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Comparative analysis of the main R&D indicators in OECD countries and Kazakhstan

Abstract. In this article, author analyzes the research and development (R&D) indicators of Organization for Economic Co-operation and Development (OECD) member countries and the Republic of Kazakhstan. R&D is the main driver of innovation, so R&D expenditure is a key indicators used to monitor resources devoted to science and technology worldwide. This paper outlines topical issues of foreign experience in financing research and development on the example of OECD countries. The following tasks were set in this research: to do a comparative analysis of R&D financing in mentioned countries and reveal the leading countries; identify a number of patterns inherent in OECD countries and Kazakhstan in recent times. The study is based on statistical analysis of expenditures on R&D of countries and its structures, such as total, government, high education, and business expenditures. In addition, author use data from Global Innovation Index and ranking of top 100 innovative universities by Reuters. The results suggest that countries that pay great attention to R&D financing are on leading positions in the world, and these countries have formed the best innovative universities in the world that are engaged in the latest developments and work at the forefront of science and technological progress, which stimulates the economy to grow.

Keywords: OECD, Kazakhstan, innovation, technology, science, research and development, innovative universities.

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Introduction. In 2011, Kazakhstan started the process of accession to the OECD and to Committees on education, entrepreneurship, investment, agriculture, industry and innovation. To join the committees, the OECD requires the applicant country to actively participate in its projects and implement the principles. Currently Kazakhstan is experiencing a period of complex system changes aimed at improving the level of science, technology, innovation and education in terms of globalization and internationalization. Analyzing the experience of OECD countries in development of innovations is very important to define ways and prospects for Kazakhstan. OECD countries have accumulated sufficient experience in the modernization of the economy, taking into account both global trends and specific features of national socio-economic development. Science, technology, and innovation currently are a key to improve economic performance and social well-being. R&D is the main driver of innovation, and R&D expenditure and intensity are two of the key indicators used to monitor resources devoted to science and technology worldwide. Governments are increasingly referring to international benchmarks when defining their science policies and allocating resources [1]. Support to R&D has a crucial role not only for companies but also for

a country's economic growth and sustainable development by increasing competitiveness and social wellbeing. Therefore, it is important to analyze R&D in complex in context of both government and higher education sectors [2].

Task setting. In this regard, R&D indicators are crucial for monitoring scientific and technological development, and its analysis will help to show the attention paid to research and development, make an assessment of which countries are investing in science and the structure of these investments.

Research methods. The theoretical and methodological bases of the article are the works of scientists from CIS and OECD countries. As a methodological basis of the study, the author uses a systematic functional and statistical analysis. For this study, author analyzes the data collected from OECD statistics, Clarivate Analytics, data of Global Innovation Index and Reuters Agency.

The Organization for Economic Co-operation and Development is an international organization that works to build better policies for better lives. Its goal is to shape policies that foster prosperity, equality, opportunity and well-being for all establishing international norms and finding evidence-based solutions to a range of social, economic and environmental challenges [3]. Today, the organization has 36 member countries (see Table 1).

Table 1

OECD member countries

Country	Date	Country	Date	Country	Date
Australia	7 June 1971	Hungary	7 May 1996	New Zealand	29 May 1973
Austria	29 September 1961	Iceland	June 1961	Norway	4 July 1961
Belgium	13 September 1961	Ireland	17 August 1961	Poland	22 November 1996
Canada	10 April 1961	Israel	7 September 2010	Portugal	4 August 1961
Chile	7 May 2010	Italy	29 March 1962	S l o v a k Republic	14 December 2000
C z e c h Republic	21 December 1995	Japan	28 April 1964	Slovenia	21 July 2010
Denmark	30 May 1961	Korea	12 December 1996	Spain	3 August 1961
Estonia	9 December 2010	Latvia	1 July 2016	Sweden	28 September 1961
Finland	28 January 1969	Lithuania	5 July 2018	Switzerland	28 September 1961
France	7 August 1961	Luxembourg	7 December 1961	Turkey	2 August 1961
Germany	27 September 1961	Mexico	18 May 1994	U n i t e d Kingdom	2 May 1961
Greece	27 September 1961	Netherlands	13 November 1961	United States	12 April 1961

