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S. I. Ashmarina
V. V. Mantulenko *Editors*

# Proceedings of the International Conference Engineering Innovations and Sustainable Development

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Editors

# Proceedings of the International Conference Engineering Innovations and Sustainable Development

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# Contents

# Current Trends in the Industrial and Agricultural Development

# Analysis of Oil Production and Export Dynamics in Russia

**O. F. Chistik**

**Abstract** This statistical analysis covers the period of several years marked by instability of the processes which took place in the Russian oil industry. Devising an informational and analytical tool for the study of the processes under consideration is vital for effective measures and the adoption of effective managerial decisions at various levels to ensure the positive socio-economic development of the Russian Federation. The aim of this study is the dynamic processes of the oil production and export. The originality of the study is focused on the informational and methodological approach, which made it possible to establish three stages of dynamic development of the extractive industry on the basis of a content analysis of oil production and export indicators and an assessment of the processes of their dynamics in Russia. This approach revealed the impact of extensive and intensive factors on the change in oil export revenues by means of general absolute and relative indicators application and the index factor analysis method. On the basis of indicators of structural differences of time series presented, analysis of changes in export structure to foreign and neighbouring countries was carried out. The results of the study can serve as a solid framework for development of a mechanism of effective management decision-making at the federal and regional levels that ensure sustainable socio-economic development aimed at improving the level and quality of life of Russian citizens.

**Keywords** Export revenues analysis · Export structure change · Periodization of processes · Oil production and export

## 1 Introduction

Russia occupies one of the leading positions in oil resources and production [1, 2]. In Russia, the major branch of the fuel and energy sector is the oil industry with oil being one of the most vital export goods in the structure of national economy. Revenues from petro-chemical industry as a taxed income comprise a substantial portion of

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the national budget. At the same time, when oil prices fall, the economic model associated with the oil resource rents brings a negative effect: rising inflation and declining population incomes take place. Moreover, large volumes of oil produced and exported feed a number of related industries, including oil refining, so this sector has a large impact in terms of creating new jobs, is aimed at innovation and, therefore, at the development of the social and economic system. The sources of information on oil production were the Federal State Statistics Service, the Federal Customs Service. The relevance of the chosen topic is mainly due to the fact that the output of national petro-chemical sector is the most important export category. The budget of the Russian Federation and the investment in many other sectors of the economy largely depend on the oil revenues received. This explains the dependence of Russia's GDP on the volume of its oil production.

The subject of the study is quantitative trends and patterns related to oil extraction and its export in the Russian Federation. Many economists were engaged in research on oil production and export. In their works [3] some experts suggest that sustainable growth of oil production in Russia can be achieved through exploration of new oil fields and modernization of the oil refining industry. A number of authors [4] emphasize a close relationship of the oil refining industry with other sectors of the economy and point out the environmental issues.

The problems related to increased production costs, low oil extraction rates, as well as negative environmental impact of oil industry are addressed by Hammatdinova [5]. In their work researchers [6] examine Russian as well as foreign experience of vertically integrated oil companies from the point of view of their strategic advantages management [7], consider methods of heavy oil and oil-bearing resources development worldwide and give a critical overview of processes of oil recovery enhancement (EOR) [8]. On the other hand, most authors agree [9] that with high oil prices, modernization and new technologies, production and oil processing of unconventional oil resources (resin sand oil, super-heavy oil, shale oil) is feasible [10]. In his work the researcher Ryabov [11] draws attention to the way to increase the competitiveness of the final products of oil refineries. Since the political and economic reforms of the 90s modernization processes are taking place in the development of Russian oil industry. In these conditions the extent of influence and its distribution between state institutions and public organizations affect the policy formation and the development of the oil and gas industry. In our opinion, along with the study of the periodization of oil production and export, significant attention should be paid to the influence of extensive and intensive factors on changes in oil export revenues in Russia. Since the effective use of oil resources largely affect foreign economic relations, sustained economic growth and the quality of life of the population.

## 2 Methods

General scientific methods of research such as dialectics and comparison were used in the analysis of the dynamics of oil production and export. The method of time series analysis with its subsequent periodization, content and quantitative analysis, the method of index factor analysis, the method of analysis of the structure of oil exports, as well as the tabular method of formation and visualization of the results of the information array study were used as statistical tools. Excel and Statistica software applications were used to utilize these methods. The information base was obtained from Global Finances homepage [12] containing data from the official resources of the Federal State Statistics Service and the Federal Customs Service. Other sources included general publications and Internet resources of the Russian Federation.

## 3 Results

The trend in oil production in the Russian Federation from 2000 to 2019 is presented in Table 1. During the study period, the volume of oil produced continuously grew. Since 2000, oil production per year has increased by 232,401 thousand tons. On average, the annual increase was 12.51 million tons, that is, 3.0%. During these 18 years, several periods of production growth can be identified.

In the first period of 2000–2007 production increased steadily. The growth rate over the year was 6.1% on average due to the growth of the economy. Annual production increased by 23,909.29 thousand tons on average. The second period 2008–2014 can be called a period of crisis, since its time boundaries are: the global economic crisis of 2008 and the conflict with Ukraine in 2014, when financial and technological sanctions against the Russian Federation were subsequently imposed. In the period of 2008–2014, the average growth was 1.1%, and in physical terms—5034.86 thousand tons per year. Compared to the previous period, oil production slowed down by 4.7%. Incidentally, in 2008, compared to the previous year, oil production decreased in the first of two times over the entire study period, by 2861 thousand tons, that is, by 0.6%. During the next period of 2015–2018 oil production increased on average by 7014.8 thousand tons per year. Compared to the first period, the growth is not that large, but significantly higher than in the second period. These processes are associated with the dire consequences of the imposed sanctions and finding the way out of the difficult situation. The average growth rate for this period was 101.3%. Compared to the previous period, there is an increase of 0.2%. At the same time, in

**Table 1** Oil production dynamics, including gas condensate for years 2000–2019

| Years | Oil production, mil. tons | Absolute increase, mil. tons | Growth rate, % | Change, % |
|---|---|---|---|---|
| 2000–2007 | 421.7 | 23.91 | 106.1 | 6.1 |
| 2008–2014 | 509.6 | 5.03 | 101.1 | 1.1 |
| 2015–2019 | 549.2 | 7.01 | 101.3 | 1.3 |
| Annual average | 484.3 | 12.51 | 103.0 | 3.0 |

**Table 2** Trends in average oil exports in 2000–2019

| Years | Exports, mil. tons | Export share, % | Absolute increase, mil. tons | Change, % |
|---|---|---|---|---|
| 2000–2007 | 218.3 | 51.8 | 16.31 | 8.8 |
| 2008–2014 | 240.8 | 47.3 | − 5.10 | − 2.3 |
| 2015–2019 | 256.4 | 46.7 | 9.14 | 3.8 |
| Annual average | 235.7 | 48.7 | 6.57 | 3.3 |

2017 there was a decrease in oil production compared to the previous year by 0.3%. That was the second drop in oil production that occured in the entire period of study. It is generally associated with the strengthening of the imposed sanctions.

The analysis of oil exports for the I, II and III periods showed a decline in oil exports of 7.8 and 4.1 million tons in the I period (2000–2007) in 2005 and 2006, respectively (Table 2). On average, in the first period there was an increase of 16.3 million tons, or 8.8%. In the second period oil exports increase took place only in 2009 and 2010 (4.4 and 3.2 million tons). In the remaining years of the II period oil exports went down, in particular, 2008 and 2014 marked a sharp decline of 15.5 and 13.1 million tons, respectively. On average, the decline in exports in period II reached 5.1 million tons, or 2.3%. In the third period, 2015–2019, there was an increase in oil exports. Only in 2017 there was a decrease of 2.1 million tons. On average, during this period, export growth has reached 9.1 million tons, or 3.8%. It must be said that the share of exports in total oil production decreased on average from 51.8% in the I period to 46.7% in the III period. Thus, on average for the entire period of 2000–2019, it made up 48.7%.

Table 3 presents estimates of oil export revenues for the time periods analyzed. In the second period, a significant annual average income from oil exports was generated. It is almost 2.6 times, or by $94.7 billion, higher than in the previous period. However, in the third period, the same indicator decreased by 34.6%, or by $ 53.8 billion, compared to the second period. Note the growth of the average annual volume of oil exports and the instability of oil profitability: growth in the II period and a decrease in the III period. The index factor analysis method determines the effect of the average size of oil exports and its average annual yield on the change in the volume of average annual average income from oil exports (Table 4). In the

**Table 3** Oil exports revenues of the Russian Federation for years 2000–2019

| Average annual indicator | Periods | | |
|---|---|---|---|
| | I (2000–2007) | II (2008–2014) | III (2015–2019) |
| Revenue, mil. $ | 60,665.4 | 155,406.4857 | 101,621.64 |
| Exports, mil. tons | 218.3 | 240.8 | 256.4 |
| Profitability of 1 ton of oil, $ | 277.9 | 645.3 | 396.3 |

**Table 4** Change in average annual oil export revenue in the Russian Federation for 2000–2019

| Period | Average annual revenue change, mil.$ | Impact on average revenue change, mil. $ | |
|---|---|---|---|
| | | average export volume | Average profitability of 1 ton of oil |
| (2008–2014)/(2000–2007) | 94,741.1 | 6272.3 | 88,468.8 |
| (2015–2019)/(2008–2014) | − 53,784.8 | 10,038.4 | −63,823.3 |
| (2015–2019)/(2000–2007) | 40,956.3 | 10,596.1 | 30,360.2 |
| 2019–2018 | − 6973.5 | 4263.8 | −11,237.3 |

**Table 5** Integral indicators of structural differences, %

| Period | K. Gatev index | V. Ryabtsev index |
|---|---|---|
| 2019–2002 | 9.9 | 8.4 |
| 2019–2018 | 0.3 | 0.2 |

II period compared to the I period, the increase in average income (100%) is due to the volume of exports (6.6%) and profitability (93.4%). In the III period compared to the I period - 25.9% and 74.1%, respectively.

In the III period compared to the II, the decrease of the average annual income by $53.8 billion was caused by a multi-directional influence of factors: a slight increase in the size of exports and a considerable decrease of oil revenues. In 2019 the trend of multi-directional action of factors continued, however somewhat weakened, since the growth in export size compensated for a decrease in profitability by 37.9%, while for the entire III period export growth allowed to compensate for only 15.7%.

A study of structural differences in oil exports [13] to foreign countries and the CIS (Table 5) showed that the changes in the period 2000–2019 occurred in conditions of a low level of differences. Values for each of the two indices (8.4%; 9.9%) reached the highest test value in 2019 compared to 2002, but is included in the interval with a low level of structural differences in the period. At the same time, in 2019, compared with 2018, index values (0.2%; 0.3%) dropped to the lowest value and fall within the interval of the test values, characterized as having identical structures. Thus, in the structure of oil exports in the period of 2000–2019 there were changes ranging from low levels of differences to unchanged structures.

## 4 Discussion

The program of petrochemical sector development in Russia for the period till 2025 [14] proves the importance of monitoring and statistical research of oil production and export processes in Russia, providing state support for the export of high-grade products and stimulating investment activity in oil industry. In this analysis the key research tool is the method of time series periodization based on content and quantitative analysis. The application of this method allows to carry out a subsequent comparative analysis of oil production and export trends using the method of general indicators analysis. Based on the index factor analysis method, the influence of extensive and intensive factors on the change in oil export revenues was examined. The proposed informational and methodological method is expected to serve as a framework for the development of a system of measures that allows executive authorities to create the necessary conditions for large oil and gas chemical investment projects implementation. At the same time, it is essential to stimulate the development of the oil processing sector and the export of petroleum products. A substantial increase of oil processing requires a set of measures and incentives from the state. Thus, in the United States, the government stimulus of refining and export of petroleum products steadily increased in the past decade. Just in years 2005–2015 it quadrupled [15].

## 5 Conclusion

Dynamic changes were identified on the basis of content and quantitative analysis, which made it possible to highlight periods different in the nature of the development of such processes as oil production and oil exports in the Russian Federation. An index factor analysis of oil export revenues was carried out and cause-and-effect relationship between the size of oil export, export yield and export volume was established for specific periods of time. Analysis of changes in the structure of exports to foreign and neighboring countries was carried out on the basis of indicators of structural differences in the time series presented. Financial crises exert substantial influence on the economy of the Russian Federation. National petro-chemical industry is no exception. Traditionally the oil industry takes a leading role in the Russian economy, so, diverse measures to achieve an increase in oil production are of top priority. In the light of current events associated with the pandemic and the collapse of demand for oil and oil condensate, it is expected that oil production in 2021 will be reduced. One of the ways to increase oil sales revenue is to shift to deeper processing of raw materials and increase the volume of processed oil to produce its derivatives. To implement a large-scale modernization of oil production and processing industry a variety of economic incentives and extensive investment is required. The level and quality of life of all Russian citizens largely depend on the well-being of the oil industry.

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# Updating of Enterprises' Fixed Assets and Business Structures

**A. V. Streltsov and G. I. Yakovlev**

**Abstract** The article studies the main idea of the process of updating the fixed assets of enterprises, its methods and forms, as well as the pace of implementation necessary to increase competitiveness. It is concluded that it is necessary to form a comprehensive mechanism that ensures its implementation based on taking into account the orientation of all market characteristics and the existing macroeconomic management model based on the incentive to upgrade the production activities. The structuring of manufacturing enterprises and business structures according to the peculiarities of the process of updating fixed assets is suggested. Groups of problems of the enterprises connected with updating of production capacities are systematized. The qualitative characteristics of these problems is presented and the main directions of their solution in relation to the conditions of the digital economy are determined. The purpose of the study is to study and solve problems related to the renewal of fixed assets of manufacturing enterprises. The work is based on the methods of theoretical and empirical knowledge of reproductive processes in processing activities. The information base of the study was statistical information and information resources of free access concerning the business practices of enterprises and business structures.

**Keywords** Entrepreneurship · Fixed assets · Manufacturing enterprises · Market characteristics · Renewal · Technologies

## 1 Introduction

The problems associated with the renewal of fixed assets of industrial enterprises and business structures engaged in manufacturing are now becoming particularly significant. This is due to the increased amount of accumulated obsolescence of the production apparatus of many industrial enterprises and in entrepreneurship,

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technological backwardness, low innovation activity of enterprises, which makes transition to digital transformation impossible. The renewal of fixed assets will ensure the growth of output of products that are competitive on the domestic and global markets, reduce production costs, increase labor productivity, and in general, the income of the population. However, the existing trends in the implementation of digital transformation in many types of economic activities show that in order to implement these tasks, it is necessary to significantly increase the scale and efficiency of updating fixed assets, introduce production management information technologies and the industrial internet of things, and conduct digital reengineering of business processes. This, in turn, requires a study of the existing problems of updating the fixed capital and the development of measures to solve them, satisfactorily solving the current problems of technical development of enterprises.

## 2 Methodology

The strategy of updating the fixed assets of enterprises is considered in the Russian and foreign economic literature quite often and in many aspects, from different positions. This is due to the fact that fixed assets (capital) are the most important economic category that determines the characteristics of various aspects of the functioning of the enterprise economic mechanism. They also form the macroeconomic features of the development of the economy of any country as a whole. It is necessary to distinguish the types, forms, directions of renewal, ways of its implementation, and the specifics of justifying methods of transforming labor resources to support the digital transformation of processing activities. First of all, we consider measures for the replacement of equipment, its repair, modernization, which are especially important today in the context of maintaining the digital transformation of traditional production systems. Issues related to the depreciation of fixed assets, its assessment and impact on the performance of the company's equipment estate, and algorithms for managing the updating of information and production systems as a process need to be studied. It is also common in business practice to explore issues related to the modernization of equipment to extend the remaining usable life expectancy, understanding it as a promising alternative to traditional equipment replacement.

Speaking about the research related to the renewal of equipment, it is impossible not to highlight a number of both classical and neo-Keynesian reproductive approaches to determining the optimal timing of replacement of machinery and equipment, mainly based on various economic and mathematical dependencies aimed at intensifying the use of fixed capital of enterprises. These approaches create a sufficiently substantial and significant theoretical basis for further solving problems and improving the efficiency of updating fixed assets. Interesting suggestions are also put forward to update the state of the reproductive apparatus of enterprises to the modern requirements of the fourth industrial revolution, especially digital transformation, which offers a deep reorganization of business processes, repeatedly reducing operating costs compared to the previous purely industrial business concepts.

At the same time, speaking about the characteristics of the renewal of fixed assets of Russian industrial enterprises, especially manufacturing industries, in relation to modern conditions, it seems necessary to highlight the great influence on the renewal of industrial technologies of certain characteristics of the existing economic mechanism of Russia, which prevent the implementation of many existing, quite significant and relevant developments in the field of modern production management. It is necessary to more fully study the impact of the current economic mechanism on the processes of digital renewal of fixed assets of Russian manufacturing enterprises.

It should also be noted that the presence and influence of these complicating characteristics is mainly Russian specifics, which is markedly different from the situation of industrialized countries with an effective market mechanism. Without identifying the areas of their influence and accounting in economic activity, it is impossible to build an effective mechanism for updating fixed assets at domestic enterprises and business structures, where the key factor will not be the possession of any underlying asset, but the development and implementation of digital innovative production platforms that ensure high competitiveness of enterprises.

In the course of the study, we used methods of analyzing cause-and-effect relationships, meaningful economic interpretation of the phenomena associated with the renewal of fixed assets, and empirical traditional methods (comparison, absolute and relative values, and retrospective series of the dynamics of key indicators). Methods of systematization, quantitative and qualitative analysis were used. The empirical basis of the study was the data of the economic practice of domestic and foreign enterprises on their technical development, updating the production and information systems in the digital economy.

## 3 Results

The strategy of updating fixed assets can be considered as a cyclical process, which is an alternation of gradual and radical transformations of the equipment estate. Gradual (evolutionary) changes are based on the measures of updating individual machines within the framework of the basic technologies already used. Each new machine in its characteristics can significantly exceed the replaced one, but its use within the framework of existing technologies determines the evolutionary nature of the update. The change in basic technologies leads to a "qualitative leap" in the level of development of fixed assets, the production potential of the enterprise, which is a radical form of renewal. It requires the replacement of not only individual machines, but also their systems, equipment, and means of monitoring the progress of production.

These patterns allow us to characterize the renewal of fixed assets of the enterprise on the basis of the S-shaped curve used to predict innovations and their life cycle. When describing the dynamics of innovations between two adjacent curves, the so-called "technological gap" is highlighted, which is quite consistent with the transition to a radical renewal of fixed assets. We can, of course, note some differences in the characteristics of the renewal of fixed assets from the traditional shape of the curve. They are related to the fact that updating the equipment estate at the enterprise is a long process, during which several product, organizational and other innovations are carried out. When passing the stage of the "technological gap", the renewal of fixed assets, despite the radical changes, is still based on some continuity of their existing set.

Based on this view of the renewal of fixed assets, it is possible to distinguish a number of forms and methods of its implementation, as well as the principles that affect the effectiveness of its implementation. For example, Namyatova identifies three main forms of renewal, two of its varieties. In the first form, the means of labor do not differ from those that are replaced, in the second they differ in value, in the third, the moral depreciation of the second form is eliminated. The latter has two varieties—simple and innovative [1]. Taking into account the complex of interrelated measures and solutions (technological, technical, economic, etc.) for the replacement, modernization, introduction of new means of labor in order to increase the competitiveness of the enterprise, it seems appropriate to distinguish its methods of implementation, forms and principles of implementation. Among the implementation methods, it is necessary to distinguish the update of an individual machine and machine systems. The forms of renewal can be presented as traditional and innovative. The principles of implementation include cyclicality, staging, systemacity, alternativeness, controllability. It seems that at the present stage, for most Russian industrial enterprises, the most priority is to update machine systems based on an innovative form. This is determined by the presence of a large volume of outdated technologies and equipment at many Russian manufacturing enterprises, and the low competitiveness of their products, especially on the world market. The existing values of the renewal and retirement coefficients also show that even though there is a need for a radical modernization of the domestic industrial potential, in practice, the rate of renewal of fixed assets remains extremely insufficient (Table 1).

The values of the renewal coefficients have slightly increased over the period under review, but even with 5% of new funds being introduced, it takes 20 years to update their totality. In the conditions of toughening competition, these terms seem unacceptably long. In addition, the low values of the retirement coefficient are noteworthy. The need to use an innovative form of updating fixed assets is determined by the fact that they allow you to move from a catch-up type of development to a leading one. By investing in the development of a promising new product, forming the technological and production potential for it, the company can, having "jumped" several

**Table 1** Coefficients of renewal and retirement of fixed assets, %*

| | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| Coefficient of renewal | 3.0 | 3.7 | 3.9 | 4.4 | 4.3 | 5.1 |
| Coefficient of retirement | 1.1 | 0.8 | 1.0 | 0.8 | 0.7 | 0.8 |

* *Source* Authors based on [2]

stages of development, become a leader among the world's competitive companies. To do this, it is necessary to update the machine systems and on an innovative basis.

However, to implement these methods and forms of updating, an integrated approach to its implementation is necessary. It is necessary to build a mechanism that ensures the orientation of all the characteristics of the market and the macroeconomic model of management for the implementation of such an update of fixed assets. Currently, such a comprehensive system has not been formed. When studying the problems of updating fixed assets, first of all, it is necessary to take into account the existing structuring of manufacturing enterprises according to the degree of integration into large corporate structures. This is due to the fact that the degree of integration of enterprises affects the target characteristics of the updating and the ways of making a decision about its implementation, resource opportunities, and the market demand for the results. From this point of view, it is necessary to distinguish enterprises that are part of large companies that process raw materials that are competitive on the world market and produce "raw" semi-finished products (oil refineries, metallurgical enterprises, etc.). It is enterprises that are not related to the primary processing of raw materials, but are of great importance for the country's economy as a whole (large machine-building enterprises, enterprises of the military-industrial complex (MIC), etc.), other enterprises of various industries and forms of ownership.

When describing the problems of updating fixed assets, it should also be taken into account that even within these groups, enterprises are not the same in their competitive status, financial condition, market position, and ability to influence decision-making in the management company. Therefore, speaking about the problems of updating, the average trends and phenomena for this group are evaluated. For the further formation of measures to solve them, all the problems associated with the renewal of fixed assets at enterprises should be systematized in a certain way. It seems appropriate to group them according to the following criteria: possible incentives for renewal and ways to make a decision on the renewal of fixed assets; market characteristics that affect the renewal; resource opportunities; relationship with research and development (R&D) and quality improvement issues; "embeddedness" of renewal in the strategic development of the organization; relationship with other participants of the innovation and investment process. The study of the problems of updating the fixed assets of manufacturing enterprises on the basis of the proposed systematization allowed us to identify the following characteristics (Table 2).

Speaking about the characteristics of renewal at the first sign (incentives and ways of making decision), it can be noted that for enterprises that are part of integrated structures, both raw and non-raw orientation, non-market incentives for renewal prevail. At the same time, it should be noted that unlike enterprises with a purely market orientation, where they are forced to update equipment to achieve the specified parameters, the decision on updating is made by the top management. The government bodies of the Russian Federation stimulate the renewal of fixed assets at such enterprises, of course, not directly, but through indirect methods and solutions. For example, for oil refineries, it is the adoption of new environmental fuel standards, the Euro-4, Euro-5 standard, with the corresponding technical re-equipment. For machine-building enterprises, the military-industrial complex is a requirement

**Table 2** Grouping of problems related to the renewal of manufacturing enterprises

| | Industries | | |
|---|---|---|---|
| Update issues | Enterprises of large "raw materials" corporations | Enterprises of great importance for the country's economy as a whole | Other enterprises |
| 1. Upgrade incentives and ways to make an upgrade decision | Market-based and mostly non-market-based. The management company decides | Mostly non-market. Management with the participation of public administration bodies | Market. Senior Management and Ownership management |
| 2. Market Characteristics | Low creditworthiness of domestic consumers and interest in the production of semi-finished products on the foreign market | Preferential focus on state orders, "distrust" of consumers to the quality of civilian products, taking into account cost parameters | Preferential orientation to the competitive market and the domestic consumer, "distrust" of consumers to the quality of products, taking into account the price |
| 3. Resource opportunities for updating:<br>(a) technological<br>(b) equipment<br>(c) human resources<br>(d) financial | The lack of domestic technologies corresponding to the world level<br>Dependence on foreign partners, owners of technologies in the choice of equipment is significant<br>Determined by the management companies of corporations | The predominant technological focus on the issue of state order<br>Difficulties with the choice of equipment of proper quality and completeness<br>Limited, according to the level of wages<br>Unstable financial condition of enterprises, even with the support from the state | Preferential focus on foreign technologies, taking into account price parameters<br>The primary focus on the equipment of foreign manufacturers, taking into account the price parameters<br>Limited, according to the level of wages<br>Unstable financial situation of enterprises, focus on price growth |
| 4.Interaction of production and personal R & D services, quality management | Low degree of interaction, focus on solving current problems in quality issues | Orientation of R&D and quality services to achieve the required indicators for the implementation of the state order | Low degree of interaction, no promising work to improve quality |
| 5. The "embeddedness" of the updating in the strategic development of the enterprise | Often the lack of an independent strategy due to the specifics of corporate governance and focus on current tasks | The predominant lack of an effective strategy beyond the implementation of the state order | Focus on the short-term perspective, focus on ensuring "fast" profits |

(continued)

**Table 2** (continued)

| | Industries | | |
|---|---|---|---|
| Update issues | Enterprises of large "raw materials" corporations | Enterprises of great importance for the country's economy as a whole | Other enterprises |
| 6. Relation with other participants in the innovation and investment process | Interaction for solving current development tasks and its absence in setting and solving strategic tasks | A built-up system of interaction within the framework of the implementation of the state defense order with the regulatory role of the state, which is not available for civilian products | Lack of system interaction |

by management and owners to fulfill state orders on time and in proper quality, which is why the pace and scale of updating fixed assets at enterprises of the first two groups is much higher.

Attention is drawn to the characteristics associated with the interaction of the processes of updating fixed assets with the innovation component, namely, with the resource capabilities of the technologies used, the relationship with R&D services, and other participants in the innovation and investment chain. Here you can note the following. Given the technological backwardness of most Russian industrial enterprises, they all have to make a decision about the choice of technology and digitalization when updating fixed assets. The enterprises of the first group are less limited in financial resources because they are part of large vertically integrated companies, and they also take into account the lack of domestic technologies that correspond to the world level. In this regard, they focus on the use of foreign technologies, which determines a number of other characteristics: the dependence in the choice of equipment on the technology exporter, the lack of need to use Russian R&D services on a significant scale, incomplete interaction with the participants of the national innovation system (NIS).

Enterprises of the second group are also less financially limited when updating fixed assets in comparison with enterprises focused on the free market, but only in the part of production that relates to the state order. The rest of the production apparatus is similar in its characteristics to the enterprises of the third group. As a difference between the enterprises of the second group, we can note the built-up system of interaction with R&D services and other NIS participants, but only within the framework of the implementation of state order. In the most unfavorable position from the point of view of innovative justification for the renewal of fixed assets, there are enterprises of the third group. As a rule, due to the unstable financial situation, they have not developed their own R&D services, there is no interaction with the NIS participants.

We can note another important characteristic of almost all types of enterprises, with the exception of enterprises of the second group, but only in terms of fulfilling state orders. This focus is mainly on current tasks, and the lack of linking renewal projects with the strategic prospects for the enterprises development. When updating, the focus on products already produced by foreign competitors, imported technologies and equipment reinforce the technological backwardness of Russian enterprises and allow them to solve the problems inherent in the catching-up development type. Without the introduction of leading breakthrough innovative developments with the appropriate provision of technologies and equipment, it is impossible to increase the efficiency of updating the fixed assets.

## 4 Discussion

This study is aimed at identifying problems and developing directions for improving the efficiency of updating fixed assets, considered in relation to the condition of the activity of enterprises and business structures of manufacturing industries in the digital economy. The fact that the problems associated with the renewal of fixed assets are considered in the Russian and foreign economic literature quite often and in many aspects is due to the fact that fixed assets are the most important economic category that determines the level of technical development of any country. Measures to replace equipment, repair it, upgrade it are considered today especially carefully in the context of maintaining digital transformation. Questions related to the wear and tear of fixed assets, its assessment and impact on the performance of the company's equipment estate, algorithms for managing the updating of information and production systems as a process are raised. For example, Karpushin studies the types of depreciation and, based on the assessment of the characteristics of physical and moral depreciation, as well as the role of accelerated depreciation, forms measures necessary for the modernization of the national economy [3]. Eremeyev and Novikova consider the main factors influencing the process of reproduction of fixed assets, and the problems associated with the choice of the process type of their reproduction [4]. Khan, West and Wuest study issues related to the modernization of equipment to extend the usable life expectancy, understanding it as a promising alternative to traditional equipment replacement [5].

Speaking about research related to the renewal of equipment, it is impossible not to highlight a number of approaches to determine the optimal timing of replacement of machinery and equipment. As a rule, they are based on various economic and mathematical dependencies. Sitorus and Brito-Parada consider for this purpose the analytical hierarchical process (AHP) method, which is based on the judgments of decision-makers [6]. Other suggestions: the formation of a program for updating the fixed assets of industrial enterprises was studied in the work of Baranov and Shinkareva. They identified the stages of this program and the indicators that characterize the update [7]. The influence of industry-specific features of fixed asset reproduction was considered in the work of Kobzev and Izmaylov, including various concepts of fixed asset reproduction, in particular, cost and innovation [8].

A number of works in both domestic and foreign literature are devoted to the relationship between innovation and investment activities and the renewal of fixed assets. Manika, Patel and Oghazi studied the relation between capital and intangible assets, considering them an increasingly dominant basis for competitive advantage in the digital economy [9]. Some researchers studied the problems of investment support for the renewal of fixed capital in an innovative form [10, 11]. They suggested a number of measures for the transition to a predominantly innovative type of fixed capital renewal that supports digital transformation. Studies by Nambisan, Siegel and Kenney showed the growing importance of industrial digital platforms as a platform for updating fixed assets and creating high consumer values [12]. Sahut, Iandoli and Teulon considered the issues of updating fixed assets and the economy of digital platforms, taking into account its positive impact on the creation of high-performance jobs and economic growth [13]. Hsieh and Wu showed how enterprises can take advantage of the creation of an innovation ecosystem based on two main stages of the production process: invention and commercialization [14]. The importance of digitizing the production activities of companies was shown in [15], including the possibility of dynamic reconfiguration of resources, in which competitive advantages are formed, while reducing operating costs. Noting the overall consistency of the results obtained in this paper with the conclusions of the above authors, it should also be noted that the study of macroeconomic features that affect the renewal of fixed assets, the differentiation of enterprises into separate types according to the characteristics of renewal will allow more reasonably form measures to improve its efficiency. It will also allow identifying the necessary stages and elements of a holistic mechanism for ensuring the reproduction of fixed assets at manufacturing enterprises in the digital economy.

## 5 Conclusion

To overcome the technical and technological backwardness of many domestic industrial enterprises of manufacturing industries, it is necessary to form a complex mechanism at the macro level that ensures the reproduction of fixed assets. It should be focused on the priority updating of machine systems at enterprises for new technologies for the production of competitive products on an innovative basis, in accordance with the requirements of the digital economy. This mechanism should take into account the existing characteristics of the market, the resource opportunities of different types of enterprises, the existing structuring of enterprises and the existing incentives for renewal. It is necessary to create a unified system of innovation and investment activities of enterprises with appropriate consideration of the interests of its individual participants. For enterprises of a certain type, it is advisable to use not only market, but also non-market incentives for renewal (for example, military-industrial complex enterprises), taking into account the promising developments of innovative products in demand by the market and the use of digital business models. It is necessary to update fixed assets within the framework of cooperative technological chains, including through the formation and implementation of large investment projects with industry-leading corporations.

