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Factors and trends in the development of the space industry in the context of the digitalization of the economy of the Republic of Kazakhstan

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Abstract

The article is relevant because of the need to formulate and consider the main tools of digital socioeconomic transformation, as well as because of the need to create a new model. The implementation of the transformation of already existing forms and concepts inherent in socioeconomic systems depends on these processes. It is shown that whereas in traditional industries, economic value is created within the enterprise, in the digital economy, value is created outside the enterprise at the time of interaction between partners, suppliers, and customers. The conceptualization of space activities in the Republic of Kazakhstan and the practical implementation of programs for the development of the space industry is considered. Based on a combination of process, sectoral, and technological approaches, the article considers the relationship between the development directions of the space industry in Kazakhstan and the processes of the national economy digitalization. The necessity of transnational strategic partnership in the field of innovative digital technologies in the space industry instead of the currently used "rent" approach is demonstrated. The results of the article can be used to develop White papers and more detailed documents in the field of interrelated policies for the development of the digital economy and the space industry in Kazakhstan.

Keywords Space industry · Digital economy · Strategic partnership · Technology

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1 Introduction

Previously a priority for individual innovative companies, today digital transformation has become a massive phenomenon. Related projects are vital for the success not only of individual companies but also of regions and countries. Currently, the global economy is rapidly acquiring the features of a knowledge economy and a digital economy (Bartczak, 2022). Such changes are also taking place in the economy of Kazakhstan. In the new economy, the concept of economic growth has been replaced by the economic development concept associated with the process of introducing innovations (Khalatur et al., 2022). In turn, the economic development form based on innovative processes is constantly undergoing changes in connection with the introduction of advanced info-communication technologies and the digital economy.

The accelerated adoption of digital technologies in the economy and the social sphere is an ambitious goal that is being successfully implemented in only a very few leading countries. It is achievable only if a number of essential conditions are met. First, business and the social sphere must be ready for digital transformation (Kaya et al., 2019). Development strategies must mature and take shape, which implies a radical change in the ways of organizing and conducting business (Yucedag et al., 2018). Such changes can be achieved through the planned intensive introduction of digital technologies, that are in demand by organizations and promising stakeholders a return on investing their own funds. Secondly, a relatively mature technology supply sector should emerge in the country, which is capable of a quick transfer and adaptation of foreign technological solutions as well as a rapid increase in the scale of its own activities (Sommariva, 2018). Thirdly, the population's demand for digital technologies should constantly grow, since namely the needs and capabilities of consumers ultimately determine the adequate demand for digital technologies, both in the B2B and B2C sectors (Cetin, 2015a, 2015b).

In recent years, studies have been conducted on the prevalence of digital technologies, regardless of the specific areas of their implementation. For example, M. A. Kantemirova et al. (2021) a study was made of the transformation of the project space for the implementation of the digital economy. According to the results of this work, the creation of a possible project environment in the digital economy is possible if there is an assumed institutional environment, reliable and systemic conditions.

In 2021, Z. Zhang et al. (2021) explored the importance of introducing such digital technology as 3D vision. Based on the analysis of one and two cameras, as well as structured light, the authors determined the functions of 3D vision in the form of accurate and high speed, which helps to optimize intelligent control in various enterprises, the ability to check the quality of manufactured products and test service equipment. The paper indicates that 3D vision technology is actively used both in the automotive industry, healthcare, nature conservation, and in the field of aeronautics and astronautics.

In recent years, Kazakhstan has been investing a fairly large amount of financial and human resources in the development of digitalization in the country. The state seeks to increase its level of international competitiveness in the world arena in this way and to become a worthy trading partner for developed countries. Kazakhstan is introducing the Digital Kazakhstan program. This initiative was proposed by the country's government. The program should be implemented in four key areas. First, it implies the creation of the "Digital Silk Road," which will support the development of digital infrastructure. Second, it aims at raising awareness of business and other sectors to increase competitiveness. Third, it focuses on the creation of digital government through advanced electronic and mobile government systems. This should make the government more open and transparent. Much attention is paid to the provision of public services. Fourth, the program aims to provide an opportunity to create a society that will be receptive to new emerging trends and challenges. At the same time, the necessary skills for the digital economy are developed. Therefore, digital literacy and learning at all levels of society are increased (Alibekova & Bapiyeva, 2019; Cetin et al., 2018).