Source: <https://www.oecd.org/about>

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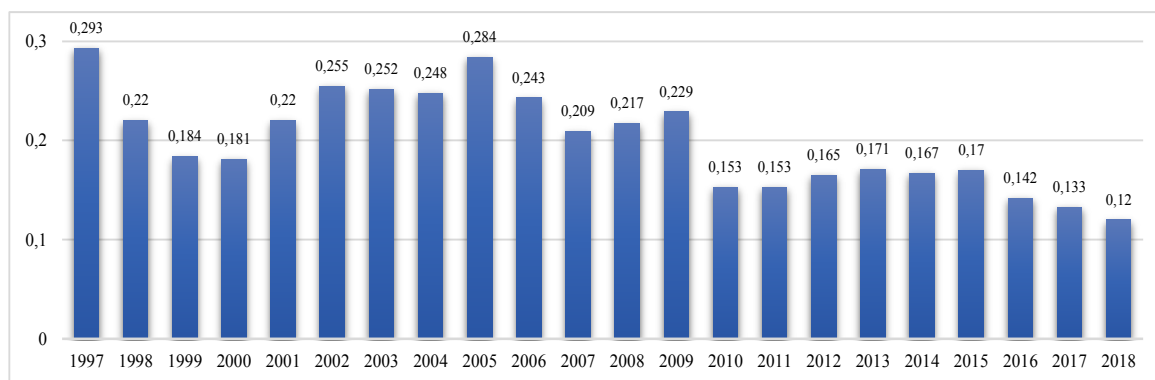
In 1972 OECD founded Committee for Scientific and Technological Policy which current goal is to promote cooperation between OECD members and partners in the field of science, technology and innovation (STI) policies to achieve economic, social and scientific goals, including job creation, sustainable development, improving the well-being of citizens, and promoting knowledge. On July 22, 2017, Kazakhstan was invited to the Committee for Scientific and Technological Policy (CSTP) in the status of «Participant» (Kazakhstan approved the invitation on September 6, 2017). As part of participating in the meetings of this Committee, countries have the opportunity to receive assistance in improving state policies in order to promote innovations and technologies for sustainable economic development, support for improving their scientific policies, and benefit from international cooperation.

Science, technology and innovation (STI) are universally recognized as key drivers for poverty eradication and essential components for achieving the Sustainable Development Goals. As mentioned above, the Committee supports and gives recommendations to countries in developing effective STI policy. To develop innovations in science and technology in our country, it is necessary to consider the experience of countries in forming this policy. First, we will define countries with high level of science and technology indicators. They are crucial for monitoring scientific and technological development, and useful for formulating, adjusting and implementing STI policies. Indicators are normally used to monitor global technological trends, conduct foresight exercises, and determine specific areas of investment [4]. The gross expenditure on R&D includes the expenditures on R&D from high education, business enterprises, government and private non-profit organizations [5].

The following main science and technology indicators are used as a statistical material for analysis:

- 1) Gross expenditure on R&D (GERD) as a percentage of GDP;
- 2) Percentage of GERD performed by the Higher Education sector;
- 3) Higher education expenditure on R&D (HERD) as a percentage of GDP;
- 4) Government expenditure on R&D (GOVERD) as a percentage of GDP;
- 5) Business education expenditure on R&D (BERD) as a percentage of GDP;
- 6) Other indicators of innovative universities.