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# Evaluation of Financial Efficiency of Irrigation Control Automation

**V. A. Savinova, E. A. Ermakova, and A. S. Usmanova**

**Abstract** The article is devoted to the issues of improving the assessment of the financial efficiency of irrigation control automation, taking into account the industry specifics of crop production. The author's methodology for evaluating the effectiveness of investment projects is formed, which allows taking into account the industry specifics of crop production in irrigation, the specifics of which are as follows: consideration of each automation project as an independent investment project; determination of additional income received in monetary terms using the method of control plots and actual sales prices; monthly construction of a financial model with mandatory discounting of cash flows at a monthly rate determined based on the actual structure of financing of the automation project. The analysis of the project on automation of irrigation control allowed us to conclude high financial efficiency, and the author's modification allows to take into account the inequality of incomes and expenditures for such projects and the seasonal nature of their implementation, as well as to ensure the correct calculation of cash flows for them.

**Keywords** Business process automation · Crop production · Financial efficiency assessment · Irrigation control

## 1 Introduction

Digitalization of the economy objectively leads to full or partial automation of business processes, which in general allows to reduce the labor costs of performers and improve the quality of the results obtained [1]. At the same time, from the point of view of financial management, automation of business processes involves the implementation of significant initial investment costs, including the purchase of equipment,

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specialized software, etc. In this regard, the correct assessment of the financial efficiency of automation is an extremely urgent task. This process has a pronounced industry specificity, which, in particular, is clearly manifested in agriculture and, above all, in crop production. The uniqueness of crop production as an object of automation is due to its significant dependence on external factors; high variability of the results obtained in terms of quantitative and qualitative characteristics; flexibility and adaptability of the applied agricultural technologies, while there are strict restrictions on agricultural production; long production cycle; significant territorial distribution of production; the need for radical reengineering of business processes, etc. [2, 3].

Most of all, the specifics of agricultural production are manifested in crop production on irrigation, in which one of the most important tasks is the systematic control of irrigation, which involves mandatory accounting of the actually irrigated area and water discharge rates. Traditional methods of irrigation control are a priori characterized by a fairly high level of error and allow only an enlarged accounting. This is largely due to the fact that control measurements should be made daily, and directly in the process of irrigation of fields, when moving through them is difficult or even impossible. The purpose of the presented research is to modify the traditional methodology for assessing the financial efficiency of irrigation control automation in order to take into account the industry specifics of crop production in irrigation.

## 2 Methodology

As a rule, when evaluating the effectiveness of automation, a simplified approach is used, which involves calculating the ratio of additional incomes received as a result of automation of business processes to the expenditures associated with its automation. In addition, this approach to assessing the effectiveness of automation, as a rule, does not use discounting of cash flows (in fact, it ignores the fact of a "chronological gap", and quite significant, between incomes and expenditures), and the assessment of the payback period of investments is carried out on the scale of a calendar year. The suggested author's methodology for evaluating the financial efficiency of irrigation control automation has a number of distinctive features.

1. The development of the author's methodology for assessing the financial efficiency of irrigation control automation involves the consideration of automation projects, in particular, the irrigation control automation project, as an independent investment project, involving the construction of free cash flow, its discounting and calculation of efficiency indicators. The expenditure part of the project will include all the actual costs incurred related to its implementation, and the revenue part of the project will be calculated as additional income received as a result of its implementation. The principal feature of calculating cash flows for automation projects is that they only account for additional incomes and expenditures, i.e. incomes and expenditures that the initiator of the automation

project would have incurred in any case (regardless of the implementation of the automation project) are not included in their composition.

2. The suggested approach implies the rejection of the use of historical data in assessing the financial efficiency of automation of irrigation control due to their low representativeness, as well as due to the variability of crop yields depending on weather conditions. For this reason, when evaluating the effectiveness of automation projects in crop production, it is necessary to use the method of control plots allocated either on each field or within a homogeneous group of fields. As a control plot, both a part of the field and a separate field can be considered. Using the control plots method allows you to get an accurate assessment of the additional gross yield received as a result of the automation project by comparing the yield on the plots with automated irrigation control with the yield on the control plots (accordingly, using the actual sales prices of products allows to correctly estimate the amount of additional income received as a result of the automation project). In addition, the method of control plots allows to achieve maximum comparability of the results obtained: on the one hand, the identity of the weather conditions and the applied agricultural technologies is ensured, and, on the other hand, it becomes possible to highlight the significance of the irrigation control factor.
3. The suggested methodology involves monthly construction of a financial model (refusing the use of calendar years) with mandatory discounting of cash flows at a monthly rate determined based on the actual financing structure of the automation project. The fact is that crop production on irrigation is characterized by an extremely uneven distribution of incomes and expenditures over time. It is due to the fact that the main investment expenditures for automation projects arise before the start of the irrigation period (the main costs are associated with the purchase and installation of equipment), and the main incomings arise some time after its completion (directly at the time of sale of grown agricultural products). It is the high degree of unevenness of cash flows that makes it necessary to switch to shorter time intervals (monthly) when building cash flows, which is of fundamental importance when assessing the payback period for automation projects.

## 3 Results

Practical approbation of the author's methodology for assessing the financial efficiency of automation of irrigation control is carried out on the example of LLC "Agroinvest", which operates in the Saratov region. The company is an agricultural producer specializing in the cultivation of agricultural crops in the conditions of irrigation (primarily soybeans and corn). In the 2018–2019 season, the company decided to launch a pilot project to automate irrigation control in fields occupied by soybeans (irrigation is carried out by circular sprinklers). Within the framework of the project, automation of 6 irrigation machines was provided in the context of

2 pumping stations (each pumping station serves 4 irrigation machines, of which three sprinkler machines were provided with automation of irrigation control and one sprinkler machine was used as a control plot).

Automation was carried out by installing an installation kit on each sprinkler machine, in particular, including a Galileosky GLONASS/GPS terminal used to determine the location of the sprinkler machine and then automatically calculate the irrigation area, and a pressure sensor used to determine the presence of water pressure in the sprinkler machine and then automatically calculate water consumption.

The data received from the terminal and the sensor were processed using the built-in mechanisms of the "AgroSignal" system, previously used by the project initiator for monitoring agricultural equipment. Automated sprinklers now have the ability to regularly obtain objective information about the actual irrigated area (with an accuracy of 0.1 ha) and the estimated water consumption for each field in real time. This made it possible to timely identify the facts of the lack of water pressure in the sprinklers (in the "AgroSignal" system, automatic alerts were set up to the email address of the hydraulic engineer of the project initiator) and the facts of sharp fluctuations in water pressure in the sprinklers (deviations from the standards of water discharge), as well as to control the completeness of the entire field irrigation (no omissions during irrigation) and the time of its implementation (relative simultaneity of irrigation). Accordingly, the automation of irrigation control made it possible to make the necessary management decisions much more quickly, in particular, decisions on the resumption or termination of irrigation, on the repair of sprinklers, etc. At the same time, installation kits were not used on the control plots (in fact, control fields), and irrigation control was carried out using traditional methods based on information collected by a specialist accountant.

In the 2018–2019 season, during the harvesting campaign, the initiator of the project used a coupon system when accepting grain, including soybeans, by weight. It allowed recording the whole yield for each field and, accordingly, calculating the yield deviations obtained on fields where automated irrigation control was used, and on control fields where irrigation control was carried out in the traditional way (the comparison results are shown in Table 1).

The obtained data, shown in Table 1, allow us to conclude that, taking into account the actual harvested area, the average yield at the NS-FR-No. 1 pumping station for fields with automated irrigation control was 2.752 t/ha and exceeded the yield at the compared control area by 4.25%, and at the NS-FR-No. 3 pumping station it was 2.774 t/ha and exceeded the yield of the corresponding control plot by 3.50%. On average, in both pumping stations, the yield on the fields with automated irrigation control was 2.763 t/ha, exceeding the average yield on the control plots (2.661 t/ha) by 3.84%. Accordingly, the additional whole soybean yield resulting from irrigation automation is 39,800 tons. In monetary terms, at the price of soybeans of 24.5 thousand rubles per ton (when sold from the site; pickup by the buyer's transport), the additional income of the initiator of the project amounted to 975.1 thousand rubles. The sale of soybeans was carried out in October 2019.

The total expenditures of the initiator of the project for irrigation automation amounted to 556.0 thousand rubles, of which 408.0 thousand rubles were spent on

**Table 1** Data on soybean yield in fields with automated irrigation control and control plots in the 2018–2019 season

| Pumping station | Field name | Availability of irrigation control | Soybean yield, t / ha | Harvested field area, ha | Whole yield from the harvested area |
|---|---|---|---|---|---|
| NS-FR-No. 1 | FR-1 | No (control plot) | 2.64 | 62 | 163.68 |
| NS-FR-No. 1 | FR-2 | Yes | 2.71 | 64 | 173.44 |
| NS-FR-No. 1 | FR-3 | Yes | 2.82 | 60 | 169.20 |
| NS-FR-No. 1 | FR-4 | Yes | 2.73 | 62 | 169.26 |
| NS-FR-No. 3 | FR-9 | No (control plot) | 2.68 | 70 | 187.60 |
| NS-FR-No. 3 | FR-10 | Yes | 2.74 | 68 | 186.32 |
| NS-FR-No. 3 | FR-11 | Yes | 2.85 | 68 | 193.80 |
| NS-FR-No. 3 | FR-12 | Yes | 2.73 | 66 | 180.18 |

the purchase of 6 installation sets of equipment (taking into account their delivery to the initiator of the project), 136.0 thousand rubles were spent on repair and maintenance of the installed equipment (taking into account the cost of visits of service specialists) and 12.0 thousand rubles on installation (before the irrigation season) and dismantling (after its completion) of the equipment. The expenditures were incurred by the initiator of the project from March to August 2019. The calculation of net cash flow, the results of its discounting and the performance indicators for the irrigation control automation project are presented in Tables 2, 3 and 4.

Taking into account the uneven incomes and expenditures in the implementation of such projects in crop production, a monthly discount rate was used, calculated on the basis of the annual rate (15% per annum), based on the actual structure of financing of the investment project by its initiator (the project was financed from the initiator's own funds).

The results obtained indicate the high financial efficiency of the analyzed project for automation of irrigation control, and the suggested modification of the methodology for evaluating investment projects allowed us to correctly consider the industry specifics.

**Table 2** Free cash flow on the project of automation of irrigation control in soybean cultivation in LLC "Agroinvest"

| Indicator name | 03.19 | 04.19 | 05.19 | 06.19 | 07.19 | 08.19 | 09.19 | 10.19 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Operating incomes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 975.1 | 975.1 |
| Operational expenditures | 0 | 0 | 6.0 | 34.0 | 51.0 | 57.0 | 0 | 0 | 148.0 |
| **Operating cash flow** | **0** | **0** | **−6.0** | **−34.0** | **−51.0** | **−57.0** | **0** | **975.1** | **827.1** |
| Investment incomes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Investment expenditures | 204.0 | 204.0 | 0 | 0 | 0 | 0 | 0 | 0 | 408.0 |
| **Investment cash flow** | **−204.0** | **−204.0** | **0** | **0** | **0** | **0** | **0** | **0** | **−408.0** |
| Financial incomes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Financial expenditures | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Financial cash flow** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Free cash flow** | **−204.0** | **−204.0** | **−6.0** | **−34.0** | **−51.0** | **−57.0** | **0** | **975.1** | **419.1** |

## 4 Discussion

At the moment, the scientific community has developed an approach that initially assumes a high variability in the assessment of the financial effectiveness of automation projects. The choice of the methodology for evaluating financial performance is determined by three main factors: the specific features of the project initiator, the investment project itself, and the availability of reliable information for its implementation. Depending on these factors, it is considered possible to use classical methods for evaluating the financial effectiveness of projects, probabilistic evaluation methods, methods of qualitative analysis, etc. From a methodological point of view, the most representative results allow us to obtain traditional methods for assessing the financial effectiveness of projects, but their use requires a large amount of initial information [4–7]. The main disadvantage of the existing methods for evaluating the financial effectiveness of automation projects is their excessive unification. It involves the use of a "standard" approach to evaluating the effectiveness of automation projects and, in particular, does not allow for full consideration of the industry specifics of the initiators of such projects. The presence of industry specifics objectively requires the need to modify existing methods for assessing the financial

**Table 3** Discounted free cash flow for the project of automation of irrigation control in soybean cultivation in LLC "Agroinvest"

| Indicator name | 03.19 | 04.19 | 05.19 | 06.19 | 07.19 | 08.19 | 09.19 | 10.19 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Free cash flow | −204.0 | −204.0 | −6.0 | −34.0 | −51.0 | −57.0 | 0.0 | 975.1 | **419.1** |
| Accumulated free cash flow | −204.0 | −408.0 | −414.0 | −448.0 | −499.0 | −556.0 | −556.0 | 419.1 | - |
| Discount rate, % | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 | - |
| Applicable coefficient of discounting | 1.000 | 1.012 | 1.024 | 1.036 | 1.048 | 1.060 | 1.072 | 1.085 | - |
| Discounted free cash flow | −204.0 | −201.6 | −5.9 | −32.8 | −48.7 | −53.8 | 0.0 | 898.8 | **352.0** |
| Accumulated discounted free cash flow | −204.0 | −405.6 | −411.5 | −444.3 | −493.0 | −546.8 | −546.8 | 352.0 | - |

**Table 4** Performance indicators of the irrigation control automation project for soybean cultivation in LLC “Agroinvest».

| Indicator name | Indicator value |
|---|---|
| Net present value, thousand rubles | 352.0 |
| Internal rate of return, % per month | 10.4 |
| Coefficient of specific efficiency, % | 102.7 |
| Discounted payback period, months | 8.0 |
| Discounting rate, % per month | 1.2 |

effectiveness of automation projects, but scientific research in this direction is practically not carried out (much more attention is paid to the automation of irrigation design [8, 9]). As a result, a simplified approach that involves a direct comparative assessment of financial performance (compared to previous periods), supplemented by expert probabilistic assessments, is becoming increasingly common, which, due to its inherent simplicity, is quite low in accuracy.

## 5 Conclusion

In the context of the digitalization of the economy, the issue of assessing the financial effectiveness of automation projects is one of the most important and relevant. However, up to the present time, it remains insufficiently developed in the specialized scientific literature, in particular, from the point of view of correct accounting of the industry specifics of such projects. One of the most complex sub-sectors in this regard is irrigated agriculture, which is characterized by a long production cycle and seasonality, both of the entire production cycle in general and of the irrigation cycle in particular. The use of traditional methods of evaluating financial performance in this sub-sector either leads to distorted results, or is significantly difficult due to a lack of necessary information. To solve the problem of correct assessment of the financial efficiency of automation projects, the author’s modification of the traditional methodology for evaluating the effectiveness of investment projects is suggested, which allows taking into account the industry specifics of crop production in irrigation. The suggested modification assumes: 1) analyzing each automation project as an independent investment project, the cash flow for which is the balance of additional incomes received by the project initiator and expenditures incurred for the automation project; 2) determination of the additional income received in monetary terms using the method of control plots and the actual sales prices of products; 3) monthly construction of a financial model (refusal to use calendar years) with mandatory discounting of cash flows at a monthly rate determined based on the actual financing structure of the automation project. From a financial point of view, the proposed author’s modification allows to take into account the inequality of incomes and expenditures for such projects and the seasonal nature of their implementation, as well as to ensure the correct calculation of cash flows for them.

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# Grain Production and Export in Russia: Current State and Development Trends

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**Abstract** Grain production is one of the drivers of Russian agriculture-based economy. At present time, the industry demonstrates steady growth trends in production and export and heads the world list of wheat export. Russia has a rich natural resource potential and intends to increase export supplies of agricultural products and food in the near future in order to contribute to solving the problem of global food safety. The author identified promising areas of Russian grain production and export that are able to strengthen Russia's position in the world food market without affecting food safety of the country. The conducted research allowed to come to the conclusion that productivity progress mainly correlates with an increase in the yield of cereals, due to the technical and technological production modernization and implementation of innovations. The current production volumes are able to meet current domestic needs and increase the export of grain and derivative products. Intensification of Russian integration into the international grain market has increased the risks of domestic prices development and their volatility. This situation affects the income of domestic grain producers and processors and also contributes to an increase in food prices. The analysis of national and world experience in product market regulation and the study of trends in the agrifood market development allowed the author to identify promising areas of grain economy development in Russia that are able to achieve the economic balance among producers, consumers, and importers of Russian grain.

**Keywords** Export · Food safety Grain · Production · Russia

## 1 Introduction

Grain production remains the leading branch of agriculture in the Russian Federation. Agriculture development has made the way from stagnation to sustainable growth. Today, Russia is one of the five largest grain producers in the world and the first wheat

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exporter. Owing to the activity in the world food market, Russia had favorable balance in agribusiness external trade balance in 2020. A grain export, which accounted for more than 1/3 of the food export value, significantly contributed to this process. Russian integration into the global agrifood market has increased the risks to transfer high world prices and price fluctuations to the domestic grain market. Therefore, the most pressing issue is the economic balance between Russian grain producers and consumers in both domestic and foreign markets. The paper is devoted to the analysis of the current state of grain production and export in Russia in order to develop promising directions in grain production and export development, that are able not only to strengthen Russian position in the world market of grain and derivative products, but also ensure an optimal agribusiness structure from the perspective of national food safety.

## 2 Methodology

The author implemented general scientific and special methods and techniques of economic research. The theoretical analysis methods allowed the author to identify the features of Russian grain economy and export potential development. The trends in grain production development and the dynamics and structure of grain export were determined on the ground of economic and statistical methods. The information base of the study is free data of the Ministry of Agriculture of the Russian Federation, the Federal State Statistics Service of Russia (Rosstat), customs statistics on foreign trade in the Russian Federation published by the Federal Customs Service, analytics of research institutions and research and information agencies, as well as the works of scientists and practitioners on grain production and both Russian and world food markets.

## 3 Results and Discussion

Cereals production is the basis of Russian agricultural industry, and it is a primary and systemically important element of agribusiness industry. The changes in the Russian economy structure, an increase in the state support for agribusiness, the development of investment and innovation processes have contributed to the grain economy development. According to the Federal State Statistics Service of Russia (Rosstat) [1], there have recently been positive quantitative and qualitative improvements in grain crop production. The gross harvest of cereals and leguminous crops in the Russian Federation increased significantly and exceeded 100 million tons in 2014–2020. By comparison, production volumes reached 135.5 million tons and 133.5 million tons respectively in 2017 and 2020, and it was a record over the past 30 years. The increase in grain production was achieved due to yield gain, which is the core qualitative indicator in the industry development. Many factors including

**Table 1** Development of cereals and leguminous crops production in the Russian Federation

| Period | Sowing areas, thou. hectares | Gross harvest, thou. tons | Yield, centners per one hectare harvested |
|---|---|---|---|
| 1990 | 63,068 | 116,676 | 19.5 |
| 2000 | 45,585 | 65,420 | 15.6 |
| 2010 | 43,203 | 61,007 | 18.3 |
| 2015 | 46,609 | 104,729 | 23.7 |
| 2016 | 47,100 | 120,677 | 26.2 |
| 2017 | 47,705 | 135,539 | 29.2 |
| 2018 | 46,339 | 113,255 | 25.4 |
| 2019 | 46,660 | 121,200 | 26.7 |
| 2020 | 47,900 | 133,465 | 28.6 |

weather conditions, farm production technology, and business factors of production influence yield. Yield gain indicates a positive development of grain economy that is able to neutralize natural and climatic risks of production in risk farming areas, which cover a significant part of Russia. According to the data in Table 1, the yield of grain per one hectare harvested exceeded 25 centners in 2016–2020 and amounted to 28.6 centners per one hectare in 2020, which is 46.7% more than in 1990.

As for the sowing areas with cereals and leguminous crops, they slightly increased in the Russian Federation over the last years and amounted to 47.9 million hectares in 2020. It is important to note that this indicator still remains 25% lower than that one in 1990 and therefore, it has the potential for further grain-growing capacity due to arable land re-usage [2, 3]. When expanding grain sowing and developing the sown areas structure, special attention should be paid to the impact of projected climate changes on agriculture. According to the scientists [4, 5], Russia, as a country with a temperate climate, is able to benefit from global warming and have additional opportunities for the grain production development.

Today, all Russian regions have grain production. The largest number of sowing areas of grain and leguminous crops is concentrated in the Volga, Southern, and Siberian Federal Districts. The Central, Volga, and Southern Federal Districts were the leaders in terms of production volumes in 2020. The highest gross harvest was in the Rostov Region (12.5 million tons), the Krasnodar Territory (12.1 million tons), the Voronezh Region (6.2 million tons), the Kursk Region (5.8 million tons), and the Stavropol Territory (5.8 million tons). The subordinate entities of the Russian Federation mentioned above are traditionally the leaders of Russian grain economy, and they demonstrate not only high annual gross harvests but also grain yields which significantly exceed the average Russian level. It is worth mentioning that the average yield of grain and leguminous crops in the Krasnodar Territory and the Kursk region was 53.7 and 51.2 centners per one hectare harvested in 2017–2020, which is twice as high as the national average. High production indicators in the grain economy were achieved owing to the technical and technological production modernization and implementation of innovations, including precision farming technologies based on the big data analytics, business processes automation, and a long distance control. The Krasnodar Territory is the leader in the precision farming technologies implementation among the regions of the Russian Federation [6]. Wheat production plays the leading role in the structure of Russian grain economy (Fig. 1). Wheat production increased from 49.6 million tons to 85.9 million tons (by 73.2%) in 1990–2020, and the gross harvest percentage increased from 42.5% to 64.4%. Forage crops such as barley and maize ranked second and third, and their share was 15.7% and 10.4% respectively in 2020. The analysis of the crop production development revealed some multidirectional trends: gross harvest of barley decreased by 23.1% and amounted to 20.9 million tons in 2020, compared with 1990, but maize production increased by 5.7 times and reached 13.9 million tons in the same period of time. Considering feeding value of these crops, the trends should be evaluated as positive. The increase in grain production contributed to growth in Russian grain self-sufficiency. The level of grain self-sufficiency has been 156% on average over the past 5 years, which is 1.6 times higher than the threshold requirement (at least 95%) established by the Food Safety Doctrine of the Russian Federation. Sufficient domestic demand for grain allowed to increase grain export. Owing to the development of grain production and related industries, the agribusiness model of the Russian Federation has changed from import-substituting to export-oriented one. There were high indicators of food export in 2020, and they exceeded the import indices. The external trade balance became positive in 2020 for the first time ever [7].

It is important to note that Russian grain industry was characterized by fundamental changes in foreign trade. Russia was the world's largest grain importer at the end of the twentieth century. Grain import reached 30 million tons. Large volumes of imported grain supplies resulted from the need to ensure domestic consumption. Due to structural transformations in Russian agribusiness, the country's grain balance has changed: the use of grain for industrial processing and seeds provision has significantly decreased [8]. Grain import decreased to the lowest levels of 1.5 million tons in 2001–2010 and 0.8 million tons in 2011–2020 on average. The grain

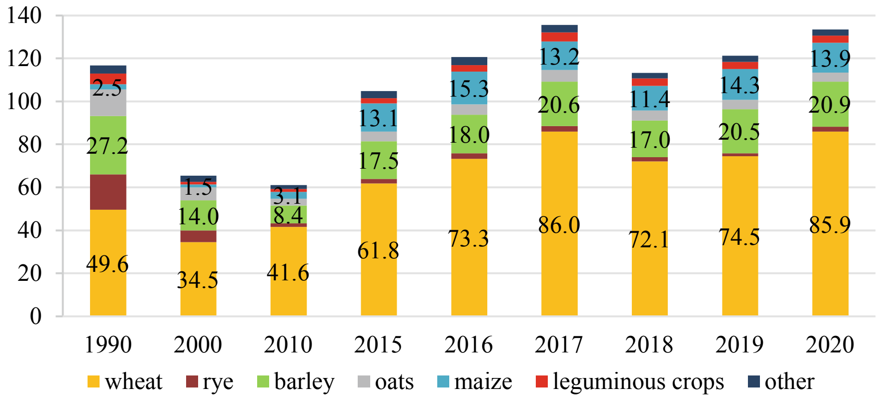


**Fig. 1** Development of gross harvest of cereals in the context of crops, mln tons

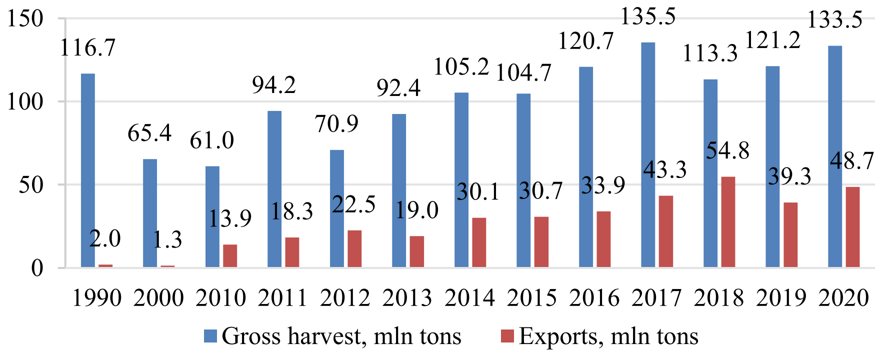


**Fig. 2** Development of cereals and leguminous crops production, mln tons

production development in 2014–2020 allowed not only to meet the growing needs of flour grinding and cereal making industry, as well as livestock, but also significantly increase export rates. Russian annual volume of grain export has been exceeding 30 million tons since 2014. It amounted 46.5 million tons on average in 2017–2020 (Fig. 2). The export ratio in grain production ranges from 32 to 48%.

Russia has rapidly reached top ten countries that have the lowest percentage of grain import and top five world's largest grain exporting countries that have the highest percentage of export in grain production [2]. Wheat export ranks first in grain crops export and occupies about 80% of the structure. Barley and maize ranks second and third (10.0% and 7.9% in 2019). Rye, oats, rice, doura, buckwheat, millet, and other cereals are exported in small volumes. The export development in Russia is supported by the state through the Federal Project "Export of Agribusiness Products" [9]. Exporters are supported through preferential loans, expanding reclaimed lands for export-oriented products, subsidizing railway rates for grain transportation from further-flung regions of the country, developing transport and logistics infrastructure, etc.

Russia exports grain to more than 130 countries and expands export destinations every year. Far-abroad countries have the largest percentage (more than 90%). The CIS countries have only about 5% of Russian grain supplies (7.2% in 2019). The most important destinations of grain export are Turkey and Egypt. These countries had about 1/3 of exported wheat in 2015–2018, and the figure reached 41.3% and represented 13,166 thousand tons in 2019 (Fig. 3). Wheat export increased by 6.2% in 2020 for the first three quarters, compared to the same period in 2019. Turkey has remained the main buyer of Russian wheat for a second year running.

Bangladesh, Azerbaijan, Soudan, Nigeria, and Yemen occupy a prominent position among the buyers of Russian wheat. There has recently been a trend of export increase to Africa and South-East Asia. These regions are promising for Russian grain export, as there is a growing population and a lack of own lands and water resources. Building a common market space with Eurasian Economic Union member countries provides for additional opportunities in grain export [10]. Global demand for grain,

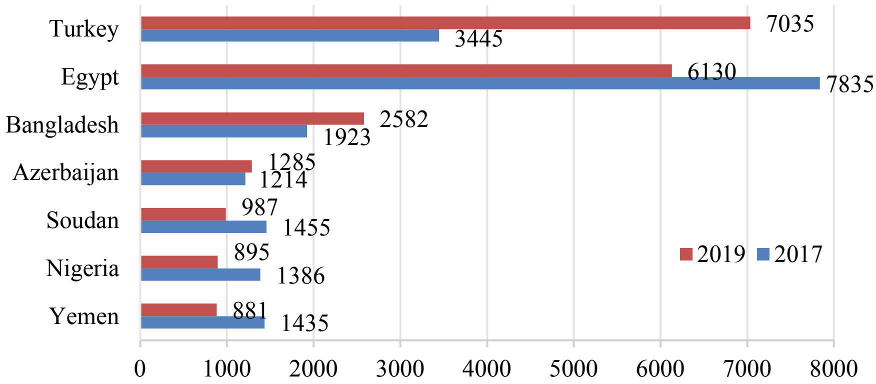


**Fig. 3** Top-7 importers of Russian wheat, thou. tons

resulted from the COVID-19 pandemic and the desire of many countries to have strategic grain reserves, became one of the incentives to increase export supplies in 2020. The heavy grain harvest in Russia in 2020 and large carryover stocks allowed to expand export volumes.

It should be noted that due to the little dynamic potential in domestic grain needs, an export increase has recently become a catalyst in the grain economy development, as well as in agribusiness as a whole. This is driven by growth of demand on behalf of rural producers for products of industries which are technologically related to grain production, as well as market infrastructure and logistics development. Positive trends in the grain production development had a significant impact on production growth in the Russian agricultural industry in 2020. As a result, the industry became the only branch of the material sphere with positive production dynamics.

Despite the fact that grain production in the Russian Federation has been intensively developed over the last years, it still has large growth potential and is able to make a significant contribution to provide the world's population with food. Long-term Strategy for the Grain Complex Development in the Russian Federation until 2035 was adopted in 2019, and the plan for the strategy implementation was approved by the Government of the Russian Federation in 2020. The purpose of the Strategy is to create a highly efficient, science-based and innovation-oriented, competitive, and investment-attractive system of production, processing, storage, and sale of cereals and leguminous crops and derivative products that is able to guarantee food safety in the Russian Federation, meet the domestic needs, and create a significant export potential [11]. The following elements of the grain complex development are prioritized in the Strategy:

- optimization of the sowing areas structure and increase in the cereals and leguminous crops yield;
- infrastructure and logistics development;
- providing for domestic needs;
- export.

Since the world demand for food is growing, and Russia has developing export-oriented economy, the author focused on the prospects for the grain export development in the Russian Federation.

Russia is planning to increase the export of agribusiness products to 45 billion dollars by 2024, including 11.4 billion dollars for grain export. In order to stimulate export supplies, the Federal Project "Export of Agribusiness Products" [9] provides for the following measures:

- developing new commodity weight of agribusiness products, including products with high value added, through technologic re-equipment of the industry;
- building export-oriented commodity distribution infrastructure;
- eliminating trade barriers (tariff and non-tariff) in order to provide target markets with agribusiness products;
- developing agribusiness products promotion.

The implementation of the Federal Project has already had some results. The export of food and agricultural raw materials increased by 20% in 2020, compared to 2019, and amounted to 30.7 billion dollars [7]. According to the expert community, the export expansion is a positive phenomenon, since the growth of export supplies provides national farmers with additional income, contributes to improvement in employment, and increases tax payments from the agribusiness production chain. However, the experience of export-oriented sectors in the Russian economy (oil industry, metallurgy, and mineral fertilizers production) proves that exports growth has risks of increasing domestic food prices and their volatility [12]. These risks have already appeared in the domestic grain market due to an intense integration of the Russian Federation into the international grain market. The integration caused an increase in prices for grain and food products in Russia in 2020–2021 due to the world prices increase for food products and agricultural raw materials. The situation was aggravated by falling in real income of the population and required the adoption of emergency measures on behalf of the state regulator in the grain market. In order to stabilize the situation, customs tariff regulation and grain damper mechanism, which consists of introducing floating duties against grain (wheat, barley, and maize) and allocating the funds to subsidize agricultural producers, was implemented.

