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BUSINESS INNOVATION ACTIVITY AND THE FOURTH INDUSTRIAL REVOLUTION IN RUSSIA[5]

The research is devoted to a comparison of the level of Russian companies' innovation activity for the period 2011-2020. The authors propose the Index of Innovative Activity based on the integrated indicator calculation, which combines a range of factors reflecting different aspects of business innovation activities. The generalised principal component approach, which was the basis of this study, didn't neglect any residual dispersion of source data and allowed us don't give any subjective weights to the factors. Based on the study results, the authors try to identify the reasons for the growth or decline in innovative activity in the specified period. The research illustrates that the role of barriers to innovation is gradually decreasing, and factors that promote innovations are becoming more important. Our study lays the foundation for the regular calculation of the index to assess the trends.
Keywords: Industry 4.0; innovations; technological development; principal component analysis (PCA)
JEL: C38; L21; O14; O31

1. Introduction

It has been ten years since Germany announced at the 2011 Hannover Messe its project to transition to the fourth industrial revolution. The German project was based on the computerisation of national production. But since then, the term Industry 4.0 has been used

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much more broadly, encompassing many innovations, including smart manufacturing, the Internet of Things, big data, artificial intelligence, nanotechnology, 3D printing in industry and medicine, quantum computing, robotics, and unmanned aerial vehicles, blockchain, cryptocurrencies. The World Bank called such technologies “disruptive” because they create opportunities for radical change and the risks associated with these opportunities (World Bank, 2021).

The introduction of new technologies does not automatically mean a transition to the best. Research on the relationship between scientific and technological development and its results for society was carried out in the late 1980s. Lvov D. S. and Glazyev S. Yu introduced the concept of a technological order into scientific circulation. It is also necessary to highlight the works of Deaton A., Krugman P., Ford M., Pikketi T., Bodrunov S.B. et al. (Deaton, 2016; Krugman, 2011; Ford, 2015; Piketti, 2014; Bodrunov, 2018). Studies by the expert of the World Economic Forum and its founder and President K. Schwab are devoted to the study of the systemic impact of the 4th industrial revolution on society (Schwab, 2017).

In a complex international environment and growing inequality in many countries, industry 4.0 is not a solution to all problems, but rather an additional problem. After all, the renewal of the means of production is only one of the elements of systemic transformations. A new management paradigm is needed, a revision of approaches to training, hiring and monitoring the work of personnel, practically all organisational processes. The development of comprehensive management strategies that take into account both technological and social requirements and constraints is becoming a priority task. Choosing a strategy for Russia, which is overcoming its economic and technological lag under the conditions of sanctions and powerful geopolitical pressure, is becoming no less difficult (Melanina, Verenikina, 2019).

For business, Industry 4.0 is a serious challenge and a test of strength. According to a literary review by Wichmann, Eisenbart and Guericke (Wichmann et al., 2019), an increasing number of companies are competing to stay relevant. They are competing not so much for leadership in their sector as for assurance that their business model is adequate to rapidly changing external conditions.

For Russia at the present stage, the key factors determining the need to introduce Industry 4.0 technologies into production are profit growth and the need to ensure control over the production process (Tarasov, 2018).

At all levels of government, at the level of corporations, small businesses and consumers, for several years, there has been a highly positive assessment of the importance of innovation and the introduction of digital technologies. Nevertheless, the Russian industry lags behind the USA, Germany and China in terms of digitalisation (Yudina, 2020).

In Russia, there is still a significant deterioration of basic production assets. The country purchases equipment and machine tools abroad and, according to Rosstat, the account for more than 40% of imports. Machine tool building in Russia has only recently begun to revive. The share of machine tools with computer numerical control (CNC) in Russia is still small in relation to the total machine tool market (according to various estimates, it is about 5% of the market, while in the EU countries – 21% (Kommersant, 2020), although it is precisely this equipment that is necessary for the introduction of digital technologies. It is also worth noting the almost complete dependence of our machine tool industry on the import of CNC systems for the production of machine tools.

