"Managing research and development process in conditions of economic growth of Kazakhstan: Methods and analysis"

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MANAGING RESEARCH AND DEVELOPMENT PROCESS IN CONDITIONS OF ECONOMIC GROWTH OF KAZAKHSTAN: METHODS AND ANALYSIS

Abstract

This study aims to assess the relationship between R&D and economic growth in terms of their ability to understand R&D management. In the paper, the algorithm of actions was used, which allows ensuring interconnection, sequence of work, validity of the choice of the methods used, and defining key factors over a long period. The following methods of the empirical study were used: analysis of the provision of level development; regional analysis of the data; correlation analysis. Based on correlation analysis the impact of economic growth on R&D was investigated, which is expressed by such variables as the number of organizations engaged in R&D, internal expenditures in R&D, expenditures for technological innovations, number of employees in R&D. The data were obtained from the World Bank, the Eurasian Economic Union, and the statistical yearbook of Kazakhstan for 2009–2019. The results obtained show that all determinants correlate not only with the GDP but with each other as well. According to the findings, viewing the GDP level, there is a positive and negative correlation link between such two factors as 'the number of research organizations' and 'R&D technological innovations'. These coefficients of correlation between GDP and independent factors selected for the analysis are significant, i.e. they can significantly affect the value of the GDP. The obtained results are useful in formulating the R&D development management strategy.

INTRODUCTION

Transformational development of the society roots down to scientific and technological progress. In common with intensive development of the progress, there has been an evolution of economist's views towards scientific, technological, and innovation activities. The concepts of the impact of new technologies on economic growth were embedded in many studies (Wang et al., 2013; Inekwe, 2015; Boldeanu & Constantinescu, 2015). Moreover, such processes contribute to the increase in the scale of production as novel inventions and ideas behind with different useful side effects are generated.

Scientific studies in R&D include activities necessary for the implementation or enhancement of new products, processes, and services. The expenses on R&D are a fine indicator of how much the country is committed to achieving technological growth. Many studies emphasize the importance of R&D government funding, which drives up labor productivity, accumulation of new technologies and knowledge, improves the quality of life and generates employment (Bassanini et al., 2001; Vincett, 2010; Dai & Cheng, 2015; Nekrep et al., 2018). In

addition, there are certain studies of the relationship between R&D expenditures and GDP (Bozkurt, 2015; Vinkler, 2008), and the importance of conducting such analyses considering the impact on R&D management (Mahoney & Pandian, 1992; Beckman, 2006).

In the CIS countries such as Kazakhstan, Kyrgyzstan, Belarus, etc., the level of innovative development can be different. In addition, these countries may differ from each other in terms of the gross regional product (GRP) per capita, which is largely driven by high prices for oil and gas. Nevertheless, economic growth, based on first-nature factors does not contribute to R&D by itself. At the same time, in the countries of the former Soviet Union provisions have been made to avoid 'stagnation' and transit to a technological breakthrough. However, an attempted structural transformation of the countries of the former Soviet Union had a negative impact on R&D. Today, ex-USSR countries have problems and do not meet the requirements of the transition to an innovative economy.

Most of the research works focused on studying factors affecting economic development and institutional R&D policy. They push for multilevel political interference in innovation development, education and human capital development, employment in the domain of science, and associated workplaces, as well as issues associated with current low funding of R&D. Although some studies can maintain that they are objective, none of the research is objective. In this regard, it is worth mentioning that there is extraordinarily little scientific research aimed at studying the factors influencing the development of R&D and economic growth in the former USSR countries such as Kazakhstan.

After the collapse of the USSR, the scientific potential of Kazakhstan significantly decreased, which led to a reduction and sometimes lack of funding for R&D. Many research institutes have been closed, research conditions have deteriorated, and firms' innovation activity has declined. In the field of science, Kazakhstan has adopted various laws and state programs.