The state regulatory actions are primarily aimed at ensuring the stability of the domestic grain market, and as a result, they provide the population with high-quality and affordable domestic food. The development of grain exchange business is able to contribute to increasing the ability of rural manufacturers to manage price risks. Nowadays, trade volume in the Russian Federation is not comparable to the world one. Grain stock trading in Russia is mainly a centralized platform for spot deals, while grain futures trading remains undeveloped. World experience has proved that farmers benefit from futures trading by hedging price risk [3]. The creation of a futures trading mechanism in Russia will allow exporters, producers, and processors of Russian grain to increase the stability and efficiency of their businesses.

One of the most important directions to develop food export is expansion of the stock list of supplies, especially goods with higher value added and produced from grain [5, 13]. Such goods include all types of livestock products on the basis of grain feed, flour, cereals, ready-made food products from the cereals group including confectionery and bakery products, as well as ultra-processed grain products. Ultra-processed grain products have the greatest prospects among the goods with higher value added. According to the scientific calculations, world demand for farina, amino acid, and gluten will grow by more than 20% by 2025 [14]. Russia is able to contribute to meeting the demand. The introduction of export subsidies for products with higher value added can become one of the incentives for the grain economy development [13]. To ensure the sustainable development of grain production and agricultural industry in Russia, it is necessary to improve the system of grain market regulation, taking into account the best world experience and trends in the development of the global food market.

## 4 Conclusion

Grain production in Russia is the leading branch of agricultural industry and the basis of the country's food safety. Owing to the intensive development of the grain industry, domestic production satisfies the current needs for grain to the full extent and tends to increase the export volume and destinations. 48.7 million tons of grain were delivered to the world market in 2020, including more than 38.6 million tons of wheat, that is 50% more than in 2015. An export increase and growth in incomes of grain producers and technologically related enterprises from other agribusiness areas led to additional risks of a significant dependence of domestic grain prices on the world grain market. The grain market volatility and increase in domestic grain prices to the level of the world ones threatens the development of national livestock production and grain processing, as well as contributes to an increase in food prices. In order to achieve an economic balance among producers, consumers, and importers of Russian grain, as well as to avert crisis in the national food supply, it is necessary to improve the system of grain market regulation. In addition, it is important to use a strategy that has proven effectiveness both in national and world experience.

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# Innovations in Agriculture: Trends in the Development of the Regional Economy

**T. E. Gorgodze, I. V. Tomoradze, and D. Yu. Denisov**

**Abstract** The article discusses innovations in agriculture and the scope of their implementation in this sector. They competently raise agriculture to a qualitative new level. The purpose of the article is to consider IT technologies that will reduce the amount of manual labor and increase yields. For this, the following tasks were solved: the types of agricultural products exported by Russia were presented, digital technologies were given that penetrate most deeply into business processes and change the structure of agriculture, setting new trends. It was found that the use of digitalization, automation and other technologies in agriculture significantly reduces the cost of fertilizers, fuel and other costs (from 20% or more), while increasing productivity. The trend of automation of agriculture is described, which involves the introduction of robots on modern farms, which are fed and fed cows, remove animals and follow their health. Technical innovation is only part of the "agriculture 2.0". The methodology consisted of researching the works on artificial intelligence and information technology. It is found that satellites and drones collect 3D cards, they apply information about the chemical composition of the soil and previous cultures.

**Keywords** Agriculture · Artificial intelligence · Digitalization · Innovation · Machine learning · Regional economy

## 1 Introduction

The agricultural industry becomes an innovative conglomerate, which attracts new investors. Today there is the era of the agrarian revolution. These are the innovations that raise agriculture to a qualitative new level. In the previous stages, people moved from the departments to cultivating fields, began to cultivate plants from other regions, mastered chemicals for fertilizer and pest control, and the tools of labor were

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constantly improved. Under the new agrarian revolution, the introduction of IT technologies to agriculture, which will reduce the amount of manual labor and increase yields [1]. Biotechnology, processing technologies, logistics, farm management—if at least one of these directions will be implemented massively, in the perspective of five years the profitability of the agro-industrial complex of Russia may increase by 500 billion rubles. The Russian Federation is directed to the fact that the country should provide itself with food. Last year it almost happened. Russian companies exported food more than imported. And the agricultural business itself is considered one of the most promising, and almost did not suffer from a pandemic. This is a set of measures from the UN World Food Program, which is designed to significantly improve the situation with nutrition on the planet for 2030, including sustainable development in agriculture [2]. Russia plays the last role in this process, being one of the leaders in food exports. All this becomes favorable with the successful modernization and timely implementation of innovative developments and products in the field of agriculture [3].

## 2 Methodology

The history of the active development of the agricultural industry began with the well-known events of 2014, when a course was taken to import substitution policy. Initially, imports were planned in several sectors of the economy, including electronics and software, but the main focus is considered to be the production of food. After the imposition of sanctions and the "product" counter displays, it turned out that in Russia there are not so many foods, but all the missing imports. While the dollar cost 30 rubles, it was almost impossible to develop his own production, but at a dollar 60 or 75 rubles it became easier. In 2020, Russia for the first time became a net food exporter. The country sold more products abroad than purchased. The difference was only $ 1 billion, this situation has developed for the first time in 30 post-Soviet years [4]. Russia exports different types of agrarian products, but still prevailing positions with low value added:

- Grain—it was 34% in the export structure;
- fish products and seafood—17%;
- oil and fat production—16%;
- products of food industry and processing—15%;
- other products—14%.

Now Russia for the first time in many years faced the need for state regulation of prices. In other words, so many agrarian products were taken out of the country that the goods remaining in Russia began to be lacking, which was naturally caused by the rise in prices. At the same time, Russian agricultural producers were in fairly interesting conditions: due to drought and other problems, world food prices began to grow, in parallel in Russia depreciated the national currency. Accordingly, Russian production has become cheaper in the foreign exchange equivalent, and other countries are in a hurry to purchase food in case of a new locked.

Therefore, the agro sector remains interesting for investors. While the Russian market does not allow part of food from other countries, the Russians will be ready to overpay for products produced within the country [4]. The key feature of agriculture—investment in it is quite large, and they must be relying for a long time. For example, the largest share of investments in Russia goes to breeding dairy cattle. This speaks of interest in this industry and confirms the need to introduce innovative solutions to attract new investors in this sector.

Moreover, the tendency of 2021 is digitalization. It concerns agriculture, in particular. The most primitive option is digitalization on Ozon and Wildberries [4]. These sites are presented a huge number of food suppliers (long storage), and in large cities, products can quickly deliver to the house when ordering. There are more serious examples when digital technologies penetrate deep into business processes and change the structure of agriculture by asking new trends. And few people argue that it is behind them—the future of the whole economy [5].

## 3 Results

The use of digitalization, automation and other technologies in agriculture significantly reduces costs for fertilizers, fuel and other costs (from 20% and more), at the same time increasing productivity. The smart farming market in Russia is not more than 1.5% of the world (leaders in the USA, Germany, China and India). Due to the digitalization of agriculture, the agro-industrial complex of Russia can make a powerful jump forward [6]. The Russian agricultural sector is intensively growing for several years in a row (the main confirmation is to reduce imports). The production of grains, beets, sugar, greenhouse vegetables, pig breeding and beef production is developing faster. At the same time, more and more businessmen who earned precisely on agriculture fall into the rating of the richest people in Russia.

The trend of automation of agriculture suggests that on modern farms, robots that are fed and drown cows are embedded, remove animals and follow their health. In the fields of the machine without a person's participation, weeds are stolen and harvest even such delicate crops are harvested, and in granaries, robots monitor the temperature and humidity of the collected fruits. Flying drones are "patrolling" agricultural areas, find dry areas and irrigate plantations, independently evaluate the health status of plants, will fall and analyze the plots where cultures grow best. There are still unmanned combines that autonomously drive around the field (they remind large robots vacuum cleaners), plow the fields, sow and remove the harvest. A person is enough just to bring the combine to the starting area of the field, and in the evening—to pick up. The interrelated network of smart gadgets, which collect different indicators and help a person build forecasts based on them. In the fields, the sensors collect data on weather conditions and the state of soil, in the greenhouses independently regulate humidity, temperature and watering. Sensors on collars and livestock tags are followed by biorhythms and activity of each animal. More sensors help determine the location of agricultural machinery and build optimal logistics.

Another trend was the machine learning. This method in which artificial intelligence collects many data, analyzes them and issues independent conclusions on them. In Australia, for example, with the help of machine learning, coffee crops predict (for this, the AI collects and analyzes a huge amount of climate data, mineral composition and temperature of different soil layers) [6]. In animal husbandry, the technology is also used: after analyzing the data of electronic collars, you can predict the reproductive period of the cow or plan the change of diet. Artificial intelligence becomes the main assistant farmers from the world IT. It uses machine learning, big data, computer vision and other technologies. As a result, a comprehensive system is obtained, which notes that the fuel consumption increases during the rain, and the harvest decreases during the rain [7].

Computer vision is a modern trend of agriculture. This is the ability of the cameras not only to record the video, but also to understand what happens on it. Smart cameras can distinguish between the necessary objects in the video and collect data about them. So, drones, flying over the field, can consider each spikelet—to find those that damaged by pests. In the fisheries of Norway, they are looking for sea lice for the same method, and in China, they detect pigs infected with East African Chuma. Computer vision helps to irrigate only those parts of the soil, which need it (this helps to avoid overflow), and with an automated harvest assembly, do not touch the fruits that have not yet dial.

Technical innovation is only part of the "agriculture 2.0.". In agriculture, more and more technologies appear, which make it possible to efficiently process the soil, improve the selection and increase yields [4]. Genetic engineering helps to cultivate plants with specific properties that are difficult to derive the traditional method of selection. For example, add agricultural cultures with the beneficial properties of other plants, bacteria and animals. It works like this. With the help of bacteria enzymes, the initial DNA (Deoxyribonucleic acid) of the plant is cleaved in the desired sites and the gene of another organism is introduced there with the desired properties. If in traditional agriculture before the start of the field, it is customary to plow, it will lead to erosion and soil degradation. To avoid this, the stems from the previous crop are left in the fields to create a special coating—mulch. And after with the help of special seeders, sowing passes into a mulch in precisely calculated quantity—such that is necessary for optimal irrigation. This method saves from erosion, interferes with the growth of weeds and increases the fertility of the soil, if one time in 3–4 years alternate it with traditional processing.

Plots of one field can have different properties, which means, and it is necessary to cultivate them in different ways. The satellites and drones collect 3D cards, apply information about the chemical composition of the soil and previous cultures. Analyzing the data from each site, the agrarians can water and fertilize them locally—up to a pair of centimeters. This approach is able to save the farm up to 30% of seeds, fertilizer and fuel [8]. Thus, it was possible in real time to track and diagnose the state of grown crops, livestock and agricultural machinery. The necessary food products can be obtained using genetic data, or even start the production of meat directly in the laboratory. Automation with the help of large and small robots makes it possible to control the greeted harvest and care for it. Engineering will provide agriculture new funds, new places and even new areas of economics.

## 4 Discussion

In Russia today an innovative infrastructure is erected, but rural households often remain unconnected due to the lack of inhabitants of funds. In some cases, local authorities perform targets due to not so much construction of facilities, how much to reduce the number of rural populations. For example, natural loss and migration of rural residents, some regions can achieve the results of drinking water. In addition, the country actively continues to reduce the number of people employed in agriculture [9]. The total financial supply of measures taken on the integrated development of rural areas in the Russian Federation amounted to 41.1 billion rubles. More than half of this amount was aimed at improving the housing conditions of the rural population and the development of engineering infrastructure.

Until now, the standard of living in the village, including the state of social and engineering infrastructure, is still significantly lagging behind the city. Such problems remain unresolved as, the provision of residents of gas supply and water supply. The low percentage of gasification of rural households is due to the high cost of technological connection: it was comparable with the size of the average salary in rural areas, and in a number of regions exceeded it more than twice.

The sphere of agribusiness itself has a promising future, as it is impossible to imagine that people will refuse plants and milk and will begin to have a recycled clay. On the other hand, the agro-industrial complex (AIC) refers to the category of risky (highly dependent on weather conditions) and is advantageous when planning in the long run (at least five years) [10]. This leads to the fact that the number of innovative startups becomes limited due to the need for cheap and “long” investment resources.

In Russia, a special attitude towards innovation in the sphere of AIC, that is, confidence occurs only after testing by Western colleagues. As an example, you can lead the story of the new technology of “pasteurization” of milk [9]. After many unsuccessful walks in domestic instances of investors, the project was found only in 2016, when a patent for the invention was already obtained in Poland and Israel, and the technology was published on the industrial level. Or idea of creating small closed ecosystems-aquariums using natural waste of fishing fish for growing plants, in turn purifying water, has found an understanding of the American “Back to the Roots” company (today in the new company, 6 people work, monthly income exceeds 4 million rubles) [9]. World practice already has more than 150 startups in agriculture, which managed to grow into a large business (with capitalization of more than 1 billion dollars). Among them are technologies to improve the efficiency of the economy: software, sensors, aerial photography, distribution channels with Internet resources involving, technological research tools and equipment. It is only the beginning of the development of a large and promising industry, the question is in thinking and the fact of innovations in the country and the operational response to the introduction of innovation.

## 5 Conclusion

The agro-industrial complex, along with the defense industry, is the main consumer, this is a large market for high-tech products. Innovation in agriculture helps farms to manage production. With their help, you can save field data in a single database, track yield, natural conditions. The computer program becomes an indispensable assistant, because it allows you to establish effective work and promptly take the necessary measures. The developed system of intelligent sensors to collect information also helps farmers make the right decisions regarding crops, animals, soils and other objects. Data is visualized instantly as charts and user reports. "Smart Systems" significantly increase productivity, since it helps to control nutrition, vaccination, inventory. They work offline without the availability of a phone or access to the Internet, and the data is synchronized with subsequent connections. All innovative development cooperates with other applications. The introduction of unmanned technology allows to reduce direct expenses at least 10%. Using the Internet of Things, Protective Algorithms Blockchard, Technologies for processing large data arrays (BigData) in applied to agronomic information in the complex makes it possible to create a fundamentally new class of agricultural machinery. Innovation allows you to maximize the entire land potential of the country, when you can grow different cultures in large-scale quantities, earning exports and reducing prices for these cultures for your population. Using this opportunity, Russian agriculture and related industries can significantly strengthen the positions of Russia in the global market.

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# Land Shares Turnover Legal Problems in Modern Russia

**Yu. A. Tarasova, Ya. Yu. Smirnov, and M. A. Shafieva**

**Abstract** The urgency of the study is caused by the impact of legal regulations of agricultural land shares and land plots turn-over on the sustainable rural economy development. Since the dissolution of the Soviet Union at the end of 1991 agricultural land has been largely privatized, individual landowners now have legal rights to most agricultural land in the country. But the most difficult question has not been solved with the registration of land plots obtained as a result of the land reform. The land was allocated to citizens only «in documents» without defining ground boundaries. The purpose of the article is to analyze the existing legal problems of excluding agricultural land plots from the general-purpose property. The leading methods of the study are the comparative legal method, the legal norms analysis, their interpretation connected to the judicial practice description. As a result of the study the main features of land share owner rights and their restrictions were described. The latter make lots of owners refuse claiming their land shares. It was concluded the legal regulations of agricultural land shares and land plots turn-over demands further development.

**Keywords** Law practice · Land reform · Land sphere · Legal problems

## 1 Introduction

More than 50% of the world blacksoil lands are located in Russia. Despite this, the Russian Federation provides itself with its own food only by 67%. The main reasons for such a poor success are the absence of free market of rural land and the lack of the clear government policies [1]. The public and private interest in land law regulations contradictions influenced the agricultural reforms in the early 1990s

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greatly and they haven't been overcome yet. The land shares of the former collective farmers participants is the most clear example of an unsolved law problem in Russia land regulation. The registration legal problems of the land plots and land lack when allocating them from general-purpose property were examined in the works of Romanko, Obushchenko [2] and Grachkova [3]. Legal restrictions in agricultural land turn-over as the form of peasant farm enterprises barrier, their successfull activities were studied by Balashov, Vladimirov, Gizzatullin, Iksanov, Lukyanova and Selezneva [4].

Despite the researchers' great attention to this problem many questions are still not solved. Grachkova notes some land shares owners do not understand the legal essence of this concept [3]. In fact they are not land owners, but right share owners to use it. In theory Russia land law include means to transfer land shares into land plots, but in reality the owner meets a number of difficulties. This can be described through the law definitions analysis and the judicial practice in land disputes related to the land plot registration formed from common property land.

## 2 Methodology

The aim of the article is to study legal problems concerning land shares, the owners' rights and the land shares and land plots turn-over in modern Russia. The following methods were used to achieve this goal:

1. The legal norms interpretation analysis method in the historical context. The land share concept in the Russia land law, its history and goals implementation is studied.
2. The legal norms comparing method makes it possible to identify the rights of the land share owners in accordance with various legislative acts adopted in Russia on the agricultural land turnover.
3. The judicial practice analysis method in land disputes allows to trace the legislative norms effect.

The statistical data analysis method was used to identify the usage dynamics and abandonment of the land shares in addition to the main legal method.

## 3 Results

The Soviet agriculture was based on land state ownership and strongly subsidized before 1992 [4]. It was a burden to the rest of the economy. The agricultural reforms of the early 1990 were aimed at changing the situation. The reformers assumed if land and assets were privatized, private farm sector would rapidly succeed [5]. But it didn't happen. According to Rosreestr data [6], the agricultural land area from January 1, 2010 to January 1, 2020 did not merely increase, but significantly decreased (Table

**Table 1** The agricultural land distribution according to ownership firms in dynamics (thou. ha)

| Data collection year | Agricultural land area | Citizen-owned land | Land shares | Legal entities owned land | Land shares |
|---|---|---|---|---|---|
| 2010 | 393,388,4 | 117,591,5 | 100,065 | 11,508,9 | 619,5 |
| 2020 | 221,955,0 | 106,630,9 | 79,753,4 | 20,915,6 | 1603,1 |

1). The agricultural land total owned by citizens has decreased as the data show, while the legal entities ownership total has increased.

Not all regions faced the agricultural land desolation problem. For example, several regions of Eastern Siberia, called Western Siberian grain belt, experienced increasing land-use intensity during the last two decades [7]. However, it does not change the agricultural land cultivation decline overall picture. According to Prishchepov et al., reducing the state subsidies for agriculture from 1990 to 2000 was an important cause for the decrease of cultivation in some rural areas [1]. The other important cause of the poor success of the reforms was the lack of the effective legal regulations of the agricultural land turn-over. The Land Code, that formulated the basic principles of land use in Russia, was adopted only in 2001. The land relationship as the most important natural resource, the basis of life and economic production was written there. Although land was recognized as real estate, the society interests were above private interests in the land usage and disposal. Thus, the agricultural land turnover numerous restrictions were laid down [8]. A special Federal Law No. 101-FL "On Agricultural Land Transactions" was enforced on July 24, 2002. It created a special legal regime for this category, based on the preferential purchase right of salable land plots and land shares by the state, while this right can be delegated to local authorities by decision of the legislative bodies of the subjects [9].

This special Law was changed by the significant amendments in 2005. The circle of would-be customers of land shares (without allocation of the land plot) was limited by other co-owners, agricultural organizations and peasant farm enterprises. So, the land share ownership share was quite restricted. Rasponomarev points out, before the converting the land share to actual land plot, the owner could renounce the ownership right to it, bequeath it to a third party, transfer it to trust management [10]. The owner could only sell or donate a land share to another participant of shared ownership. The land share could also be included in the agricultural organization authorized (stock) capital using the shared ownership land. Thus, the shared ownership participant could have all the owner rights only after converting the land share into real land. The legislator idea was quite clear - the purpose of restrictions on the land shares disposal was to preserve the existing economic connections and to encourage joint agricultural production. It should be noted the same principles are reflected in the land relations legislative regulation in some other post-Soviet republics, for example, Kazakhstan [11].

However, the distinct time limits and the lack of a clear procedure for the allocation to the land plot made it difficult or almost impossible to privatize an agricultural land share. Moreover, a significant part of the land shares remained unclaimed by the participants of the former Soviet collective farms or other authorized persons. In 2010 the law was changed. The land shares which were not disposed for 3 or more years in a row by the land owners become municipal property [9].

Currently, the procedure of converting land share into the real land plot (allocation to the land plot) is the following. It is necessary to survey the common land plot outline. It is formed on the general meeting decision basis of all shared ownership participants. If the shares composition and size are registered, the surveying land project of the formed land plots must be made. If there is no such project, the land share owner signs a contract with the cadastral engineer, who prepares a land plot surveying project for allocation. Thus, the law provides the land share allocation to the land plot possibility jointly with other owners or alone. The latter is more difficult while outline defining of a common plot, the terrain features were not taken into account, and included water and forest territories [6].

They cannot be included in the allocated land plot. In this regard, the real unconverted land suitable for land plot allocation is decreasing every year. The allocated land plot can be smaller or larger than in the land share documents, however they must meet the limited (minimum and maximum) sizes that are established by Federal Law No. 101-FL "On Agricultural Land Transactions" of 24.07.2002 [9]. In case of these norms deviation it is necessary to justify the site allocation validity.

The owner of the land share has the right to apply to the court for the land plot allocation or its cost compensation if the registration authority refuses to register it (in case its area does not coincide with the land share legal documents) and the local administration legal assistance absence. All the problems mentioned above are confirmed in the judicial practice on land disputes.

## 4 Discussion

There are frequent cases when a person applies for his land share after the three-year expiration period provided by the law for its claim. The potential owner recklessness is not always the reason. Sometimes it's a result of the law awareness lack, when the law interprets the claim as renting out or another disposal. For example, in the case decision of Rozhdestvenno rural settlement administration demands to recognize the land share of the defendant Velmin unclaimed and to recognize its ownership for the rural settlement, the Volga Region Court of Samara region indicated: "According to the article 12.1 FL of 24.07.2002 № 101-FL "On Agricultural Land Transactions" (further – the Law on Transactions), an unclaimed land share may be recognized as a citizen owned land share who has not leased or disposed this share otherwise" [12]. To avoid the possible legal disputes, the local government or rural settlement body at the shared-ownership land plot location should make up a list of persons whose land shares may be considered unclaimed on the basis of paragraph 2, Article 12.1, the Law on Transactions. The local self-government body publishes the list of unclaimed shares in the mass media and official website at least three months before the shared ownership participants' general meeting. The specified list is also placed on the municipality territory information boards.

People consider their land plots are unreasonably included in the unclaimed land shares list have the right to submit objections by writing to the rural settlement local self-government body. The list of unclaimed land shares was published in the newspaper "Volzhskaya Nov", among the unclaimed shares. The share of the defendant Velmin was also listed; however, the defendant objections were not received by the administration within the time limit established by law. Therefore, the Volzhsky District Court of Samara region recognized the defendant's land share unclaimed and recognized the rural settlement ownership right.

Another example is the Sasina claim to the "Development of Regions" consumer cooperative, being considered in the Stavropol Region Court of Samara region. Sasina, being the consumer cooperative member, borrowed money from the company, depositing the loan agreement as collateral in the form of 106/197385 share in the common shared ownership right for a land plot belonging to the agricultural land category. The plaintiff demanded the return of the land plot allocation after her cooperative membership termination. The plaintiff was not satisfied with the cost compensation offer. However, the court refused her claims, since the company, in accordance with the charter, had the right to choose to return the contribution in cash or in land plot [13]. We have to point out the plaintiff would not have received a land plot allocated, but a share in the general land ownership right, which she made.

Finally, the most controversial disputes are about the boundaries allocated from the common land ownership and often formed from the land used by other shareholders. In the Shcherbina court case of the land plot allocation from the LLC "Steppe" general land ownership, the land share owner insisted on recognizing the land survey project as approved, and the objections of the shareholders against this project as untenable [14]. The shareholders' arguments were the following, the most valuable land-arable land are the allocated plot part, and cultivated by the community. These arguments were not taken into account by the court, since they were not presented at the dispute settlement pre-trial stage. The company agronomist explanations were also not accepted by the court, since he was not declared as a witness and was not questioned by the court. In such circumstances, the court sided with Shcherbina, leaving the claims of LLC "Steppe" without satisfaction.

## 5 Conclusion

We could conclude, the land relations regarding the land share use as a production asset are extremely complex and require good legal preparation. After the Soviet era collective farms termination the question of the agricultural cultivated land further legal status was being resolved for a long time. The agricultural production market features required this land conversion into private ownership.

However, the legislator limited the future owners' rights to a complex procedure for allocating land plots, practically stimulating the general economic structure preservation. Some researchers point out the Soviet era collective farms changed only the organizational form, retaining the worst features of intensive land use and inefficient labor organization in their activities [15].

Statistics show the Russian agriculture has not achieved rapid growth since the Land Code adoption. Surely, it can be pointed out that there may not be a direct connection between the agricultural land total and the legal regulation effectiveness. But the number of legal disputes related to the land shares circulation and the land plots allocation indicates the land regulation still needs to be improved.

In our opinion, it is necessary to limit such a legal institution existence as a land share legally, which can stimulate the allocation of land plots. At the end of this period, the unallocated shares are released by the largest owner at the average market price and are allocated as one large plot.

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# Methodological Approaches to the Assessment of Social Management of Industrial Enterprise

**S. V. Sharokhina, L. V. Popova, and V. V. Krilova**

**Abstract** The article defines the criteria for the effectiveness of social management of an industrial enterprise. It is emphasized that the successful solution of social problems at the enterprise can be carried out with the implementation of a clear division of management activities, both by objects of influence and by problems. Some methodological approaches to assessing the effectiveness of social management are considered. A method for determining the enterprise effectiveness in the sphere of social management is proposed here. This method is based on the use of certain conditional calculation indicators and can be applied in the conditions of the economy digitalization, and also involves the implementation in several stages. It is suggested to evaluate the social management effectiveness based on the analysis of the implementation of the enterprise social development plan. This approach to assessing the effectiveness of social management is regarded by the authors as one of the examples of finding ways to create objective prerequisites and methodological basis for the study of a systematic approach to the organization of labor activity.

**Keywords** Economic efficiency · Labor productivity · Social development · Social efficiency · Social management

## 1 Introduction

Social efficiency is based on the economic essence, but the social essence has a real content, since in practice it actively affects labor productivity and its effectiveness. It is possible to achieve social efficiency only if it meets the goals and objectives of

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social development, social theory and practice. In the scientific literature, two main approaches to determining the effectiveness of enterprise management are considered. The first is based on a simple logic: if the company's activities are effective and efficient, then management (including social management) can be assessed as effective [1]. The second approach to determining the effectiveness of enterprise management is based on the allocation of the direct contribution of management (including social) to the results of economic activity [2]. Each of these approaches has its own advantages and disadvantages. For example, the first approach determines the social efficiency of the enterprise in terms of the final result, but in this case the contribution of management to the overall result of the activity remains uncertain. The second approach is more objective, because if we calculate the effectiveness of social management by the enterprise and the index of social efficiency of the enterprise, the results obtained can be compared, and if they are qualitatively related, we can assume that the first indicator is effective.

## 2 Methodology

To develop an approach to assessing the effectiveness of social management, it is necessary, first of all, to clarify the concept of management effectiveness as an economic category. There are several scientific points of view on this issue. Management efficiency is understood as an indicator of management excellence, which is a comparison of the received profit and management costs [3]. However, this approach may not always be considered correct, since: the result of management is not always reduced to profit; the profit, as a mediated result, significantly "obscures" the overall picture of management [4]; the result of management contains not only an economic, but also a social, environmental component [5]; management costs are quite difficult to accurately determine, so in practice, the effectiveness of management is most often determined by comparing such important indicators as: labor productivity, the degree of achievement of the enterprise's goal, manageability, the rhythm of work, the level of organizational culture [6, 7], etc. The most successful, in our opinion, is the attempt to determine the economic component of management efficiency, presented by Bulygin. Under the economic component of efficiency, the scientist understands its effectiveness, which is characterized by the ratio of the costs on achieving the goal, solving the tasks set to the result obtained, if they can be quantified [8].

The social component of management efficiency, in our opinion, characterizes the degree to which the enterprise uses the potential capabilities of the workforce and each employee, the success of solving social problems of team development, and improving working and living conditions. In the framework of global transformations in the socio-economic sphere, the social effectiveness is considered as an aspect that is influenced not only by the material factors, but also by the nature, dynamics, specific features of the value orientations, needs, interests of different social groups. In this regard, we can distinguish three groups of criteria for the effectiveness of social management at the enterprise: criteria reflecting the public benefit received as a result of the functioning of the relevant management systems; criteria that reveal the essence of the organization and functioning of the actual control systems; criteria for the specific social effectiveness of each organizational management structure, each participant in a single management decision, actions and relationships.

Successful solution of social problems at the enterprise is possible only if there is a clear division of management activities, both by objects of influence and by problems themselves (it is quite difficult to determine the management limits without taking into account these aspects). It is possible to distinguish a number of content blocks of the program for improving the effectiveness of social management, namely: the study of its object, the definition of goals, internal relations and tasks from the position of manageability; structural and functional analysis of management systems and mechanisms of object influence; development of management technologies, in other words, the definition of the basics of digital information support for management; analysis of the decision-making process. The effectiveness of social management of an enterprise directly depends on the ability to achieve social indicators based on standards.

In this context, the most generalized criteria for the specific social effectiveness of each organizational management structure can be as follows: the level of team cohesion of the enterprise; the degree of employee satisfaction with the results and organization of work; the degree of participation of shareholders or participants (co-owners) in the activities of the enterprise; social activity of team members; indicators of staff turnover; labor productivity; the level of employee satisfaction with the performed work.

The main goal of the business activity is to satisfy needs of consumers. Achieving this goal is possible by increasing the level of socio-economic development of the enterprise, that is, obtaining maximum efficiency. The measure of the socio-economic efficiency of the enterprise is the degree to which it has achieved certain goals, which can be summarized through indicators of the planned level of socio-economic efficiency. The definition of a complex indicator of the level of socio-economic efficiency is based on a general methodological approach to the assessment of social phenomena, since all economic phenomena have a social meaning.

The implementation of social measures, as a rule, gives a significant economic effect, and the social effect, in turn, is often reduced to economic, denoting in monetary terms the significance of certain social phenomena and processes, for example, the price of improving working conditions. Thus, the concept of "social efficiency" is replaced by the concept of "economic efficiency".

## 3 Results

The cost-effectiveness of the implementation of almost all social measures cannot be evaluated directly. But some social measures are economically unprofitable, and the effectiveness of their implementation is exclusively social. Thus, the essence of social phenomena cannot be expressed only in terms of cost indicators. And the ratio of the social efficiency to the material costs on its achieving, or the social efficiency per ruble of the spent funds, allows to assess the effectiveness of material costs for social activities. Similarly, the ratio of social effects to the timing of their achievement determines only the social development paces in relation to the enterprise team, and not the social management effectiveness. In our opinion, the attempt to determine the social efficiency exclusively from the position of the economic methodology is rather debatable.

It should be taken into account that the indicator of social management efficiency (Esoc.i) can be presented in terms of the level of the enterprise social development as a relative increase in its social results. To determine it, we recommend the formula [5]:

$$E_{soc.i} = \frac{SE_{soc.i}}{P_{soc.pi}} \times 100 = \frac{P_{soc.fi} - P_{soc.pi}}{P_{soc.pi}} \times 100, \tag{1}$$

where $E_{soc.i}$ is social efficiency of management in the ith direction of social development of the enterprise (rub); $SE_{soc.\ i}$ is social impact; $P_{soc.fi}$ is actual social outcome; $P_{soc.pi}$ is planned social result.