Currently, the Russian national government is focusing on the development of artificial intelligence technologies, which will allow it to leapfrog and compete on a par with China and the United States. The use of artificial intelligence in Russian enterprises will allow to achieve an increase in productivity of up to 20%, depending on the industry and the available capacities (RBC+, 2020). Russia is able to gain leadership in the use of artificial intelligence in traditionally developed industries such as metallurgy, oil and gas industry and chemical industry.

The digitalisation of production is also constrained by the insufficient degree of distribution of industrial automation systems (for example, MES-systems). This is largely due to the shortage of proven national development. Few enterprises can afford significantly more expensive import solutions. Also, domestic (vs multinational) manufacturers still do not widely use Enterprise Resource Planning (ERP) systems, corporate information systems, which are a set of integrated software packages that allow you to create a unified environment for automating planning, accounting, control and analysis of all major business processes at the enterprise.

Meanwhile, Russia has sufficient prerequisites for a successful transition to Industry 4.0 – the country is one of the leaders in terms of the development of digital infrastructure and the spread and availability of broadband Internet. The largest Russian industrial enterprises have already implemented ERP-systems. Many enterprises have mastered the technologies of virtual modelling and engineering analysis. For example, in the aviation or automotive industry, a large number of situations are simulated digitally, both at the level of development and at the level of product manufacturing.

The country is in demand for solutions for creating systems for continuous monitoring and diagnostics of the state of industrial equipment in real time. Corporations create laboratories for testing and implementing IIoT ("Industrial Internet of Things" – the industrial Internet of Things – a multi-level system that includes sensors, controllers on equipment, means of transferring the collected data and their visualisation, as well as analytical tools for interpreting the information received). For example, the Novolipetsk Metallurgical Plant and SAP, a German ERP solutions company, have opened a joint innovation laboratory (including in the field of IIoT).

Russia has broad prospects for making technological breakthroughs in many areas of economic activity. It is important to create its own priority niches for digital innovations, where it is possible not only to achieve independence in the domestic market at the lowest cost, but also to become a recognised global leader.

The most significant contribution to the digital transformation of the country's economy will come from the implementation of the Digital Economy of the Russian Federation National Programme, developed in accordance with Presidential Decree No. 204 of 07.05.2018 "On National Goals and Strategic Development Objectives of the Russian Federation for the

Period until 2024" and approved in December 2018. The main objective of the National Programme is to create a favourable organisational, legal and infrastructural environment in the country for developing the digital economy to improve competitiveness in the globally (On National Goals and Strategic Development, 2018).

An autonomous non-profit organisation (ANO) has been established to ensure a productive dialogue between business and government in implementing the Digital Economy of the Russian Federation National Programme, which includes Yandex, Mail.Ru Group, Rambler & Co, Rostec, Rosatom, Sberbank, Rostelecom, Skolkovo Foundation and the Agency for Strategic Initiatives. The Digital Economy is also engaged in supporting socially significant projects and initiatives in this area, and assesses the effectiveness of the implementation of strategic directions (Melanina, 2019).

For the development of the digital economy in Russia, the most rational step seems to be the creation of a number of industrial digital platforms under the leadership of relevant ministries or state corporations that will focus their efforts on key areas: transport, telecommunications, energy and data processing. These platforms will create the necessary infrastructure for the fastest possible development of the digital economy and the spread of related technologies, and will make it possible to build a single digital space uniting all industries and sectors in the future. Such an approach will significantly increase the transparency, manageability and flexibility of the country's economy (Strelkova, 2018).