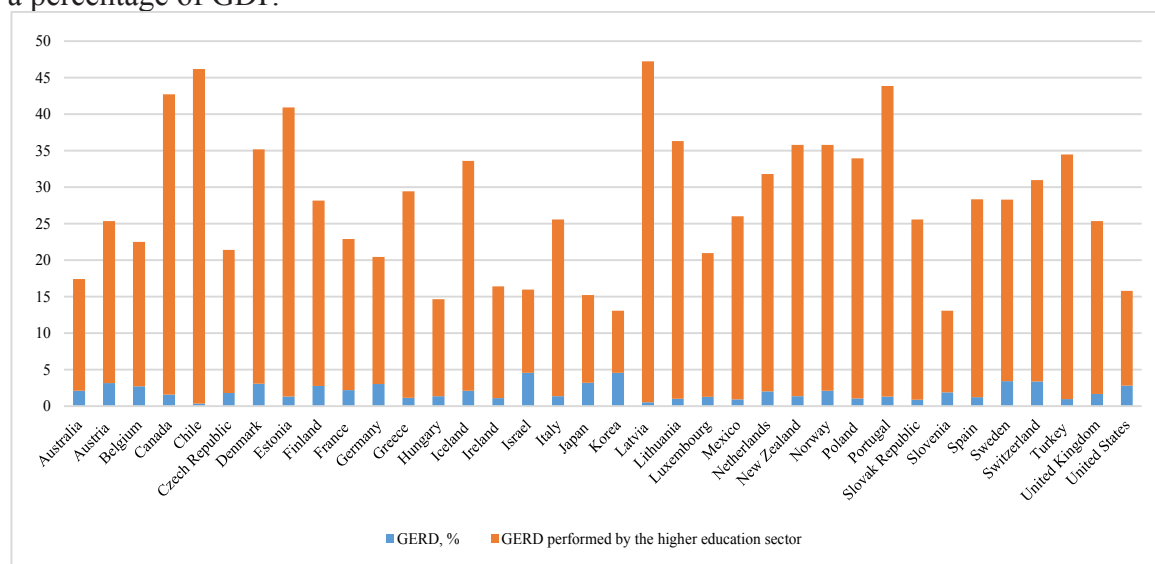
Results and discussion. According to OECD Statistics, GERD is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. Figure 1 represents Kazakhstan research and development expenditure as a percentage of GDP over the past 21 years from 1997 to 2018.



Source: UNESCO Institute for Statistics

Figure 1. Kazakhstan - Research and development expenditure (percentage of GDP) over the past 21 years

The average value of R&D expenditure for Kazakhstan during 1997 to 2018 period was 0.2 percent with a minimum of 0.12 percent in 2018 and a maximum of 0.29 percent in 1997. There is clearly a downward trend in the past few years. To illustrate and benchmark Kazakhstan's R&D ecosystem, we compare a few key R&D indicators with those of a number of other countries – OECD members. The indicators of these countries are much higher than in Kazakhstan. Figure 2 shows 36 OECD countries gross domestic expenditure on R&D performed in the each country, as a percentage of GDP.



Source: OECD statistics

Figure 2. OECD countries - Gross expenditure on R&D as a percentage of GDP in 2017

It can be seen from the Figure 2 that developed countries like South Korea, Israel, Sweden, Switzerland, and Japan have the highest level of GERD as a percentage of GDP, 4.54%, 4.55%, 3.4%, 3.37% and 3.21% respectively. This indicator in the USA is 2.8%. These countries are seeking to increase substantially public and private spending on R&D. This means that mentioned countries allocate significant funds from GDP for the R&D, but expenditure of the higher education sector in these countries occupies a smaller part out of total GERD. Most likely, the financing of research in this case comes from the business, government sector and non-profit private organizations.

According to the second indicator, GERD performed by the higher education sector, Latvia (46.7%), Chile (45.8%), Canada (41.1%), Portugal (42.5%) and Estonia (39.6%) show the highest values that are higher than in other countries. It demonstrates that more research and development of innovations take place within the walls of universities and institutions of higher education. In 2017, GERD performed by higher education sector was 19.13% in Kazakhstan [6].