We believe that on the basis of formula (1), it is possible to evaluate not only the partial social effectiveness in separate spheres, but also the social effectiveness of enterprise management as their combination. Many authors believe that the effectiveness of the enterprise social management and the enterprise social development are interchangeable or equivalent concepts. In this connection, the level of social development of the enterprise (Ysr) is determined by the formula [9]:

$$Y_{sr} = \sum_{i=1}^{n} a_i y_i, \tag{2}$$

where n is the number of primary indicators of the enterprise social development that are considered; $y_i$ is a primary indicator of the level of the enterprise social development in the ith direction; $a_i$ is a coefficient of significance or priority of a particular direction of the enterprise social development.

In this case, Y_i = K_f/K_p − for maximizing indicators; Y_i = K_p/K_f − for minimizing indicators, where $K_f$ is the actual value of the ith indicator; $K_p$ is the planned value of the ith indicator. The integral indicator of the effectiveness of social enterprise management ($I_{se}$) can be determined by the formula [9]:

$$I_{se} = \frac{I_e}{Y_p} = \frac{Y_f - Y_p}{Y_p} \times 100, \tag{3}$$

where $I_e$ is the social effect (rub); $Y_f$ is the actual level of the enterprise social development; $Y_p$ and the planned level of the enterprise social development.

Based on the generalized indicator of the social management effectiveness and the indicator of the economic management effectiveness, we have the opportunity to get a full assessment of the enterprise's activity. At the same time, the problem of determining socio–economic efficiency remains unresolved.

## 4 Discussion

In the general form, the complex socio-economic efficiency of the enterprise (KE) can be determined by the formula [9]:

$$KE = \frac{K_{SEE}}{Y_p} = \frac{Y_f - Y_p}{Y_p} \times 100, \quad (4)$$

where $K_{SEE}$ is a complex socio-economic effect; $Y_f$ is the actual level of the enterprise socio-economic development (in rubles); $Y_p$ is the planned level of the enterprise socio-economic development (in rubles).

This can be determined by the formula:

$$Y = \sum_{i=1}^{n} a_i y_i, \quad (5)$$

where n is the number of indicators used for the assessment; $y_i$ is the primary indicator of the enterprise social or economic development; $a_i$ is the significance coefficient of the corresponding indicator.

Y_i = F_i/P_i – for maximizing indicators;
Y_i = P_i/F_i – for minimizing indicators,

where Fi is the actual value of the ith indicator;

Pi is the planned value of the ith indicator.

The practical implementation of the considered approach requires appropriate information support. Currently, many enterprises do not have a single social development plan, although an organic combination of economic and social development should be basic to ensure the prospects of each enterprise. We believe that the work on the development of a social development plan should be preceded by the definition of the goals of the enterprise social development and a set of measures to achieve them. Such goals can include, for instance, an increase in the labor productivity or in the level of employees' satisfaction with the performed work, an increase in the number of shareholders or participants (co-owners), a reduction in the staff turnover, etc.

When assessing the effectiveness of social management of an enterprise, various criteria and indicators should be considered that are relevant for the dual-purpose orientation of social management-both to create a set of prerequisites for increasing labor productivity (for employees of the enterprise), and for increasing the social activity of shareholders or participants (co-owners) in management.

## 5 Conclusion

The effectiveness measure of the social management is the approximation degree in relation to the achievement of all the final goals outlined in the social development plan of the enterprise. The attribution of cost estimated indicators adjusted for the overall assessment to the methodology for determining the effectiveness of the social development plan will allow to determine the effectiveness of social management, both in relation to enterprise employees, and in relation to shareholders or participants. At the enterprise, it is advisable to apply the methodology proposed for assessing the social management effectiveness based on the evaluation of the social development plan implementation, which is usually based on the use of certain conditional calculation indicators.

This technique involves the following sequential stages:

1. Determining the list of social management indicators.
2. Classification of social management indicators by sections, taking into account their target orientation.
3. Establishment of the actual quantitative values of social indicators based on the latest reporting data (according to the statements of various sources: operational and statistical reports, social surveys, etc.).
4. Determination of coefficients that reflect the significance of social indicators in relation to the their influence degree on the economic result. Here we can use the methods of expert assessments that correspond to mathematical models [10]. The significance of factor indicators can be determined by the degree of their influence on the performance indicator, which reproduces the main goal of the enterprise socio-economic development.
5. Determination of derived indicators of the social indicators significance, taking into account their actual quantitative value (scoring, calculation).
6. Calculation of the average values for sections and general assessment of the indicators of social activity of employees, shareholders or participants (co-owners) of the enterprise based on such an indicator as the index of participation of shareholders or participants (co-owners) in the activities of the enterprise (1y) according to the formula [11]:

$$I_y = \frac{\sum_{i=1}^{n} P_i}{n}, \tag{6}$$

where $P_i$ is the share of employees, shareholders or participants (co-owners) who are engaged in a specific type of economic activity of the enterprise; n is the number of specific types of activities that reflect the presented activity area of the enterprise.

7. Calculation of the social management effectiveness ($E^p_{su}$) by the formula:

$$E^p_{su} = \frac{P \times O_{sa}}{C_{ser}}, \tag{7}$$

where $E^p_{su}$ is the social management efficiency, calculated by the profit P (rub); $O_{sa}$ is general assessment of the impact of social management indicators, %; $C_{ser}$ is an integral indicator of the degree of influence of social management on the result (units).

The significance coefficients for each indicator while calculating the social management effectiveness (gi) can be set based on the expert evaluation. The calculation is carried out according to the formula:

$$g_i = \frac{g_i'}{\sum_{i=1}^{n} g_i'}, \tag{8}$$

where g, i is the rank number of factors in the final ranked ith row according to expert estimates; n is the number of all factors.

An expert assessment of the significance coefficient can be obtained by questioning the management personnel of the enterprise performing the functions of social management [12]. The considered approach will be used in the future to create objective prerequisites and methodological basis for the study of a systematic approach to the organization of labor activity.

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# New Paradigms of Technological Digital Design in Industry in Economy Transitivity Conditions

**O. E. Pudovkina, I. V. Kosyakova, and I. A. Agafonov**

**Abstract** Digital transformation is driving the technological transformations of production. This is especially true for industry, whose share in the country's GDP is quite high. In this regard, the development of a digital technological development contour that provides an optimal way to increase business efficiency in economy transitivity becomes particularly relevant. The purpose of the study was to develop a frontier of technological transformations of production and priorities in the field of advanced production technologies in industry. This study suggested a new framework consisting of digital manufacturing tools used at every stage of the product lifecycle. The map of digital development technologies of industrial enterprises associated with the launch of the innovation and technological cycle is described in detail. The main research method was a foresight methodology based on long-term models of a comprehensive assessment of the development of the global production and technology market in a scenario form. The result of the study is a comprehensive forecast of the development of advanced production technologies and foresight of the priority of technological development in Russia for the modernization of the industrial complex in the conditions of deep penetration of digital technologies, based on the concept of a new industrial society.

**Keywords** Digital manufacturing · Digital platform · Foresight · Industry · Technology frontier

## 1 Introduction

The digital revolution in manufacturing shifted from individual technologies to integrated systems. Most companies that go into digital transformation are trying to enter new business models based on new digital technologies. Industry 4.0 describes

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the fourth industrial revolution, which leads to intelligently connected and decentralized production, standing at a new level of organization and regulation of the entire value chain of a product throughout its life cycle [1]. Today, industrial enterprises are clearly aware of its potential and are ready for high investments in digital transformation [2].

In the conditions of transitivity of the economy, there is a need for innovative technological transformation of industry—a process that reflects the transition of the industrial sector from one technological mode to another in order to increase the efficiency and competitiveness of the enterprise. Outdated technologies preserve the technological structure of the economy, which blocks its innovative development.

The digital modernization of industry carried out in modern Russia contributes to the renewal of the technological image, covers the transition to the electronic industry, the reconstruction and technical re-equipment of production facilities, the creation of new technological directions, the development of breakthrough electronic industrial technologies, etc. Artificial intelligence, unpopulated and additive manufacturing, industrial wearable electronics, digital reverse engineering, and other things are changing the nature and content of business processes. These priorities correspond to the big tasks specified in the Order of the Government of the Russian Federation of January 17, 2020 No. 20-r "On the strategy for the development of the electronic industry of the Russian Federation for the period up to 2030 and the action plan for its implementation" [3].

However, we note that the packages of disruptive technologies are already known to everyone: platformization technologies, digital doubles or virtual modeling, artificial intelligence for data analysis and processing. But the technological frontier is constantly moving forward, the speed of this movement is constantly increasing. Against the increasing requirements for the development of the industrial complex, insufficient study of the nature of technological and organizational reengineering tools based on the use of simulation modeling is a contradiction, which requires the development of a model of an integrated digital decision-making module that accelerates the digital development of the company. The model of technological development in the field of industrial technologies will provide the basis for state industrial policy, contributing to the achievement of state priorities. The movement towards technological transformations will be successful if it is to be more accurately correlated with the overall trajectory of global economic and technological development.

## 2 Methodology

To solve the research problems, authors used a set of scientific methods. The theoretical and methodological basis was the basic provisions of the study of processes and phenomena: system analysis, abstraction, analysis and synthesis. The main method was the foresight methodology, which includes a wide range of research methods: scanning horizons, analyzing scenarios, market prospects and technologies. This method allowed to identify the most functional information resources necessary for the research. Recently, the foresight methodology has become extremely popular in shaping the vision of the future. The use of foresight methodology is a fairly new phenomenon that leads to institutionalized scenario forecasting. The foresight scenario model is more flexible, allowing to see all the scenarios related to the accelerating globalization and modernization of the world economy. The use of the foresight methodology makes it possible to more clearly define the main directions of strategic modernization of the national economy priority sectors, in particular industrial enterprises. Studies that use scenario forecasting are based on purely econometric modeling, statistical analysis, partial equilibrium modeling, and similar methods [4, 5]. The analysis was supplemented by a horizontal scanning that included a literature review, which was applied to identifying technological trends for the industry.

## 3 Literature Review

Many scientists and researchers studied the digital transformation of industry and its impact on the economy. The author of the article believes that the prerequisites for the emergence of the concept of industry 4.0 are historically associated with the concept of computer-integrated production [6]. The authors of this article also share this point of view. The analysis of the literature shows that in 1960–1980 the process of reengineering was launched, the decision was made to optimize and automate intellectual activity, to change the nature of design, to provide template design of complex technological systems [4, 5]. The breakthrough happens in a moment when workstations enter the market, the movement is aimed at increasing the volume of computer programs that provide speed, accuracy, reproducibility, and archiving of knowledge. In 2010, there was another key decision-the transition to modular structures, which provided savings in human costs and time. At this point, there was an institutionalization of production, automation. The key advantage here is that computer engineering is developing, providing control of complex equipment at speeds in the zone of complexity that exceed the human reaction.

For industries based on advanced production systems, the most important success factors are a deep understanding of production processes, as well as the ability to adapt and develop [7]. For Russia, this is especially important, because in addition to external threats, Russian industry must compete with global European players with a higher technological level.

In their work, the authors define that digital transformation is a broad term that covers changes in business models, activities, processes, and competencies that allow to get all the benefits from the full implementation of new technologies [8]. We believe that industrial production in the next 10–15 years will need to implement a set of tasks that have the importance of fundamental ones. The industry must cope with the growing complexity of production, the organization of technological chains and the complexity of products. To manage this complexity, a qualitative leap in reengineering and technology processes management is needed.

Industry 4.0 transforms the business models of manufacturing firms [9]. The studies focus on the maturity of industry 4.0 in terms of value creation processes. They developed a model called the “Production Cost Modeling Methodology”, which consists of five stages, starting with the analysis of the maturity gap and ending with the identification of improvement areas [2]. The author’s approach is not limited only by processes, it covers a wide range of Industry 4.0. The key processes that, in our opinion, will determine the technological sphere of the strategic directions of industrial sector development will be associated with the launch of the next innovation and technological cycle, the implementation of three interrelated “revolutions»:

1. Within 5–7 years, one of the dominant processes will be the transfer of the import of information platforms that are the basis for design.
2. Using new materials. The peculiarity lies in the fact that the revolution in design means the revolution of such materials.
3. "Revolution” in infrastructures: “smart environments”, the system of “smart things”, “smart factories” as overcoming the linear architecture of traditional industrial architectures.

Digitized and virtualized systems lead to new scenarios of industrial works, i.e. cooperation between a person and a machine within the framework of a “smart” factory [10]. According to the authors, digital modeling is a core function in digital manufacturing, as it supports experiments and validation of various scenarios and configurations for existing and new production resources and systems, contributing to improved design and productivity [11].

Modeling involves processes or systems modeling, so that the model simulates the actual system’s response to events that occur over time [2]. In a fully integrated digital production, the product and its production processes are developed and modeled in a digital environment even before the first part of the material is purchased. This saves significant time and money on new product development, resulting in higher product quality and lower costs [11]. The authors have the opinion that one of the most effective means of digital production is the process of simulation modeling. Simulation modeling is a method of studying a system by replacing a real system with a computer model and further conducting experiments on the system model [12]. The main conclusion, which was made based on the results of the literature analysis, is that it is necessary to find a new platform solution that provides the possibility of using various types of software with an integrated digital module.

## 4 Results

Today, the pressure of the external market and external circumstances on any business is very high. In order for the business to cope with this pressure, it is necessary to frequently change the production plan to launch new orders, quickly launch new products, and find ways to accelerate production without large investments. A new digital direction—simulation modeling or digital double will deal with the task.

In the prevailing trends of digitalization, most enterprises that strive for effective work should go through the process of digital transformation [13]. In practice, this means moving from the basic technological package to new production technologies. The modern scenario model of the foresight forecast of industrial development, developed by the authors, is presented in Fig. 1. On the left, the network markets of digital systems are highlighted. The horizontal line at the top is the end-to-end technology. The authors believe that in order to achieve significant results, it is necessary to focus on position number five, that is, new production technologies that allow to design and manage complex systems throughout the entire products lifecycle, including business processes such as design and analysis, integration, verification and validation of the product being developed. Next, a smart factory is a movement towards an unpopulated manufacturing, it is a robotic, flexible manufacturing cell. The virtual factory, respectively, is digital design and modeling, it is industrial sensorics, industrial internet. Accordingly, predictive analytics is formed in big data and all this is collected to the factories of the future.

Let's note that one of the dominant processes of the digital frontier is the transfer of import of information platforms, which are the basis for design. If we do not provide the design with modern tools, we will "fail" any production process in the world. The transition to modular designs provides savings in human costs and time. The key gain here is that computer engineering is developing, providing management of complex equipment at speeds in the zone of complexity that exceed the human response.

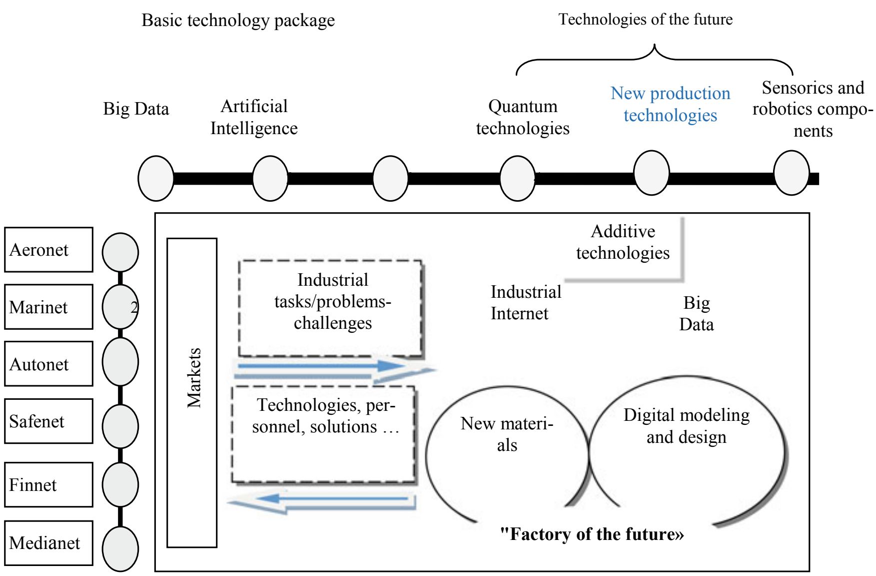


**Fig. 1** Forecast matrix of industrial development

Today, digital technologies help a company to develop and become much more efficient. The digital environment of Industry 4.0 is the result of creating a network of technological components [7]. We will highlight the technologies that, in our opinion, are advisable to use in industrial production: MDC/MDA data collection and management, AR, VR, XR and wearable electronics, PLM and ERP vendors, additive technologies, Napoleon IT, BFG, Rubius, robotics, and more.

The next key processes that we believe will define the technological frontier are new materials and their integration into automated design systems. In Russia, there is no digital global catalog that allows to access the digital image, although many new developments are underway in this direction. The problem is that we will have to combine the development of materials and structures, and we do not have a general idea of the variability of tools for using these new materials. This system is not fully completed all over the world. Smart materials for Russia, this is the region of 2025–2030. With these materials, the construction is designed immediately, and not the composite material.

At the heart of the digital driver, which, in our opinion, will determine the technological breakthrough in the industry, is the process of simulation modeling in the system of digital infrastructures. In our opinion, simulation modeling is a test of scenarios and hypotheses using mathematical model. It is associated with the presentation of a digital model for the integration of technological business processes of the enterprise to improve the physical aspects and support production planning. The ability to connect different parts of the product lifecycle through digital data, which mean design intentions and management information, and use this information for intelligent automation and more smarter and efficient business decisions, is the role of digital manufacturing [1]. In our opinion, the main function of processes' simulation modeling is forecasting the future, it is an opportunity to find the best way to improve the efficiency of the entire enterprise, it is an opportunity to build an end-to-end management system, from scenario analysis of the development strategy to the calculation and issuance of shift-daily tasks.

Simulation modeling of technological business processes includes a number of tools that, using elements of artificial intelligence in semi-automatic mode, based on the inside algorithms, and regulatory and reference information, allow to create a simulation model. The following data is used as normative reference information:

- products specification;
- technological routes linked to equipment;
- equipment and professions that are involved in the value creation process.

The data is created with the help of artificial intelligence and the optimal simulation model for the enterprise is formed, which can be used to build a system of end-to-end management. The simulation model is a tool for everyday management. If there is data on how things are produced and in the process of simulation modeling we know exactly which part came to which machine, when it was processed, which profession was involved, therefore, this data can be used to form a daily task. If you connect data sources about work in progress to the model, this database can be used to perform functions of the MES system, form a daily task and issue it to work places, and get back the connection in the form of data, on where which parts are located. And in this case, we get a digital way of building end-to-end enterprise management, when it is possible to make strategic decisions at the top level, and at the operational level, use digital technologies to issue operational production plans, manage business processes.

The creation of simulation models is based on simulation modeling environments: the traditional way of building models and the approach based on digital platforms. A significant disadvantage of the traditional construction method is the large time spent on describing the current business processes of the production system, which, as a result, can lead to distortion of the simulation model and it will not correspond to reality. The authors believe that when implementing digital production, it is advisable to use an approach based on digital platforms. This is, firstly, the speed of construction, and secondly, the adaptability of the system to the modern realities of digitalization. As a result, we get a model by which we can transform the enterprise (Fig. 2). The feedback of the dynamic simulation model of digital production can be obtained through the dispatching system from the digital module that the enterprise already uses. The simulation model is connected to the digital landscape, to the general enterprise management system.

The result of the system design activity is a consistent system model, which focuses on the development and improvement of the model using methods and tools

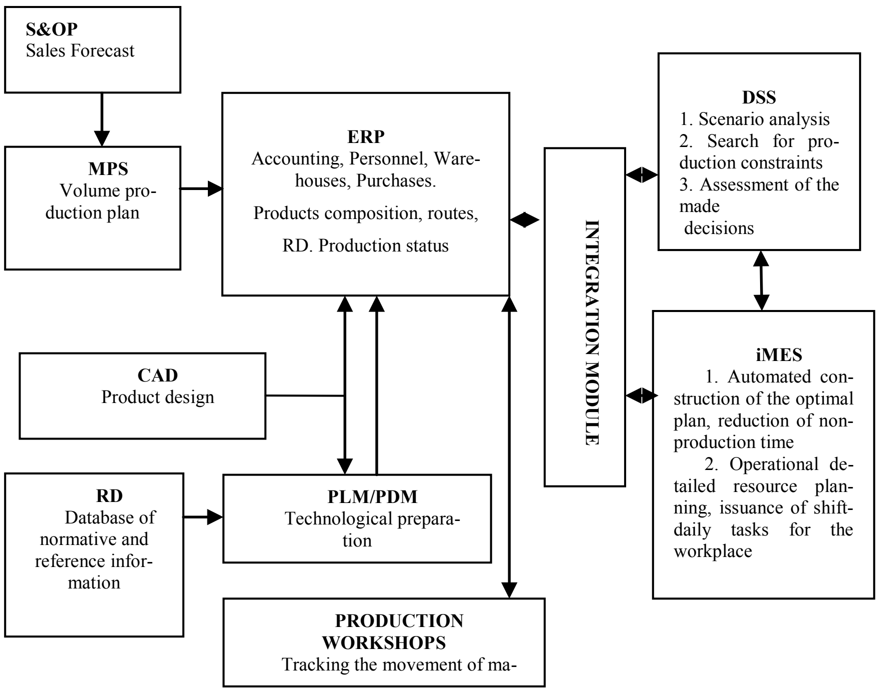


**Fig. 2** Digital model of the technological frontier in industry

based on simulation modeling. A system model is an integrative representation of the structure and behavior of a system, sometimes called a system architecture [14]. The proposed technological frontier allows to create an image of the industry that will be in the next 10–15 years. This is super-accuracy, super-speed, super-complexity on the basis of automation and intellectualization, on the basis of the formation of complexes of information tools, digital infrastructures.

## 5 Conclusion

Technological modernization means the transition to a new stage of civilizational development, which requires a radical renewal of all economic growth components [15]. The paper focuses on the transformation of industry in connection with the entry into a new phase of industrial development under the influence of the fourth industrial revolution, in which it is important to urgently take measures to implement breakthrough development in order to overcome Russia's lag from the world leaders. The analysis of the key processes of the technological breakthrough allowed us to form a number of conclusions and recommendations. Nowadays, it is becoming clear that the next technological breakthrough needs to be launched and advanced production technologies need to be involved in the process, in which growth should not come at the expense of workers and capital, but through the use of new scaled electronic systems. The transition to the fourth industrial revolution is an inevitable innovation process that will result in fully automated digital production with the prospect of integration into a global industrial ecosystem [13]. The results of the study are of great economic importance, which is to establish a forecast of the development of production and technological provisions for the modernization of the industrial complex in the context of reindustrialization, the implementation of which can serve as a factor in increasing Russia's competitiveness at the world level. The article analyzes the key processes that will determine the technological frontier of the industrial sector associated with the launch of the next innovation and technological cycle. The authors concluded that in the conditions of reindustrialization and for the implementation of the breakthrough development of the Russian economy, it is advisable to use scenario models of the industry image based on simulation modeling. The formed conclusions on the implementation of the foresight results will contribute to scientific studies aimed at implementing programs of structural changes in the industry.

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# Innovations in the Advanced Development of Industrial Enterprises

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**Abstract** The purpose of this article is to study the issues and problems of advanced innovative development. The authors actualize the issues of the formation of scientific and innovative centers of excellence, determined by the levels of readiness of technologies—they suggest the creation of centers of technological superiority (CTS), which can create superior products and technologies on a global scale, which ensures the effective development of the activities of economic entities in the market. The processes of formation and functioning of CTSs are a promising form of economic activity, since their organization makes it possible to advance the development of economic entities. The paper suggests the Concept of creating a CTS, based on improving the efficiency of the use of its own UTC of world superiority, by accelerating the processes of formation and promotion of globally superior technologies and products based on the creation of new innovative tools in the form of management systems of UTC, CTS and their teams, tasks and problems, owners, mechanisms for creating and integrating open innovations, training and practical activities.

**Keywords** Advanced development · Innovations · Ecosystem · Industrial Sector · Infrastructure · Networking

## 1 Introduction

The relevance of the study lies in the fact that the innovative development of the Russian economy, which determines the strategic areas of activity of the industrial sector, currently does not meet the challenges and requirements of the global economy, especially in the context of import substitution and countering the economic sanctions of Western states against the Russian Federation. The advanced innovative development of the state *i*s a continuous process of activity of economic

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entities aimed at the formation, production and commercialization of new products and technologies that exceed the existing world analogues in terms of consumer qualities and technical and economic indicators, which provides a temporary monopoly position in the innovation market.

Advanced innovative development is considered as conditions for the innovation activity of the industrial sector, through the integration of science, technologies and product sales. Advanced innovation development forms the conditions for the creation, implementation and diffusion of innovations, carried out in the organization of network connections between the elements of the innovation system, in order to develop innovation activities. Insufficient knowledge of the processes of advanced innovative development of the industrial sector, based on the creation of new integration forms and organizational structures presented in earlier studies on this topic, determines the relevance, objectives and choice of the topic of this study, based on the development of scientific provisions, additions and clarifications of scientific concepts in this area.

Based on the digitalization of the global economy, the development and promotion of solutions of the National Technological Initiative of Russia (NTI), which includes high-tech global markets in which the struggle for leadership will manifest itself in the next 15–20 years, the domestic industry has significant chances of success. But, given the current global environment, all attempts to catch up with the leaders of industrial production in existing markets or adapt their business models for the Russian economy are considered unpromising in the global economy and the practice of managing innovation processes [1]. This work is devoted to the study of the issues of innovative technological breakthrough of the domestic industry in the strategic perspective. Recently, domestic manufacturers and representatives of science have come to the point of view that the state is lagging behind in innovation activities due to the fact that this activity is carried out on the old technological base that does not correspond to the new technological order. Therefore, for the development of innovations, it is first necessary to modernize the technological base, and then to start innovation activities.

Based on this, at present, the terms "technological superiority" and "centers of technological superiority" (CTSs) became actively used in economic science. Superiority in something means that its bearer has such characteristics that are not available to his opponents. Thus, technological superiority is based on the possession of a certain set of technological advantages of an individual industrial enterprise that are unachievable for other subjects. It follows that technological superiority is based on the predestination of technological development. The predestination or anticipation of technological development is based on the integration of technological knowledge and experience to predict future technological development. It can even be said that technological superiority represents the ability of an enterprise to achieve its sustainable, advanced technological development.

The authors understand CTS as an organizational and economic association of organizations, industrial enterprises and scientific structures that integrated their resources and competencies for the formation and implementation of technological competencies, expressed in technological products and services, on the global market, in promising technological sectors of high-tech products, which implies their development and concentration of funds on key points of technological growth, in priority areas of science and technology. To achieve technological superiority in industry, the following processes are required: development and creation of technological knowledge; formation and accumulation of technological knowledge; selection of priority areas and development trends. For the organization of technological superiority, it is necessary to have all of the above-mentioned interrelated processes. The theoretical justification for the feasibility of forming the CTS is the idea of the Matthew action, according to which "success breeds success", and, therefore, if interested researchers are united and additional resources are provided, this success can be multiplied [2]. Issues that represent the essence and content of technological superiority in industry are reflected in the works of such researchers as: Chemezov, Volobuev, Koptev, Kashirin [3], Asheim, Isaksen [4]. In their opinion, technological superiority is an integrated technological advantage that is achievable only for a narrow range of industrial enterprises and becomes the basis for their advanced technological development.

Many scientists, such as Varabin, Zayko, Kashirin, and Strenalyuk [5], are of the opinion that to organize technological superiority in industry, it is necessary to consider centers of technological superiority as "organizations that carry out research and developments in breakthrough areas of knowledge and have unique material, technical, intellectual, and human resources."

Kashirin, Baranov, and Kashirin note in their works that chronologically, the creation of centers of excellence in the world economy was based on the presented approach, which determined their activities on the basis of newly created or already existing innovation centers, research structures, and institutes [6]. The functioning of the CTS may face problems with the introduction of innovations in production. To fulfill this task, the state is implementing the National Technological Initiative of Russia (NTI), within the boundaries of which the markets in which CTS will operate are defined. The issues of creating centers of technological excellence in industry began to be implemented through state programs in the priority areas of science and technology, starting in 2016. These centers were formed in a number of scientific organizations and universities of the country, on the basis of existing research centers and design laboratories. But these measures did not accelerate the innovative development of enterprises and organizations that carried out these organizational changes. According to the Federal Statistics Service, in 2019, domestic enterprises produced innovative products for the world market in the amount of less than 0.1% of the Russian Federation GDP. Kashirin, Semenov, Ostrovskaya, Kokuytseva, and Strenalyuk also note that the question remains unresolved: how can we solve new problems and challenges of global competitiveness, as well as the use of third-party unique technological competencies (UTC) in the centers of global technological excellence (CGTE) [7].

Currently, there is an opinion that centers of technological excellence are innovation centers. According to the authors, this expression is not quite correct, since innovation centers are designed to promote innovation activity when there is already an idea and it needs to be implemented in the form of innovation. Comparing the positions of different researchers on this problem, authors determined that the proposed formulations, approaches and methods are given in other works. Having carried out a critical analysis of the scientific literature on this topic, limitations and shortcomings were identified in the works of other authors—not many studies are presented on the centers of technological superiority. The authors propose additions in this area, by developing methodological approaches to this category.

## 2 Methods

### *2.1 Scientific and Innovation Centers of Superiority in the Industrial Sector*

The fundamental prerequisites for the creation of CTS and, on their basis, the processes of creating added value in industrial production, acting as a specific set of relations between management and production, which represents the labor culture and the content of production goals aimed at generating new knowledge, initiating innovative processes, creating innovative technologies and producing new products [8]. The specifity of CTSs is their ability to generate innovations, that is, the formation of added value, which is created not by summing up the effects of the elements included in the CTS, but by organizing the ways of their interaction [4]. Thus, CTS is a team that has unique technological competencies (UTC) and is aimed at creating innovations and their active commercialization, through the use of the required financial and material and technical resources, which, when integrated, ensure the creation, production and implementation of innovative technologies whose technical characteristics meet the criteria of global superiority. Therefore, the study was based on the position that the mechanisms for the formation of technological superiority are technological competencies, as well as the formation and sale of products of the future on the market, providing on this basis the growth of the innovative component of the country's GDP.

In the scientific literature, there are many publications in which CTSs in industry are presented in two ways: as "scientific" and "innovative" centers. Indeed, agreeing with the opinion of scientists, we see that without the development of science, it is impossible to develop innovative activities. But, at present, the issues of transformation of science into innovation remain poorly studied, which negatively affects the innovative development of the country. In this direction, there is an approach of researchers Chemezov, Volobuev, Koptev, Kashirin, based on the practice of "technology readiness levels" (TRL) [3]. From the theory of innovations, it is known that a project turns into an innovation when its characteristics surpass world analogues, and innovations are in demand on the market. This state is shown in Fig. 1, where the research centers are represented by TRL 1–3 phases of the idea and design emergence. And the innovation centers are represented by UGT 4–6, reflecting the R&D

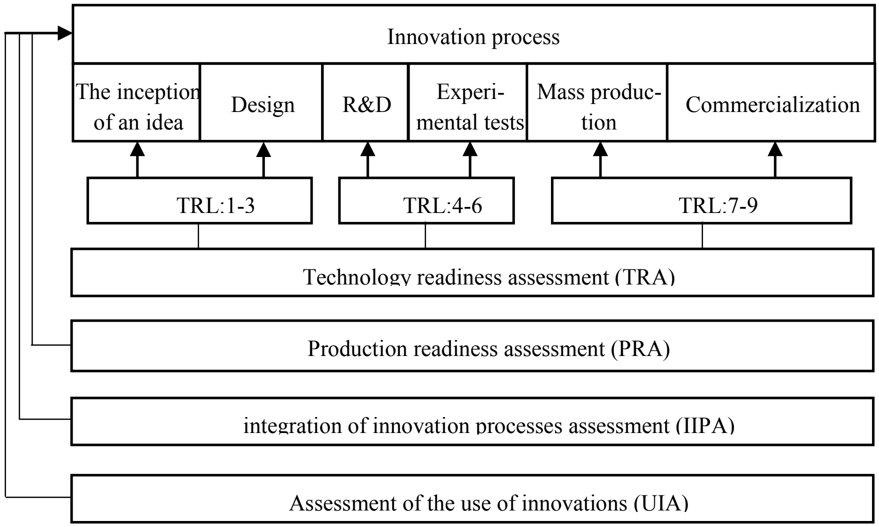


**Fig. 1** Scientific and innovation centers of superiority of the industrial sector, determined by the levels of technology readiness

and experimental tests phases; UGT 7–9 are represented by the mass production and commercialization phases. Thus, Fig. 1 presents "scientific" and "innovative" CTS, depending on the level of availability of technologies. This figure shows the division of scientific and technological centers of superiority.