Another step toward innovation is free vocational training and education for young people. In Kazakhstan, this is viewed as an investment in human capital. Thus, Kazakhstan expects to create a quality basis for the future development of the country (State program "Digital Kazakhstan", 2017). The digitalization of the space sphere concerns not only the management of the processes of creation, launch and regulation of space objects, but also the training of personnel so that all the described processes are implemented. In addition, the use of computer innovations in the process of training future employees of space enterprises significantly saves time, both at the stage of project preparation and during the adjustment of regulatory functions (Cetin et al., 2021). It is important do not forget that the field of astronautics requires large material investments. If workers do not have the necessary skills to work with various digital systems, the industry risks becoming unprofitable. Butterfield J. et al. (2007) the need for a transition to digital training of future space engineers and designers is considered.

According to the International Telecommunication Union's Global Cybersecurity Index, the country's position improved in 2018. In a report by the International Telecommunication Union, Kazakhstan ranked 40th in the Global Cybersecurity Index for 2018/2019, up 42 points from last year's ranking (82nd place) (Zhanbayev et al., 2020). However, Kazakhstan is still lagging behind in the innovative development of priority sectors of the economy, which affects its competitiveness. For example, according to the World Economic Forum (WEF), Kazakhstan is ranked 87th in terms of "innovative opportunities" and 74th in the World Intellectual Property Organization's index (Chkoniya, 2019). In Kazakhstan, there is an increase in the so-called digital divide due to the lag in the development of digital technologies from the level of this indicator in the developed countries of the world. According to the WEF, only 25 countries of the world are ready for the fourth industrial revolution, which is based on digital technologies (Chkoniya, 2019). Among the strategic priorities identified in the main STI policy documents, space technologies are in 19th place out of 22, while e-commerce is in 9th place (Deloitte, 2019). However, a good example here is China, which has never independently produced innovations and still does not export them, although in the ranking of the GII, it is in 54th place. The Chinese took other people's developments and implemented them. Due to this fact, the country achieved tremendous success in economic and technological development. Effectively introducing innovation and getting financial results is just as important as inventing it.

For Kazakhstan, it is extremely important to increase its involvement in digitalization issues and develop unique opportunities. That will make its economy more attractive in the course of the development of global production processes. A country's readiness for the future is determined by the scale and structure of production, as well as strong driving forces that can accelerate the transformation process. The space industry is one such driving force.

Space activities have long included entire sectors of the economy (space telecommunications, coordinate-time orientation, space imagery, etc.). While retransmission and communication services are currently well monetized and there is a well-developed market for these space services, the economic potential for other space services has yet to be fully revealed. This suggests the need to consider not only the technical capabilities of space services but also the possibility of appropriate data processing using modern artificial intelligence methods. Based on Earth remote sensing (ERS) data and regulatory information, these methods are able to objectively assess the object under study and formulate economically sound recommendations regarding the task of researching this object (Greason & Bennett, 2019). Such projects as "Digital Earth" (similar to such projects in Russia) are organically integrated into projects of the digital economy and can serve as a basis for increasing the economic efficiency of using the results of space activities.

M. Wittig (2007) in the work "Regenerative communication satellites developments in Europe, past present and future" studied the need to update communication satellite technologies in Europe using new technologies such as regenerative transponders, regenerative repeaters, turbo encoders, and technologies developed according to the DVB-RCS standard. The author of the study says that such regenerative additions make it possible to switch any type of signal from an uplink to a downlink. A detailed study of the technical concepts of the listed regenerative payloads indicates the need for the introduction of new technologies to ensure the expansion of opportunities from the use of space objects and thereby increase national influence. The importance of the development of communication satellites is determined by the high percentage of material benefits from their services. Thus, more than 80% of launches are carried out with the aim of putting satellites into the appropriate orbit. This means that the introduction of innovative digital technologies in this industry has not only scientific but also financial value.

K. Imai et al. (2002) presented an overview of the development and use of the digital satellite uplink system in Japan. Emphasis is placed on the consideration of factors that may hinder the successful operation of satellites in order to develop methods for their elimination. For example, scientists talk about automatic control of the uplink system to improve satellite performance in the event of rain. The active development of computer technologies was largely influenced by the COVID-19 pandemic, as there was a vital need to develop remote control systems for many processes. The space industry is no exception. C. Giannopapa et al. (2021) demonstrate the importance of the space industry in the extraordinary conditions faced by all the inhabitants of the planet. Scientists present space satellites as the main competitors of terrestrial communication systems. Particular attention is paid to the description of the Starlink mega constellation as an example of a successful high-tech space project. The future dependence of European telecommunications on the non-European megagroup is also predicted.

The methodological development of the article is an innovative complex of many approaches and methods that will reflect the analysis of economic digital transformation processes in the space industry. In this regard, the issues of space technologies of the future and the principles of their development, the state and prospects of the market for space products and services, the direction of development of space instrumentation, etc., are becoming extremely important. Thus, the analysis of factors and trends in the development of the space industry in the context of the digitalization of the Republic of Kazakhstan`s economy seems to be a very urgent task.