National innovation systems differ from each other in a variety of forms, methods and sources of financial support for innovation. In developed countries, funding is provided from both public and private funds. In countries with economies in transition, the bulk of investment in innovation is made up of centralized funds [7]. The distribution of financial resources for R&D between the public and business sectors in 2017 in different countries can be analyzed next.

We show in Table 2 the highest and lowest expenditures of OECD countries for HERD, GERD, BERD, and GOVERD as a percentage of the country's GDP. It is clear that there is a large spread in these values, and variations in the proportions from each sector are characteristics of each country's economy and strengths or weaknesses [8].

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Table 2.

Highest and lowest HERD, GERD, BERD and GOVERD of OECD countries for 2017

Highest HERD (%GDP)		Highest GERD (%GDP)		Highest BERD (%GDP)		Highest GOVERD (%GDP)	
Denmark	1.01	South Korea	4.54	Israel	3.91	South Korea	0.49
Switzerland	0.9	Israel	4.55	South Korea	3.62	Germany	0.41
Sweden	0.86	Sweden	3.4	Japan	2.53	Luxemburg	0.33
Austria, Finland, Norway	0.7	Switzerland	3.37	Sweden	2.42	Czech Rep	0.31
		Japan	3.21	Switzerland	2.34	Norway	0.29
		USA	2.79				
OECD	0.41	OECD	2.37	OECD	1.67	OECD	0.24
Lowest HERD (%GDP)		Lowest GERD (%GDP)		Lowest BERD (%GDP)		Lowest GOVERD (%GDP)	
Slovak Rep.	0.22	Turkey	0.96	Spain	0.66	Iceland Denmark Turkey	0.09
Slovenia	0.21	Mexico	0.9	Greece Turkey	0.55	Portugal Israel	0.07
Hungary	0.18	Slovak Rep.	0.88	Lithuania	0.3	Chile Ireland	0.05
Chile	0.15	Latvia	0.51	Latvia	0.14	Switzerland	0.03
Mexico	0.13	Chile	0.36	Chile	0.12	Poland	0.02

Source: Main Science and Technology Indicators, Volume 2019 Issue 1

As we can see from our analysis of statistical data, European countries are leading the way in terms of indicators. Large amount of funding for research and development in these countries leads to a high rates of innovation, technology and business, human capital and education development. This is demonstrated by the high index of innovation and high positions in world rankings. Moreover, development and stable growth of the economy and the transition to a new technological level are the most important effect of effective innovation policy. Table 3 shows GERD by source of funds (%) in Kazakhstan in the period between 2010-2018.