To create the CTS in the industry, certain levels of technological competence (TC) are required. In this study, for the formation of the mechanism of advanced innovative development of the state, the authors suggest the creation of new elements of the innovation infrastructure, called CTS integrators, representing the hubs of the innovation ecosystem of advanced development. An innovation hub is usually understood as a platform, or a network node of business communications, in which scientific and entrepreneurial structures participate in order to organize processes of continuous updating of products ( services), technologies, processes and business models [8]. The innovation hub provides attractive conditions for innovation activity in the industrial sector and a modern innovation infrastructure in terms of networking. The main goal of the hub is to develop partnerships with domestic and foreign startups, business organizations and other companies for the mutual implementation of projects in the areas of the introduction of innovative technologies in the field of production. Innovation hubs play the role of CTS integrators or connecting links, which are able to provide conceptually new solutions for the cooperation efforts of market participants. An innovation hub, in its essence, represents an innovation infrastructure, i.e. a complex set of resources, enterprises and organizations to ensure innovative activities (Fig. 2).

From the study of the world experience in creating ecosystems, it is known that the involvement of external teams and specialists in the ecosystem based on the

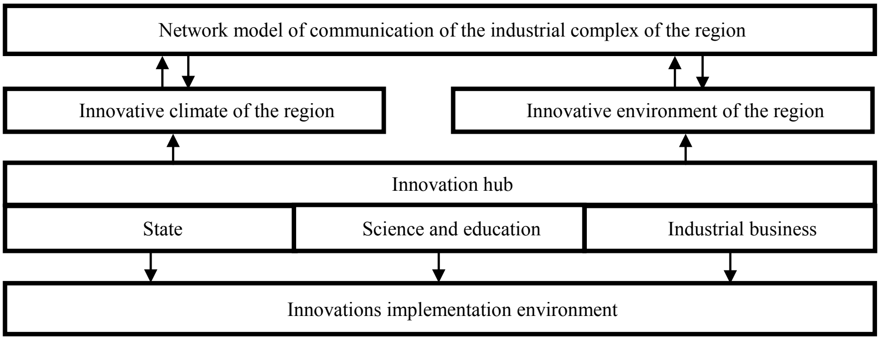


**Fig. 2** Innovation hub of the region

organization of network connections that have UTC, as well as the purchase of innovative companies that have UTC, represent significant efficiency. A number of domestic high-tech industrial corporations use these tools to diversify their activities. From the practice of forming technological competencies, it is known that they are formed by teams of specialists who already have the required technological competencies to perform new scientific and technical tasks that are aimed at forming advanced technologies and new products [8].

The main difference between the innovation ecosystem and other systems and platforms for organizing activities is that it acts as a generator of ideas for the implementation of innovations, creates new intellectual property for the state and economic activities. In addition to the UTC teams, the innovation ecosystem includes various stakeholders who carry out their activities together with scientific and educational departments, as well as investors, corporate specialists in innovation financing, and other funds [9]. As a result of complex interaction, in the ecosystem, interested participants create a stream of innovations that are in demand by the market. The functions of the market are to create demand for innovations in the "broad sense" by paying for them through interested stakeholders. The result of the ecosystem is the provision of commercialized innovations. In the category "ecosystem", the prefix "eco" indicates the fact that innovations are born massively, collectively, in an information network environment, based on the organization of horizontal connections of legally independent participants.

The authors note that technological competencies of world superiority are created to solve global problems and tasks. The fundamental basis for the development of solutions to global issues is the global challenges and the results of scientific and technological forecasts of development. Global challenges are the strengthening of existing or the emerging of new problems that are caused by contradictory trends and processes in the economic, social and technological spheres, which are the result of the emergence of new influence factors in world development. Global challenges include the creation of artificial intelligence, hyper sound, quantum technologies, biotechnologies, etc. Advanced innovative development can be introduced through the implementation of forecasts of scientific and technological development and the solution of problems of global challenges, as well as the formation on this basis of technological competencies of world superiority.

## 2.2 The Concept of Innovative Activity Development of the Aircraft Industry

Let's consider the status and algorithm of the CTS functioning of the positions of advanced innovative development of industrial enterprises, as well as the processes of innovative products commercialization. According to the authors, it is necessary to make changes in the activities of scientific and innovative centers of superiority, taking into account the existing foreign and domestic experience:

– the basis of CTS is a team of specialists acting as an independent management entity and creating superior technologies and products based on the actual developed CTSs;
– in addition to scientific and innovation centers, it is necessary to introduce the concept of "innovation center of superiority", the function of which is to develop global excellence in the product and technological spheres of use;
– the determination of the technological superiority of technologies and products should be carried out on the basis of an analysis of their technical and economic characteristics, in comparison with world analogues;
– based on the CTS status, it is necessary to determine the level of innovative potential that can be used for the advanced development of the economy;
– globally superior technologies and products with unique technical and economic characteristics and consumer properties form a monopoly position of technologies and product in the market, which allows to create their monopoly value and provide excess profits.

In this study, the authors propose the concept of creating the CTS in the industry, based on improving the efficiency of the use of their own UTC of world superiority. To integrate the centers of global superiority into the global chain, it is necessary to provide its own concept of their formation and development, as well as the organization of innovative activity on the basis of integration with foreign partners. The proposed concept is presented in Fig. 3. A prerequisite for the development of the concept of creating the CTS was the adoption of the strategy of scientific and technological development of Russia, which requires ensuring the global competitiveness of the Russian Federation in the advanced sectors of the economy and mastering the leading positions on the world stage in promising technological sectors [10]. The main principle of the implementation of the concept is the close interaction of science, business, government and education, including a common responsibility for obtaining practical results. The goal of this concept is to achieve the organization's leading positions in the global market by accelerating the formation and promotion

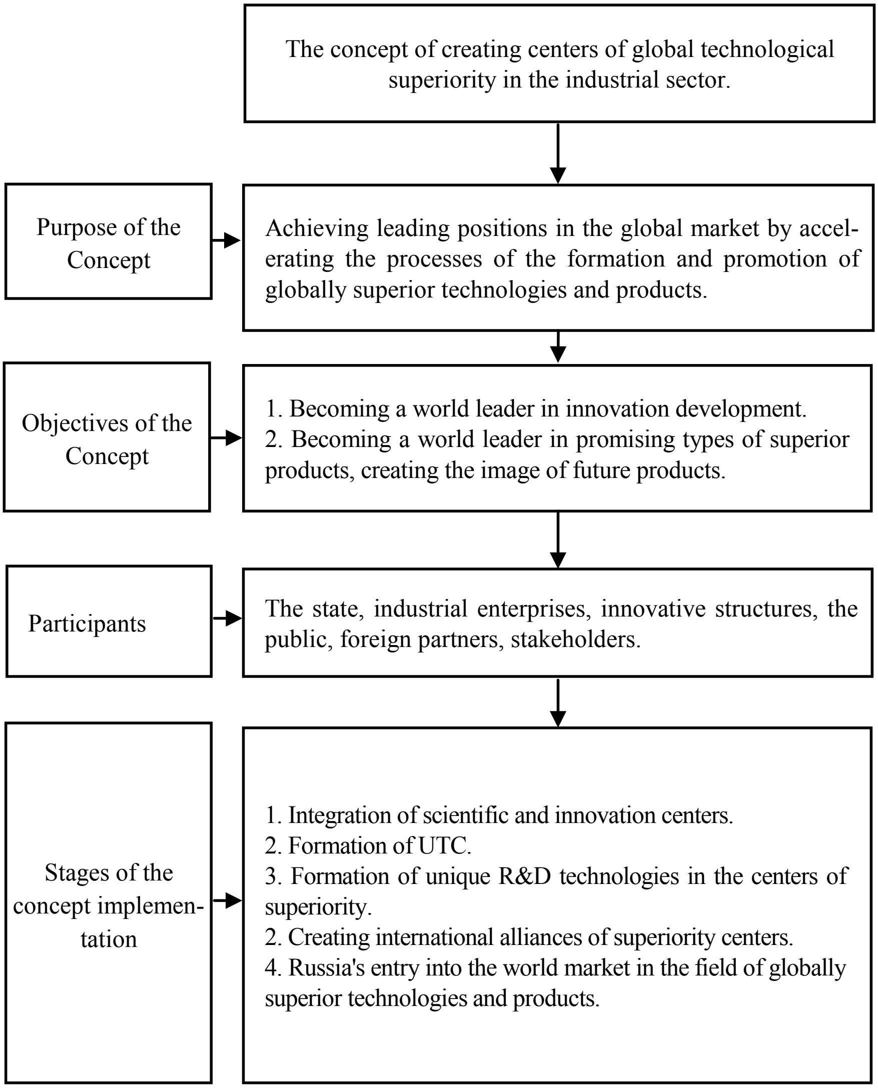


**Fig. 3** The proposed concept for the development of innovative activities of the aircraft industry

of globally superior technologies and products based on the creation of new innovative tools in the form of UTC management systems, CTS and their teams, tasks and problems, owners, mechanisms for creating and integrating open innovations, training and practical activities [11–14].

The main aspect of the concept is the formation of a corporate idea, a system of motivation and values of the company, which ensure the involvement of personnel in the processes of creating unique technological competencies, continuous innovations, CTS, as well as the organization of a corporate platform that provides communication for the company's employees involved in working with UTC and CTS.

It is planned that as a result of the implementation of this concept, the company will identify the existing internal reserves of UTC, use external teams of unique technological competencies, create a global-level CTS, which will ensure the creation and launch of globally superior innovative technologies and products to the markets.

According to the authors, the CTS of the industrial sector should meet the following requirements: organization of a center with its own structure and its own research program; sufficient availability of high-level specialists; availability of the center's capabilities for intersectoral and interdisciplinary studies; significant opportunities for innovations development; availability of prerequisites for the mobility of highly qualified personnel; international studies and international recognition of the center; active cooperation with industrial R&D; independence of financing from state support and availability of stable financing of activities.

The organizational structure of the CTS can be represented as separate centers, laboratories, research institutes, and network structures [15]. The criteria for selecting partners for creating centers of superiority can be the following indicators: the availability of unique technologies and developments, the availability of patents for applicants; significant publication activity of the candidate; the number of research staff; the volume of concluded innovation contracts; participation in international innovation development programs.

## 3 Results

Analyzing the conducted study, authors present the final results:

1. The effective forms of advanced innovative development of the industrial sector, which are CTS, are proposed. The definition and content of the activities of CTS that operate in new growing and developing markets, as the main condition for the formation of globally superior products and technologies, industrial innovations, are specified.
2. The issues of the formation of scientific and innovation centers of superiority, determined by the levels of readiness of technologies, are actualized.
3. The paper suggests the creation of new elements of the innovation infrastructure, called the CTS integrators, representing the hubs of the innovation ecosystem of the advanced development of the industrial complex, based on the platform, or network node of business communications, in which scientific and entrepreneurial structures participate in order to organize the processes of continuous updating of products( services), technologies, processes and business models.

4. In the study, the authors proposed the creation of a CTK in industry based on the imperatives of ecosystems that serve as a generator of ideas for implementing innovations that create new intellectual property for the state and economic activities, with the involvement of external teams and specialists, with the organization of network connections that have UTC, as well as the purchase of innovative companies that have UTC.
5. The study suggests the concept of creating CTS in industry, based on improving the efficiency of the use of its own UTC of world superiority, by accelerating the formation and promotion of globally superior technologies and products based on the creation of new innovative tools in the form of management systems of UTC, CTS and their teams, tasks and problems, owners, mechanisms for creating and integrating open innovations, training and practical activities.

## 4 Conclusion

Advanced innovative development is considered as conditions for the innovation activity of the industrial sector, through the integration of science, technologies and product sales. Advanced innovation development forms the conditions for the creation, implementation and diffusion of innovations, carried out in the organization of network connections between the elements of the innovation system, with the aim of developing innovation activities, based on the use of technological superiority. In the work, authors revealed that the following processes are required for the implementation of technological superiority: the development and creation of technological knowledge; the formation and accumulation of technological knowledge; the selection of priority areas and development trends. Special attention is paid to the issues that reflect the creation of new elements of the innovation infrastructure, called the CTS integrators, representing the hubs of the innovation ecosystem of advanced development, based on the platform, or network node of business communications, in which scientific and entrepreneurial structures participate in order to organize the processes of continuous updating of products (services), technologies, processes and business models.

The authors put forward and confirmed hypotheses that contain provisions that the creation of CTS and UTC are conditions for the transition of domestic industry to an effective and sustainable state; the implementation of the integration of innovation activities requires the formation of new forms, methods and approaches that affect the development of superior technologies and products. The creation of new objects of innovative infrastructure of the industrial sector in the form of CTS integrators, innovative competence hubs (ecosystems) is a unification of the mechanisms of advanced innovative development of the state. The creation of CTS and UTC are the conditions for the transition of the domestic industry to an efficient and sustainable condition. The implementation of the integration of innovation activities requires the formation of new forms, methods and approaches that affect the development of superior technologies and products. This study has a novelty in the presentation of additions to the analyzed issues, in terms of the CTS creation and functioning, the formation of which is based on the materials of previous studies.

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# Risk Management at Small and Medium-Sized Enterprises Under the Coronavirus Pandemic

**Yu. S. Sergeeva and E. V. Volkodavova**

**Abstract** The economic prosperity of many countries of the world directly depends on the share of the gross domestic product, which is made up of products and services of small and medium-sized enterprises. Currently, new risks associated with the coronavirus pandemic have emerged in the external environment of their functioning. This study identifies and analyzes these risks, identifies the main measures that contribute to their leveling, supplements the classification of internal and external risks that influence the economic sustainability of small and medium-sized enterprises (SMEs) significantly. The developed conceptual aspects of risk management at SMEs enable to identify, minimize and effectively prevent the impact of risks that can negatively affect the main business processes, considering the peculiar functioning of enterprises. At the same time, an emphasis is made on the dual influence of risks, because small and medium-sized enterprises can open new positive opportunities and directions for business development in the crisis. It was concluded that timely and reliable identification of possible risk situations will help the management of small and medium-sized enterprises to organize or adjust business processes affected by the coronavirus pandemic, ensure the sustainability of activities in the risky economic environment and stay in occupied market niches.

**Keywords** Factors of external and internal environment · Risk management; risks of functioning and development · Small and medium-sized enterprises

## 1 Introduction

The activities of any enterprise are accompanied by numerous risks of the global environment. In current conditions, they were supplemented by risks of managing in the context of the coronavirus pandemic, for which many enterprises were not ready. The main characteristic of functioning in today's uncertain business environment is complex long-term forecasting. Consequently, the ability of management to

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anticipate, identify and mitigate many of risks, to adapt the business model of the enterprise to activities in new, changed conditions, determines the segment of the geo-economic space where the enterprise will confidently take its niche. And it is very important because the sustainability of any business depends on the ability to anticipate risks and the presence of the risk management system.

For small and medium-sized enterprises (SMEs), the influence of external and internal factors is especially significant, since their influence is the objective reason for the occurrence of risk situations, the negative consequences of which reduce the efficiency of entrepreneurial activity. Despite the flexibility and mobility of small and medium-sized enterprises, their possible successful adaptation to conditions of the market niche largely depends on the prompt identification of the system of risks that determine the result of their economic activities.

This work is aimed at the study of SMEs' activities in the crisis, the assessment of the risk management relevance for small and medium-sized organizations. The article is based on the hypothesis that these enterprises are one of the key factors in the economic development of the country. Nowadays, for the successful SMEs operation, it is important to assess risk parameters and, based on the data obtained, implement the elements of the risk management system. The indicator of GDP (gross domestic product) is an indicator for assessing the efficiency of the country's economy. It is assumed that one of the key points of GDP growth in the country's economy is the efficiency of the company, including through building a risk management system.

## 2 Methodology

When studying this issue, the authors used:

- neoclassical risk theory with additions introduced by Keynes [1] in terms of the propensity of entrepreneurs to take a large risk to obtain a larger expected profit [2];
- method of complex analysis, which made it possible to cover a wide range of issues, problems and solutions in the field of identification, assessment and analysis of risks of SMEs in crisis conditions;
- comparative analysis, which allows drawing conclusions about the solution of the problem of risk assessment and analysis of activities of Russian and international companies;
- inductive method, which was used to create a table for assessing the consequences of the global financial crisis on the international market.

The experimental research base is the entrepreneurial practice of small and medium-sized companies.

## 3 Results and Discussion

In the global business environment, small and medium-sized enterprises are the backbone of the development of national economies. According to the United Nations (UN), about 90% of all enterprises in the world are classified as small and medium-sized enterprises. They employ approximately 70% of the working-age population and account for more than 50% of world GDP (Fig. 1) [3]. The current situation associated with the pandemic of the new viral infection Covid-19 is transforming the economies of the world and Russia. The International Labor Organization (ILO) estimates that the coronavirus pandemic could have a serious devastating impact on the economy, reduce the GDP growth to 8% and leave about 25 million people unemployed [4]. According to the estimates of the World Trade Organization, in 2020 there was a decrease in the volume of world trade by 13–32% [5, 6].

Even though in Russia the share of the small and medium-sized business (SME) sector is just over 20%, the SMEs functioning efficiency determines the entrepreneurship level in the country and affects the whole economy (Figs. 2, 3). According to the survey of SMEs conducted by experts from the Russian Union of Industrialists and Entrepreneurs in November 2020 [7], the main risks affecting the ability of SMEs to function and develop during the crisis caused by the Covid-19 pandemic include:

- interruptions in activities of counterparties, non-fulfillment of contractual obligations by counterparties;
- sharp decline in demand for a product/service;
- reduced availability of raw materials/components;
- decrease in cash flow (money does not arrive on time or does not arrive at all due to bankruptcy/withdrawal from the market of counterparties);
- absence of employees in the workplace;
- costs associated with ensuring the safety of employees during the coronavirus pandemic;
- lack of anti-crisis management;

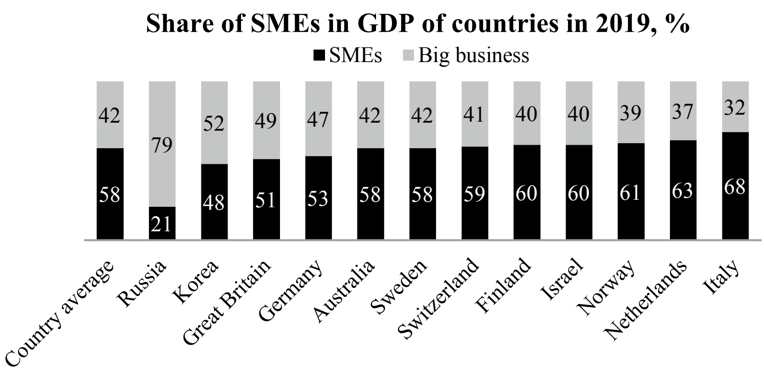


**Fig. 1** Share of small and medium-sized enterprises in GDP of countries in 2019

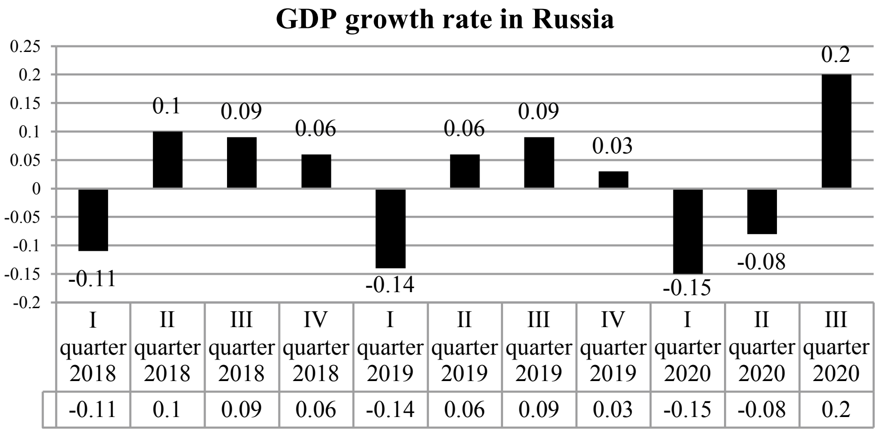


**Fig. 2** The growth rate in the Russian WFP in 2018–2020

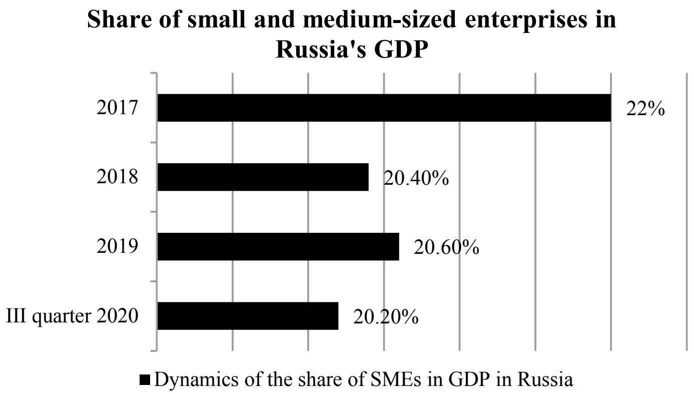


**Fig. 3** The share of small and medium-sized enterprises in Russia's GDP

- dismissal of employees;
- lack of the necessary documentation for registration (for example, the inability to sign documents by all necessary employees, difficulties in the process of approving documents).

In Fig. 4, the risks are ranked according to impact on SMEs. The key factor that has a limiting impact on the SMEs development and functioning under the current conditions is non-fulfillment of contractual obligations by business partners, interruptions in activities of counterparties (noted by 49.3% of respondents) [8]. The sharp drop in demand due to customer behavior during the Covid-19 pandemic was experienced by 42.8% of respondents. The third answer "raw materials/components are not supplied at the moment or have increased in price", was indicated by 37.9% of respondents.

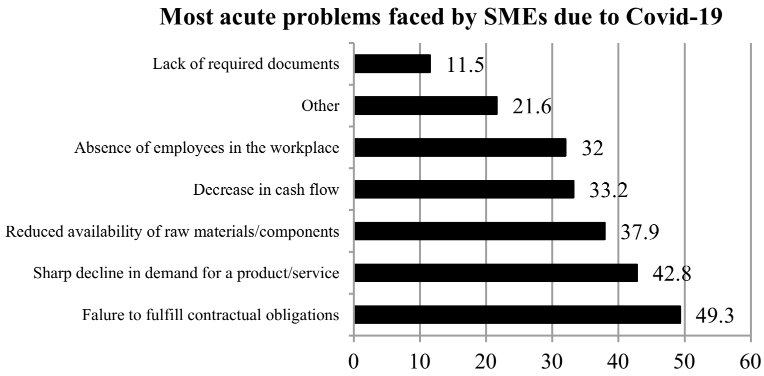


**Fig. 4** Risks arising from the Covid-19 pandemic, which can have a significant impact on the development and functioning of SMEs

Changes in the macro environment had a significant impact on business processes within the organization, including business relationships with company employees and stakeholders [9]. Some employees switched to remote work, others were laid off due to financial difficulties of companies and the need to cut production/services due to a decrease in demand. Some SMEs provide additional support measures for workers in the pandemic, such as: providing personal protective equipment (masks, gloves, napkins, antiseptics, sanitization of premises), ensuring the delivery of workers to and from work with official transport, taxi, additional payment for work in a special regime, advances, gratuitous payments, bonuses, benefits, distribution of food packages [10–12].

Even though SMEs are more mobile in the changing market environment than large enterprises, they are more vulnerable due to limited resources. Therefore, the implementation of consistently arising interconnected risk events, even if each of them is insignificant, can lead to the unfavorable outcome, the termination of economic activity. Therefore, it is necessary to identify and systematize risks. Based on the study of theoretical and methodological foundations of risk management, as well as survey data during the study, the classification of risk-forming factors for SMEs was supplemented. External (existing outside the company) and internal (arising in company's activities) risks are shown in Fig. 5. The increasing complexity of the risk situation leads to changes in the risk management mechanism. In current conditions, risk is viewed not as an episodic adverse event, but as an integral attribute of the external and internal environment of the economic entity, whose financial and economic activity occurs in conditions of constantly growing uncertainty. In the context of the global economic crisis, the priority areas of risk management for SMEs are:

- build a system of transparency of activities and operations in general;
- focus on protecting the interests of customers-consumers and on the system of control over the implementation of all stages of protection;

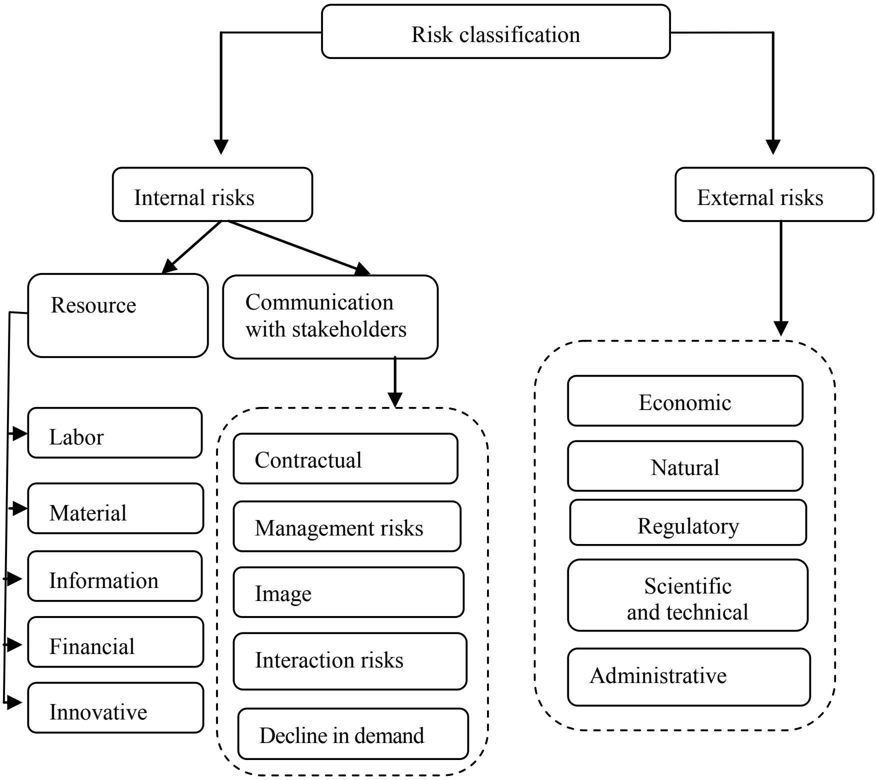


**Fig. 5** Classification of risks arising during the functioning of SMEs in the crisis

- develop the elements of the quality management system necessary for the effective management and functioning of the organization;
- use elements of the anti-crisis management system, if necessary, provide restructuring in accordance with the needs of the market (analysis of key risks affecting business processes in the organization; considering information about possible risks and how to regulate them, when the organization has several options in advance, depending on market situation);
- realize the potential for a positive impact on the investment process (mobilization and optimization of internal resources of the organization: labor, financial, organizational and others).

In the scientific literature, there are many opinions about the benefits of operating a risk management system at the enterprise. At the same time, in most cases, economic entities consider the risk as the possibility of losses or non-receipt of income in comparison with the predicted option [13]. However, according to some researchers, just the existence of risk does not means possible damage only, it also means possible deviations from the set goal. So they consider a risk as a complex phenomenon that may generate new opportunities. Therefore, we can say that there is a duality of economic risk. An equally interesting perspective of risk research is subjectivity and the impact of the human factor on managerial decision-making. Many elements of risk management are universal and can be applied in various fields of knowledge, they contribute to the system improvement and enable to achieve the set goals. So, in legal practice, the concepts of "honor" and "justice" are significant factors influencing decision-making. Situations arise when, despite the realization of the risk event, the decision is made subjectively in accordance with the own understanding of honor and justice, at the same time, the decision maker is completely satisfied with such a decision.

## 4 Conclusion

SMEs make a significant contribution to maintain economic growth, ensure employment, expand the consumer sector, as well as saturate the market with goods and services, satisfying effective demand. Even though the share of small and medium-sized entrepreneurs is low in Russia, they perform the most important functions in the economy, ensuring regional development, sustainable employment of the population, providing consumers with access to a wide range of goods and services. Although, SMEs are more mobile in the changing market environment than large ones, they are more vulnerable due to limited resources. Therefore, the implementation of several consistently arising interconnected risk events, even if each of them is insignificant, can lead to the unfavorable outcome, the termination of economic activity.

In today's competitive environment and in the face of growing competition and the emergence of unpredictable situations, the economic activity of a small and medium-sized enterprise is impossible without risk analysis and assessment. The business entity can survive, if it studies and constantly monitors the factors of the external and internal environment, considers and predicts situations associated with risk. The existence of risk and the constant change in its level is a constant and powerful factor in the business continuity of the organization.

The main mechanisms for increasing protection against risks of SMEs are new methods of risk management, which are transformed using classical methods of risk management through mobilized resources, optimized business processes, and eliminated unproductive costs. The use of modern risk management technology will provide small and medium-sized enterprises with prompt identification of risks and the formation of a flexible enterprise management system adequate to their impact, which quickly responds to the external environment.

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# Import Substitution Strategy as a Factor of Increasing the Russian Industry Competitiveness

**K. Yu. Doladov, I. G. Frolova, and I. V. Laguta**

**Abstract** During the period of economic restrictions imposed on Russia, the priority task of the country's government is to apply a strategy of import substitution in various branches of the national economy. To achieve this goal, the priority of production areas and their prospects were determined. Machine tool construction is one of the key industrial branches. And the set of state strategic objectives includes increasing its competitiveness. This article investigates the implementation mechanisms of the import substitution strategy and its impact on the economic security of the country. As a response to the West sanctions, the Russian Federation banned the import of goods. It was this measure that prevented a shortage of strategically important products during the 2020 pandemic. Currently, small and medium-sized businesses was provided with new opportunities for the development of import substitution in Russia. They have every chance to develop and improve their competitiveness, since the list of products prohibited for import into the country is very extensive. So, the study of the potentials of an industrial production enterprise, taking into account the expediency of replacing certain types of imported products and its harmonious displacement by domestic analogues, is a very relevant issue for modern Russian economic science.

**Keywords** Competitiveness · Efficiency · Import substitution · Industrial enterprises · Investments · Strategy

## 1 Introduction

In the last few years, import substitution has become the most relevant production area for the activity of Russian companies, as well as for the country as a whole, due to Western sanctions against Russia. As a result of such a policy, import substitution is able to significantly minimize the negative effect of anti-Russian sanctions. The isolation measures by Western countries act as certain restrictions that hinder the

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access for our country to the global market of financial resources and technologies. And the use of such measures may lead to the situation when the technological gap between our countries will grow. To avoid this situation, Russia has to apply new tools for increasing its investment attractiveness, technological modernization, and the improvement of the human capital quality, the readiness of various institutions to changes [1].