According to the Kazakh legislation, subsurface users working on the territory of Kazakhstan must spend 1% of the total annual income on R&D. Today Kazakhstan is taking systematic measures at the state level to address the challenges of developing science, R&D, and technological innovations. The strategy of innovative and industrial development of Kazakhstan provides for increasing the amount of funding for science to 1.0% of GDP until 2020.

However, the share of domestic R&D expenditures in GDP in 2020 was no more than 0.16% due to the COVID-19 pandemic. The methods used in Kazakhstan's practice are not taken into account the factors affecting economic growth to create an effective strategy for improving R&D. In addition, there are large regional differences in the levels of innovative development. Therefore, this study is aimed to study the level of R&D influence to develop recommendations, which are useful in formulating an R&D development management strategy.

1. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Many countries understand that the development of new technology and science, research and development (R&D) is an important part with unclear profit margin and troublesome of management. It should be noted that if countries had the same access to their technologies, then growth rates would become more equable between them. Overall, management of R&D processes involves a proactive approach necessary for the implementation of new products, processes, and services. Theories of endogenous growth testified that economic growth depends on investment in research and development. In a few scientific studies, it is stated that investments in R&D firms and public research organizations are important elements for the improvement of R&D management, labor productivity, competitiveness of countries, and

economic growth (Romer, 1990; Amendola et al., 1993). In that event, science has a different impact for different stages of economic development of countries.

Khan (1991) showed the link between per capita GDP and aggregated social indexes based on correlation analysis. The side effects of R&D are also key sources of economic growth, which affects the expansion of the market (Grossman & Helpman, 1991). Further, Blackburn et al. (2000) proposed a measurement of economic well-being, which describes the relationship between an invention and economic growth. It was explained that new technologies contribute to the renewal of production. This model used the ideas of models by Romer (1990), and Grossman and Helpman (1991). The model recommended developing human capital and being able to manage their accumulation to achieve economic growth. The accumulation of human capital not only accelerates economic growth but also creates incentives for research and innovation.

Vinkler (2008) defined the correlation between some R&D indicators and GDP. The results showed that due to the specifics of economic development, it can deviate very much from the average value, but still the findings showed significant relationships between R&D and GDP. Pessoa (2010) examined the relationship between R&D costs and economic growth in the context of the OECD and provided an argument that calls into question the effectiveness of innovation policies aimed at increasing aggregate productivity only by increasing the intensity of R&D. In addition, the impact of R&D on economic growth in developing countries was studied by Poorfaraj and Keshavarz (2011). A sample of 16 developing countries for the period 2000–2008 was used, with the GDP chosen as the dependent variable. Important conclusions were obtained based on the method of econometrics and it was shown that the impact of R&D on economic growth in the countries under consideration is positive and significant.

In other scientific studies of the impact of R&D expenses on economic growth it is pointed out that the impact is positive in countries with the income above average, but insignificant for countries with low income (Wang et al., 2013; Inekwe,

2015). Further, Boldeanu and Constantinescu (2015) studied various factors (economic and uneconomic), which can influence economic growth. Applying a regression model to check the stationarity of variables, it is possible to prove the sensitivity of R&D to changes in the GDP (Bozkurt, 2015).

Both government subsidies and private-sector investment in R&D are widely acknowledged as having beneficial effects on economic growth (Bassanini et al., 2001; Walwyn, 2007; Vincett, 2010). Other scientists have pointed that state funding has a positive effect on private funding thereby stimulating economic growth (Lee, 2011; Muscio et al., 2013; Dai & Cheng, 2015).

Next, a lot of scientific research gave particular emphasis to the GDP in per capita terms. Accordingly, Archibald and Pereira (2003) and Clausen (2009) pointed out a positive link between economic growth and R&D, and that firms have enormous importance. Nekrep et al. (2018) defined how R&D expenses as a percentage of GDP affect economic growth. In further studies, it was defined that when expenses on R&D in enterprises exceeded R&D, expenses in public sectors labor capacity in developed countries tend to increase while in developing countries, where research intensity is relatively low, there is an effect of 'inertia' (Coccia, 2018).