2 Research design and methodology

Digital transformation presupposes a complete transformation of the socio-economic system, its concept, and its form of functioning. Such transformation brings goal-setting to the category of extremely complex, particularly important, and responsible tasks that require close attention and scientific substantiation.

On the one hand, the goal of digital transformation appears as a consequence of the existing needs of society and the state in the digital economy. On the other hand, the choice of the goal of digital transformation is purely subjective and is determined by individuals or a group of people whose competence the solution to this problem is. Thus, when determining the goal of digital transformation of a particular socio-economic system (a country as a whole, a region or an industry, a firm or an association of firms), it is necessary to harmoniously combine business interests and strategic development guidelines, the needs of society and the interests of the state (Tuleubekova, 2020).

To conduct this study, scientists needed to carefully select scientific methods that would satisfy the requirements for achieving the goals of the study. Among the selected methods, the analysis method was used (both theoretical information and the results of practical research by other scientists), with the help of which it was possible to identify the current state of the space industry abroad and in the Republic of Kazakhstan; comparison method, which made it possible to identify the most effective approaches to the introduction of digital technologies in the space industry of the economy of Kazakhstan; the formalization method was used to study and further apply mathematical formulas; Finally, the deduction method was used to take a detailed look at the state of the space industry in Kazakhstan and determine the exact types of IT technologies that should be applied.

As a subject of research, it is traditionally accepted to define a certain problem, an existing real contradiction that requires its resolution. In the methodology of digital transformation of socioeconomic systems under the conditions of economic digitalization, as a subject, we define the interconnected unity of the set of processes for the introduction and development of transforming digital technologies. Among relevant processes, it also could be mentioned the formation of digital infrastructure, the subsequent setting of digital interaction of users in the digital space and further transformation of the model of functioning of the socioeconomic system and shifting of its digital plane with the inevitable strengthening of its service orientation. All of the listed processes are observed in the nowadays space industry.

The next element of the methodology is the set of approaches which represent the perspective of scientific knowledge that determines the direction of the research in relation to the goal. According to the analysis of literature sources, the main approaches to the digital transformation process, are sectoral (industry-wide), and technological (Neethu, 2020).

The process approach to digital transformation proceeds from the presentation of the socioeconomic system in the form of a value chain that includes the stages from the development and release of a prototype of an innovative product/service to its production, sale, and service. The sectoral approach to digital transformation is based on the study of cross-sectoral connections of the transformed system with other sectors. The technological approach to digital transformation is based on a set of technologies, the implementation of which will provide the transforming system with a transition to the digital space (Ozcan, 2020). In this study, an attempt is made to combine these approaches to analyze the factors, trends, and prospects for the development of the space industry in Kazakhstan within the framework of the general features and trends of digital transformation in the country.

In addition, attention should be paid to the formulation of the main tools for conducting digital socioeconomic transformation, which will be further considered. The main goal of such actions in the context of the methodology of digital transformation and development of the space field is to find ways to create a new model. In this regard, business processes are becoming one of the priority subjects of research and analysis, since the description of the business process is the only way to model the future state of the socioeconomic system.

The description helps to imagine how it will function after the introduction of transformational technologies.

3 Findings

In Kazakhstan, the above-mentioned program "Digital Kazakhstan" has been developed, which should become the basis for the rapid growth of technologies in the republic and reorientation to an electronic format for providing services. As the developers of the concept note, the goals of the state program "Digital Kazakhstan" (2017) are to accelerate the pace of economic development and improve the quality of life of the population through the use of digital technologies in the medium term. The second task of the program is to create conditions for the transition of the economy to a fundamentally new trajectory of development, ensuring the creation of the digital economy of the future in long term (Saparalieva, 2018). Digitalization has an impact on all sectors and will lead to a change in the structure of the economy of Kazakhstan as a whole by diversifying and unlocking the potential of non-resource industries, stimulating start-up activity, and opening new industries (Abbate et al., 2022). Meanwhile, the extent of influence of digital technologies in different industries is not uniform – the greatest potential for value creation is assumed within the framework of traditional sectors of the Kazakhstan economy, including the raw materials sector. But fundamentally new opportunities for creating value in the space industry are also opening up. Considerable efforts have already been made in this direction. According to N.A. Nazarbayev, many states, including Kazakhstan, came to understand the importance of geopolitical interests in space. As a result of such view changes, the exploration and use of outer space have become one of the priorities of national policy today (Nazarbayev, 2017). The scientific work of S. Alam et al. (2020) describes the importance of introducing IT technologies in the field of space science and aeronautics. As part of the study, an ICT committee was formed, and a leadership strategy for space institutions in the field of IT was developed.