The result of import substitution should be represented by the technological modernization of industrial production, an increase in the competitiveness of the own products (goods and services), the economic efficiency of industries, and the production of new competitive types of goods with a high added value. These measures will lead to the reduction of import goods and support of domestic producers. This will also create new jobs, preserve foreign currency in the country, and reduce the prices of goods. Currently, a set of measures is implemented to support Russian industrial enterprises:

- functioning of public–private partnership mechanisms;
- tax incentives for new production facilities;
- subsidies for paying loans taken for technical re-equipment;
- co-financing of R&D and state capital investments from the federal budget;
- regulatory framework is improved.

However, this is not enough to overcome Russia's technological dependence, and a consistent policy of import substitution is needed. In the current conditions, it is fundamentally important to accurately set import substitution priority tasks and focus resources on the most promising spheres. It is also important to direct the state support measures to technological development (electronic components, petrochemicals, new equipment for the oil and gas complex, machine tool construction, and others). To solve these tasks effectively, certain organizational measures should be also be taken which include the formation of institutions and structures implementing the science and technology policy, and coordinating the strategic planning process. The implementation of these tasks also needs an effective long-term state industrial policy. The primary task of this policy is to form and apply measures for legislative, organizational, financial support of reindustrialization. The main criteria for the import substitution process should be economic, social and strategic expediency.

## 2 Methodology

Depending on the policy in the field of foreign direct investment, there are three methodological approaches to the application of the import substitution policy [2]. The method of autonomy—in the basis of the "new economic policy" and is often contrasted with the policy of industrialization. It is widely used in South Korea and Taiwan. It consists in the development of local industrial production and limitation of foreign direct investments. At the same time, a number of traditional import

**Table 1** Positive and negative aspects of methodological models of import substitution

| Methodological model | Positive aspects | Negative aspects |
|---|---|---|
| New economic policy | Diversifying the economy, improving the well-being of citizens, high rates of economic growth, increasing the share of high-tech industries in GDP | Reduction in the efficiency of capital investments, deterioration of the foreign trade balance (growth of the deficit), dependence on imported equipment, increasing shortage of consumer goods |
| Import-substituting industrialization | GDP growth, high rates of industrial production development | High rates of inflation, relatively low (relative to the potentially possible level) innovation activity |
| Self-sufficient economy | GDP growth, technological modernization, the quality improvement of the labor organization, development of the domestic market | Low activity of key sectors of the economy, weak export potential |

substitution tools is used, such as export support, the development of the necessary infrastructure, and the reduction of the cost of domestic products through the use of cheap labor. This method is used in Indonesia, Malaysia, Thailand and the Philippines.

Depending on the set of methods used, three fundamentally different methodological models of import substitution can be distinguished (Table 1).

1. The model of the new economic policy. Implementation example: East Asian countries. It assumes a focus on intensive modernization of high-tech industries, export support, innovation in production, introduction of new technological equipment, standardization, government spendings on social and industrial infrastructure, protectionism, and firm currency regulation. The target focus is on the transport engineering, pharmaceutical and chemical industries, electronics and software industries, and engineering.
2. The model of import-substituting industrialization. Implementation example: Latin American countries. It involves the use of a policy of protectionism, the restructuring of state-owned enterprises. The target focus is on the light (primarily food) and heavy industries.
3. A model of a self-sufficient economy. Implementation example: India. This model is based on the protectionism policy in the priority economic key sectors.

## 3 Literature Review

Under the import substitution we usually understand a set of successive changes in the national economy. Each stage of this policy is characterized by a smaller share of imports and a larger share of the own production. The process of import substitution was criticized from the position of the general economic benefit in the framework of concepts of absolute and relative advantages. The applicability of the import substitution policy was discussed later in the context of ensuring the food security in the developing countries [2]. The idea of replacing external financial sources and imported goods with internal ones was justified by representatives of the Neo-Keynesian school Chenery & Bruno [3]. The concept of 'virtual water' introduced by Allan is among the economic views on the topic of import substitution. It is based on the idea that states with water scarcity should focus their own production on goods that require a minimum amount of "virtual water". Thus, the production of wheat leads to a serious depletion of water resources in Saudi Arabia, so wheat and other "water-intensive" food products should be imported to the country [4].

According to the views of Prebisch (Prebisch–Singer hypothesis), countries that primarily import final products (for instance, technologically complex equipment) benefit more from the world trade than the countries importing raw materials [5]. In these conditions, the import substitution policy with the focus on the domestic market and the active industrialization is the best solution for developing countries. In the process, a specific role belongs to the state, in particular to its active intervention institutional, financial, agricultural transformations. As a result, the development of the domestic market in this direction will ensure a sustainable economic growth. Based on the provisions of the hypothesis, Latin American countries since the end of the twentieth century began to implement strict measures of protectionist nature in the framework of the implementation of import substitution policies in the agricultural sector [5].

## 4 Result

To date, the share of imports in the cost of Russian industrial goods is quite high. This is due to the need to increase the competitiveness of exported products and increased requirements to the innovative component of the national economy. So, the import substitution became particularly relevant, as it will make it possible to avoid the tension that arises as a result of the use of imported products and services in the manufacture of industrial products. At the same time, domestic enterprises do not receive potential orders for making products necessary to overcome the crisis situation [6]. In this regard, enterprises need to increase the level of development of machine tool construction in order for Russian companies to produce equipment that can compete with imported analogues, as well as avoiding the use of imported materials and necessary components. When implementing the import substitution strategy, enterprises have to constantly interact with the domestic and foreign markets, and these relations are constantly changing (Fig. 1).

The management algorithm for the implementation of this strategy consists of the following stages:

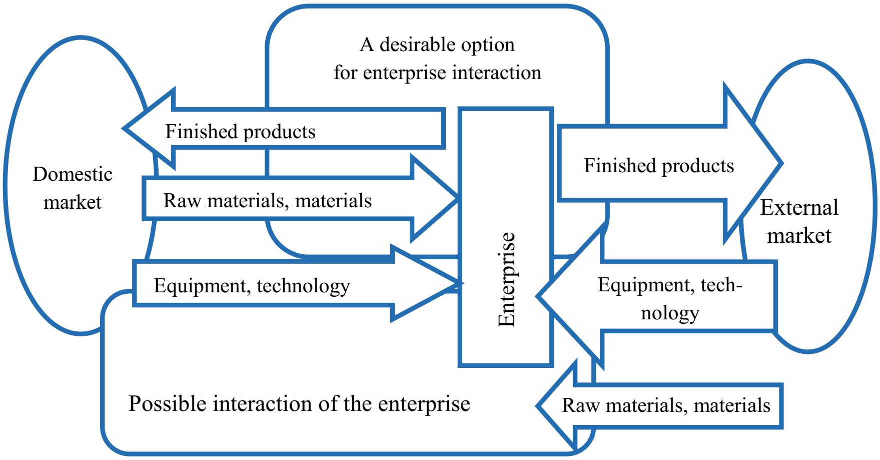


**Fig. 1** Interaction of the enterprise with the internal and external markets in the process of implementing the import substitution strategy

- the analysis of domestic producers, companies that are capable of replacing imported goods, components and equipment;
- organization of the own production;
- promotion of produced products to markets [7].

If the company decides to act in the direction of the first or second course, the product promotion stage may not be applied, since the replacement of components will most likely not bring changes to the finished products and thus the end user will not notice changes. For the third year of the import substitution strategy, this stage is mandatory and decisive, since the finished equipment is completely a replacement for imported equipment, and without a marketing policy, it is difficult to enter the market.

At the stage of selecting domestic suppliers, the organization evaluates the counterparty market, analyzes suggestions to select the best supplier, in terms of the reliability of its reputation, product quality, product price, provided service, delivery speed, product satisfaction with the necessary characteristics [8]. The second stage—the organization of production, focuses on the analysis of the feasibility of introducing new production at the enterprise, taking into account the existing functioning of the organization. In the process of assessing the feasibility, the market is analyzed and the search for ways to conquer it, the assessment of the available resources necessary for the implementation of the import substitution strategy, the implementation of design, the analysis of the necessary technologies, the development of the production organization process, the analysis of necessary costs, the assessment of operating expenditures, the analysis of the project effectiveness.

In the analytical process, the company determines the implementation course of the import substitution strategy. The successful implementation of each stage of import substitution management will ensure the competitiveness of the produced products and will achieve the main goal: the displacement of imported goods on the Russian market. Thus, the import substitution management system can be represented as follows (Fig. 2). The management of the import substitution strategy includes the assessment of the market, the analysis of the feasibility of the modifications carried out by calculating the efficiency indicators, the availability of the necessary resources, the development of the plan and its implementation, as well as continuous monitoring of the timely achievement of the set goals [7]. The effectiveness of the implementation of the import substitution strategy is primarily represented by the successful replacement of imported equipment and, secondly, by the revenue generated from the implementation of this strategy (Fig. 3) [9]. When analyzing the possible volume of sales of import-substituting products, it is necessary to take into account the flexibility of demand for imported goods at a price that allows to assess the prospects of products sales when the price on it decreases in comparison with import. The more elastic the demand for the product, the faster the sales of the product increase with a decrease in its price, i.e. the implementation of import substitution is more reasonable [1]. The evaluation of the implementation effectiveness for the import substitution strategy in a company is based on the study of its performance in terms of reducing the applied import, or in terms of competition with imported products.

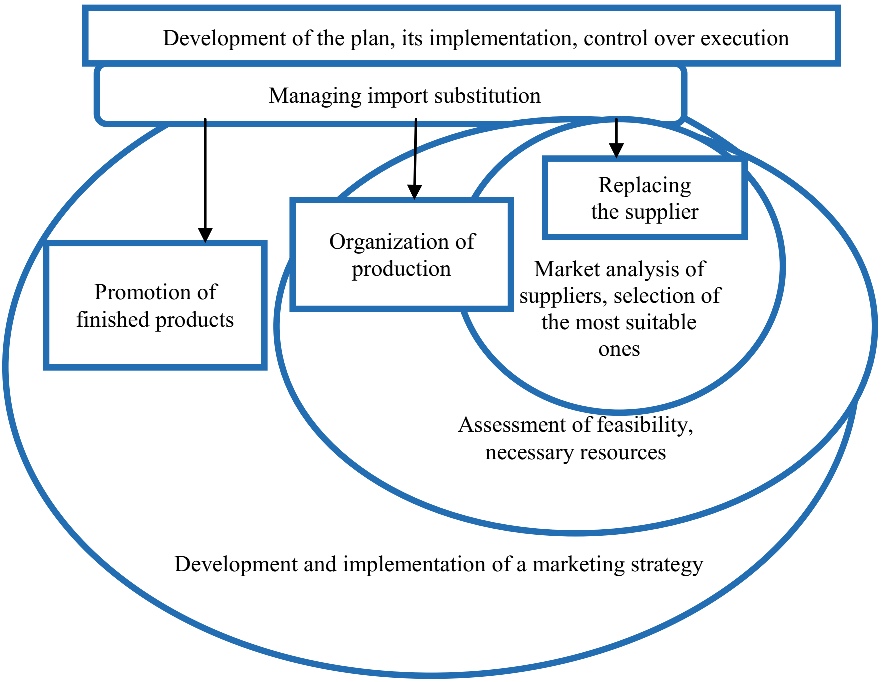


**Fig. 2** Import substitution management system at the enterprise

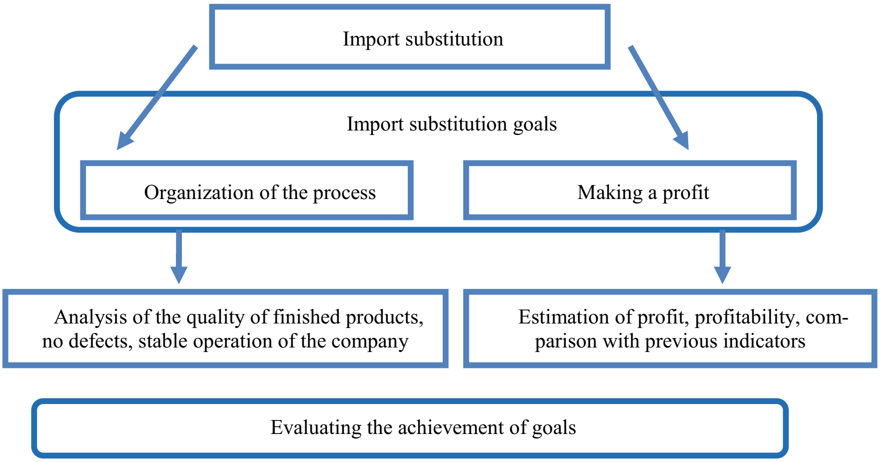


**Fig. 3** Evaluation of the effectiveness of the import substitution strategy at the enterprise

## 5 Conclusion

During the conducted research, the authors concluded that the implementation of the import substitution strategy will be effective if you follow the basic rules:

- it is necessary to choose the best ways to implement import substitution in each specific situation: replacing foreign suppliers with Russian ones, organizing the production of components at existing domestic enterprises, organizing production from the start;
- to analyze a number of factors, such as the market, the sufficiency and availability of resources, i.e. the availability of the necessary suppliers of resources, materials, necessary technologies, qualified personnel, investment and demand from buyers to assess the possibility of implementing import substitution;
- when creating and implementing an import substitution strategy at an enterprise, it is desirable to sell goods not only on the domestic market, but also on the external market, while importing equipment and technologies is acceptable, but it is not desirable to import raw materials, materials and components;
- when choosing a domestic supplier that produces import-substituting products, the company needs to analyze the relevant market and some factors that influence its reputation, the products quality, its pricing policy, the offered services, and some others;
- one of the most important stages of implementing an import substitution strategy is the development of a marketing strategy, since the product has to compete with imported analogues that are already known on the market and have already won regular customers;

- the effectiveness of the implementation of import substitution lies in the successful organization of import-substituting production at the enterprise and as a result in the growth of the company's profitability;
- it is important that the products produced as a result of the implementation of the import substitution strategy would be equal to imported analogues in quality, it is the price-quality ratio that will ensure the competitiveness of domestic products.

On the one hand, it is important to emphasize that the current economic situation in Russia hinders the implementation of the planned measures, on the other hand, this crisis position may be considered as an opportunity for a comprehensive modernization of the domestic industry.

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# The Factories of Future as Industrial Enterprises Digitalization Way in Russia

**A. A. Chudaeva, V. A. Gorbachev, and D. I. Ratner**

**Abstract** The introduction of digital technologies into the activities of manufacturing enterprises transforms the process of creating products and changes the structure of its value, and is a prerequisite for the emergence of factories of the future, which include such elements as: digital factory, smart factory, virtual factory. In the Russian Federation, there are enterprises that have taken a course towards digitalization and are actively introducing elements of factories of the future in their activities. However, there are few such examples, due to the high cost of digitalization projects for industrial enterprises. Such projects are successfully implemented only by enterprises generating high profits, they are able to forward to the introduction of digital technologies. The rest of the enterprises require support from the state. This also applies to the financing of industrial digitalization projects, and the development of the national innovation system, in which science and education are important elements. It seems expedient to change the policy of training specialists for manufacturing enterprises in the higher education system. When developing issues of state policy supporting and regulating the activity of factories of the future, it is advisable to focus on the experience of countries that are already implementing such projects.

**Keywords** Digital technologies · Factories of the future · Investments · Risks · Smart factory · Virtual factory

## 1 Introduction

Industry around the world has already felt the necessity to make changes under the fourth industrial revolution, which should lead to economic growth through the creation of new industry through the interconnection between physical systems and

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digital big data, resulting from the further development of disruptive and innovative technologies such as artificial intelligence, robotics and IoT [1]. This breakthrough in the technological aspect involves total inclusion of digital technologies into various human activities. Digital technologies provide an opportunity to go through many challenges and as a result they are adopted by the production sector faster and faster, especially in high-tech sector. The process of global competition is now very tense at the design stage, which importance is significantly increasing. The digital twins of high-tech goods or production processes are the most current decision for overcoming extra costs at R&D part of the process and for analyzing all factors affecting the product in the process of its creation.

Manufacturing models develop in a spiral. First, there was a transition from individual manual production to mass machine production, which became possible after the introduction of the assembly line. The next step is mass customization, when, within the framework of mass production, it is possible to produce numerous variations of one product considering the individual requirements of the customer (various design options, the presence of some additional functions, etc.). It provides a transition back to customization.

As part of the customization of production, digital design and modeling and additive technologies will become the main tools, allowing you to get a completely personalized product. “Makership” has great prospects, when people themselves will be able to produce what they need. The rise is supported by an increase in the availability of 3D printers, the improvement of 3D printing technologies and a large selection of materials with a wide variety of characteristics. At production sites, flexible manufacturing and the Internet of Things will play a key role. In the future, perhaps, people themselves will be able to send their requests to the enterprise using the Internet and interact directly with the manufacturer.

The global trend towards individualization of consumption and the ability of digital technologies to simulate processes shoves the modern high-tech industry to shifting its “center of gravity” to the design stage. Before the fourth technological revolution, the manufacture of a high-tech product involved many field tests. Now, in the era of digitalization, fine-tuning a product to the production stage with the use of tests is becoming too expensive and uncompetitive. This is due to the fact that when designing complex high-tech products, errors are inevitable and they are revealed during subsequent tests. Correcting such errors and making the necessary changes brings the product development back to the design stage, followed by the production of a new prototype and new field tests. Prototyping and testing is expensive. Moreover, the later the changes are made, the higher the costs are borne by the enterprise.

## 2 Methodology

The authors used such research methods as analysis, synthesis, description and comparison. Their application is determined by the theoretical nature of the study, which included the following stages: formulation of the problem, analysis of information on this topic, comparison and description of different scientific views on the studied issues, synthesis of different approaches to the problem, analysis of practical cases of real enterprises in the studied area.

## 3 Results

Digital design and modeling involves the use of complex multidisciplinary mathematical models, including: fundamental laws and sciences, geometric (CAD) and computational finite element (CAE) full-scale models of real objects and physical and mechanical processes, complete data on the materials from which the product is made, information on operating modes, information on production and assembly technologies of both individual elements and structures as a whole, other characteristics and parameters. Thus, instead of making prototypes and testing them under the conditions of digitalization of the design process, a digital model tested in digital conditions is being developed. At the same time, the number of virtual tests, which make it possible to achieve the highest degree of detail, is several hundreds of times higher than the number of full-scale tests carried out with the traditional approach. This model, often referred to as a “smart” object model or digital twin, is a key element of digitalization. The digital twin goes through constant updating with data on the real object condition and it should show its functioning in real time.

The digital twin allows you to identify problems in just-in-time mode and predict the object future condition for in time repairing and making decisions about functioning regulations in the future. It is basically used to reduce the number of downtimes and the size of operating costs in order to increase the efficiency of the equipment. In addition, production cycles are shortened and it intensifies the process of bringing the product to market.

The emergence of digital twins, certain stages of the life cycle and links in the value chain, a certain set of technologies to achieve specific goals predetermined the emergence of a new generation of enterprises. Such enterprises are called factories of the future (Factory of Future), which, depending on the technologies used, are divided into three types: digital, “smart”, virtual) [2]. The characteristics of each of them are reflected in Table 1.

There are manufacturing enterprises focused on digital transformation, actively introducing certain elements of the Factories of the Future into their activities in Russia. Examples of the introduction of elements of the Factory of the Future in the Russian Federation are presented in Table 2.

It should be noted that the enterprises shown in Table 2 are included in the groups of companies with a high level of generated profit. Consequently, they have funds that can be invested in digital transformation projects, the introduction of elements of factories of the future, or the creation of new enterprises based on the concept of a “factory of the future”. Unfortunately, there are few such enterprises in the Russian Federation. According to the monitoring data of regional and sectoral projects for

**Table 1** Factory of future types and technologies lying in the basis of their idea

| Factory types | Characteristics | Key technologies |
|---|---|---|
| Digital factory | product development process up to the prototype stage—the final product is the prototype itself or a sample or its digital twin | • Technologies of digital design and modeling, additive technologies, technologies for collecting and analyzing big data required to create digital twins<br>• New materials, the properties of which are considered in the design within the framework of a systematic approach,—their use helps to reduce the number of errors at R&D stage and shorten the time of the product release to market<br>• Technologies of the Digital Factory, which allow using the obtained digital models and samples for further serial production—due to the technologies increased productivity could be achieved, reduce the number of rejects, and speed up the production process |
| «Smart» factory | Everything that is directly related to production facilities—robotics, industrial Internet, various technologies for organizing and managing production<br>• industrial (integrated) control systems (ICS)<br>• manufacturing execution systems (MES)<br>• sensors and controllers | |
| Virtual factory | Expands and continues the physical production site, linking it to other factories, in the case of multiple sites of the same enterprise, as well as to suppliers and contractors; thus, a single information field is formed, in which each participant in the value-added chain has access to the most relevant information. This helps to make the process more transparent, improve and speed up communication both between divisions of the enterprise and between contractors | Technologies of the industrial Internet, allowing to receive feedback from all components of the production chain |

**Table 2** Examples of implementing some elements of factory of future paradigm in Russian enterprises

| Enterprise | Project | Idea of the project | Implementation effect |
|---|---|---|---|
| JSC "North-West phosphorus Company" (Acron Group subsidiary company) [3] | Integrated system «TO&R» («Maintenance and repairs») | Program on the platform 1C-ERP, installed at the workplaces of the repair services of the Oleniy Ruchey ore-dressing and processing plant, at the mine, at the mechanical repair section, accumulates data on current technical inspections and repairs. On the basis of these data, technological maps of repairs were created with the display of the work schedule, responsible performers, data on the amount of time that the equipment worked. The database is being updated in real—time mode | Scheduling technical inspection and replacement of spare parts, which leads to<br>• leveling of emergency situations<br>• reduction of off-schedule repairs by 15%<br>• effective management of warehouse stocks of material and technical resources |
| JSC "SREDNE-NEVSKY Shipbuilding yard" (part of JSC with state capital "United Shipbuilding Corporation (OCK) [3] | Additive technologies application | Creation of complex and unique turbine elements from metal powder, rather than from iron blanks, as it was in the traditional method of producing parts for aircraft engines | Reduction of material consumption in production |
| | Super-computer center | Computing power—the highest in the Russian Federation | • Reduction of the engine development cycle by four times<br>• Reducing the number of prototypes for testing structures by ten times |

(continued)

**Table 2** (continued)

| Enterprise | Project | Idea of the project | Implementation effect |
|---|---|---|---|
| LLC "West-Sibiria fuel and chemical refinery plant" (100% asset of JSC SIBUR) [4] | Innovative system «Econs» | • Online recalculation of the most important indicators of technological processes in financial terms<br>• The operator sees in real time the parameters by which he earns more profit for the company, and according to which he is in the "red zone"<br>• Electronic reports, which are created to monitor the decisions made by operators<br>• Allow engineers to evaluate the effectiveness of work and, if necessary, correct their actions | |

(continued)

**Table 2** (continued)

| Enterprise | Project | Idea of the project | Implementation effect |
|---|---|---|---|
| | Digital tool «Mobile wastes» | • Planning by an employee of the optimal bypass route, excluding the intersection of the trajectory with colleagues<br>• While driving, the lineman with the help of a special device in an explosion-proof housing reads NFC tags on technological equipment<br>• Transmission of information in real time to the central control room of the petrochemical complex, it helps to follow in just-in-time mode the results of the bypass<br>• The function of processing operational handwritten documents into electronic format contributes to the maximum concentration of employees' attention on the process<br>• Storing data on the time the employee traveled the route, the reasons for stopping and its early completion, the state of the equipment and other information | In 2020 allowed<br>• To achieve an economic effect of 41 million rubles<br>• Free up more than 40,000 man-hours,<br>• Fix more than 40 thousand defects at early stages and promptly eliminate them, excluding additional financial and time costs in the future for equipment repair |

(continued)

**Table 2** (continued)

| Enterprise | Project | Idea of the project | Implementation effect |
|---|---|---|---|
| | «Industrial Internet of Things» | Automation of the procedure for collecting technical parameters of industrial installations, including in hard-to-reach places, and transferring them to predictive diagnostics and Data Science models using installed wireless IIoT sensors | • Saving staff time on collecting and analyzing data on the state of equipment and technological processes taking place in it<br>• Increasing the efficiency of production processes<br>• Minimization of the influence of the human factor |
| PJSC «GAZPROM NEFT» [5] | "Digital oil" | The use of artificial intelligence for calculating hidden oil reservoirs | Additional oil inflow at the Vyngapurovskoye field |
| | "The asset of the future" | Complex transformation of the operating model of the exploration and production block, six business products, three service products and an Integrated Operations Center were formed that ensure maximum efficiency of the value chain | Economic effect of 1.2 billion rubles by optimizing production |

(continued)

**Table 2** (continued)

| Enterprise | Project | Idea of the project | Implementation effect |
|---|---|---|---|
| | Introduction of unmanned aerial vehicles for the purpose of inventorying goods in warehouses | The data on the type of product and its characteristics are obtained automatically, aerial photography to calculate the volume of inert materials in the warehouses of an enterprise, accounting for bulk materials by summarizing data from the results of surveys from unmanned aerial vehicles 3D model, on the basis of which the volume of resources and the occupied area for their storage is calculated | • Reduction of time for recalculation of one pallet with cargo was reduced from 10 min to 1–2 s<br>• Optimization of routine operations<br>• Refusal to use loading and unloading equipment during inventory |

the digital transformation of industrial enterprises, the number of projects directed at the industry digital transformation at the moment of the departmental project “Digital Industry” presentation [6] in 2019 was 1990. The total amount of financing of these projects amounted to 430,620 million rubles, of which 86.78%—funds of enterprises. 13.21%—budget funds. Data on organizations using information systems for managing industrial enterprises indicate their low prevalence: by the end of 2019, ERP systems are used by 14.8% of the total number of surveyed organizations, CRM systems—13.9%, SCM—systems—6.6% [7]. The simple explanation is the lack of the company’s own funds and the inability to raise funds for the implementation of digitalization projects. This issue is especially acute for factories of the future, and not for digitalization projects within existing enterprises. The implementation of such systems as ERP, CRM, SCM are improvement projects, and digital factories are new generation projects that include changes not in one or several areas of the enterprise’s activities, but functioning on completely new principles, using end-to-end digital technologies that permeate all areas of the enterprise and allow you to create products with a different cost structure. In addition the main focus on the design stage, the importance of which is significantly increasing, cause new costs, the share of which is high. It is an investment in an effort to provide protection against cybercrime, which accounts for $ 600 billion of global GDP [8].

## 4 Discussion

Numerous examples of cyberattacks on industrial enterprises [9] demonstrate how dangerous they are for the company’s activities and how costly it is to eliminate their consequences. Enterprises need to use IT security measures to protect their CPS infrastructure from IT availability risks [9]. Appropriate IT security measures include, but are not limited to, redundancy using backup components, industrial equipment with built-in IT security mechanisms, intrusion detection systems, or related service level agreements. Carías, Labaka, Sarriegi, and Hernantes note in their research that the investment strategy for cyber resilience should include the costs of technical security (first of all) and personnel training (this part of the costs should be mandatory, but go after investments in technical security) [10]. In the process of developing such an integrated approach, it is advisable to consider the experience of countries in which factories of the future have already been introduced. One of these countries is Italy [11].

It should be noted here that personnel training should be the prerogative not only for enterprises implementing digital technologies, but also for educational institutions involved in training personnel for such enterprises/ And here we should talk about both the training of specialists in the field of information and communication technologies, and specialists in economics and management. It is critically important for students of the areas of training “Economics”, “Management” to have digital competencies in their broad sense (programming skills, systems-analytical thinking, etc.). According to the research conducted by the authors of the publication “Digital Competencies: Requirements for Information Technologies in the Framework Management University-Industry-Science-Market” [12], future managers should have some extra competencies in the field of information technology.

## 5 Conclusion

Thus, it seems possible that new specialties and areas of training will emerge in the context of a new paradigm of industry [13]. In our opinion, it is fair to say that new specialties should appear that combine knowledge in the field of digital technologies and management, digital technologies and ecology, digital technologies and economics, digital technologies and risk management, etc. the power to solve such problems for the development of the Russian economy on a new technological basis, using digital technologies, through the development of new training programs for bachelors and masters. However, this will have a point effect. To achieve a wider spread of this practice, it is advisable to revise the state policy in the field of higher education. Perhaps it makes sense to return to specialization in specialist training programs at the junction of several areas of training. Moreover, the digitalization of the industry of the Russian Federation is a global task that affects many institutions. An integrated approach is needed that allows solving both the tasks of training personnel for the industry of a new generation, and the tasks of infrastructure development, and the tasks of creating and developing institutions of state support for projects in the field of industrial digitalization, and the tasks of state funding for research and innovation, etc. interactions between the structural elements of the national innovation system.

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# Export Potential of Russian Agribusiness Products in a Regional Perspective

**E. P. Afanaseva, A. M. Kumratova, and A. B. Malina**

**Abstract** Russian agrifood production demonstrates sustainable development trends. The production volume allows the country to satisfy domestic demand for food and export food products. Today, the Russian Federation ranks 19th among the world's food exporters. The foreign trade development remains one of the strategic goal of Russian agricultural industry. 72 Russian regions out of 85 are involved in this process. Russia continues exporting grain, fat-and-oil products, fish, and seafood. In addition, there is a leading region for each product category. The authors of the paper studied exporting regions and considered the export potential. The purpose of the research is to study the factors that contribute to the implementation and growth in the export potential of Russian agribusiness industry. Using statistical analysis methods, the authors determined the dynamics of the export development in the context of both federal districts and regions. The methods of theoretical analysis allowed to identify the features of the export potential development in the Russian agribusiness industry. The authors came to the conclusion that when maintaining the current development rate in agribusiness and taking into account the world food shortage, Russia will be able to strengthen and expand the position in the world food market. The macro trends in agricultural industry and international trade such as changes in the world food balance, climate changes, agricultural crops displacement to the north, sales of finished products with higher value added, and others will bring new opportunities to Russia up to 2030.

**Keywords** Export · Fish · Food · Grain crops · Markets · Oil crops

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## 1 Introduction

The year 2020 was very difficult for Russian agricultural economy due to COVID-19 pandemic. However, Russian agribusiness industry demonstrated a stable and reliable activity. The agrifood production increased in actual prices by 5.3% and amounted to 6.1 bln rubles, crop production—by 7.2% to 3.3 bln rubles, and livestock production—by 3.2% to 2.8 bln rubles compared to 2019 [1]. The volumes of agrifood products make it possible to satisfy not only domestic food needs, but also intensively increase an export potential and strengthen positions of the Russian Federation in the world market. The agrifood export amounted to 30.7 bln dollars in 2020. Supplies to foreign markets have nearly quadrupled compared to 2010. The shipment volume is more than 79 mln tons. The sales geography is represented by 157 countries. The top five largest importers of Russian food are China with the proportion of 13% (4021 mln dollars), the EU with the proportion of 11% (3343 mln dollars), Turkey with the proportion of 10% (3138 mln dollars), Kazakhstan with the proportion of 7% (2087 mln dollars), and Egypt with the proportion of 6% (1956 mln dollars) [2].

## 2 Methodology

The authors of the study used special and general scientific methods of economic research. The statistical analysis allowed to identify the features of the regional implementation of the export potential in Russian agribusiness. Economic and mathematical methods made it possible to distinguish the trends in the food export development in the Russian Federation. Official data of the customs statistics, the Federal Center for the Development of Agrifood Export of the Ministry of Agriculture of the Russian Federation, as well as the works of scientists and practitioners on Russian and world food market represented an information base of the study.