In 2016 the World Bank published « World Development Report 2016: Digital Dividends», which provides an overview of the digital economy in the world and analyses the increasing development benefits of digital technology for countries. The report shows that the Internet contributes to development through three main mechanisms (World development report, 2016):

1. Integration (overcoming information barriers, creating new markets: expanding trade, creating new jobs and increasing access to public services);
2. Efficiency gains (first, the dramatic drop in the price of digital technologies has provided companies and governments with an incentive to replace existing factors of production – labour and capital not related to information and communication technologies (ICTs) – with ICT capital, as well as to automate certain activities. Secondly, digital technology reinforces non-substituted factors of production and increases their productivity);
3. innovation (by enabling virtually seamless communication and collaboration, the Internet can support new delivery models, facilitate collective action and accelerate innovation).

By overcoming information barriers, building productive resources and changing the nature of products, digital technologies can make development more inclusive, efficient and innovative.

The impact of the main mechanisms of digital economy development on various economic entities – enterprises, both small and large, the state and society, as well as on various segments of the economy – is differentiated (see Table 1).

In general, the World Bank's digital economy experts note that its development not only stimulates economic growth, but also tangibly accelerates its pace.

Table 1

Impact of the main mechanisms of digital economy development on economic agents

	Digital technology		
	Integration	Efficiency	Innovation
Companies	Trade	Use of capital	Competitiveness
Population	Employment opportunities	Labour productivity	Consumer welfare
Government	Participation	Public sector capacity	Voice

Source: composed on World Development Report, 2016.

The COVID-19 outbreak has created an imbalance in the global economy due to supply chain disruptions resulting from production closures in China, lockdowns in various countries around the world – either simultaneous or simultaneous (Wang, Melanina, 2021). This has negatively affected investment, profitability and other important production parameters as well as production processes in general. Consequently, the revision of value chain security by both countries and large multinational companies (MNCs) triggered by the global pandemic of new coronavirus infection, especially through the further advancement of digitalisation in this aspect, has become imperative and has significantly affected the global value chain structure and its shaping in the future, as the critical challenge to the viability of the value chain becomes not only its efficiency but also industrial safety.

The impact of COVID-19 on the economy is likely to be less than the impact of stringent policy measures taken to prevent the spread of the virus (Digilina, Lebedeva, 2021). The pandemic caused a severe oil price collapse, the largest since the 1991 Gulf War. As a result of the pandemic, global stock markets recorded their biggest and steepest drop since the global financial crisis in 2008. At the political level, coordinated action by all countries to implement a medical protocol to reduce the spread of the pandemic, as well as fiscal measures to support the manufacturing sector, will be needed to spur economic recovery. Measures that may have a positive impact on economic recovery after the pandemic include reductions in central bank interest rates (based on US experience) to improve access to credit and stimulate investment, as well as reductions in the tax burden on businesses and individuals. If we analyse the list of industries that have benefited from the lockdown, it will be those that are somehow related to the use of digital technology (Drobot, 2020).

It is important to integrate digital technologies into public investments, such as those in cities and infrastructure, to support innovation and the transition to a more sustainable economy. This should be a key objective of regional development funds. For example, public authorities' investments in transport and urban infrastructure to create jobs and develop the local economy should also be smart, i.e. digital. This would reduce traffic congestion and pollution, and improve productivity and quality of life for residents and those who work in the city. Equally, governments should ensure that support for specific sectors, such as agriculture, is directed at enabling such sectors to reduce their environmental impact and move towards more sustainable business models (Teslenko, Digilina, 2021).

Such investments could include:

- Funding to improve the energy efficiency of public buildings and to digitise the building and construction equipment sector to take advantage of the benefits that building automation can create.

- Smart city initiatives for technology ecosystems, where data can be collected on traffic, noise, air quality, energy consumption and movement (related to COVID response). These will lead to informed, sustainable decision-making by authorities
- Encourage remote services for all installed infrastructure as an alternative to services provided solely in person.

In Russia, companies that manufacture equipment with components or spare parts sourced from abroad, as well as companies developing software for transport, tourism and hospitality businesses, are mainly affected due to the introduction of quarantine measures.