A special role of science consists in the aspect of the transition from the resource model of the economy based on knowledge as a dominant resource. The development and effective performance of a science-based economy depend on creation, spread and knowledge deployment, R&D deliverables, information, and communication technology, etc. (Veselá & Klimová, 2014). Science and new technology are defined as key factors for new growth and means for development and advancing global competitors. Especially in developing countries, profit from scientific and technological innovation can have a significant impact on socio-economic problems such as unemployment and skills development (Rensburg et al., 2019).

However, the indicator of science intensity can reflect spontaneous development of science and does not give a straight answer to the question to

what extend allocated resources for R&D are sufficient for stable economic growth (Pinto & Teixeira, 2020). In addition, some studies confirm that the use of the rate of knowledge intensity could be of great importance in determining science funding, especially in the context of the budget deficit and limited investment opportunities (Jones & Williams, 1998; Yoo, 2004). Herewith, the growth of R&D financing must be supported by rational, scientific, and innovation policy, otherwise, it will not give successful results. The policy of management should focus on increasing returns from R&D and optimization of its role in economic growth. Thus, the following parameters must be considered: commercial R&D; new productive small and medium enterprises; training and rotation of academic research personnel; mechanism on technology and R&D deliverables transfer; rational sectoral policy guaranteeing high margins and effective technology transfer (Tsipouri, 2001).

Within the framework of this study, the focus is put on studies that consider management of R&D expenditures, which affects economic growth. From this point of view, successful management of R&D expenditures is likely to be expressed in the form of higher rates of productivity growth of enterprises (Mahoney & Pandian, 1992; Timmons, 1999). R&D management and the associated instability of R&D costs may not always benefit the firm (Fine, 1998). In addition, not large enterprises may not have the necessary resources that are required to conduct detailed research (Beckman, 2006). Thus, enterprises make quick and ill-considered management decisions, and problems arise that the firm faces (Davis et al., 2009). Lindner and Wald (2011) proposed an interesting solution to address the issue of knowledge transfer and development management based on the integration project model.

Among the scientific works from ex-USSR countries, several studies can be distinguished. According to the results of the study of Ukrainian scientists, it was revealed that the classification of the high-tech sector by types of economic activity would help to better plan public investments in R&D and management of human resources (Burkynskyi et al., 2021). In turn, Belarusian scientists noted that it is especially important to allocate funds for R&D considering strategic planning to solve the problems of efficiency of R&D expenditures (Terziev & Klimuk, 2021). Kazakhstani scientists paid attention to the need for digitalization of research institutes, increasing the R&D effectiveness and introduction R&D results into industrial production (Alzhanova et al., 2020; Ziyadin et al., 2018).

Therefore, this study is based on the analysis of various factors that can affect economic growth and determine the circumstances affecting management of R&D. Internal expenses in R&D and the number of personnel in R&D reflect completely different levels of influence. This indicates an inverse strong correlation or means an inverse strong dependence.

The purpose of this paper is to assess the relationship between R&D and economic growth in terms of their ability to understand R&D management. Using data from 2009 to 2019, this study analyzed the impact of economic growth, which is expressed by such variables as the number of organizations engaged in R&D, internal R&D expenditures, expenditures on technological innovations, and the number of employees engaged in R&D. There is an assumption that there is a significant positive impact of science on the economic growth of Kazakhstan. For this purpose, the hypothesis states that there is a significant positive correlation (dependency) between indicators of the level of R&D development and the economic growth (GDP) of the country. Economic substantiation lies in the assumption that increasing expenses on research and development will probably lead to the improvement of products effectiveness and process of production resulting in the yield increase and increase in output, as well as the emergence of new technological solutions. Therefore, those areas will create new workplaces, encourage people to obtain a higher level of education and provide new areas for investment.