## 3 Results

Russia's agricultural export is quite concentrated in a regional perspective. 10 Russian regions (the Rostov Region, Moscow, the Krasnodar Territory, the Primorsky Territory, the Kaliningrad Region, St. Petersburg, the Moscow Region, the Murmansk Region, the Kamchatka Territory, the Leningrad Region) have 70% of all export. Taking into account the industrial characteristics of the federal districts, key industries and promising products were identified (Table 1).

The analysis of the export development in different federal districts in the Russian Federation within particular agricultural sectors shows that the Southern Federal District has the leading position in oil crop products (373.7 mln dollars) and grain export (802.8 mln dollars), the Far Eastern Federal District—in fish and seafood

**Table 1** Dynamics of the export value of Russian goods (mln dollars)

| Federal District in the Russian Federation | Oil crop products | | Cereals | | Fish and seafood | | Meat and dairy products | | Food and processing industries products | | Other agribusiness products | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| Central | 106.4 | 282.9 | 419.1 | 508.4 | 11.4 | 9.1 | 94.5 | 115.5 | 284.9 | 271.6 | 237.4 | 147.9 |
| Northwestern | 237.3 | 186.3 | 67.5 | 78.7 | 143.8 | 117.5 | 3.4 | 14.7 | 121.2 | 96.5 | 55.5 | 48.5 |
| Southern | 373.7 | 335 | 802.8 | 1313.5 | 11.5 | 10.1 | 20.2 | 16.5 | 66.4 | 68 | 199 | 121.2 |
| North Caucasus | 3.4 | 4.6 | 30.4 | 38.1 | 0.1 | 0.2 | 24.2 | 18.8 | 9.8 | 5.9 | 13.8 | 5.6 |
| Volga | 123.4 | 148 | 29.1 | 57.3 | 0.9 | 1.8 | 8.4 | 11.7 | 40.5 | 31.6 | 41.2 | 27.2 |
| Ural | 737.8 | 673.9 | 929.8 | 1487.6 | 156.3 | 129.6 | 56.2 | 61.7 | 237.9 | 202.0 | 309.5 | 202.5 |
| Siberian | 22.4 | 29.4 | 15.4 | 102.6 | 3 | 3 | 3 | 6.5 | 57.7 | 57.9 | 51.2 | 72.5 |
| Far Eastern | 8.6 | 4.8 | 9.7 | 51.5 | 625.2 | 437.2 | 2.4 | 2.2 | 4.1 | 5.6 | 74.0 | 357.9 |

export (625.2 mln dollars), and the Central Federal District—in meat and dairy products (94.5 mln dollars), food and processing industries products (284.9 mln dollars), and other agribusiness products export (237.4 mln dollars). To sum up, the Central Federal District is the most export-oriented area, since it leads in many industries export.

The authors identified the leading export positions of Russian regions in the context of each federal district in 2020. The leading positions in the agribusiness products export in the Central Federal District belong to the Voronezh Region (27.1 mln dollars for oil crop products), Moscow (345.4 mln dollars for cereals, 7 mln dollars for fish and seafood, and 92.4 mln dollars for other agribusiness products), and the Moscow Region (34.2 mln dollars for meat and dairy products, and 80.8 mln dollars for food and processing industries products).

The top positions in the agribusiness export in the Northwestern Federal District are given to the Kaliningrad Region (214.1 mln dollars for oil crop products, and 25.2 mln dollars for other agribusiness products), St. Petersburg (42.5 mln dollars for cereals), the Murmansk Region (93.4 mln dollars for fish and seafood), St. Petersburg (2.1 mln dollars for meat and dairy products), and the Leningrad Region (56.1 mln dollars for food and processing industries products).

The Rostov Region (269.2 mln dollars for oil crop products, 394.5 mln dollars for cereals, 9.6 mln dollars for fish and seafood, 10 mln dollars for meat and dairy products, and 52.5 mln dollars for other agribusiness products), and the Krasnodar Territory (37.7 mln dollars for food and processing industries products) are the leading exporters in the Southern Federal District. It should be emphasized that the Rostov Region is the leading exporter of agribusiness industry in the Southern Federal District.

The top agribusiness products exporters in the North Caucasus Federal District are the Stavropol Territory (3.2 mln dollars for oil crop products, 24.3 mln dollars for cereals, 23 mln dollars for meat and dairy products, and 7.7 mln dollars for food and processing industries products), and the Republic of Dagestan (0.1 mln dollars for fish and seafood, and 5.3 mln dollars for other agribusiness products).

The pioneering positions in the agribusiness export in the Volga Federal District are presented in the Samara Region (45 mln dollars for oil crop products, and 9.5 mln dollars for food and processing industries products), the Saratov Region (14.8 mln dollars for cereals, and 10.1 mln dollars for other agribusiness products), the Orenburg Region (0.4 mln dollars for fish and seafood), and the Penza Region (4.9 mln dollars for meat and dairy products). To sum up, the Saratov Region, the Samara Region, and the Republic of Tatarstan became the export leaders of oil crop products in 2020. The Udmurt Republic, the Kirov Region, and the Republic of Mari El did not export a lot. The industry-leading regions in the Ural Federal District are the following: the Sverdlovsk Region (6.9 mln dollars for oil crop products, and 0.3 mln dollars for fish and seafood), the Kurgan Region (1 mln dollars for cereals), the Tyumen Region (2.1 mln dollars for meat and dairy products), and the Chelyabinsk Region (3 mln dollars for food and processing industries products, and 7.4 mln dollars for other agribusiness products).

The top positions in the agribusiness products export in the Siberian Federal District belong to the Altai Territory (8.4 mln dollars for oil crop products, and 13.2 mln dollars for other agribusiness products), the Novosibirsk Region (5.9 mln dollars for cereals, and 2.2 mln dollars for fish and seafood), the Tomsk Region (1.1 mln dollars for meat and dairy products), and the Kemerovo Region (24.3 mln dollars for food and processing industries products). The key exporters in the Far Eastern Federal District are the Amur Region (5.5 mln dollars for oil crop products), and the Primorsky Territory (9.3 mln dollars for cereals, 273.5 mln dollars for fish and seafood, 1.4 mln dollars for meat and dairy products, 2.1 mln dollars for food and processing industries products, and 30.1 mln dollars for other agribusiness products) [3].

The rating of exporters is not related to their geographical location, but is correlated to the features of industry that provides for the main export indicators. The region position in the rating is determined by the product export from its territory, but not production. It is possible to observe some situations in customs statistics when a region of import/export is not a region that produces goods, but is equipped with a large logistics center. Therefore, the top ten largest regions for the agrifood raw materials export includes Moscow and St. Petersburg that have no agricultural production, but many wholesale trading companies work there. The other leaders of the rating are the Kaliningrad Region, the Rostov Regions, and the Krasnodar Territory. They have developed their own production, but its volume is less than the export volume reportable. There is little misrepresentation only in the fish and seafood export sector, since both fishing and foreign trade operations are carried out through the same infrastructure that is a seaport. The fleets that export salmon and whitefish are located in Vladivostok and Murmansk. That is why these regions are among the leaders in the fish products export. Grain is collected from different geographic areas (Voronezh, Volgograd, Saratov, and Samara Regions), but it is exported from the Rostov Region and the Krasnodar Territory. The products are accumulated in the transshipment elevators in these regions, entered the market, and are evaluated as export, despite the fact that they were produced throughout the country. This situation is also typical in the sunflower oil export. Oilseeds are purchased throughout the country, but oilseed processing is concentrated in the Rostov Region and the Krasnodar Territory. Therefore, the central regions of the country are not included in the top ten, since they provide for raw material base, which is exported through ports.

The Russian Federation has achieved the most significant results in the cereals export, which is a traditional leader in the country's food export structure. The cereals export increased by 7 times in 2005–2020 and amounted to 10.265 mln dollars. The share in the export value structure of food products and agricultural raw materials was 33.5%. Today, Russia is among the leaders in the world grain market. The country has been ranking first as the wheat exporter for several years in a row. Wheat is the basis of Russia's food export. The growth is supported by a production increase, an intense foreign economic activity to expand sales geography for grain supplies, and state support for export [4]. The main importers of Russian grain are Turkey, Egypt, Saudi Arabia, Azerbaijan, Sudan, and others. Nigeria, Bangladesh, Korea

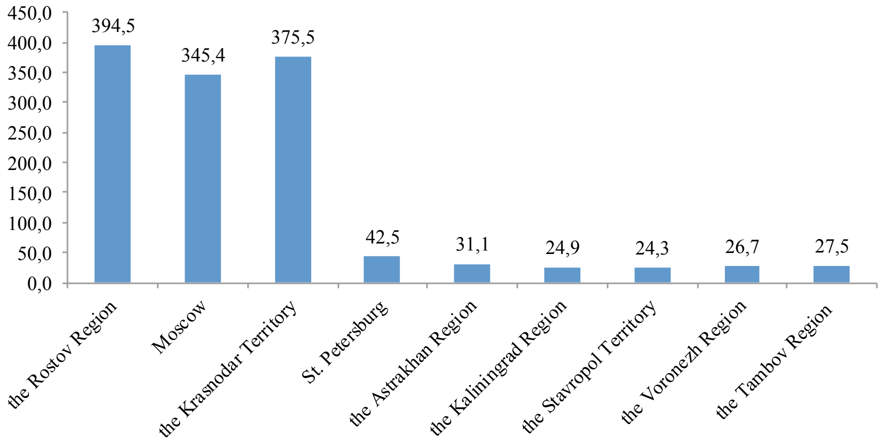


**Fig. 1** Top ten cereals exporters in 2020, mln dollars

are becoming new and rapidly growing markets for Russian export [5]. The regional rating of agrifood exporters is as follows: the Rostov Region, Moscow, The Krasnodar Territory, and others (Fig. 1).

Grain will not only retain the position as the main food in future, but also increase it and prove the importance in the international trade system [5]. Fish and seafood ranks second in the food export structure with the proportion of 17.4% (5329 mln dollars). The fish and seafood production in Russia increased by 22.9% and reached 5.4 mln tons. The production increase was due to the fish crop. In addition, the depreciation of ruble has made Russian products more competitive in foreign markets. The volume of Russian fish and seafood export has increased by 16.5% over the past five years. Frozen fish has the largest share in the total volume of fish and seafood export. The core importers are South Korea, China, the Netherlands, Japan, Belarus, Ukraine, Kazakhstan, the United States, and others. The regional rating of agrifood exporters is as follows: the Primorsky Territory, the Murmansk Region, the Kamchatka Territory, the Sakhalin Region, and others (Fig. 2).

Seed oil ranks third in the food export structure (4953.9 mln dollars, 16.2%). Today, Russia is one of the leaders in the world seed oil market [6]. There has been an export increase in all major groups of fat-and-oil products. Sunflower-seed oil deliveries have increased by 42%. The core importers are China, India, and Turkey. The rape-seed oil export has increased by 31% to 195 mln dollars. The main importers are China, Norway, and Lithuania [6]. The soya oil export from Russia has increased by 19% by 2019. The key importers of Russian protein meal are Latvia, Turkey, and Denmark. Sunflower-seed oil has 59% in the export structure of fat-and-oil products; protein meal and oilseed meal—14%; rape-seed oil—10.7%; soya oil—10.5%, and other products—5.8%. The regional rating of agrifood exporters is as follows: the Rostov Region, the Kaliningrad Region, the Krasnodar Region, and others (Fig. 3).

The export of food and processing industries products (4497.7 mln dollars, 14.7%) increased by 14% to 2019. The industry exports the following products: chocolate,

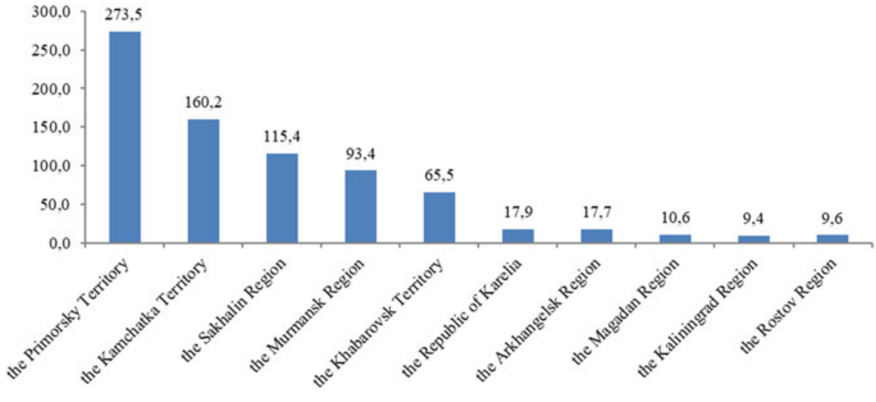


**Fig. 2** Top ten fish and seafood exporters in 2020, mln dollars

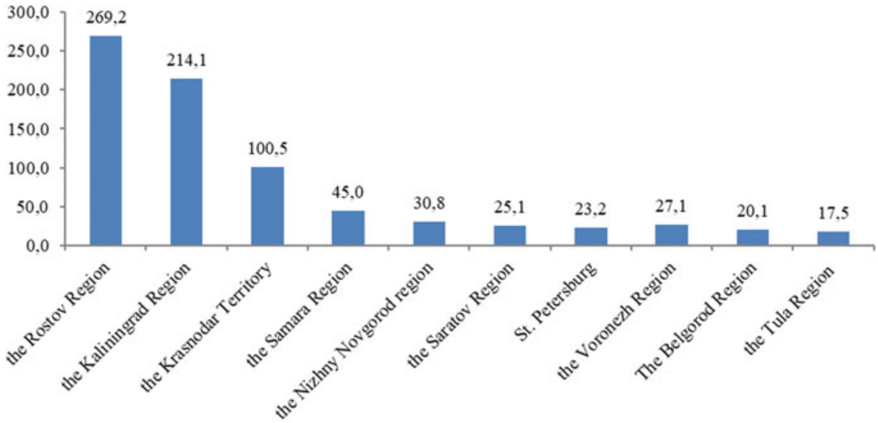


**Fig. 3** Top ten exporters of fat-and-oil products in 2020, mln dollars

flour confectionery goods, sugar, malt extract, and others. The leading importers are Kazakhstan, Uzbekistan, Belarus, China, Azerbaijan, Kyrgyzstan, and others. The exporters are Moscow, the Moscow Region, St. Petersburg, the Krasnodar Territory, and the Rostov Region. As a rule, they are large production and logistics centers [2].

Russian export of meat and meat products increased by 55% in 2020 compared to 2019, and amounted to more than 500 thousand tons. In monetary terms, shipments increased by 54% to 887 mln dollars (2.9%). China, Vietnam, Ukraine, Belarus, Kazakhstan, Saudi Arabia, Kyrgyzstan, Mongolia, and Armenia are importers. Regional exporters are the Belgorod Region, the Moscow Region, the Stavropol Territory, Moscow, the Tambov Region, the Bryansk Region, the Penza Region, the Kursk Region, the Krasnodar Territory, and the Pskov Region.

Dairy products export increased by 12% in 2020 and amounted to 318 mln dollars (1.03%). In physical terms, the growth was 16% or 197 thousand tons. The export leaders are cheese and cottage cheese (28 thousand tons), ice cream (26 thousand tons), milk and cream (53 thousand tons). The key importers are Kazakhstan, Ukraine, Belarus, Azerbaijan, Uzbekistan, USA, and others. The regional exporters are the Moscow Region, Moscow, the Rostov Region, the Krasnodar Territory, St. Petersburg, the Novosibirsk Region, the Omsk Region, the Samara Region, the Tyumen Region, and the Belgorod Region. Other products export accounts 4407.7 mln dollars (14.4%). This product group includes leguminous crops, noodle products, animal feed, and miller's bran. The importers are China, Turkey, Belarus, Kazakhstan, Ukraine, Bulgaria, Germany, Latvia, Pakistan, and Uzbekistan. The regional exporters are the Rostov Region, Moscow, the Moscow Region, the Krasnodar Territory, St. Petersburg, the Kaliningrad Region, the Primorsky Territory, the Altai Territory, the Novosibirsk Region, and the Amur Region.

The export development is supported by the State within the National Project "International Cooperation and Export" and the Federal Project "Export of Agribusiness Products". According to the Federal Project, the purpose of the agribusiness development is to increase the agribusiness products export to 45 bln dollars in monetary terms by 2024 [7]. Grain export should be increased to 11.8 bln dollars, fat-and-oil industry—to 8.6 bln dollars, fish and seafood export—to 8.5 bln dollars, and meat and dairy products export—to 2.8 bln dollars. The key destinations are Africa, the Middle East, and Southeast Asia, as well as China, India, and the CIS countries.

It is worth mentioning that export supplies have strategic risks. The poorly governed risks include sanctions, environmental, political, and social threats. The manage risks include decline in profitability due to lower demand and higher production costs, lack of government support, dependence on situation, introduction of prohibition against technologies [8]. The development of Russian agrifood export should include target-focused public support: reducing commissioning period for new varieties and hybrids, reducing terms for VAT refunds, introducing a system for subsidizing exchange risks, improving the agribusiness insurance system, developing exchange trade, improving the law on agricultural cooperation, increasing transport costs, developing intellectual property protection of Russian agricultural exporters' rights in target markets, modernizing infrastructure, improving agricultural technologies in order to ameliorate product quality, providing for monetary compensation of capital expenditures to build and upgrade production, and offering easy-term loans to producers and processors for raw materials and equipment purchase [8]. It is very important to differentiate all these measures to promote agribusiness products in a particular market. On the other hand, it is necessary not to contrast with the national strategy of the export development and promotion support.

## 4 Conclusion

The study revealed the fact that due to the growth in agrifood production, the Russian Federation has an opportunity to ensure the country's food safety and increase the export potential. The current growth rates of food export, which result from an increase in the volume and range of exported goods, as well as the sales geography, allow Russia to strengthen the position in the world food market. The export diversification and the growth in export of products with high added value will contribute to the sustainable development of agriculture and food industries [9]. The Federal Project "Export of Agribusiness Products" sets ambitious goals at country's exporters. They need to study target markets, reorganize production in accordance with foreign consumers' needs, be accredited, and develop logistics [7]. At the same time, the authors came to the conclusion that a regional exporter is not related to production, but is only a logistics center [10]. Consequently, what should the regions that are not included in the export rating do? They should provide for supplies of high-margin products with higher value added or build a forward integration between production and logistics. The growth potential of Russian export is high due to climate changes, agricultural crops displacement to the north, changes in demand from traditional raw materials to advanced food products (Russia is one of the world's largest producers of non-GMO soybeans), and increased demand in emerging markets. Frequent natural disasters and lack of sowing areas become another reason for Russian export growth. The Russian Federation owns huge resources which means that it has the chance to take a worthy place in the world food market in the near future [8]. On the other hand, the exporting regions need a target-focused public support in the context of industries. To minimize the risks of food export growth, Russia has to improve the system of agrifood markets regulation.

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# Mathematical Modeling of Labor Market Indicators as Tool for Enterprise Innovative Development

**E. Y. Nuykina**

**Abstract** One of the aspects of sustainable development of the enterprise's economy is planning and calculating the required number of labor resources and production assets. Currently, it is required to create conditions that can preserve innovative activity, which is the main factor in the sustainable development of the economy. Improving the efficiency of labor resources and production assets may be a prerequisite for accelerating the recovery from the economic crisis. It is now very important to find methods and mechanisms that would help develop innovative mechanisms of action during a pandemic that can steer the economy out of the deepest recession. These levers include mathematical methods. The work examines the indicators of labor resources and fixed assets, which can be used to calculate the total need for employees and production assets at enterprises in various industries. These indicators are defined through the prism of the input–output balance and the power-law production function. As model examples, tasks are presented that can serve as a good "simulator" for solving specific economic problems.

**Keywords** Indicators of labor resources · Innovation activity · Mathematical modeling · Production assets

## 1 Introduction

In connection with the Covid-19 pandemic, society is faced with new realities. The crisis hit major areas such as investment, industry, retail, cash income, demand. The main problem for many enterprises at the moment is the situation in which there is a sharp decline in innovations [1]. Since innovation is the most important factor in the sustainable development of the economy, a decrease in this process can negatively affect profits, support and strengthen the company's image. The workforce has a huge impact. There is an optimization of the personnel of various firms and enterprises, there is an increase in the number of job seekers in the labor market, the

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**Table 1** Dynamics of vacancies by industry in the 2nd quarter of 2020 in relation to the 3rd quarter of 2020

| Job industry | Rate of increase, % |
|---|---|
| Marketing/Advertising/Media | −37 |
| Finance/Insurance | −36 |
| Services sector | −34 |

selection criteria and requirements of employers are changing [2]. Companies are more responsible in opening new vacancies.

In March 2020, a sharp decline in economic activity began around the world. In this regard, with the changed demand, there is a shift in labor resources, the forms of which can be different. Business leaders are trying to find new innovative ideas in order to stay ahead of their competitors and get out of the pandemic with the least losses [3]. There is a change in the overall demand for labor resources in various sectors of the economy: services, construction, education, tourism. According to the Sberbank Index [4], the largest decrease in the number of vacancies in the Russian Federation in the second quarter of 2020 compared to the first quarter of 2020 was observed in marketing and advertising, finance and insurance, and the service sector. Table 1 shows the dynamics of vacancies by industry.

In the third quarter of 2020, there is a change in the labor market compared to the second quarter of 2020. The demand for specialists in "failed" industries is gradually starting to grow. However, the nature of hiring has changed significantly. Preference is now given to employees with such qualities as digital literacy [5], adaptability to change, the desire for self-development, self-organization and time management skills. Currently, it is necessary to create conditions that can preserve the capacity of enterprises. Improving the efficiency of labor resources, production assets is a guarantee of sustainable development, as well as a prerequisite for accelerating the recovery from the economic crisis [6]. Without a competent approach, it is impossible to achieve successful adaptation of enterprises to new realities, the revival of innovation. For modeling innovation processes and innovation, the most appropriate is the use of economic and mathematical methods.

## 2 Methodology

Now it is very important to find methods and mechanisms that would help to develop an algorithm for action during a pandemic, capable of directing the economy towards sustainable development, to a way out of the deepest crisis, and to revive innovation processes. Such levers include mathematical methods [7], in particular, the determination of indicators of the use of labor resources and fixed assets, which make it possible to calculate the total demand for labor resources and the total demand for fixed assets.

Let $L_i$—the number of employees in the i-th industry. Let's introduce the coefficients of direct labor costs into consideration:

$$t_i = \frac{L_i}{x_i}, i = \overline{1, n} \tag{1}$$

where $x_i$ is the gross product of the i-th industry.

After calculating these coefficients, you can find the total demand for labor resources with a known volume of gross output:

$$L = \sum_{i=1}^{n} L_i = \sum_{i=1}^{n} t_i x_i \tag{2}$$

Gross output is expressed in terms of final products:

$$x_j = \sum_{j=1}^{n} b_{ij} y_j, i = \overline{1, n} \tag{3}$$

where $b_{ij}$—total material cost ratios, $y_j$—final product.

Using formula (3), expressions (2) can be written as:

$$L = \sum_{i=1}^{n} t_i \left[ \sum_{j=1}^{n} b_{ij} y_j \right] = \sum_{j=1}^{n} \left[ \sum_{i=1}^{n} b_{ij} t_i \right] y_j \tag{4}$$

The product $b_{ij} t_i$ represents the amount of labor resources of the i-th industry, which is necessary to provide the i-th product for the output of a unit of the j-th final product. If we sum up all the industries, we get:

$$T_j = \sum_{i=1}^{n} b_{ij} t_i, j = \overline{1, n} \tag{5}$$

where $T_j$ is the coefficient of total labor input or total labor intensity, showing the amount of social labor required to produce a unit of the j-th final product.

Based on this, the total demand for labor resources can be found in two ways [8]:

$$L = \sum_{i=1}^{n} t_i x_i = \sum_{j=1}^{n} T_j y_j, \tag{6}$$

Along with the indicators of labor costs, the indicators of capital intensity show how efficiently the enterprise operates [9].

Let $F_i$ denote the value of fixed assets. The direct capital ratio can be defined as:

$$f_i = \frac{F_i}{x_i}, i = \overline{1, n} \tag{7}$$

The total capital intensity ratio is calculated as follows:

$$K_{f_j} = \sum_{i=1}^{n} b_{ij} f_i,\ j = \overline{1, n} \tag{8}$$

Similarly, to formula (6), you can determine the total need for fixed assets:

$$F = \sum_{i=1}^{n} f_i x_i = \sum_{j=1}^{n} K_{f_j} y_j \tag{9}$$

The capital-labor ratio of the enterprise directly affects labor productivity [9].

The need for labor resources, as well as for production assets, can be determined through the prism of the Cobb–Douglas production function.

$$L = (\propto_0 \propto_2^{\propto_1} \propto_2^{1-\propto_1})^{\frac{1}{1-\propto_1-\propto_2}} c_p^{\frac{1}{1-\propto_1-\propto_2}} r^{\frac{\propto_1}{\propto_1+\propto_2-1}} z^{\frac{1-\propto_1}{\propto_1+\propto_2-1}}, \tag{10}$$

$$K = (\propto_0 \propto_2^{\propto_2} \propto_2^{1-\propto_2})^{\frac{1}{1-\propto_1-\propto_2}} c_p^{\frac{1}{1-\propto_1-\propto_2}} r^{\frac{1-\propto_2}{\propto_1+\propto_2-1}} z^{\frac{\propto_2}{\propto_1+\propto_2-1}}, \tag{11}$$

where $L$—labor demand; $K$—need for funds; $c_p$—product prices; r—fixed assets price; z—specific wage fund.

## 3 Results

This approach makes it possible to develop sufficiently working economic and mathematical models that make it possible to find a way out of the current difficult situation at various firms and enterprises and are suitable for developing a strategy for innovative development. For example, considering the problem of input–output balance, knowing the technological characteristics of the production of a particular product at three enterprises, as well as the planned output, one can calculate the coefficients of direct material costs, the coefficients of direct labor costs. Part of the manufactured products is used for the needs of each enterprise. Using these indicators, you can calculate the total labor requirement.

$$A = \begin{bmatrix} 0.3\ 0.0\ 0.1 \\ 0.1\ 0.4\ 0.2 \\ 0.2\ 0.1\ 0.3 \end{bmatrix}, \quad t = \begin{bmatrix} 12 \\ 15 \\ 20 \end{bmatrix}, \quad Y = \begin{bmatrix} 150 \\ 140 \\ 170 \end{bmatrix}$$

$$E - A = \begin{bmatrix} 0.7 & 0.0 & -0.1 \\ -0.1 & 0.6 & -0.2 \\ -0.2 & -0.1 & 0.7 \end{bmatrix}$$

$$B = (E - A)^{-1} = \begin{bmatrix} 1.49 & 0.04 & 0.22 \\ 0.41 & 1.76 & 0.56 \\ 0.49 & 0.26 & 1.57 \end{bmatrix}$$

There are two ways to apply: 1) find $X = BY$, then use the formula $L = (t, X)$; 2) find the coefficients of total labor costs $T = tB$ and then use the formula $L = (T, Y)$.

The first way:

$$X = BY = \begin{bmatrix} 1.49 & 0.04 & 0.22 \\ 0.41 & 1.76 & 0.56 \\ 0.49 & 0.26 & 1.57 \end{bmatrix} \times \begin{bmatrix} 150 \\ 140 \\ 170 \end{bmatrix} = \begin{bmatrix} 268 \\ 404 \\ 377 \end{bmatrix}$$

$$L(t, X) = 12 \times 268 + 15 \times 404 + 20 \times 377 = 16816$$

Second way:

$$T = B^T t = \begin{bmatrix} 1.49 & 0.41 & 0.49 \\ 0.04 & 1.76 & 0.26 \\ 0.22 & 0.56 & 1.57 \end{bmatrix} \times \begin{bmatrix} 12 \\ 15 \\ 20 \end{bmatrix} = \begin{bmatrix} 33.9 \\ 32.1 \\ 42.57 \end{bmatrix}$$

$$L(T, Y) = 33,9 \times 150 + 32,1 \times 140 + 42,57 \times 170 = 16816$$

At present, of particular interest may be tasks in which the change in the main characteristics of production is determined depending on changes in working conditions. In times of economic instability, it is especially important to be careful when planning and forecasting economic performance.

Production functions built on the basis of a power-law dependence have properties that sufficiently correspond to the laws of behavior of real economic entities [10]. If we describe production by means of a mathematical model, then we can assume that some production is described using the Cobb–Douglas function:

$$y = 3,7x_1^{0,3}x_2^{0,5},$$

where y—volume of marketable products in value terms; $x_1$—salary fund; $x_2$—cost of fixed assets.

There was a change in the resources used: the wage fund fell by 4%, the cost of fixed assets increased by 2%. It is necessary to determine by what percentage the volume of marketable output, labor productivity, capital productivity will change. Possession of elements of mathematical analysis will allow you to find a solution to this problem.

Logarithm the production function:

$$\ln y = \ln\left(3,7x_1^{0,3}x_2^{0,5}\right)$$

$$lny = ln3,7 + 0,3lnx_1 + 0,5lnx_2$$

We differentiate the obtained equality:

$$\frac{dy}{y} = 0,3\frac{dx_1}{x_1} + 0,5\frac{dx_2}{x_2},$$

then

$$\frac{\Delta y}{y} \approx 0,3\frac{\Delta x_1}{x_1} + 0,5\frac{\Delta x_2}{x_2}.$$

The quantities $\frac{\Delta x_1}{x_1}$, $\frac{\Delta x_2}{x_2}$ express the relative increments of the quantities $x_1$ and $x_2$:

$$\frac{\Delta x_1}{x_1} = -0,04; \frac{\Delta x_2}{x_2} = 0,02$$

Determine how the volume of marketable products will change:

$$\frac{\Delta y}{y} = 0,3(-0,04) + 0,5(0,02) = -0,012 + 0,01 = -0,002$$

Thus, the volume of commercial products increased by 0.3%.

Let us find out how labor productivity will change, which is determined by the equality:

$$A_{x_1} = \frac{y}{x_1} = 3,7x_1^{-0,7}x_2^{0,5}$$

Taking the logarithm of this equality, we obtain:

$$lnA_{x_1} = ln3,7 - 0,7lnx_1 + 0,5lnx_2,$$

$$\frac{\Delta A_{x_1}}{A_{x_1}} \approx -0,7(-0,04) + 0,5(0,02) = 0,028 + 0,01 = 0,038$$

According to calculations, labor productivity increased by 3.8%.

The change in capital productivity can be calculated in the same way:

$$A_{x_2} = \frac{y}{x_2} = 3,7x_1^{0,3}x_2^{-0,5},$$

$$lnA_{x_2} = ln3,7 + 0,3lnx_1 - 0,5lnx_2,$$

$$\frac{\Delta A_{x_2}}{A_{x_2}} \approx 0,3\frac{\Delta x_1}{x_1} - 0,5\frac{\Delta x_2}{x_2} = 0,3(-0,04)$$
$$-0,5(0,02) = -0,012 - 0,01 = -0,022$$

Thus, the return on assets fell by 2.2%.

As you can see, the process of economic and mathematical modeling can quite effectively show the most possible scenarios for the development of events and help in solving the problem posed [11].