Table 3

GERD by source of funds (%) in Kazakhstan, 2010-2018

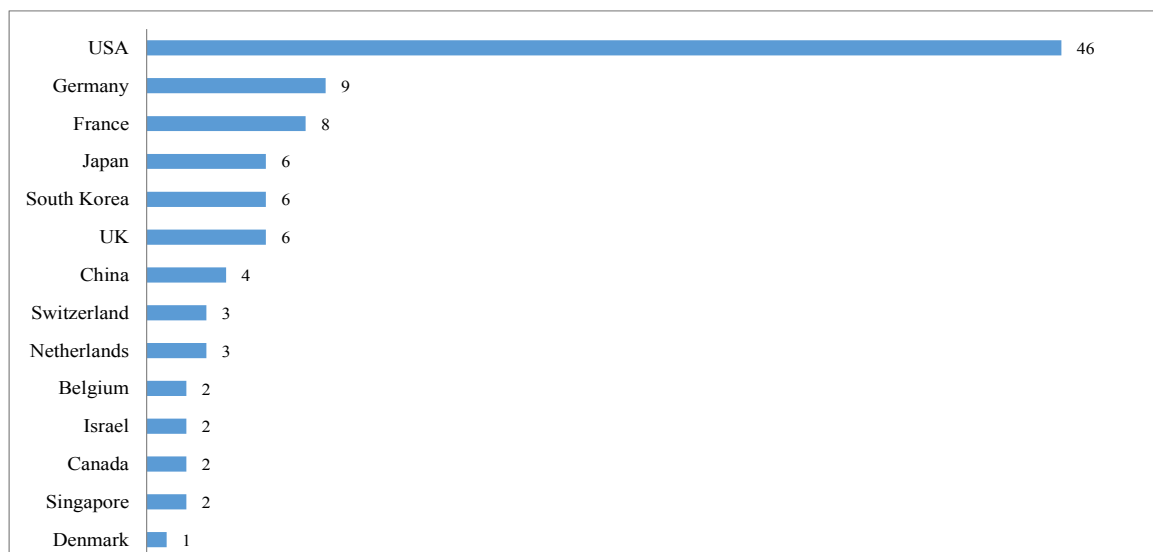
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Business enterprise	36.60	51.59	...	28.92	29.93	36.59	39.62	40.92	47.42
Government	36.73	24.89	...	63.68	65.33	58.76	53.21	52.23	44.51
Higher education	17.21	16.35	...	...	0	...	...	...	...
Private non-profit	8.89	0.27	...	...	0	...	...	...	...
Funds from abroad	0.58	0.27	...	0.76	0.74	1.81	1.53	1.85	2.66
Not specified	0	0	...	6.64	4	2.85	5.63	5	5.41

Source: UNESCO UIS

As can be seen from the table below the largest part of the financing of internal R&D expenditures come from the national budget – 44.5%. The share of business expenses on research is 47.4%, while other sources – 8% [6]. Specifically, there are no statistics on the higher education and non-profit organization expenditure in the database. In any case we see that most of the expenses are financed by the government of the Republic of Kazakhstan.

According to Global Innovation Index 2017-2019 rankings these countries are also on the top 10 level and they occupy leading positions in their regions [9, 10]. Switzerland ranked 1st place and Sweden – 2 in this ranking in 2019. According to this rating, Kazakhstan is ranked 79th (in 2018, it was 74th). So, what is the peculiarity of the innovation policy of these countries? Why do they evade the contribution of innovation to the economy and show growth? As we can see, these countries have highest HERD, GERD, BERD values. It is worth noting that business funding of R&D activities is significant which means that business innovation plays an important role in the country's economy [7]. The activity of business entities in financing innovation activities in these countries was achieved due to the favorable investment climate in the country, the widespread use by governments of methods of financial stimulation of innovation activities, as a result of which the load on the state budget of these countries was reduced.

Leading universities around the world invest millions in modern equipment, development and expansion of the scientific and technical base. University research, science and technology parks are important tools-not only for creating and maintaining employment in modern high-tech industries, but also as places where discoveries occur and the “economy of the future” is born. The sphere of R&D, as a link between science and production, can no longer remain without the proper attention and support of the state. Here we reviewed the ranking of the most innovative universities in the world called Reuters Top 100: The World's Most Innovative Universities - 2018. It is a list that identifies and ranks the educational institutions doing the most to advance science, invent new technologies and power new markets and industries. In general, Figure 4 shows that the United States prevail in the list, with 46 universities in the top 100. It is known fact that research and technology are an important part of public policy of the USA. In this context, a multi-stage structure that develops innovative research, development and production in the United States is an effective system that has been producing results for decades. Next, Germany is the 2nd best performing country with 9 universities. France rank 3rd, with 8 universities on the list; Japan, South Korea and the United Kingdom each have 6; China has 4; the Netherlands and Switzerland have 3; Belgium, Canada, Israel and Singapore have 2, and Denmark has 1 [11].