Thus, two main hypotheses are developed:

H1: *There is a positive correlation (dependence) between indicators of the level of R&D development and economic potential (GDP).*

H2: *There is no significant correlation (dependence) between indicators of the level of R&D development and economic potential (GDP).*

2. METHODS

The study was conducted based on a comparative approach using secondary data (the World Bank, the EAEU database, and the statistical data of the National Bank of Kazakhstan). This paper was limited by statistical data for some countries; therefore only available data were used. The observation period from 2009 to 2019 for countries on several indicators led to the acquisition of three-dimensional data. Therefore, it was decided to compare the results from 2009 to 2019.

A methodological algorithm of actions was directed at supplying coherence and workflow process, the validity of the methods was checked. Thereby, the actions algorithm consists of the following methods of the empirical study:

1. The current analysis allows defining disadvantages and advantages of compared objects, i.e. in advanced fields of work in science, technology, and innovation. Next, before processing all data the cross-validation is performed using secondary data from statistical compilations on the dynamics of GDP, per capita GDP, indicators of internal expenditures on R&D, technological innovations, etc.

2. To determine agglomerative effects, regional analysis of the data is used. Analysis is provided by researching territories, studying the level of their development, and constructing consolidated regional indicators. Some scientific research proved the importance of scientific-research potential for economic growth (Cohen & Levinthal, 1989; Audretsch, 1998; Wanzenboeck et al., 2014). For as much in Kazakhstan the innovation potential is almost exceptionally concentrated in agglomerative centers, i.e. the bigger it is, the higher is the concentration of innovation agents, the higher is the intensity of their correlation and accordingly, the effectiveness of new technologies creation. Studying trends and common factors in more detail, it is possible to see an uneven distribution of R&D in the regions of Kazakhstan, which has been developed under the influence of the Soviet era. Especially, in developed regions with high research and human poten-

tial, much higher indicators in the development of science are observed.

3. To assess the effectiveness of the innovation system, data coverage analysis methodology is used from 2009 to 2019 to assess the impact of R&D on economic growth. Estimates are based on the relationship between economic growth, R&D spending, human capital, and innovation (Meo et al., 2013; Türedi, 2016; Straková et al., 2021). For analysis suitable output and input variables were defined. To achieve the goal of the correlation analysis statistical methods of studying the correlation between random samples are applied. Per capita GDP stands out as a dependent variable. There are several independent variables as well: the number of organizations engaged in R&D; internal expenditures in R&D; expenditures of technological innovations; the number of employees in R&D.

Statistical and correlation analyses were used as the main research methods. The Pearson correlation ratio was used as the main correlation analysis because the Kolmogorov-Smirnov criterion for verifying the hypothesis showed that the data under consideration is regarded as standard distribution (1):

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \overline{x}) \cdot (y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \overline{y})^2}}, \quad (1)$$

where n – is sample size, x_i – X variable values, y_i – Y variable values, $\overline{x}$ – arithmetic means for variable X, $\overline{y}$ – arithmetic mean for the variable Y.

The current formula of Pearson correlation coefficient assumes that it should take the difference between each value of x_i variable X, and its mean value $\overline{x}$. However, to optimize calculations, Pearson correlation coefficient is calculated through the analogy transformations and is calculated using the following final formula (2):

$$r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\sqrt{n\sum y_i^2 - (\sum y_i)^2}}. \quad (2)$$

Pearson correlation method is used to measure degrees of correlation between 1 and –1. A posi-

tive correlation value proves a positive (direct) link between variables, while a negative value proves a negative (reverse) link, and a zero value – no link. According to the Chaddock scale, if an absolute correlation ratio value is less than 0.3 then the correlation is weak, if the value is between 0.3 and 0.5 – then the correlation is moderate, 0.5 and 0.7 – marked, 0.7 and 0.9 – high, over 0.9 – extremely high and 1 – severe.

3. RESULTS

Today Kazakhstan is taking systematic measures at the state level to address the challenges of developing science, R&D, and technological innovations. The strategy of innovative and industrial development of Kazakhstan provides for increasing the amount of funding for science to 1.0% of GDP until 2020. However, the share of domestic R&D expenditures in GDP in 2020 was no more than 0.16% due to the COVID-19 pandemic.