Kazakhstan is also considered a space power – in particular, in the budget expenditures, there is a column "Development of the space industry." In 2019, the country spent about 7.2 billion tenge on this direction (Elyubaeva, 2020). However, when comparing the costs of the space industry in Kazakhstan and, for example, India, the difference is clear (Fig. 1).

After the heads of Russia and Kazakhstan signed a new agreement on the lease of the Baikonur space-vehicle launching site until 2050 in 2004, the implementation of the very

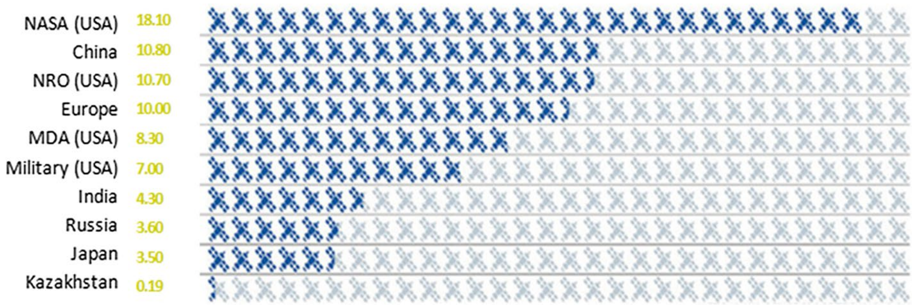

Fig. 1 Expenditure for space research, 2019, $bln

first program for space activities development in Kazakhstan began. In 2008, the regulator Kazkosmos developed a Strategic Plan for 2009–2010. According to this plan, the key task of Kazcosmos at that time was the formation of a new space industry for Kazakhstan (Kovalev et al., 2019). In addition, its priority areas were identified, such as the creation of space target systems and technologies, the development of the Baikonur complex, and spacecraft launch vehicles. The formation of a regulatory and legal framework specifically for carrying out space activities in Kazakhstan is important too. As part of this plan, two satellites were launched, the manufacturers of which, however, were the Russian State Space Research and Production Center named after M.V. Khrunichev. In 2014, a third satellite was launched. The most ambitious event in the field of regulatory support of space activities in Kazakhstan was the adoption of the Law of the Republic of Kazakhstan "On Space Activities" in 2012. The strategic plan for the development of the Republic of Kazakhstan until 2020 was approved by the Decree of the President, and in accordance with this plan, the "Strategic plan for the development of space activities" was renewed. It is emphasized that the urgent task for the Kazakh leadership is to improve and modernize the ground space infrastructure, the need for the early completion of the Baiterek space rocket complex, which will allow the launching of environmentally friendly carrier rockets, is indicated. In addition, the document notes the fact that a full-fledged market is being formed in the global economy, which is a large and rapidly developing segment of the world`s high-tech market (Zhumagaliyev, 2020).

Space rocket launches happen regularly. So, last August, a total of 12 objects were released from space stations of different countries (Fig. 2). The largest number of launches took place in China, where 6 missiles were fired, but one did not complete its task. In second place in terms of the number of launches was the USA – 3 launches and one failure. Russia, India, and the European company Arianespace each made one launch in August, but the Indian rocket failed. From the statistics, it can be seen that despite the constant improvement of launch and design technologies in the space sphere, cases of unsuccessful

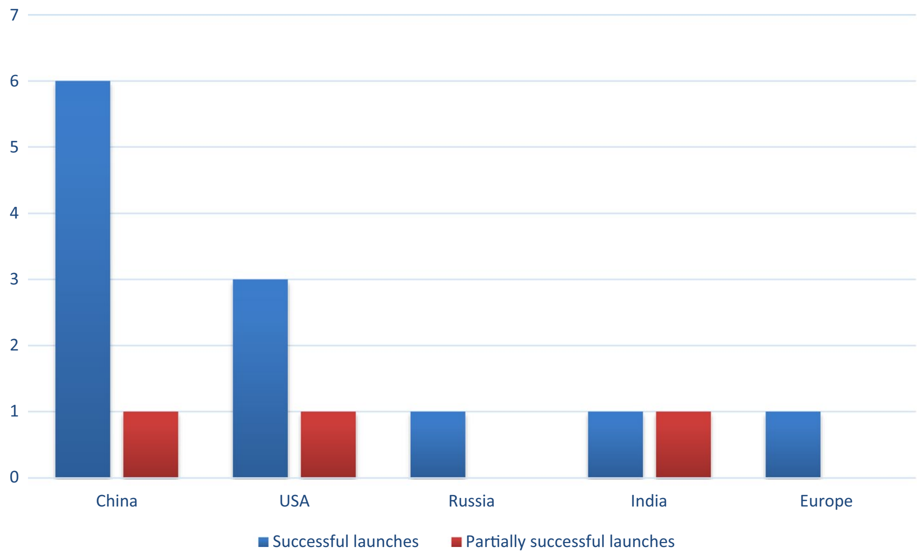

Fig.2 Rocket launches from spaceports in different countries in August 2022, modified from Space statistics…, 2022

rocket launch still occur. In view of this, an important task both for Kazakhstan and for other countries with developing space potential is the digitalization of all processes occurring within the stations. Digitalization of the space sphere will help minimize unsuccessful launches and help avoid material losses.