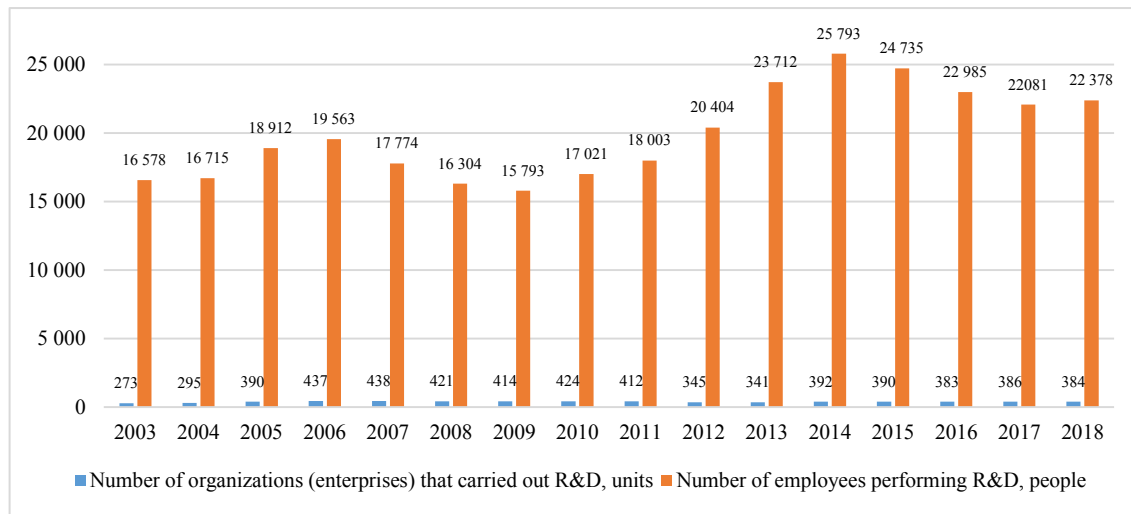


Source: Clarivate Analytics

Figure 4. Countries ranked by number of innovative universities in the Top 100 (2019)

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The main indicators of statistical analysis in the field of R&D also include – the number of research organizations and the number of employees who performed research and development. In the next bar chart, we can see the dynamics of changes in these indicators from 2003 to 2018 in Kazakhstan (Figure 3).



Source: Statistics committee

Figure 3. Main science and technology indicators of Kazakhstan, 2003-2018

By the beginning of 2018, 384 organizations engaged in research and development work in Kazakhstan, compared to the maximum number for 424 enterprises eight years earlier and the minimum number for 273 in 2003. The number of employees performing R&D increased to 22,378 compared to 22,081 employees a year earlier. Overall, for 15 years, these figures ranged from 15,793 to 25,793 people. There was no continuous growth, as there were periods of decline in 2009 and 2017.

Conclusion. Despite numerous initiatives in recent years, Kazakhstan’s innovation system is still in its infancy in many respects. Business innovation remains weak and undiversified [12]. The exact values of several indicators were not found by the author, which makes it clear that such statistics are not in the public domain or they are not maintained.

Based on the analyses it can be noted that Kazakhstani innovative development indicators are significantly lower than OECD countries, namely:

- gross expenditure on R&D only 0.12% and has tendency to decrease yearly;
- absence of Kazakhstani universities in the rankings of innovative universities;
- most of the expenses are financed by the government of the Republic of Kazakhstan.
- low R&D expenditures and capability of the private business firm. These challenges considerably affect the development of the country’s innovative economy since financing and investment play an important role in the implementation of any project.

Having studied the world practice of financial support for innovation activities, we can see a number of patterns inherent in OECD countries in recent times: first, the role of innovation as a factor of economic growth and improving the country’s competitiveness is gradually increasing, which causes the interest of countries and corporate structures to increase the volume of investment in R&D. Secondly, as the economy develops, the share of non-government sources in financing innovation activities increases, while the government’s share remains mainly financial support for basic research and the creation of innovative infrastructure. Governments aim to stimulate and activate the development of innovative private business. Third, countries that pay great attention to R&D financing are on leading positions in Global Innovation Index, and these countries have

formed the best innovative universities in the world that are engaged in the latest developments and work at the forefront of science and technological progress, which stimulates the economy to grow.