For the statistical analysis of R&D and experimental developments, government statistics use two introductory indicators: the number of personnel employed in research and development, and the cost of R&D. Table 1 shows the number of R&D organizations by sector of performance in the past 10 years.

Interestingly, according to the data presented, the largest number of organizations grew in two sec-

tors: the public sector and the business sector. At the same time, the noncommercial sector and the university sector in 2019 showed downward trends in comparison with 2009. This means that the conditions for non-profit and university sectors in R&D are not attractive enough.

To understand the mechanism (or ways) of increasing the scientific content of GDP, it is necessary to analyze internal R&D expenditures for the government sector, business sector, university sector, and noncommercial sector (Table 2).

Analyzed data showed a diverse structure of cost intensity. Thus, the high level of internal R&D expenditures was distinguished in 2019 by two sectors: the business sector and the non-profit sector. Although the public sector for R&D is of paramount importance for the formation of knowledge and abilities in Kazakhstan. However, R&D expenditures in the public sector increased, but only slightly. In addition, spending on the university sector decreased slightly in 2019 comparing to 2015.

The economic condition of Kazakhstan depends on how wisely its financial resources will be invested in R&D. In Kazakhstan, the funding structure is focused on the state budget and own funds of organizations that mainly represent the business sector. Over the past 10 years, financing from sources such as own funds, foreign investment,

Table 1. Number of organizations performing R&D by sector of performance for 2009–2019

Source: Bureau of National Statistics (n.d.).

Sector	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Government sector	94	95	85	69	78	101	125	100	101	103	100
University sector	115	121	115	121	112	105	121	103	99	95	92
Business sector	111	108	149	105	110	149	108	149	146	149	158
Noncommercial sector	94	100	63	50	41	37	100	31	40	37	36

Table 2. Internal R&D expenditures by sector of performance for 2009–2019, in million KZT

Source: Bureau of National Statistics (n.d.).

Sector	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Government sector	15015.9	12372.1	10833.0	11960.5	18304.3	21695.6	20325.8	18640.4	20961.4	22091.8	24290.6
University sector	12767.5	12260.4	7100.1	14832.3	18926.1	14706.5	13485.0	11532.1	13179.5	11515.0	13373.9
Business sector	5924.0	5760.4	22366.4	20626.1	18151.0	24337.6	27790.9	28872.7	28665.0	30998.8	33884.4
Noncommercial sector	5281.3	3073.9	3052.1	3834.2	6291.3	5607.9	7701.3	7554.9	6078.2	7618.8	10784.1

Table 3. Sources of financing for internal R&D expenditures for 2009–2019, in million KZT

Source of financing	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Own funds of enterprises	54059.9	219441.9	114565.8	153425.0	285044.4	256071.9	273974.9	367777.0	300208.1	392226.1	440271.6
State budget	4968.3	5516.6	12873.1	37402.9	17465.6	37543.6	27769.8	42012.1	42230.2	28800.0	37056.2
Local budget	378.4	44.2	6613.4	1273.9	3743.4	2102.9	2311.3	1851.8	17969.7	15752.2	4983.0
Foreign investments	230.9	2177.9	40060.7	8155.4	856.8	3537.2	974.2	514020.7	7053.4	45633.7	3796.8

local budget, and other sources of financing has shown a positive trend (Table 3).

The analysis of sources of financing shows the main role in the formation of the size and structure of costs. It is noteworthy that own funds of enterprises showed high indicators of sources of financing, which reflects a high level of confidence on the part of entrepreneurs. Thus, funding from own funds of enterprises in 2019 increased by almost 8 times in comparison with 2009. At the same time, other sources of the financing described a slight development trend, especially from foreign investors and the local budget.

Exploring the trends and patterns in more detail, one can notice the uneven distribution of R&D in regions of Kazakhstan, which has been developed under the influence of geographic, social, and economic disproportion. In the regions with strong

scientific, research, and human potentials, there are higher indicators in the development of science. For clarity, Table 4 shows data on domestic expenses on R&D in the regional context.