C. J. Newman (2019), for instance, studied the provisions of the space industry law in the UK in 2018. In the work, the scientist subjected a similar law, approved in 1986, to a critical analysis. The government's arguments were also considered regarding the launch of a bill with the aim of developing space launch systems and the infrastructure necessary for this in the country. According to the law considered in the article, the space economy will develop by facilitating the process of entering the market of space startups. Taking into account the national course to ensure the digital economy in all priority areas, the development of the space industry in the UK will also fall under the influence of digitalization with the introduction of new computer technologies.

It should be admitted that this Strategic Plan has been implemented much more efficiently than its predecessors' it contains a constructive analysis of the strengths and weaknesses of Kazakhstan in the area of cosmonautics development, and sets goals and objectives commensurate with the real capabilities of the space sector of the Kazakhstani economy. In general, the conceptual foundations for the space activities development in Kazakhstan are laid down in numerous program documents and constitute a single basis on which the space policy of Kazakhstan is built. Space activities of the RK are just beginning to develop, in contrast to other countries of the "space club." Perhaps precisely because of the lack of experience in this area, Kazakhstan often faces problems in the implementation of projects (extension of terms, poor-quality fulfillment of orders for the manufacture of satellites, lack of highly qualified personnel, and so on).

Today, the country's participation in space programs is enshrined in many documents signed at various meetings, aerospace shows, etc. Thanks to this, Kazakhstan is able to adopt the experience of countries with developed space industry. Managing and coordinating the implementation of all projects and development programs in the space industry is carried out by the organization "Kazakstan Garysh Sapary" the activities of which include the implementation of several goals. Firstly, control and processing of all data of remote sensing of the Earth. Secondly, solving the needs of various sectors of Kazakhstan`s economy, from preliminary processing of images to automated thematic analysis and creation of geoproducts. The space industry of Kazakhstan is represented by several complexes – the only launch site in the CIS (Commonwealth of Independent States), the Baikonur, ground infrastructure that has been created in recent years, space research institutes, and two satellite constellations. Two satellite constellation is the KazSat communication system, which consists of two working satellites and a system for remote sensing of the earth (at the moment 3 satellites are working on it). In addition, an assembly and testing complex (SBiK) of spacecraft near the city of Nur-Sultan was commissioned last year. It should be noted that SBiK is an enterprise where preparatory work and tests are carried out, and a number of components of space technology are also produced, including assembly. Over the years, thanks to space industry development, Kazakhstan has placed itself among the number of highly developed international states. At the moment, in the CIS whole territory, only Russia and Kazakhstan have satellites in Earth orbit.

Meanwhile, the decision to terminate the KazSat-2R project is one of the signs of a serious reorientation of the Kazakhstani space program. The national space industry again found itself at a crossroads – in his report, the Minister for Innovation justified the decision to abandon the development of the Kazakh satellite constellation KazSat by the presence of more cost-effective and innovative solutions (Zhanbayev et al., 2020).

Back in 2018, it was planned to launch the next KazSat-2R satellite using a Russian rocket. The first device of this series, developed and assembled at the M.V. Khrunichev, got out of order in June 2008. The “unlucky” KazSat worked for only 2 years instead of 15 years. As a result, the KazSat program unlikely can only be called a real “satellite constellation”, because, over the 15-year history of the project, only two working geostationary satellites were received: KazSat-2 and KazSat-3. For the time being this was enough to provide all services related to television, Internet, and mobile communications. But this word “enough” is the problem, since the use of satellites, which ‘hang’ at an altitude of 35,786 km above the earth’s surface, means that “the entire telecommunications industry in Kazakhstan is in a deep pit of technologies of the last century” (Drozd, 2020). Meanwhile, the world has entered the era of ubiquitous broadband data access that is sensitive to the rate at which a satellite signal is transmitted to tracking antennas on the ground or on board a vehicle. However, geostationary satellites, which include KazSat, have a fundamental drawback precisely because they are inferior to low-orbit spacecraft in terms of signal response speed. That is, any communication network that the country would try to build with the help of KazSat will work slower than the new LEO satellites. Apparently, Kazakhstan no longer feels technologically connected with the Russian rocket and space program, relying on the purely economic feasibility of space projects, and not on the long-term perspective.

