Factor analysis of trends for national innovation-driven development

Lilia Ustinova[*1][0000-0002-9226-9829]

[1]Kazan State University of Architecture and Engineering, 420043 Kazan, Russia

Abstract. The global innovation trends involve ever new and more flexible systems for the development of industries, goods, and services. The consumer ability of society creates stable needs for new state-of-the-art goods, technologies, and products. Within this context, the need to develop innovations as a way to achieve market demands can hardly be overestimated. The article includes an overview of a number of important innovation-based factors, such as the share of domestic spending on research and development in GDP in the Russian Federation, domestic current spending on research and development in the Russian Federation, the overall level of innovative activity of industrial organizations, etc. Besides, following the study, it was found that the overall level of innovative activity of industrial organizations has a direct notable correlation dependence on domestic current spending on research and development.

Keywords. Innovation, innovative, development, building.

1 Introduction

The era of the sixth wave of innovation was marked by the evolution of artificial intelligence systems, radio technologies, global information networks, deterministic models of growth and development in bioenergy, formation of energy-intensive resource objects on a transnational scale, and much more, which was a consequence of the preexistent and developed intellectual resource in the country. However, nowadays, the fact of the matter is that the conventional instruments of economic growth based on solving the problem of production for domestic consumption due to additional loading of production capacities, are no longer competitive in the world market.

The purpose of the article is to conduct factor analysis of trends for national innovation-driven development, which makes it possible to define its state.

The purpose gave rise to the following objectives:

1. To consider the dynamics of particular factors representative of the innovation development in the Russian Federation.

2. To determine the best analysis tools.

3. To study factors having impact on the innovation-driven development in the Russian Federation.

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*Corresponding author: buro.ustinova@mail.ru

2 Methods

In the article we used the method of factor analysis: correlation analysis which is a multi-stage process of a solution finding.

The algorithm for proving the advanced hypothesis on the correlation between various numerical sets includes the following steps:
- preparation of a reliable and sufficient sample of study;
- calculation of correlation coefficients;
- assessment of the significance of the correlation coefficients;
- conclusion of the null hypothesis or proof of the hypothesis.

Correlation is a feature that indicates the relationship of a number of numerical sequences allowing us to characterize the strength of the relationship in the data. If it concerns the relationship of two numeric arrays x_i and y_i, then we are talking about pair correlation.

Thus, the correlation analysis brings us to the conclusion about the strength of correlation between the pairs of data x and y.

2.1 Role of innovations in the national development

The topicality of the article is driven by the decrease in the indicators of innovative status of Russia not only world-wide, but also in the domestic chronological dynamics. The indicators of innovative activity of organizations in the country are rather unstable.

This topic has been studied by many domestic and foreign scientists. As a rule, the national innovation-driven development is considered as an area of research the object of which is the economic sector, and the subject of study is a set of organizational, managerial and economic relations arising in the process of formation and development of the innovative sector of economy [1, 2].

Trends of national innovation-driven development are inextricably linked to scientific and technological progress in the world, to the economic growth rate, social situation, political aspects, etc [3]. And in the contemporary context, when it comes to innovative development, the planning is prioritized [4].

«The Wealth of Nations» by Adam Smith served as the theoretical and methodological basis for the formation of innovations in the XVIII century. As far back as 1776 he declared the need for a transition to new technologies. Later, in the XX century, the Austrian Scientist J.A. Schumpeter in his «The Theory of Economic Development» noted that innovations are not just novelties, but a factor of production, which made it possible to change the view of contemporaries on the production process as a purely technological production to meet the needs of society for opportunities to form the capital through the use of innovations in production [5].

Currently, there is a certain tendency in Russia when the vast majority of the Russian companies invest mainly in the material aspect of the business, acquiring buildings, structures, and equipment, while giving little weight to the intangible component of the business and its impact on the key figures of the company [6].

The study of the dependence of labor productivity on education, in particular, has shown that with a 10% increase in the level of education, productivity increases by 8.6%. The economic efficiency of leveling up of personnel education is becoming evident. However, the Russian system of public education turns out to be imperfect in view of the fast-moving system of the national economy and the volatility of the market. In many higher educational institutions, there is neither much connection with the true-life production, nor training of employees for specific enterprises, and the level of research work is insignificantly low [7, 8].

Foreign practice, however, gives evidence not only of great desire of universities to provide innovative vector training of students, but also of great potential of such universities.

Moreover, the innovativeness and scientific and technical equipment of educational institutions has long become one of the main criteria for evaluating foreign universities [9-12].