Undoubtedly, in today's challenging pandemic and demand constraints across many industries, investing in innovation does not always seem like a good idea. Moreover, the rapid changes in the technology market force businesses to think about the feasibility of investing now with the risk of obsolescence of systems in five to ten years, or to wait a few more years and introduce more advanced technologies. Nevertheless, the organisation that does not move forward, does not just stand still, but lags behind the leaders more and more. Therefore, investment in innovation is necessary for both business and the entire national economy.

2. Methodology of the Research

In our study, we will compare the level of business innovation activity by year for the period 2011-2020. To do this, we will calculate the Index of Innovative Activity of Russian Business. Based on the results obtained, we will try to identify the reasons for the growth and decline in innovative activity in the specified period.

Our research methodology is based on principal component analysis (PCA), which is widely used in multivariate statistics (see, for example, Armeanu, 2008; Park et al., 2016; Doukas at al., 2012; Gavrilets et al., 2019; Kendyuhov, 2013; Petrişor at al., 2012; Tan, 2015; Zhgun, 2017).

In line with a number of studies (see, for instance, Barrington-Leigh, 2018; Pérez-Moreno et al., 2016), we try to avoid any expert judgment in the choice of weighting coefficients when constructing a composite indicator.

The innovative activity of a company is a multidimensional characteristic that includes many indicators $X = \{x_i\}_{i=1}^{n}$ (in this case, n = 30, see Table 1). Each i-th indicator characterises the innovative activity of companies from the sample in year j (j = 1, ..., m; in this case, m = 10). We took data for 2011-2020.

The principal component analysis is a multivariate statistical technique that combines various factors that appear to be nearly incompatible (Aivazian et al., 2006). It converts a set of original variables:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{pmatrix} \quad (1)$$

into a set of artificial uncorrelated variables:

$$Z = \begin{pmatrix} Z_1 \\ \vdots \\ Z_n \end{pmatrix} = \begin{pmatrix} z_{11} & \cdots & z_{1m} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nm} \end{pmatrix} = LX \qquad (2)$$

where $Z_1,\ldots,Z_m$ - vectors from the first to the m-th principal component,

$$L = \begin{pmatrix} l_{11} & \cdots & l_{1n} \\ \vdots & \ddots & \vdots \\ l_{n1} & \cdots & l_{nn} \end{pmatrix} \qquad (3)$$

- matrix of linear orthogonal transformation.

Principal component loads are eigenvectors of the covariance matrix of the original data:

$$\Sigma\colon (\Sigma - \lambda I) l_1^T = 0. \qquad (4)$$

The corresponding characteristic equation (5) has n real non-negative roots (5) - eigenvalues of the covariance matrix:

$$|\Sigma - \lambda I| = 0 \qquad (5)$$

$$\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_n \geq 0 \qquad (6)$$

The load of the first principal component is defined as the eigenvector corresponding to the largest eigenvalue λ_1. In subsequent main components:

$$Z_k = (z_{k1},\ldots,z_{km}) \qquad (7)$$

Other eigenvectors are used as component loads corresponding to successively smaller eigenvalues λ_k, k=2,...,n. λ_k is equal to the variance of the k-th principal component. The total variance of the principal components coincides with the total variance of the primary data, thus (8) is the proportion of the total variance of the primary data explained by the k-th principal component.

$$\rho_k = \lambda_k \Big/ \sum_{k=1}^{n} \lambda_k \qquad (8)$$

Source data can be grouped in a row subsets or pillars that reflect certain attributes of a company's activities:

$$X = \begin{pmatrix} \widetilde{X}_1 \\ \vdots \\ \widetilde{X}_\theta \end{pmatrix} \qquad (9)$$

where

$$\widetilde{X}_\alpha = \begin{pmatrix} X_{n_{\alpha-1}+1} \\ \vdots \\ X_{n_\alpha} \end{pmatrix} = \begin{pmatrix} x_{n_{\alpha-1}+1,1} & \cdots & x_{n_{\alpha-1}+1,m} \\ \vdots & \ddots & \vdots \\ x_{n_\alpha,1} & \cdots & x_{n_\alpha,m} \end{pmatrix} \qquad (10)$$

$1 \le \alpha \le \theta$, $1 \le \theta \le n$.