Indeed, after the rapid development of cosmonautics in the 60 s and 70 s, the time has come for the forced rethinking of expensive projects by the main players: the Soviet Union and the United States. The logical consequence of this reflection were two big events that occurred ten years apart: the flooding of the Soviet (and later Russian) Mir orbital complex in the Pacific Ocean and the closure of the Space Shuttle program. Throughout the 1990s, a new technological order was growing and forming in the world, which brought a large group of developing countries to the level of full-fledged space powers. Even by such a simple indicator of activity as the number of annual spacecraft launches, India, China, and Pakistan suddenly began to take the lead. As a result, many countries entered the twenty-first century with an already formed strategy of exploration and landing on space bodies in the nearest space. The pivot of the new lunar expansion was the agreement on the joint creation of the lunar station, announced by the American space agency NASA in 2017 (Main trends and challenges in…, 2019). In accordance with the plan, the launch site for the exploration of the moon will be an orbital station called Gateway, which will be built in circumlunar orbit. So far, four countries have joined the American lunar program: Australia, Japan, Italy, and Great Britain. In reality, the partnership will certainly be broader.

In parallel with the American lunar program, which implies a wide international association, which are several national astronaut landing projects. Among them, it is worth highlighting the Russian and Chinese segments. As in the case of NASA, the lunar station should become the first frontier for the landing of Russian manned spacecraft. The ultimate goal of the program will be to create a long-term lunar base that will work for at least 5 years. As for the timing, Russian researchers are looking at their capabilities more “soberly” by postponing the landing of astronauts to 2030 (Mukherjee, 2018). As for the Chinese lunar exploration program, there is some possibility that it will transform from a purely national project into a relatively broad international concession. in connection with the latest statements by the Roskosmos leadership, this program will include Russia and partly Europe. Against this complex international background, Kazakhstan will have to somehow build its own main path of space program development. A huge advantage of the country is that Kazakhstan initially has a more solid position in the world market for the division of space roles. Namely, on its territory, the largest operating launching site in the world is located. This opens up wide opportunities for cooperation, not only on the basis of traditional cooperation but also competition. Simple providing leasing of the launching site is the worst of all possible options, corresponding only to the rental economy of the nineteenth century.

Precisely because of the lack of efforts to create effective partnerships, Kazakhstan is not such commercially successful as Russia in the space area. For example, the partnership with NASA alone since 2011 has brought Russian Roscosmos more than $2.6 billion (Undseth et al., 2020). The RK government logically believes that the space industry should be developed in partnership with its neighbor (Russia). According to these plans, the Baiterek space rocket complex will appear at Baikonur by the end of 2023. The Russians will make new middle-class missiles Soyuz-5, and Kazakhstan will create a ground complex and infrastructure for them. For the implementation of the project, the budget in 2020 allocated 1.7 billion tenge, and by 2022, expenditures will reach 45.7 billion (Karpovich et al., 2020). Another project is the modernization of launch pad No. 1 – "Gagarinsky Launch," from which spacecraft of various customers will be launched into low-earth, sun-synchronous and geostationary orbits. According to ICRIAP, the total investment in the project will amount to $87 million, and Russia and the United Arab Emirates will be part of the "share" with Kazakhstan. However, the participation of Kazakhstan is again limited only to services and the provision of leases of facilities. Such a partnership is not strategic, and even less conducive to the development of the digital economy in the country.

Sometimes, one hears that Kazakhstan cannot afford space exploration and that space technologies are the privilege of great powers (Ozcan, 2020). Meanwhile, the space industry of Kazakhstan has already become an integral part of the national economy – the products and services offered by the enterprises of the industry are in growing demand. In particular, the Ministry of Agriculture is one of the main consumers of space monitoring services. Kazakhstan has a developed system for collecting geodata and processing them using elements of artificial intelligence. The geodata market is systematically shifting from the supply of "raw" information from the satellite to the provision of ready-made analytics. Thanks to the Digital Earth project, satellite images of the entire territory of the country are becoming publicly available, and innovative digital services for processing Earth remote sensing data appear. Some of the software modules of Digital Earth are already working in experimental mode. Among them, there are specialized industry information and analytical services.

Within the framework of the state investment project "Creation and commissioning of a medium-resolution Earth remote sensing space system," it is planned to create and launch three ERS satellites, modernize the ground-based complex of the ERS space satellite, and a ground-based target complex for receiving and remote sensing data processing. The second one includes a ground-based control complex for an ERS optical satellite of medium resolution (Drozd, 2020). It is assumed that the implementation of the Project will provide the following results (Zhumagaliyev, 2020):

- to receive high-quality RS ERS products with competitive characteristics in comparison with foreign counterparts;
- to reduce the cost of geoproducts due to the high performance of the system;
- mastering new skills and technologies for the production of space systems, as well as increasing the competence of Kazakhstani specialists;
- to increase the percentage of Kazakhstani content in the production and operation of space systems up to 50%;
- to stimulate the development and bring Kazakhstani technologies to the world market;

- to replenish the satellite of the RK ERS CS of medium resolution;
- to create a multiplier effect from the development of the space industry through the effective use of space infrastructure, including the design and construction, and production capacities of the Republic of Kazakhstan.