2.2. Indicators of national innovation-driven development

Many domestic researchers rightly note that one of the most important efficient indicators of innovation-driven development is the gross domestic product which reflects the dynamics of the national economic system. This dynamic is the result of investment and innovation policy in individual industries and market segments, and this enables us to see the bigger picture of development [13, 14] (fig. 1).
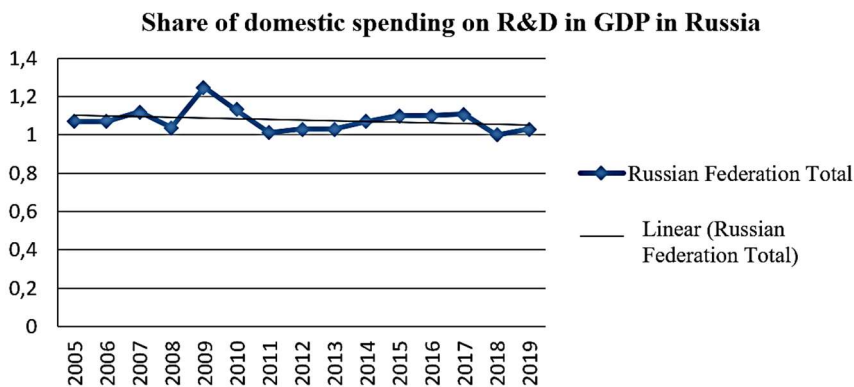

Fig. 1. Share of domestic spending on research and development in GDP in Russia [15].

It should be noted that the trend line specifying the diagram of the share of domestic spending on research and development in GDP is exponential, which indicates a decrease in the volume of investments in high technologies and scientific and technological development.

At the same time, there is a deterministic increase in the indicator of domestic current spending on research and development in the Russian Federation (fig. 2).
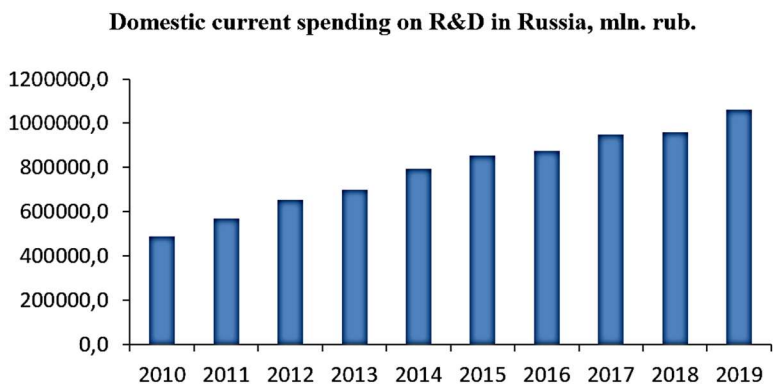

Fig. 2. Domestic current spending on research and development in the Russian Federation [16].

The increase in the indicator of domestic spending on research and development in the period from 2010 to 2019 equaled to over 200 percent. It should be noted that the consumer will experience the growth of an innovative product only in a few years, when all the stages of product creation would be passed. As a rule, the payback period for investments in intellectual capital is much longer than the payback period for investments in the material

and technical facilities of the company [17]. The dynamics of changes in the proportion of innovative goods, works, and services in the total of shipped goods indicates a nonlinear dependence of these indicators (fig. 3).

Proportion of innovative goods, works, and services in the total of goods shipped, works performed and services provided, %
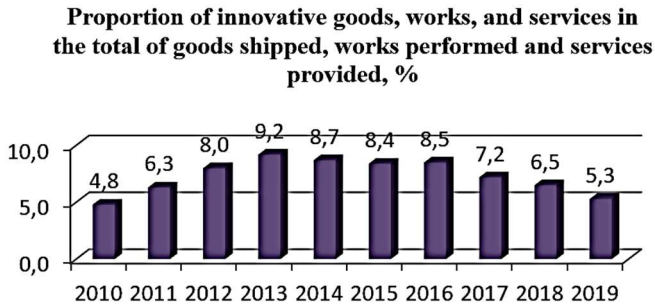
Fig. 3. Proportion of innovative goods, works, and services in the total of goods shipped [18].

The system of higher education, as a national science-intensive sector, is a priority tool for the creation of innovations. According to the conducted studies, the share of universities among organizations carrying out innovative developments is quite large. It is obvious that the key accelerators for innovation are R&D centers, design bureaus, pilot enterprises, etc., however, the Russian universities are capable of generating up to 20% of innovative ideas [19, 20].

The level of innovative development of Russia is clearly shown in Figure 4, where the domestic spending on research and development in 2019 in a country context is represented. In terms of this indicator, Russia is far below Korea (by 4 times), Switzerland, Sweden, Japan (by 3 times), Austria, Germany, USA, France, etc., leaving behind only Turkey and India.