Aggregate indicator I_j can be broken down into the sum of partial indicators (11), which reflect the impact of certain components on the company's results of operations (12):

$$I_{j\alpha} = \sum_{i=n_{\alpha-1}+1}^{n_\alpha} \sum_{k=1}^{n} \lambda_k l_{ki}^2 x_{ij} \Big/ \sum_{k=1}^{n} \lambda_k \qquad (11)$$

$$I_j = \sum_{\alpha=1}^{\theta} I_{j\alpha} \qquad (12)$$

There are two possibilities: if the indicator corresponds to the case "more is better" (for example, the level of a company's cost to innovation), then we bring it in line with a ranking scale of 1-10 as follows (13). And in the case of "less is better" (for example, obstacles to innovation), the following normalising transformation is applied (14), where x_{ij}^n is the normalised variable, and $x_{ij}^{\max}$ and $x_{ij}^{\min}$ - respectively "best" and "worst" value of the initial indicator.

$$x_{ij}^n = 1 + 9\left(\frac{x_{ij} - x_{ij}^{\min}}{x_{ij}^{\max} - x_{ij}^{\min}}\right) \qquad (13)$$

$$x_{ij}^n = 1 + 9\left(\frac{x_{ij} - x_{ij}^{\max}}{x_{ij}^{\min} - x_{ij}^{\max}}\right) \qquad (14)$$

Here we use the modified principal component estimates as a weighted sum of all principal component estimates (15):

$$I_j = \sum_{k=1}^{n} \rho_k y_{kj} = \sum_{k=1}^{n} \rho_k \sum_{i=1}^{n} l_{ki}^2 x_{ij} \qquad (15)$$

The method was tested in our previous studies (Verenikin et al., 2018, 2020). This avoids negative assessments of principal components as constituent elements of the composite index. The modified principal components y_{kj} are weighted according to the respective fractions of the explained variance ρ_k. In this case, there is no loss of variance of the data under consideration. The explanatory power of the proposed indicator extends to the total variance of the original variables. A distinctive feature of the proposed composite indicator is that it is not sensitive to subjective preferences regarding the relative importance of specific factors in companies' innovative activity.

3. Russian Industry 4.0 – Indicators of Business Innovation

The objective of our research is the public reports of the Russian Union of Industrialists and Entrepreneurs on the state of the business climate for 2011-2020 (RSPP, 2020). We have selected a number of indicators (see Table 2) that are common for the analysis of information on the innovation activity of Russian companies included in the sample. According to the Report, the survey was conducted among member companies of the Russian Union of Industrialists and Entrepreneurs, that is, these are 277 largest Russian companies – industrial, scientific, and financial – in all regions of Russia.