In 2020, space monitoring of agricultural lands was carried out in six regions of Kazakhstan: Akmola, North Kazakhstan, East Kazakhstan, Almaty, Karaganda, and Zhambyl. Based on the analysis of remote sensing data, more than 1 million hectares of unused arable land, 19.7 million hectares of unused pasture land, and 367 thousand hectares of unaccounted land were identified (Zhanbayev et al., 2020).

So, the space industry is one of the leading modern industries that contributes to the development of the national economy. The digital transformation of the economy also has a significant impact on the space industry. The main approaches to the implementation of digital transformation are a fundamental increase in the efficiency of economic processes, the formation of fundamentally new economic models, and the creation of innovative products and services.

In the same 2020, the Competence Center for Geospatial Data Analysis was created. This means that all the data that are received from earth's remote sensing satellites and those received from precision navigation systems will be collected in one center, and will be combined into finished products. So that they can be used by builders, power engineers, and farmers. This is a much-needed center for applied cosmonautics. The digital transformation of many processes will help to better allocate tasks, and create new implementations, so this has positive practical implications for managers who explore the consequences of co-creation processes.

4 Discussion

Another important area where satellite imagery can be of significant use is accounting for greenhouse gas emissions. Today, neither in Kazakhstan nor in the world there is a single accepted methodology that would allow assessing the impact of both individual enterprises and households and entire states on the environment. Estimates of a country's carbon balance using different methods can vary significantly. This may be due to, for example, land transfer from one type of use to another or overgrowth of agricultural land (Main trends and challenges in…, 2019). Space imagery data are perfect for solving the problems of generating relevant statistics, and the available artificial intelligence technologies will allow such large-scale work to be done faster due to the automation of processing information from satellites.

Today, space is entering its traditional spheres among which forestry and agriculture, subsoil use, and emergency situations, with innovative products. Also, it is actively exploring new markets: banks, insurance, and investment areas. Without space data, the solution to issues in the field of eco-monitoring, the formation of environmental passports of enterprises, and ratings of environmental pollutants are unthinkable. Digital space services can make the economy of Kazakhstan more transparent and give a concrete economic effect (Measuring the economic impact of…, 2020). Historically, space technology development, like a locomotive, contributes to the rise of other sectors of the economy. The presence of its own remote sensing system is of great strategic importance for increasing the efficiency of various sectors of the country's economy. For example, the presence of a remote sensing system will allow obtaining independent and prompt access to remote sensing data for national institutions for solving their tasks in agriculture, in emergency situations, in the field of ecology and nature management, land use, geodesy, cartography, defense, and national security. In particular, space technologies open up great opportunities in water resources management. In particular, today in Kazakhstan, there are about 4 thousand reservoirs with an area of 100 thousand square km. The lack of control over their condition has repeatedly led to tragic consequences. The use of remote sensing data in forest resources management is no less promising. Space monitoring makes it possible to update the forest cadastre databases, assess the consequences of forest fires, and control the processes of wood cutting and reforestation (Undseth et al., 2020).

A wide field for the use of remote sensing is also available in the energy sector, subsoil use, and geological exploration. For example, mapping the subsoil use infrastructure, monitoring environmentally hazardous objects, developing an electronic map of the location of power lines, and identifying places of damage and unauthorized tie-ins into pipelines. However, the use of artificial intelligence methods significantly expands the possibilities of objective analysis of Earth`s remote sensing data. The greatest added value of a remote sensing service can be achieved when using space services in a complex. Therefore, there is a need to talk about the creation of an intelligent space system. This system should include both space technologies for remote sensing, telecommunications, coordinate-time positioning, and intelligent data analysis tools. The creation of such a system will allow solving problems of objective analysis and monitoring of various processes, as well as the development of economic recommendations.