Domestic spending on R&D as a percent of GDP
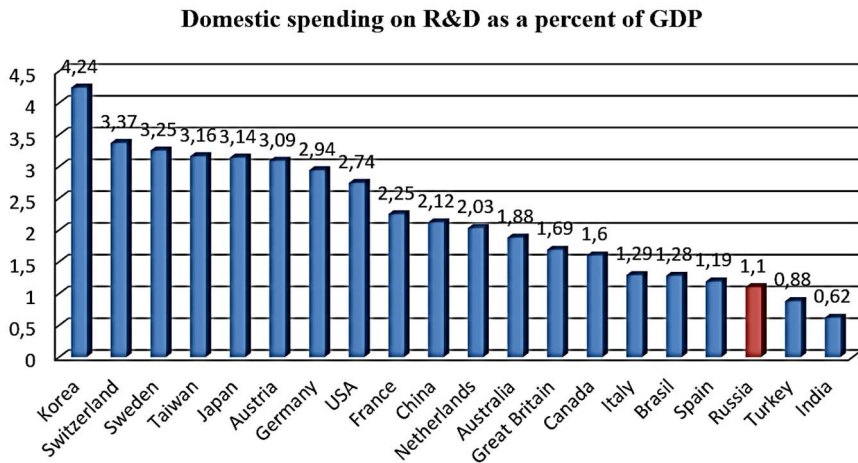
Fig. 4. Domestic spending on research and development: 2019 [21].

If we consider the development trends of the top 3 countries in terms of amount of science financing, it is worth noting that Korea has been dynamically developing for six years, being at the top of the ranking of innovative economies due to the significant concentration of high-tech companies in the country, a developed system of higher education and a significant share of research and development expenditures in GDP. The high competitive advantages of innovative Korean products in the world market allow upscaling sales in the field of electronics, nanotechnology, auto business, medicine, etc. up to 30% annually. Korea's strategic priority is an innovative partnership, including with Russia, which has a huge intellectual resource (fig. 4) [21].

Sweden, placed third, did not always make good progress in innovation. For a long time, the country was fairly average with a large number of socio-economic problems. Since the middle of the last century, the economy has begun to develop more actively, and GDP growth has been notably accelerated. The key to the successful development of an innovative economy in Sweden was the creation of an effective National Innovation System (NIS). And the Ministry of Education and Science and the Ministry of Entrepreneurship and Innovation became the dominant elements in the NIS structure. Thus, the state participation in innovative development of Sweden is enormous.

Interestingly, the overall level of innovative activity of industrial organizations in Russia does not visually correlate either with the volume of domestic spending on research and development, or with the proportion of innovative goods, works, and services in the total of goods shipped (fig. 5-6).

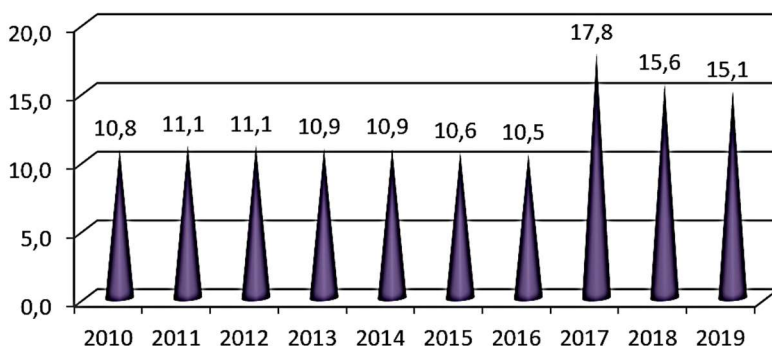**Overall level of innovative activity of industrial organizations, %**

Fig. 5. Overall level of innovative activity of industrial organizations [22].

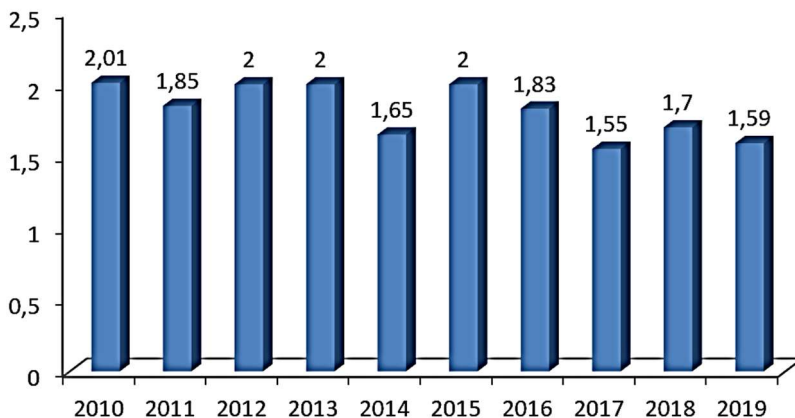**Inventive Activity Coefficient, 1 unit/10 000 person.**

Fig. 6. Inventive Activity Coefficient [23].