Table 2

Indicators of business innovation activity

Chapter	Subsection
A. Drivers of firm innovation	
A1. Cost of innovation	
Average cost to companies for innovation *,%	A1.1
Median value of the level of innovation costs to companies *,%	A1.2
Percentage of companies in which innovation costs are not incurred	A1.3
Share of companies where innovation costs are less than 5% of revenue	A1.4
Costs for innovation from 5% to 10% of revenue	A1.5
Innovation costs 10 to 20% of revenue	A1.6
Innovation costs over 20% of revenue	A1.7
A2. Using international tech standards	
International technical standards do not apply	A2.1
From 5 to 10% of manufactured products are manufactured using European or other international technical standards	A2.2
From 11 to 20% of manufactured products are manufactured using international technical standards	A2.3
From 21 to 50% of manufactured products are manufactured using international technical standards	A2.4
More than 50% of manufactured products are manufactured using European or other international technical standards	A2.5
A3. The level of automation of production processes,%	
No process is automated	A3.1
Separate technological processes are automated	A3.2
Several processes are automated	A3.3
All functions are performed automatically (automated workshop)	A3.4
B. Key Barriers to Firm Innovation	
Lack of own financial resources	B1.1
Lack of skilled workers and specialists	B1.2
Lack of applied tax incentives	B1.3
Lack of state support for innovations at the federal level	B1.4
Lack of state support for innovation at the regional and/or local level	B1.5
Low predictability of business conditions	B1.6
Difficulty attracting credit	B1.7
Underdeveloped innovation infrastructure	B1.8
Low quality and/or high cost of services provided by Russian scientific and design organisations	B1.9
Lack of the necessary technological solutions on the market	B1.10
Lack of information about scientific organisations and advanced Russian developments	B1.11
Difficulties in obtaining quality engineering services	B1.12
Disinterest of the owners of the company	B1.13
Difficulty in ensuring the required quality of supplies	B1.14

Source: composed by the authors, based on RSPP Reports, 2011-2020.

Further, we grouped the indicators into 2 sections: a) factors contributing to the innovation activity of companies (including 3 subsections – the cost of innovation, the use of international technical standards and the level of production automation) and b) the main obstacles to innovation. The highlighted sections reflect certain features of the studied models and give an idea of the factors of innovative activity of companies, as well as the potential for improvement.

As we have already mentioned, the indicators were normalised in 2 ways: "more – better" and "less is better". In the first group, the following indicators were included: A1.1, A1.2, A1.5, A1.6, A1.7, A2.2, A2.3 A2.4, A2.5, A3.2, A3.3, A3.4, and in the second group the following indicators were included: A1.3, A1.4, A2.1, A3.1 and all the indicators of chapter B. Key Barriers to Firm Innovation (from B1.1 to B1.14).

Table 3

Values of indicators for 2011-2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
A1.1	9	9	9	9	9,9	9,9	9,9	9,9	7,9	9,2
A1.2	5	5	5	5	5	5	6	7	6	5
A2.1	10	9	10	6,2	9,4	2,9	5,2	4,4	7,9	1,4
A2.2	44	41	53	47,7	45,3	45,2	39,6	42,2	49,1	53,5
A2.3	21	29	19	24,6	20,5	18,3	23,3	28,9	25	20,7
A2.4	14	12	9	13,8	17,1	19,2	19	12,6	11,1	16,1
A2.5	11	9	9	7,7	7,7	14,4	12,9	11,9	6,9	8,3
B1.1	25	42	43	37,1	46	39,1	43,4	46,3	41,2	46,5
B1.2	11	13	10	8,8	10,2	7,7	10,9	9,7	10,3	11,1
B1.3	8	5	6	8,8	5,1	7	5,4	10,3	8,2	5,3
B1.4	10	12	10	15,7	10,2	11,9	5,4	11,5	8	7,4
B1.5	49	28	29	29,6	28,5	34,3	34,9	25,7	28,8	29,6
C1.1	5,3	10,4	10,4	10,4	10,4	10,4	10,4	10,4	10,4	10,4
C1.2	56	50,6	50,6	50,6	50,6	50,6	50,6	50,6	50,6	50,6
C1.3	34,2	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6
C1.4	4,5	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2
D1.1	54	50,7	62,5	62,6	50,6	68,5	57,7	59	47	58
D1.2	35	29,3	35,9	25,9	19,9	31,5	29,7	38	28	40
D1.3	26,2	23,7	27,1	29,9	22,4	30,2	35,4	37	39	49
D1.4	20,9	18,1	25	16,3	22,4	24,8	28	30	27	31
D1.5	19,8	15,6	21,9	19	20,5	20,8	24	22	26	31
D1.6	22,4	22,2	26,6	22,4	27,6	24,8	32,6	26	30	33
D1.7	21,3	24,4	26,6	29,9	25,6	34,9	36	26	19	33
D1.8	11	11,5	7,3	12,9	12,2	10,1	11,4	14	17	27
D1.9	16,3	14,4	15,6	12,2	10,3	12,8	16	13	18	15
D1.10	19	11,5	10,9	12,2	15,4	11,4	14,3	12	10	16
D1.11	10,6	10,4	13	7,5	7,7	10,1	10,3	12	13	24
D1.12	6,8	7,8	7,3	8,8	8,3	5,4	8,6	10	12	12
D1.13	5,3	5,9	4,7	4,8	2,6	2,7	5,1	6	6	3
D1.14	5,7	6,7	5,7	6,1	8,3	5,4	6,9	6	4	8