According to experts, the introduction of end-to-end digital technologies makes it possible to achieve multiplier economic growth (Berdykulova et al., 2014). Western expert agencies highly appreciate the effect of the digitalization of the economy in developed countries – a doubling of economic growth rates and an increase in labor productivity by 40% (Neethu, 2020). Such growth should be expected in Kazakhstan, where attention is paid to economic digitalization at the state level. To describe the growth in the aggregate productivity of factors under the influence of space information, let us consider the Nelson-Phelps model as a basis (Ozcan, 2020). It argues that the rate at which technology spreads, on average, depends on the level of education and competencies of workers. Dependence on the value showing to what extent the current level of technology development is less than some "theoretical" achievable with the instantaneous diffusion of technology exists as well. Under these conditions, the growth of the aggregate productivity of factors under the influence of space information can be mathematically expressed by the following ratio:

$$R(A(T)) = c(t)\left(\frac{T(t) - A(t)}{A(t)}\right), \tag{1}$$

where, c (t) is a function that depends on the level of specialists' competence development in the field of using space information to manage economic processes; T(t) is the theoretically possible level of development of technologies in the field of using space information for managing economic processes, which would take place if all the necessary technologies were developed and implemented immediately (i.e., in the absence of a time lag between the emergence of technology and the beginning of it industrial development).

The region`s economic growth, under the digital technologies influence, relates to the region's infrastructure development level, which ensures the use of digital technologies. Infrastructure development in our model can be taken into account using the infrastructure development indicator g (t) $\in$ [0, 1]. Meanwhile, the maximum value of the indicator, equal to one, indicates sufficient preparation of the infrastructure for digital technologies, while zero indicates the complete absence of infrastructure. The growth of the aggregate productivity of factors under the influence of space information, with the consideration of the indicator of infrastructure development, will be defined as follows:

$$R(A(T)) = \gamma(t) \cdot c(t) \cdot \left(\frac{T(t) - A(t)}{A(t)} \right) \tag{2}$$

The gap between the theoretical and real level of development of technologies on which space services are based can be measured by the entropy H of space information required to control economic processes. In this sense, entropy is not only a measure of the quantitative assessment of space information itself but also a measure of the development (innovativeness, progressiveness) of technologies for processing this information in order to obtain economic knowledge. Quantifying information is an essential concept in information theory. Such an assessment measures information flows and their effectiveness, regardless of their nature. The processes of development of space and digital terrestrial infrastructure lead to rapid growth in the amount of information received from space. To process big data from space, new algorithms are being developed that allow, based on space information, using modern mathematical methods (artificial intelligence and machine learning, Data Mining, etc.) to extract economic knowledge. They give an idea of the economic state of the object, and the space information about which has been received. In particular, the Digital Earth project involves the implementation of a number of works aimed at creating a domestic digital platform for collecting, processing, storing, and distributing remote sensing data. Such a platform will meet the needs of authorities, businesses, and civil society in the operational and relevant information in the format of GIS services.

An important element of the potential for civilian applications of space information is the integration of space services and information products for the management of the regional economy. Thus, a set of cross-industrial information innovations of the space industry is formed, the elements of which should form an offer to potential consumers of information services under various conditions. This innovative approach helps to accelerate and increase the efficiency of digital transformation processes in the country.

5 Conclusions

Today the global economy is changing, and Kazakhstan needs to find its place in it again. As a starting maneuver, the Government chose a strategy for accelerated digitalization of ten industries, including energy, agriculture, industry, logistics, and the information technology sector. However, the space industry is not included in the number of these designated priority sectors, possibly due to the regulators' understanding of the lack of appropriate scientific potential and qualified personnel. Meanwhile, in the new economy, the concept of economic growth has been replaced by the concept of economic development associated with the process of introducing digital innovations. The promotion of the space sector as a key driver for the development of the digital economy has become a worldwide trend.

In contrast to the linear innovation model, when the costs of innovation are gradually transformed into the results of innovation, in the digital economy, various types of innovation develop in parallel with each other and are characterized by constant improvements due to feedback from consumers. In traditional industries, economic value is created within the enterprise. In the digital economy, value is created outside the enterprise at the time of interaction between partners, suppliers, and customers. The growth in partnerships and networking across industries underscores the need to pool resources to invest in R&D and pool scarce digital skills and competencies. The most important competitive advantage of the digital economy is the ability to capitalize on open innovation.

The popularization of the space industry can also be enhanced by digital transformation. This innovation will help create economic stabilization, improve the level of progress in modern trends, and create more promising compatible projects in this sphere with other countries. The space industry can and should become the locomotive of Kazakhstan's innovative development. This is one of the few sectors where the economy of the fifth and sixth technological orders is concentrated. It has the necessary technological infrastructure for further development and has a high level of integration with world technology leaders. The space industry creates a demand for the development and application of new technologies – in the creation of composite materials, software development, assembly, and testing of spacecraft. At the same time, it supports the demand for highly qualified engineering and labor personnel and is able to become one of the central elements of the national innovation ecosystem. However, it will be possible subject to the implementation of mutually beneficial promising strategic partnerships with leading space powers.

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Declarations

Conflict of interest The authors declare that there is no conflict of interest.

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