According to the Inventive Activity Coefficient shown in Figure 6 it is evident that from 2010 to 2019 the indicator decreased by more than 20%, which negatively affects the overall development of innovations in the country. Obviously, this indicator is influenced by a

significant number of factors, one of which is undoubtedly the outflow of Russian qualified specialists abroad, where working conditions and wages are much more attractive for developers and scientists. We are talking about such countries as Germany, the USA, Israel, Japan, etc [24, 25].

3 Results and discussion

With the use of the correlation analysis, and, in particular, the pair correlation method, we will determine the nature and strength of the relationship between certain indicators of innovation-driven development.

We will also use this research tool to prove the following proposed hypotheses:

H1: The indicator of the proportion of innovative goods, works, and services in the total of goods shipped is in direct proportional correlation with the indicator of domestic current spending on research and development in the Russian Federation.

H2: The strength of correlation between indicators specifying the innovation-driven development of the Russian Federation is deterministic and differentiated (Table 1).

Table 1. Reference data to conduct correlation analysis[*].

Years	Domestic current spending on research and development in Russia	Proportion of innovative goods, works, and services in total of goods shipped, works and services provided	Overall level of innovative activity of industrial organizations	Inventive Activity Coefficient
2010	489450.8	4.8	10.8	2.01
2011	568386.7	6.3	11.1	1.85
2012	655061.7	8.0	11.1	2.00
2013	699948.9	9.2	10.9	2.00
2014	795407.9	8.7	10.9	1.65
2015	854288.0	8.4	10.6	2.00
2016	873778.7	8.5	10.5	1.83
2017	950257.0	7.2	17.8	1.55
2018	960689.4	6.5	15.6	1.70
2019	1060589.7	5.3	15.1	1.59

[*]compiled by the author.

The correlation modelling made it possible to analyze the relationship during the period of 10 years. According to that analysis, it can be stated that:

1. The actual increase in innovative products on the market does not correspond to the actual financial investment in research and development in view of the aforementioned lag (time shift) over several years $r_{cor} = 0.076815$ (Table 2).

Table 2. Pair correlation calculation data[*].

No	Regions of Russia	Correlation Coefficient, r	Critical Value, r_{crit}	Significance, Strength of Correlation
1	Proportion of innovative goods, works, and services in total of goods shipped, works and services provided	0.076815	0.602	Non-significant, no correlation
2	Overall level of innovative activity of industrial organizations	0.665279		**Significant, notable correlation**
3	Inventive Activity Coefficient	-0.7191265		Significant, notable inverse correlation

[*]calculated by the author.

2. The overall level of innovative activity of industrial organizations does have a notable direct correlation dependence on domestic current spending on research and development. (r_{cor} = 0.665279).

3. The Inventive Activity Coefficient, representative of the number of applications for inventions filed by domestic applicants to the country's patent office, showed an inverse correlation with the amount of R&D financing, which indicates a low patenting level of created innovations (r_{cor} = - 0.7191265).

4. H1 hypothesis is rejected, H2 hypothesis is proved.

4 Conclusions

Heading for the innovation-driven path of development requires the development of a global innovation infrastructure that promotes the growth of innovative activity of industrial organizations, consolidation and cooperation with higher educational institutions, formation of bases and systems of innovations, etc.

According to the analysis made, we propose the following recommendations to improve innovative activity in the Russian Federation:

- creation of a mechanism to improve efficiency of innovative developments and their patenting;

- government support for research centers, research institutes in the area of tax, patent, and antimonopoly policy;

- improvement of the institutional framework for innovative activity;

- development of a government program for the involvement of higher educational institutions in the process of creation and formation of innovations;

- training of scientific personnel having high level of professional competencies under the program for the development of scientific activities;

- re-targeting of the R&D system towards the development of commercially viable projects;

- creation of flexible conditions for interaction of those who involved in the innovation process;

- increasing the amount of R&D financing, stimulating the developers.

Improvement of the innovative status of Russia is an important condition for the creation of competitive advantages in the world market. It is the state that takes the key and the most important role in this matter expressed in such functions as regulation, organization, motivation, coordination and control.

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