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ЭЫДҰ елдері мен Қазақстандағы зерттеулер мен әзірлемелер көрсеткіштерін салыстырмалы талдау

Аңдатпа. Бұл мақалада автор Экономикалық ынтымақтастық және даму ұйымына (ЭЫДҰ) мүше елдердің және Қазақстан Республикасының зерттеулер мен әзірлемелер көрсеткіштерін қарастырады. Зерттеулер мен әзірлемелер инновацияның негізгі қозғаушысы болып табылады, сондықтан оларға жұмсалған шығындар бүкіл әлемде ғылым мен техникаға бөлінетін ресурстардың мониторингі үшін пайдаланылатын негізгі көрсеткіштер болып табылады. Сондықтан зерттеу шеңберінде келесі міндеттер қойылды: көрсетілген елдердің зерттеулер мен әзірлемелерді қаржыландырудың салыстырмалы талдауын жүргізу және инновациялық даму тәжірибесін зерттеу үшін жетекші елдерді анықтау; қазіргі кездегі осы салада ЭЫДҰ елдері мен Қазақстанға тән

бірқатар заңдылықтар мен ел алдында тұрған мәселелерді анықтау. Зерттеу жалпы, мемлекеттік, жоғары білім мен бизнестің шығындар сияқты елдердің зерттеулер мен әзірлемелер және олардың құрылымдарына арналған шығындарды статистикалық талдауға негізделген. Сонымен қатар, автор Reuters нұсқасы бойынша 100 үздік инновациялық университеттердің рейтингі мен Жаһандық инновациялық индексі деректерін пайдаланады. Алынған нәтижелер зерттеулер мен әзірлемелерді қаржыландыруға үлкен назар аударатын елдер әлемдегі көшбасшы позицияда тұрғанын және осы елдерде экономикалық өсуге ықпал ететін жаңа әзірлемелермен айналысатын және ғылыми-техникалық прогрестің алдыңғы қатарында жұмыс істейтін әлемнің үздік инновациялық университеттері қалыптасқанын көрсетеді.

Түйін сөздер: ЭБДҰ, Қазақстан, инновациялар, технологиялар, ғылым, зерттеулер мен әзірлемелер, инновациялық университеттер.

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Сравнительный анализ основных показателей исследований и разработок в странах ОЭСР и Казахстане

Аннотация. В данной статье автор анализирует показатели исследований и разработок стран-членов Организации экономического сотрудничества и развития (ОЭСР) и Республики Казахстан. Исследования и разработки является основным двигателем инноваций, поэтому расходы на них являются ключевыми показателями, используемыми для мониторинга ресурсов, выделяемых на науку и технику во всем мире. В рамках данного исследования были поставлены следующие задачи: провести сравнительный анализ финансирования исследований и разработок в указанных странах и выявить ведущие страны для дальнейшего изучения опыта инновационного развития; данных стран; выявить ряд закономерностей, присущих странам ОЭСР и Республике Казахстан за последнее время, и проблемные вопросы данных стран. Исследование основано на статистическом анализе расходов на исследования и разработки стран и их структур, таких как общие, государственные расходы, расходы высшего образования и бизнеса. Кроме того, автор использует данные Глобального инновационного индекса и Рейтинга 100 лучших инновационных университетов по версии Reuters. Полученные результаты свидетельствуют о том, что страны, уделяющие большое внимание финансированию науки, находятся на лидирующих позициях в мировых рейтингах, и в этих странах сформированы лучшие инновационные университеты мира, которые занимаются новейшими разработками и работают в первых рядах научно-технического прогресса, что в свою очередь стимулирует рост экономики.

Ключевые слова: ОЭСР, Казахстан, инновации, технологии, наука, научно-исследовательские и опытно-конструкторские работы, инновационные университеты.

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