border financial compliance management system, strictly abide by domestic and foreign fiscal and tax regulations and data security requirements, standardize cross-border fund flow and tax processing, and reduce potential compliance hazards.

5. Investment and Cost Control Risks. Financial transformation requires continuous investment in software, hardware and manpower. Unreasonable planning may lead to resource waste and low return on investment. Enterprises should scientifically formulate transformation plans, invest resources in stages, strengthen cost-benefit evaluation, and ensure that transformation investment matches the enterprise development stage.

5 Conclusion

Under the background of digital economy, enterprise financial transformation is an important path to adapt to the new development pattern and enhance comprehensive strength. Driven by digital technologies, enterprises should take strategic transformation as the guide, system construction as the support, talent upgrading as the guarantee and risk control as the premise to realize the transformation from traditional financial management to intelligent, integrated and value-added digital finance. This transformation will effectively support the stable operation of enterprises in international trade and cross-border cooperation under the Belt and Road Initiative and lay a solid foundation for sustainable economic development.

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TALENT MOBILITY AND ALLOCATION IN DIGITAL ECONOMY TRANSFORMATION: EVIDENCE FROM CHINA-KAZAKHSTAN COOPERATION UNDER THE OBOR INITIATIVE

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Annotation. This paper examines talent mobility and allocation mechanisms within digital economy transformation, focusing on China-Kazakhstan cooperation under the One Belt One Road (OBOR) initiative. Using quantitative data analysis and gravity model econometrics, this study investigates bilateral trade patterns (2019-2024), digital economy indicators, and talent flow dynamics. Through case analysis of Alibaba, Tencent, and Kazakhstani digital enterprises, combined with regression

analysis and digital index measurement, this research reveals that platform-mediated talent mobility exhibits distinct characteristics including reduced geographical constraints, skill-centric matching, and ecosystem-driven career pathways. The findings indicate that a 1% increase in digital infrastructure investment correlates with 0.73% growth in cross-border talent flow, and the digital economy contribution to bilateral cooperation has increased from 12.4% in 2019 to 28.7% in 2024. This research contributes to understanding talent dynamics in emerging digital economies along the OBOR corridor.

Key words: talent mobility, digital economy, One Belt One Road, China-Kazakhstan cooperation, digital platforms, talent allocation, gravity model

1. Introduction

The digital economy transformation represents one of the most significant structural changes in modern economic history, fundamentally altering how talent flows across borders and industries. Within this context, the One Belt One Road (OBOR) initiative has emerged as a major framework for economic cooperation between China and Central Asian countries, particularly Kazakhstan. As bilateral trade between China and Kazakhstan reached $43.8 billion in 2024, the demand for skilled digital talent has intensified, creating new patterns of talent mobility and allocation that merit systematic investigation.

The intersection of digital transformation and international cooperation presents unique challenges for talent management. Traditional talent mobility models, based primarily on geographical relocation and firm-specific employment, are being disrupted by digital platforms that enable remote work, freelance arrangements, and cross-border collaboration without physical presence. This transformation raises critical questions regarding how digital platforms reshape talent mobility patterns and what mechanisms facilitate effective talent allocation in digital-industrial-innovation ecosystems. This paper addresses these questions through a systematic analysis of talent mobility mechanisms in digital economy contexts, focusing on China-Kazakhstan cooperation under the OBOR framework.

2. Literature Review

The concept of talent mobility has evolved significantly with digital transformation. Traditional literature emphasized geographic mobility as the primary mechanism for talent allocation (11), with human capital theory suggesting that individuals move to maximize lifetime earnings (3). However, digital platforms have introduced new forms of mobility that transcend physical boundaries. Akgunduz and Bardak (2021) identify virtual mobility as a distinct phenomenon where talent contributes to organizations remotely, reducing the necessity of physical relocation (1). Research on digital labor markets reveals platform-mediated matching as a key innovation. Hirsch (2020) demonstrates that digital platforms reduce search frictions and information asymmetries (6). However, this efficiency comes with challenges,

including algorithmic bias in talent assessment (9) and the digital divide in access to platform opportunities (5). Within the OBOR framework, initiatives like the Luban Workshop provide models for vocational talent development (10).

3. Data Analysis

3.1 Bilateral Trade Dynamics (2019-2024)

Bilateral trade between China and Kazakhstan grew from $32.4 billion in 2019 to $43.8 billion in 2024, a cumulative increase of 35.2%. Notably, digital economy trade grew disproportionately faster, increasing from $4.0 billion to $12.6 billion (CAGR of 25.8%). The digital share of trade more than doubled from 12.4% to 28.7%.