Source: composed by the authors, based on RSPP Reports, 2011-2020.

The costs of companies for innovation costs include: investments in new machines and equipment, R&D costs, technological preparation of production, acquisition of patents and licenses, digitalisation of production. International standardisation is an effective tool for improving the technical level and competitiveness of production. The assessment of the level of automation of production processes was carried out only in 2019 and 2020, there is no previous data. Therefore, we had to accept the values of these indicators in 2018-2011 as equal to 2019 (see Table 3).

We used Gretl to calculate principal component loads for all 30 indicators over 10 years. Received 9 vectors of principal components with positive eigenvalues.

The Index of Innovative activity of Russian business I_j in the modified components of the main components y_{kj}, weighted by the form of the proportion of the explained variance ρ_k (see Table 4).

Table 4

Values of the Index and sub-indices of innovative activity of Russian business

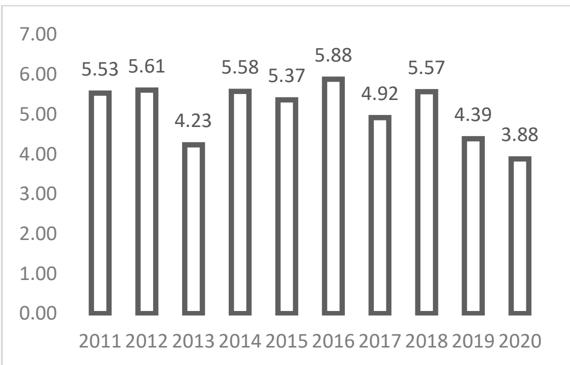
Year	Index value	Rating	Section A.	Rating	Section B.	Rating
2011	5,53	5	2,60	5	2,93	5
2012	5,61	2	2,35	7	3,26	2
2013	4,23	9	1,47	10	2,77	6
2014	5,58	3	2,40	6	3,18	3
2015	5,37	6	1,99	8	3,38	1
2016	5,88	1	2,77	3	3,11	4
2017	4,92	7	2,92	2	2,00	9
2018	5,57	4	3,30	1	2,27	8
2019	4,39	8	1,98	9	2,40	7
2020	3,88	10	2,61	4	1,27	10

Source: composed by the authors.

As we can see (see Figure 1), the value of the Index of Innovative Activity of Russian Business reached its maximum value (5.8807978) in 2016. Indicators for 2012, 2014, 2018 and 2011 are not far behind. 2015, 2017, 2019 and 2013 can be considered problematic for the development of the innovative activity. And finally, the most unsuccessful year for innovation activity was predictably 2020, which is understandable given the lockdown and a serious reduction in the already insignificant investment resources of enterprises.

Figure 1

Russian business innovation activity index



Source: prepared by the authors.