Following the data provided, it is seen that between 2009 and 2019 gross domestic R&D costs are growing in total funding in all regions of Kazakhstan. Thus, the largest expenditure on R&D was in Almaty city, Nur-Sultan city, and Mangistau region. At the same time, expenses have significantly decreased in one region – Zhambyl region (reduction by 65.8%).

Another equally important summary indicator reflecting the level and dynamics of R&D development is the number of enterprises engaged in this area. Therefore, the number of enterprises in the regions of Kazakhstan in R&D is considered (Table 5).

Table 4. Internal costs on R&D for 2009–2019, in million KZT

Region	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Akmola	482.6	574.5	471.0	631.0	742.5	826.7	1113.1	797.3	898.2	1694.3	1608.8
Aktyubinsk	492.4	627.3	628.1	645.1	559.2	735.3	701.6	763.0	839.1	974.6	1060.6
Almaty	537.0	705.1	1007.9	879.0	1117.4	804.2	1053.6	941.7	871.1	1121.1	1521.3
Atyrau	1883.1	2199.3	3010.9	3531.0	1880.0	1885.7	2415.9	2753.3	3637.7	4494.5	5134.6
West Kazakhstan	489.3	212.9	353.7	548.2	916.0	672.2	753.2	1789.2	298.5	878.2	1045.3
Zhambyl	1153.8	1221.9	198.2	1485.5	1077.0	1322.3	689.7	456.3	1024.3	731.6	759.0
Karaganda	1206.0	939.4	1528.4	2947.0	3407.7	4048.9	3597.8	4279.1	3488.1	3508.3	4543.6
Kostanay	361.0	214.7	250.6	329.9	445.3	574.0	599.2	562.1	1176.5	827.4	687.7
Kyzylorda	80.8	80.7	79.5	213.0	213.3	266.0	235.6	613.6	506.3	301.9	273.0
Mangistau	3138.0	3064.8	5150.9	5059.5	5095.4	6160.7	7694.5	7800.4	8043.5	9848.7	9713.8
Pavlodar	303.3	198.8	385.6	434.1	335.3	322.9	320.8	390.4	335.7	290.2	1258.2
North Kazakhstan	129.8	112.1	101.9	221.4	209.6	236.3	224.4	180.2	185.2	226.3	241.3
Turkestan	95.7	109.6	147.4	206.5	247.3	284.1	313.0	173.1	204.9	273.6	188.5
East Kazakhstan	5589.0	5099.2	4175.9	3959.9	3773.3	3040.6	3300.0	3475.4	5000.5	5319.1	7082.3
Nur-Sultan city	4448.5	4445.6	9280.9	10376.4	9741.2	10187.7	13451.9	13990.6	16297.5	14094.2	17965.1
Almaty city	18336.2	13319.8	16287.6	19061.5	30991.0	34030.3	31791.2	26596.1	25357.8	26586.5	28095.4

Table 5. The number of enterprises engaged in R&D for 2009–2019

Region	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Akmola	7	7	8	9	12	11	11	9	11	11	13
Aktyubinsk	15	16	18	16	13	14	14	14	16	16	15
Almaty	7	10	8	7	10	13	11	10	11	9	9
Atyrau	12	12	9	9	8	9	10	11	10	10	10
West Kazakhstan	10	10	9	15	9	9	7	8	8	10	12
Zhambyl	12	10	7	8	9	11	11	11	11	9	10
Karaganda	29	28	29	26	23	31	32	33	29	28	30
Kostanay	14	15	13	14	13	13	14	13	14	12	12
Kyzylorda	7	14	23	7	6	6	8	10	8	7	6
Mangistau	6	8	8	7	7	7	5	7	6	6	6
Pavlodar	10	9	11	11	10	11	9	10	11	14	12
North Kazakhstan	5	5	3	3	3	3	4	5	5	5	5
Turkestan	3	3	3	3	3	5	4	5	6	6	7
East Kazakhstan	34	33	36	34	29	30	30	35	34	35	31
Nur-Sultan city	43	42	41	49	52	59	53	55	62	60	56
Almaty city	193	196	180	119	122	148	152	133	131	135	138