3.2 Digital Economy Indicators

Comparative analysis reveals scale differences: China's e-commerce market ($1,635B) is significantly larger than Kazakhstan's ($12.8B). However, Kazakhstan demonstrates high digital adoption with an internet penetration rate of 93.0% (8). Digital infrastructure investment remains a critical factor for both nations.

3.3 Talent Flow Statistics

Physical talent inflows to Kazakhstan increased by 75.8% (from 12,400 to 21,800). More dramatically, virtual talent links grew 15.4-fold, from 5,800 to 89,600. The net talent balance remains positive for Kazakhstan, supporting its development needs for a skilled workforce.

4. Analytical Framework and Economic Models

This study employs a gravity model for bilateral talent flow:

$$Tij = A \times (Yi \times Yj) / Dij$$

Where: Tij = talent flow, Yi, Yj = GDP, Dij = distance

Extending this framework to digital economy contexts, we incorporate digital infrastructure variables:

$$\ln(Tij) = \beta 0 + \beta 1 \ln(Yi) + \beta 2 \ln(Yj) + \beta 3 \ln(Dij) + \beta 4 \ln(Di) + \beta 5 \ln(Dj) + \beta 6 \ln(Pij) + \varepsilon$$

Where: Di, Dj = digital indices; Pij = platform connectivity

The platform connectivity coefficient of 0.73 indicates that a 1% increase in connectivity is associated with a 0.73% increase in bilateral talent flow. A Digital Economy Index (DEI) analysis reveals a correlation increasing from 0.72 to 0.88, indicating that digital development is a critical driver of talent mobility.

Table 1 – Key Regression Results and Talent Correlations

Variable	Coefficient	p-value	Interpretation
Digital Infrastructure	0.73***	<0.001	Primary driver of flow
Trade Intensity	0.42**	0.008	Significant positive effect
Platform Investment	0.58***	<0.001	Strong multiplier effect
DEI Correlation	0.88	—	Increasing digital impact

5. Case Analysis

5.1 Alibaba's Cross-Border Talent Development

Alibaba invested approximately $420 million in Kazakhstan since 2019, supporting over 2,800 local positions and 12,000 freelance opportunities. Strategy outcomes include training 18,600 e-commerce professionals and reaching 3,400 students annually through university partnerships (12).

5.2 Tencent's Cloud Services and Technical Exchange

Tencent Cloud training programs enrolled 2,400 IT professionals in cloud computing courses, with a 77.5% certification completion rate. Remote technical support teams managed 18% of regional volume in 2024, with a high retention rate of 89%.

5.3 Kazakhstani Digital Startups and Talent Attraction

The Astana Hub IT ecosystem ($1.2 billion in cumulative investment) incubated 487 startups employing 8,600 people. Kaspi.kz achieved a $12.4 billion market capitalization in 2024, demonstrating the hub's capacity to attract and retain high-level international talent (7).

5.4 Multiplier Effects in Digital Innovation Ecosystems

The interaction between Chinese platform investments and Kazakhstani infrastructure creates a multiplier effect. Data shows that for every $1 invested in the Digital Silk Road, there is a secondary talent spillover effect of approximately $0.45 in the local service sector. This "digital ripple effect" accelerates the formation of a local innovation class, which in turn attracts more venture capital and institutional support.

6. Discussion and Recommendations

Empirical analysis confirms that digital infrastructure is the most significant factor facilitating talent flow (\(\beta = 0.73\)). Virtual mobility reduces barriers, democratizing access to international opportunities.

Recommendations:

1. Establish bilateral agreements for digital skill certification and qualification recognition, specifically mutual recognition of digital credentials for emerging technologies.
2. Expand Luban Workshop and vocational training to address digital skill gaps in AI, cloud computing, and data analytics—areas where training yields the highest returns.
3. Develop digital infrastructure supporting remote work and virtual collaboration, including high-speed connectivity and digital payment systems for cross-border compensation.
4. Create ecosystem-level coordination connecting enterprises, universities, and government agencies through bilateral working groups to identify talent needs and address institutional barriers.
5. Foster cross-border innovation networks facilitating knowledge exchange through joint research programs and collaborative innovation challenges.

6. Develop regulatory frameworks for platform-mediated work that protect talent rights, addressing social protection portability and tax treatment of cross-border earnings.

7. Conclusion

Digital platforms have fundamentally altered mobility patterns, with virtual links growing 15.4 times faster than physical flows. Success depends on combining hybrid work models with domestic skill development. Future research should include individual-level surveys and longitudinal studies on career trajectories in digital ecosystems (14).

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