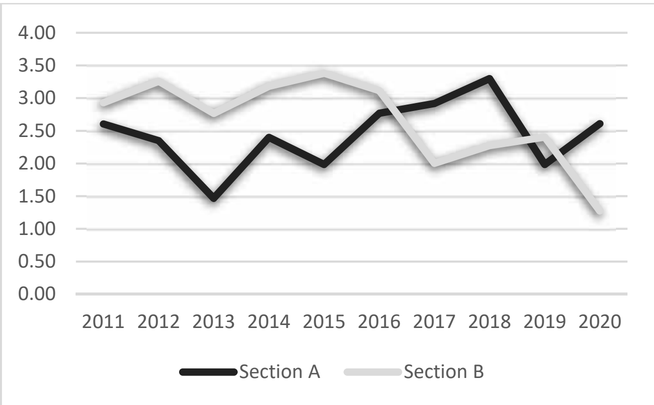
The index of innovative activity of Russian business is a linear combination of the entire set of modified estimates of the main components:

$$I_j = \sum_{k=1}^{n} \left(\lambda_k \sum_{i=1}^{n} l_{ki}^2 x_{ij} \right) \Big/ \sum_{k=1}^{n} \lambda_k \quad (16)$$

Thus, it can be viewed as a composition of partial indices that summarise the weighted modified principal component estimates for each pillar (section) of the data. These sub-indices form the rating for individual components (see Table 3 and Figure 2). As we can see, the contribution of Section B (main barriers to innovation) to the overall index is gradually decreasing, and factors that promote innovation are becoming more important (Section A).

Figure 2

Sub-indices of innovation activity of Russian business



Source: prepared by the authors.

In Russia, the state system for supporting the development of new technologies is currently actively developing. Several programs were adopted at the federal level, for example: the Federal Target Program “Electronic Russia”, the Strategy for the Development of the Information Society in the Russian Federation (2008-2015), the State Program “Information Society” (2011-2020), the Strategy for Scientific and technical development (2016-2035), Strategy of the Information Society (2017-2030), state program “Digital Economy” (2017-2030), Resolution of the Government of the Russian Federation of August 28, 2017. N1030 “On the management system for the implementation of the program” Digital Economy of the Russian Federation”; Comprehensive program for the development of biotechnology in the Russian Federation for the period up to 2020; Roadmap for the Development of Biotechnology and Genetic Engineering until 2020, etc., as well as many programs at the regional level.

The current crisis has affected all sectors of the economy in one way or another. The pandemic has reduced demand and sales for many companies, forcing them to cut costs on new equipment, materials, software, labour, etc. In such an environment, it is unlikely that companies will seek to innovate. Analysts believe that the challenges are a boon for the domestic economy. The previous challenge – sanctions – led to a market cleansing and companies turning to innovation.

The coronavirus pandemic has increased interest in high technology. And while it used to take companies quite a long time to prepare for a technological upgrade, from 2020 they have begun to implement this process rapidly – literally in weeks. Priority areas for digital technology development will be: enabling social distance activities, increasing the efficiency of remote work, study, leisure, and increasing the availability of medical care. Experts believe that the current crisis and its consequences in Russia will accelerate the digitalisation of businesses, not only in such areas as services and retail, but also in the real sector.

After the coronavirus pandemic, the world will not be the same. So forms of distance working and learning will definitely take hold, marking a new modern way of living and working. And the intensified creation of next-generation information technology will enable Industry 4.0 to be implemented everywhere, making the products and services of the national economy competitive on global markets.

4. Conclusion

The level of investment in technological innovation and other indicators characterising the development of the innovation sector indicate so far an insufficiently successful innovation policy in the country. This is partly due to objective reasons, global problems and instability. In many respects – with insufficient domestic demand for innovations and a lack of own financial resources and qualified labour force at the enterprises themselves.

The index the authors have constructed reflects an integrated approach to assessing innovative activity and gives an integral assessment of the current state of innovative activity in Russian business. The authors do not rely on any expert judgment and do not attach subjective weights to factors. This study lays the foundation for the regular (for example, once a year) calculation of the innovation activity index of Russian enterprises. As a direction for improvement, the authors postulate, we can indicate the need to include new indicators that expand the understanding of the factors influencing the innovative activity of a business.

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