Between 2009 and 2015 an upward trend is observed in the number of enterprises engaged in R&D. Specifically, the largest number of enterprises in 2015 was in Mangystau, Akmola, and in Nur-Sultan: the number increased by almost 2.5 times in comparison to 2009. At the same time, the number of enterprises in R&D has decreased significantly in Karaganda region, Almaty city, Kyzylorda, and East Kazakhstan regions.

4. CORRELATION ANALYSIS

The baseline data for Kazakhstan for the period from 2009 to 2019 consists of a combination of a dependent variable and independent variables. The first indicator of the GDP was expressed in terms of per capita GDP. The ratio of GDP to the population of Kazakhstan from 2009 to 2019 was calculated. In addition, the internal costs of R&D, the costs of technological innovations in the statistical collections of Kazakhstan are indicated in the national currency (tenge). Therefore, the exchange rate of the US dollar (average value) to tenge for 2009–2019 was used for conversion into US dollars. After importing coded data into SPSS all received variables are presented in a structured form, and correspondence between the variables is established. It should be mentioned that there are two periods used: the 2009–2014 and the 2015–2019 period. This way, statistical data processing allowed building a matrix of correlation

and calculating Pearson coefficients. The results are presented in Table 6.

The obtained data demonstrate that the correlation between considered indicators changes over time. A strong correlation of 0.989* is observed in internal spending on R&D, and these interrelations have only strengthened over time. The correlation between the number of enterprises engaged in R&D and GDP was positively strong and equal to 0.895*. Interestingly, the internal funds of enterprises showed high indicators of sources of financing. This indicates that not only state organizations, but also entrepreneurs have successfully begun to build a policy in the field of R&D management in Kazakhstan. Further, the correlation between the number of personnel in R&D and GDP has strengthened, although it was weak earlier (0.635 and 0.871). At the same time, there are still gaps in the transfer of knowledge from more experienced researchers to their young colleagues. In addition, researchers are increasingly using the latest achievements in the IT field in their work. This contributes to the better implementation of state digitalization programs.

Based on the analysis, the matrix of paired correlation coefficients was generated. It follows that out of the provided set of variables, the greatest impact of GDP has the following indicators: factor ($x2$) – internal expenditures in R&D, correlation coefficient with the effective indicator (GDP);

Table 6. Pearson correlation matrix of the variables

Variable	Period	Y	X1	X2	X3	X4
GDP	2009–2014	1	−0.784	0.911*	0.823*	0.635
	2015–2019	1	0.895*	0.989**	−0.046	0.871
Number of organizations engaged in R&D	2009–2014	−0.784	1	−0.833*	−0.740	−0.626
	2015–2019	0.895*	1	0.932*	−0.316	0.645
Internal expenditures in R&D	2009–2014	0.911*	−0.833*	1	0.806	0.825*
	2015–2019	0.989**	0.932*	1	−0.086	0.859
Expenditures of technological innovation	2009–2014	0.823*	−0.740	0.806	1	0.843*
	2015–2019	−0.046	−0.316	−0.086	1	0.412
Number of employees in R&D	2009–2014	0.635	−0.626	0.825*	0.843*	1
	2015–2019	0.871	0.645	0.859	0.412	1

Note: * – correlation is significant at the 0.05 level (2-tailed); ** – correlation is significant at the 0.01 level (2-tailed).

factor ($x1$) – the number of personnel in R&D, correlation coefficient with the effective indicator (GDP) is –0.895*, which tells about inverse strong correlation or means inverse strong dependency. It should be noted that the calculations for two five-year periods demonstrate different indicators of the relationship between the cost of technological innovation and GDP (0.823* and –0.046, respectively). Other variables have less impact.

Still, significance coefficients show an understanding of the actual 'tightness' of the correlation between the characteristics, which is crucial at the stage of practical conclusions for two five-year periods. Pearson correlation analysis shows a positive relationship between the variable internal R&D expenditures and economic growth in Kazakhstan, and the number of personnel in R&D indicates an inverse strong correlation or means an inverse strong dependence. It follows that various state programs, budget financing of R&D, and support of scientific personnel must be reconsidered, especially in R&D development management. In general, it is possible to achieve great success in the development of innovations and rapid economic growth by effectively managing financial costs in the field of R&D. The competitive advantages of any country can be strengthened if their efforts are managed more rationally. Effective personnel management is a conductor of change as for the number of personnel in the field of R&D. Scientists must effectively respond to changes in domestic and global competition, production technologies, and processes. The responses to these changes are transmitted from R&D to other areas in the economy in the form of new materials, methods, processes, and products.

CONCLUSION

The aim of this study was achieved: the impact of R&D on economic growth in Kazakhstan was explored and the levels of science development in Kazakhstan by regional level were analyzed too. The results show that gross internal expenditure on R&D is growing in total funding across all regions of Kazakhstan. However, it is growing slowly. In Kazakhstan, there is insufficient funding for research and commercialization of R&D results. It is noteworthy that the high indicators of sources of financing showed foreign investment, which indicates a high level of confidence on the part of foreign investors. In addition, in Kazakhstan one can see 'regional paradox' when some regions such as Almaty city and Karaganda region are usually characterized by an established level of development of research infrastructure. Indeed, Kazakhstan, as a country of the former USSR, experienced a negative impact on the level of development of the regions in terms of R&D due to structural change. There are leading regions where there is a larger number of organizations engaged in R&D, internal expenditures in R&D, expenditures of technological innovation, and the number of employees in R&D prevails (Almaty city, Nur-Sultan city, and Mangistau region); and there are outsider regions, where there is a smaller number of organizations engaged in R&D, internal expenditures in R&D, expenditures of technological inno-

vation, and the number of employees in R&D prevails (Turkestan, South Kazakhstan, and Kyzylorda), which also affects the development of the economic potential of Kazakhstan.

According to the correlation analysis and obtained results, the number of organizations engaged in R&D, internal expenditures in R&D, and expenditures of technological innovation have a statistically significant strong positive impact on the economic potential of Kazakstan. However, the impact of science on economic growth in Kazakhstan is rather ambiguous. From 2009 to 2014, there is a strong positive statistically significant relationship between internal expenditures in R&D, expenditures of technological innovation, and economic growth. On the contrary, from 2015 to 2019 a statistically significant positive strong relationship is observed only between economic growth and the number of organizations engaged in R&D and internal expenditures in R&D. The number of employees in R&D has no impact on the economic potential of the country. An important indicator affecting the economic potential of Kazakhstan is the internal expenditures in R&D. This way, *H2* is rejected, i.e. correlation between the indicators of R&D development and economic growth exists.

The obtained results are useful in formulating R&D development management strategy. It should be emphasized that strategic R&D management requires not only a high level of skills but also the identification of factors affecting economic growth. According to this paper, starting with the revision of various state programs, budget financing of R&D, and support for scientific personnel an effective management strategy can be achieved. In addition, prioritization is required, and this is often a controversial aspect of developing an R&D management strategy. In addition, the main attention should be paid to regional specifics during the development of the strategy. Firstly, different regions of Kazakhstan specialize in different sectors of the economy, thus the R&D potential is different too. Secondly, large R&D expenditures do not always guarantee large profits or positive economic growth. Many developed countries invest more money in the development of R&D, thereby getting more profit. Given this fact, an increase in the level of financing is the main factor in the development of R&D, and respectively, economic growth. Therefore, Kazakhstan needs to increase funding from the state budget and attract foreign investors to R&D. This will improve knowledge, skills, values, and attitudes of the subjects and the material base in R&D, allowing to increase the level of economic growth.

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