## 4 Discussion

The main mission of economic and mathematical modeling, which contributes to the development of innovative management solutions, is to ensure the reliability of the results of assessment, analysis and forecast. As a result, the achievement of the reliability of plans for the implementation of innovative projects and processes, the maximization of profits from the implementation of innovations, the achievement of the economic system of competitive advantages in the current period and in the long term. Planning and calculating the required number of labor resources and production assets in various sectors of the economy can be one of the steps to mitigate the consequences of the crisis that has erupted around the world in connection with the coronavirus pandemic [12]. However, the difficulty lies in the fact that the labor market in 2020 acquired the character of uncertainty [13]. Serious disruption has occurred in many manufacturing areas, as well as in the service sector. In this regard, there are changes in the world of work, requiring some people to move to new sectors, mastering new professions and new forms of work. In the current situation, it is necessary to look for various ways and methods that can not only stop the spread of infection throughout the world, but also that can analyze the available data, develop ways to solve a huge problem [14]. The process of determining various economic indicators using mathematical modeling plays an important role in scientific research, bringing innovative ideas to the development of optimization models. This will help steer the economy along the path out of an unprecedented crisis. However, along with the negative consequences, one can observe some positive trends for the economy in general and for the labor market in particular. For example, interest in healthcare, education, distance business, and logistics has increased. This can lead to the need for new specialists and be one of the drivers of economic growth. There are positive shifts in the dynamics of labor resources. According to the Federal State Statistics Service [15], the number of people employed in the economy is recovering. The percentage of the economically active population in February 2021 was 0.7% against 0.34% in January 2021. Perhaps this is due to the increase in the retirement age. However, the very fact of an increase in the number of working people is one of the powerful factors for sustainable development and economic recovery.

## 5 Conclusion

The use of mathematical modeling contributes to the development of innovative solutions that allow raising the economic processes of production to a higher level. Despite the educational and methodological nature of the considered model examples, they can serve as a good "simulator" for solving specific economic problems. Innovation activities may include research and development that are not directly related to the development of a certain innovation, but significantly affect the sustainable development of the economy of the enterprise and the country as a whole. Determination of the number of labor resources and capital-labor ratio of the enterprise through the prism of the input–output balance and production function showed that this method can be applied to study the labor market during negative events associated with a serious economic crisis. The study of the relationship between changes in the economic indicators of the enterprise will make it possible to find the optimal plan for solving the problem, which is currently especially important. It is necessary to conduct further studies of changes in the labor market in order to identify the main consumer trends and be able to mitigate the negative economic consequences by the effectiveness of management decisions.

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# Methods of Corrosion Mitigation in the Gas and Oil Industry

**L. V. Ermolina, E. V. Alekina, and L. V. Sorokina**

**Abstract** The article deals with corrosion control in the oil and gas industry. The main methods of corrosion mitigation on the main elements of structures are considered. The role of import substitution policy in the country's leading oil and gas sector is outlined, which consists in the targeted impact of the state on the non-diversified national economy, the foundation of which is oil and gas enterprises, and the creation of such institutional conditions, under which the possibility of scientific research, creation and development of production of oil and gas equipment within the country, which is more competitive in the domestic market than imported, is provided. Examples of domestic analogues of materials and equipment are given without loss of technological safety and quality in order to optimize costs in conditions of uncertainty. The implementation of the current approaches to management revealed certain shortcomings and risks of the development of the corrosion protection system at production, which indicate the need to begin the process of reforming the management system of the oil and gas complex taking into account modern scientific strategies, within the framework of new methodological approaches.

**Keywords** Corrosion · Chemical reaction · Import substitution · Oil and gas industry

## 1 Introduction

Russian industrial enterprises import significant volumes of many strategic raw materials—titanium, aluminum, tin, manganese and other materials. The annual import of import-dependent mineral resources amounts to more than 12,000,000 tons in the amount of about US $4.5 billion and accounts for 47% of the total import of mineral raw materials. Such dependence reduces the level of economic security of

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Russian enterprises sensitive to the dynamics of mineral supplies, and, as a result, increases political risks in our country. The problems of import substitution in Russian economic science began to be considered almost from the very beginning of market reforms. After the crisis of 1998, when import substitution was implemented with the greatest effect, the topic of import substitution is constantly raised in public and scientific discussions. However, in Russia there was no consensus on the essence, goals and methods of implementing import substitution policies, which leads to a different understanding of this phenomenon and, accordingly, to the use of the concept of "import substitution." Thus, in modern Russian economic science, the need remains to formulate the universal con-cept of "import substitution," its principles and the relationship with the concept of "import substitution policy."

Volkodavova defines import substitution as a system of measures that ensure the achievement of the enterprise's goals on the volume and structure of import substitution to increase the efficiency of its activities [1]. Import substitution means a system of measures that ensures the achievement of the intended goals in terms of the volume and structure of production of domestic products while reducing the consumption of imported goods. In this case, import substitution is understood as a deliberate process of mastering new, previously imported products without indicating the need to ensure the competitiveness of these products and the economic feasibility of their production.

The problem of import-dependent industries, to which the oil and gas industry can be fully attributed, requires a deep study of the causes of this dependence. In Russia, these issues are considered both at the level of enterprises-producers and consumers of mineral products, and at the level of the state. One way to manage the import substitution of scarce minerals is to manage the system of production and use of such raw materials.

## 2 Methodology

In this system, it is necessary to apply effective administrative tools, which will primarily use legal methods, through the creation or development of regulatory legal instruments, and production tools. Production tools include methods of replacing import-dependent raw materials, equipment and technologies with domestic analogues, without loss of technological safety and quality [2]. Corrosion is the destructive effect of a material as a result of a reaction with the environment and potential natural hazards associated with the extraction and transportation of gas and oil [3]. Natural gas and crude oil can carry various high purity products that are corrosive in nature. Lines and fittings of line components will undergo material decomposition depending on changing well conditions due to changes in fluid composition, well injection during the period and changes in operating pressure and temperature conditions. Such material degradation results in loss of mechanical properties such as strength, ductility, toughness, etc. This leads to the loss of materials, a decrease in thickness, and sometimes a complete failure. A state will be reached where the component can break completely and the assembly needs to be replaced while production is stopped. The serious consequences are that corrosion has become a global problem.

Corrosion in modern realities is one of the unresolved problems of the industry. Most industrial structures cannot be made without considering the effect of corrosion on the life of the equipment. Reports around the world confirm that some oil companies have destroyed the pipeline due to corrosion and that oil spills have occurred, this has undoubtedly led to environmental pollution. In addition, resources are lost to repair the damage caused. The possibility of corrosion in an industrial plant is of great concern to oil engineers and chemists. It is currently known that corrosion can have some effect on the chemical composition of the selected process, and the corrosion product can affect the reaction and purity of the reaction products (Fig. 1).

The costs of corrosive damage of all types amount to about 3–5% of the gross national product of industrialized countries. The annual amount of corrosive costs in the oil and gas industry is estimated at US $1.372 billion, broken down by US $589 million for terrestrial piping and facilities, US $463 million per year for downhole tubing, and an additional US $320 million for capital costs associated with corrosion.

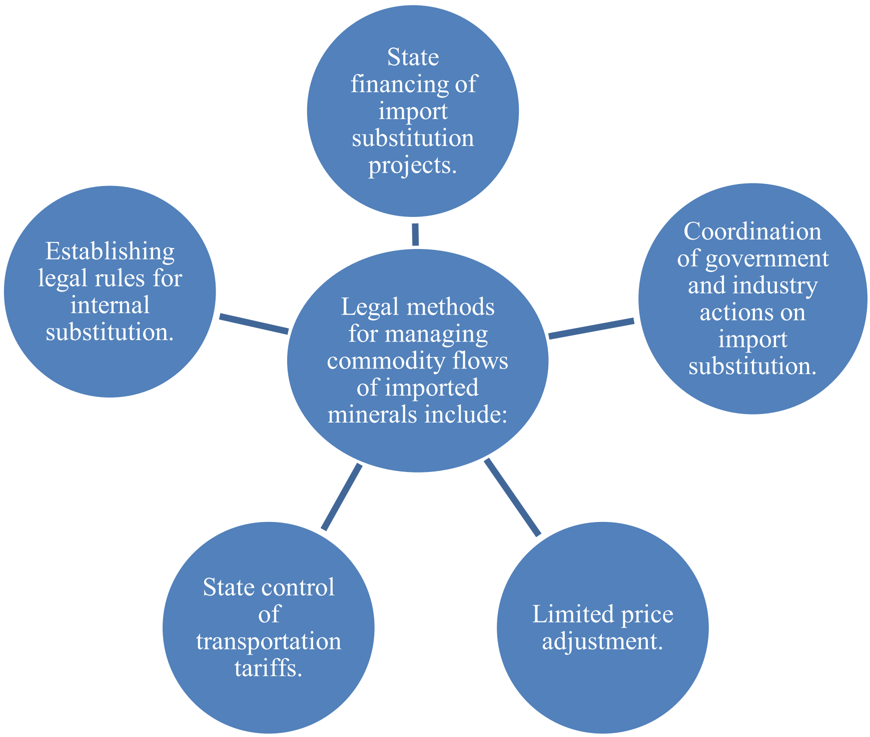


**Fig. 1** Legal methods for regulating commodity flows of imported minerals

Corrosion costs the gas and oil industry tens of billions of dollars in lost revenue and cleanup costs each year. Corrosion costs American industry alone about $170 billion a year, in which the gas and oil industry incurs more than half of that cost.

Internal corrosion in wells and pipelines depends on temperature, content of $CO_2$ and H2S, chemical composition of water, flow rate and state of steel surface. A significantly reduced corrosion rate (mm/year) can significantly extend the life of the components, resulting in much greater benefits, such as lower maintenance costs. Currently, many components used for gas and oil production are made of alloys based on carbon steel. Organizations now strive to move from these types of alloys to a more corrosion-resistant alloy at much higher costs. Corrosion was a problem for the world and must be addressed to a great extent. Technical parameters such as cathodic and anodic protection, material selection, chemical dosing and internal and external coating shall be used in the field of corrosion control and prevention in the gas and oil industry. In the gas and oil industry, it is widely recognized that effective corrosion management will help maintain asset integrity and optimize mitigation, monitoring and verification costs. Although many methods have been recommended to prevent these events, we identify the most effective, in our opinion, methods that can be broadly classified as follows (Fig. 2):

Material Selection

Structural materials are corrosive and usually the organization decides to replace structural materials with alternative materials according to specific needs [4] corrosion resistance and mechanical properties. The applied corrosion-resistant alloys in the gas and oil industry offered by Smith include 13Cr, Super 13Cr, 22Cr duplex, 25Cr

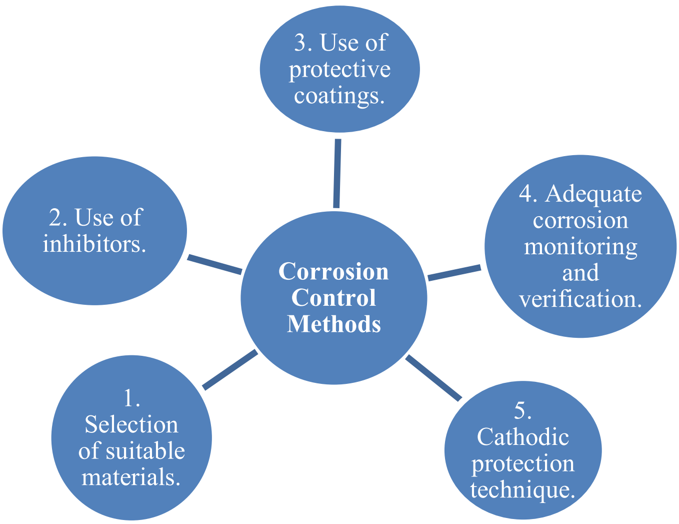


**Fig. 2** Corrosion control methods

duplex, 28Cr from stainless steel, the 825th nickel alloy, etc. Johansson proposed special stainless steel to solve corrosion problems in the gas and oil industry LDX 2101, 254 SMO and 654 SMO.
Use of inhibitors

A corrosion inhibitor can act in several ways: it can limit the rate of the anodic or cathodic process by simply blocking active areas on the metal surface [5]. Another method of exposure is that it can increase the potential of the metal surface, so the metal enters the passivation region, where a natural oxide film is formed. Another mode of action of some inhibitors is that the inhibiting compound promotes the formation of a thin layer on the surface that inhibits the corrosion process. In the coming years, the production of inhibitors of IKAR-1, I-1-A and I-1-V will be discontinued. And the growing needs of the gas and oil industry in the appropriate types of inhibitors will be met through the industrial production of inhibitors IFHANgas-1, Taiga, I-K, I-D, as well as newly developed inhibitors that most fully meet the requirements of SNPKh-1004, NAPOR-1007, Catasol 28–5, DON-52, ANP-2 M.

Use of Protective Coatings

A protective layer or barrier on the material to avoid direct contact with the process medium will increase the life of the material and equipment. The barrier layer may be paint, coating or lining. There are also non-metallic pads, such as glass fibers, glass flakes, epoxy resin and rubber, which are typically applied to equipment such as separators, knock-out drums and storage tanks. Nickel, zinc and cadmium coatings are also sometimes preferred for certain components such as flanges and bolts. Wells with low levels of H2S, CO2 were previously filled with foreign materials, for example, a tube N-80. A plastic coating on the tube N-80 with periodic treatment with an inhibitor every 30 days gave a tube life of 7 years. Epoxy resin (FBE) and three-layer polyolefin (3LPO) (polyethylene or polypropylene (PP) are currently the most widely used external anticorrosion coating systems.

## 3 Results

Leading domestic oil and gas companies have long implemented an import substitution policy. The result was the inclusion of responsible Russian suppliers in the guidance documents. For example, the VMP holding (Fig. 3) stands out against the general background of domestic manufacturers: VMP products are included in the guidelines of Rosneft PJSC, Transneft PJSC, Gazprom PJSC and are actively used to protect tank farms, metal structures and equipment.

Holding VMP has developed the following materials for corrosion protection: a system with thick-layer epoxy enamel ISOLEP-mastic and a finishing layer POLITON-UR, ISOLEP-oil, ISOLEP-oil 350 AS. These systems comply with the guidelines of Rosneft PJSC. The high performance HPCC composite coating system is a single layer, fully powder, multi-component coating system consisting of an

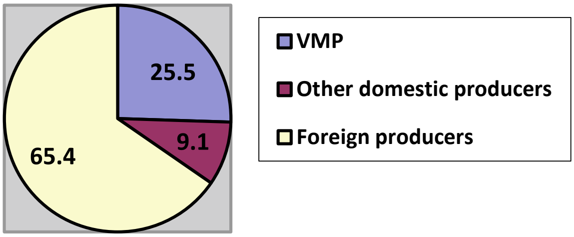


**Fig. 3** Share of VMP in the development of domestic protection

FBE base coating, a medium density polyethylene outer coating, and a binder layer comprising a chemically modified polyethylene adhesive. All materials of the three composite coating components are applied by electrostatic powder coating. The binder layer is a mixture of glue and FBE with a gradation of the FBE concentration. Thus, there is no clear defined interface between the binder layer and the FBE base coating or the outer polyethylene coating. Domestic analogues of such systems are systems with carbonaceous nanotubes and carbon nanofibers. The main advantages are:

– increase of electrical conductivity;
– increase of thermal conductivity and heat resistance;
– improvement of antistatic properties;
– improvement of mechanical characteristics;
– increase of adhesion strength and expansion of temperature range of application (from −60 to 250 °C);
– ensuring resistance to aggressive working media.

The main material is polyethylene with a filler of grades SV MEP + 2% UHF and SV MEP + 10% UHF. And another important result of the import substitution policy is the use of domestic technology for coating from thermotite flow. Thermotite technology consists of a multilayer polypropylene composite FBE as a layer for steel. Special requirements for protection or thermal insulation are fulfilled using the individual design of the system. Resistance to the compression and creep effects of sea depths and high temperatures can be considered by adjusting the density and nature of the layers. Figure 4 shows the construction of the Termotite system with five layers.

**Fig. 4** Thermotite system: 1—FBE, 2—glue, 3—solid, 4—foam, 5—protective layer

A three-layer anticorrosive coating is applied by extrusion with a side or transverse head, then a heat insulating layer (foam and external screen) is applied. The thermal layers, outer shield or polypropylene covering the layer are simultaneously applied to the heat insulation lines by transverse extrusion. This method provides a fixed outer diameter and uniform foam structure without air inclusions. The global market for ultra-strong pipes for the oil and gas industry by 2025 will grow 1.66 times compared to 2018 and reach $13.41 billion.

The development of new deposits in the Arctic requires modern technologies, including the use of flexible ultra-durable composite polymer pipes. Sanctions on the supply of modern technologies and materials make the development of the production of ultra-durable composite pipes in Russia extremely relevant. The level of import dependence in the segment of super-strong pipes for the gas and oil industry is more than 90%. Given the high level of import dependence, domestic manufacturers have developed modern technological lines for the production of composite polymer ultra-strong flexible oil and gas pipes based on new technological solutions and modern fibers and polymers (PA, PPS, PE-RT). In addition, third-generation fibers have appeared in foreign literature called HPF—High Performance Fibers (HPF), and carbon, ceramic and new types of glass fibers are included in them along with new polymer fibers. Third, the production of a new generation of fibers is characterized by an increased requirement for their operational properties in traditional and new applications (aerospace, automotive, oil and gas, army, construction). These applications place increased demands on the physical and mechanical properties of materials.

It is not possible to fully satisfy this set of requirements with a range of natural and chemical fibers of the 1st and 2nd generation. This problem is solved by successes in the field of chemistry and polymer physics, solid state physics and the production of HPF on this basis. Created 3rd generation fibers with predetermined properties and, above all, with high breaking strength, resistance to friction, bending, pressure, elasticity, thermal and fire resistance fully satisfy the requirements of the gas and oil industry [6].

## 4 Discussion

The first use of cathodic protection dates back to 1824, long before its theoretical basis was created. Cathodic protection is a method of reducing corrosion by minimizing the potential difference between the anode and cathode. This is achieved by supplying current to a protected structure (such as a pipeline) from an external source [7]. When sufficient current is applied, the entire structure will be at the same potential. Typically, the method is used in combination with coatings and can be considered as a secondary corrosion control method. Two methods of applying cathodic protection abroad include: galvanic protection (SACP); current cathodic protection (ICCP). The most common in Russia is a high-tech installation—Minevra—3000. Its power is sufficient to protect 30,000 m. ASKG-TM are also used, although their power is low, their equipment with a telemetry complex or remote control allows them to be no less popular.

## 5 Conclusion

Effective results in the development of the corrosion protection system are possible only with the implementation of new management approaches, taking into account the identification and timely response to reduce possible risks, such as: high physical and moral deterioration of oil and gas complex funds; high share of imported equipment in production (up to 90%) at all stages of the oil and gas complex—production, transportation, processing and service [8].

The identified shortcomings indicate the need to begin the process of reforming the management system of the oil and gas complex, taking into account modern scientific strategies, within the framework of new methodological approaches. Corrosion is a random, probabilistic phenomenon that requires interdisciplinary concepts. This brings tens of billions of dollars in lost revenue and processing costs to the oil and gas industry each year. The principles of corrosion should be understood in order to effectively select materials, as well as design, manufacture and use metal structures to ensure optimal economic life of facilities and ensure safety in oil and gas operations. Each case must be considered in its entirety before a decision can be made on the relevant materials. Indeed, the use of domestic technologies and materials to replace imported ones in the oil and gas industries is already noticeable, primarily in gas production, processing and transportation of oil. Gazprom has 95% of purchases of material and technical products made inside Russia, including 100% of pipes. In this area, both the investment of the company itself and its cooperation with government structures are realized.

Some companies began to create scientific and technical centers and try to develop new technologies on their own, which they lack. In my opinion, this is the wrong way. Such developments are generally not effective enough in a highly competitive market. In any case, the Russian engineering school is still strong. And thanks to sanctions, we are witnessing the development of technology today. The problem is in building integration chains between science, testers and implementers, companies and financial institutions. In addition to direct investment, one of the most effective import substitution tools is cluster approaches, which significantly optimize costs for the development of production and their further scaling. In such clusters, various industries are assembled that sell all stages of production from raw materials to the final product. Summing up the five-year period of import substitution in the Russian Federation, we can conclude that the country confidently demonstrates the development of the potential of domestic enterprises and organizations for the production of competitive goods and services, as well as their application in various sectors of the

Russian economy and promotion to the international market. Domestic products in some segments can no longer just completely replace imported analogues, but also compete with them.

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# Logistic Outsourcing as a Tool for Sustainable Development of Industrial Enterprises

**N. P. Karpova and T. E. Evtodieva**

**Abstract** The authors of the paper analyzed the trends in the industrial enterprises development under modern conditions. The features of logistic outsourcing in the context of basic and innovative logistics were revealed. The logistics services content of business processes in production enterprises that are of greatest importance in the context of globalization and Industry 4.0 was determined. The reasons for the logistic outsourcing development in supply chains were defined. The necessity to implement logistic outsourcing for the sustainable development of industrial enterprises was justified. The authors identified the following priority areas of logistic outsourcing for manufacturing enterprises: warehousing, shipment, recyclable waste logistics, green logistics, and logistization of economic flows in supply chains. Logistics providers were structured and decision criteria were summarized. The importance of logistics providers in reducing not only economic costs of industrial enterprises, but also in minimizing the impact on the ecosystem was justified. The authors generalized the advantages and disadvantages of logistic outsourcing and identified the risks to implement it in industrial activities: management, information, market, financial, and competence-based.

**Keywords** Industrial enterprise · Logistic outsourcing · Logistics provider · Innovative logistics · Sutainable development

## 1 Introduction

Modern industrial enterprises operate under hard and unstable conditions: shortage of funds, poor quality of products, high degree of depreciation of basic assets, etc. Consequently, enterprises are looking for new business tools that will improve the

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efficiency of their activities. The purpose of the study is to give reasons for implementing logistic outsourcing into modern industrial enterprises in order to ensure their sustainable development. Logistic outsourcing is a tool that contributes to sustainable development of enterprises under the conditions of market variability and globalization, reduction of the product life cycle, and increased consumer demands on the final product quality. Logistic outsourcing is particularly relevant in the context of the innovative economy and new technological revolution [1]. Logistics providers have competencies and are able to introduce the latest developments into the economic flows management at industrial enterprises. We can mention the use of green logistics principles in the supply chain of manufacturing enterprises, the implementation of the latest technological advances in shipment, warehousing, materials handling, maintenance, etc. To sum up, industrial enterprises are looking forward to cooperating with logistics providers that have valuable resources and skills, which are difficult to obtain, imitate or replace, in order to supplement the own resource base [2].

## 2 Methods

Up-to-date industry is a complex, dynamic, flexible, and adaptive system. In order to study and analyze it, the dialectical method of cognition, which is based on the systems approach principles, was used. The principle of the systems approach is focused on a comprehensive analysis of the study object and is closely interrelated with the external environment. The principles are particularly relevant in the context of the supply chain globalization where isolated functioning and examination of market participants is unacceptable. Among the general scientific research methods that have been used in the study we can distinguish the methods of analysis, synthesis, induction, and deduction. The study is also based on the logical justification of the need to use logistic outsourcing as a tool for the sustainable development of manufacturing enterprises. The practice of modern industrial enterprises that are operating in developed countries has demonstrated the flexibility of this mechanism in order to improve operating performance of industrial enterprises, as well as develop the customer service quality in the supply chain.

## 3 Results

The sustainable development of industrial enterprises is the process of minimizing negative impacts of the external and internal environment on their economic status. However, the current state of economy in the context of the coronavirus pandemic has a negative impact on Russian industry development. The profit of large and medium-sized national enterprises has decreased by half for the first nine months of

2020, compared to the same period of 2019 [3]. Many sectors, such as hotel business, tourism, and railway and air passenger traffic, have suffered losses. Small and medium-sized enterprises, which account for a fifth of GDP, have suffered even more. According to the analytical data, the number of small and medium-sized enterprises has decreased by 4.2% for the first six months of 2020, compared to the same period of 2019 [3]. A decrease in external and domestic demand had a negative impact on Russian industrial production. Regional mineral production has suffered the most [4]. Industrial production has increased only in 34 regions for the first three quarters of 2020 (72 regions in 2019). In general, an economic activity in the manufacturing sector remained unchanged over a corresponding period last year, but it significantly decreased in the extractive sectors by 6.5%, compared to the same period last year. The largest decline in industrial production was in the Republic of Tyva (−48.5%) due to the extractive industry, and in Kostroma Region (−15.1%) due to the electricity production decrease. At the same time, there was a positive trend in manufacturing in almost all regions of the North Caucasus due to the food industry which was not so badly affected by quarantine restrictions [5].

These circumstances encourage domestic enterprises to look for new tools to reduce costs and maintain a market niche in order to improve the consumer service quality. In our opinion, logistic outsourcing is the most appropriate tool to achieve these goals. Outsourcing is a way of strategic interaction between counterparts in the supply chain in order to delegate a part of production processes (activities) to special-purpose contractors. Logistic outsourcing is usually defined in terms of basic and innovative logistics, where basic logistics focuses on using existing tools to manage economic flows of logistics systems, and innovative logistics aims at introducing innovative techniques and technologies into management procedures of industrial enterprises [6].

According to the basic logistics, logistic outsourcing is a set of logistic activities that are transferred to independent market entities. In the context of innovative logistics, logistic outsourcing is logistics services which are offered on monetary base by external contractors [6]. Logistics services include the development and implementation of innovative technologies and efficient management of economic flows in logistics systems at both micro and macro levels. However, we believe that the boundaries between basic and innovative logistics are vague under current conditions, because innovations are closely integrated with basic operations and functions at industrial enterprises [7]. Therefore, logistic outsourcing can be represented as a strategic way of interaction between contractors in the supply chain to provide a set of basic and innovative logistics services (logistization services).

Industrial enterprises tend to delegate a part of logistics functions to an outsourcing company in order to diversify production activities, minimize costs, and improve the product quality, especially since the logistics functions are not their main activity. At the same time, logistics providers, which have necessary knowledge and special equipment, guarantee not only a reduction in enterprises' costs, but also provide end users with a high-quality service. Consequently, it helps manufacturing companies remain competitive and retain the lead. The development of the logistic outsourcing concept resulted from economic globalization. Even small enterprises are becoming part of one global production network. Due to the commodity weight growth, both distribution and supply are becoming more complex. Growing consumer demands for the service level encourage enterprises to deal with logistics providers services. That is why logistics knowledge is becoming valuable for all enterprises without exception. The benefits of introducing logistic outsourcing at industrial enterprises are the following [2]:

– lack of knowledge and experience in logistics activities;
– possibility to focus on the core business, not a secondary one;
– close intercommunion of supplying companies and corporate consumers with shipping organizations in the value chain;
– improving enterprise flexibility;
– benefits from logistics companies with no need for developing the own logistics infrastructure;
– decrease in production costs;
– reduction of delivery terms;
– possibility to have high-quality logistics service offered by a logistics provider;
– increase in the customer service quality that builds positive brand image.

It is of importance to note that industry is a source of emissions of a wide range of polluting substance into the environment. This is particularly true for petrochemical industry. In addition, Russia is the leader in hydrocarbons production and exports [4]. Taking into account such events as Russia's accession to the World Trade Organization membership, expansion of international environmental requirements, and consumer emphasis on the use of environmentally friendly green products, the role of logistic outsourcing based on the green logistics principles is significantly increasing. Green logistics focuses on providing end users with material flows under terms of reducing not only economic costs, but also negative impact of the supply chain results of commodity stocks and supplies on the environment and society. The main harmful effects on the ecosystem are the following: greenhouse gas emission (during the shipment of raw materials, equipment, and finished products), soil contamination with industrial waste, and inefficient waste burial. Outsourcing in green logistics is manifested through green shipment, green warehousing, green packaging, logistics of recyclable waste, etc. [8].

A logistics provider can be a commercial organization that offers services for bringing economic flows to a consumer and integrates both particular logistics functions and a complex approach in a logistics activity of industrial enterprises: warehousing, shipment, inventory management, distribution, logistics services, etc.

There are 5 types of logistics providers (PL):

1PL (autonomous logistics). Logistics functions are performed by a manufacturing company, that is to say, the company has its own warehouse and vehicles for shipping goods. Today, only small companies are engaged in logistic insourcing at the initial stage of their development [9].

2PL (traditional logistics). Logistics services are offered by a logistics provider to an industrial enterprise at a particular stage of the supply chain: shipment, warehousing, materials handling, etc.

3PL (logistics for third parties). It provides a range of logistics services that go beyond traditional shipment (warehousing/storage, materials handling and shipment, customs formalities, freight forwarding, etc.). All logistics business processes at industrial enterprises are transferred to logistics operators that have the necessary capacity. However, supply chain planning remains the responsibility of industrial enterprises.

4PL (integrated logistics). A provider offers a full range of logistics services in the process of bringing products to end users, including such logistics services as procurement management and planning, customs formalities management, transportation management, warehouse management, etc. It allows industrial enterprises to focus on performing key functions and finding resources for diversification. Many well-known foreign manufacturers such as Ford and Sony, entirely use the logistic outsourcing concept in business practice in order to achieve sustainable development in the context of globalization and market variability.

5PL (Internet logistics). Logistics elements are managed by electronic means of communication integrated into a single supply chain [10]. Virtual logistics is becoming increasingly widespread in the context of globalization and Industry 4.0. The technologies help optimize transport routes, use the storage capacity of industrial enterprises to the full extent, plan loading, etc. Therefore, modern technologies stipulate production and management system transformation in supply chains. Industry 4.0 offers billions of opportunities to connect people to smartphones, store big data, and have access to unlimited knowledge. These options derive from such new trends as artificial intelligence, robotics, the Internet of things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, etc. [1].

To sum up, 1PL and 2PL provide a traditional (usual) list of services. 3PL and 4PL have more complex logistics. Such companies usually deal with large database. Also, these providers have a very close interaction among all logistics departments (purchasing, sales, and shipment departments). They work on the basis of ERP system (a computer system that serves for processing business operations and planning enterprise resources, as well as analyzing enterprise activity). 5PL offers the Internet as a virtual platform for providing industrial enterprises with a full range of logistics functions. In the context of Industry 4.0, people, machines, equipment, logistics systems, and products will be interconnected in a single information space through the use of modern achievements of science and technology. It will allow to quickly respond to market changes thanks to intelligent tracking and transparent processes that ensure constant monitoring and control over material flows [1].

The most frequently outsourced logistics functions are warehousing (80% of outsourced logistics services), internal and external shipment (60%), and cargo consolidation (40%) [11]. In our opinion, warehouse outsourcing is quite common, since industrial enterprises have to spend a large amount of money to build and maintain their own warehouses. That is why, a company decides whether to build its own warehouse or address a logistics provider, in accordance with the specifics of production activities, annual sales revenues, capacity and storable lift of inventory.

In case if an industrial enterprise does not have enough funds and great volumes of products for storage, and building a warehouse is not necessary and profitable, the enterprise delegates this function to a logistics provider.

Logistic outsourcing in a warehouse activity is implemented as a safe storage service: commodities delivery to a warehouse; adherence to climatic regime and sanitary standards; order-picking, packaging, and formation of shipping lots; punctual shipment according to customer orders; cargo marking and bar coding. The difference between warehouse outsourcing and conventional leasing is as follows:

– only occupied shelves/racks in a warehouse need to be paid for;
– storage, distribution, and offloading/loading is handled by qualified staff;
– it is possible to regulate the volume of deliveries and free/occupied space in a warehouse;
– a logistics operator is responsible to the cargo owner for goods safety.

Choosing a reliable logistics provider is an important stage on the part of an industrial enterprise that delegates some of the competencies [12]. There are the main criteria for choosing logistics outsourcers: outsourcer experience (the number of customers), reliability (customer's satisfaction), qualified staff, flexible terms of agreement (possibility to correct work by an outsourcer).

This area of logistics, just like many others, has its own advantages and disadvantages. The advantages of logistic outsourcing are: alternative for an industrial enterprise to focus on the core competence, costs reduction in distribution network development, reduction in fixed costs at a production enterprise due to transferring logistics functions to a logistics provider (outsourcer), increase in the service quality due to outsourcer experience and professionalism, possibility to change the volume of deliveries in the season of fluctuating demand for various products, reduction in the risks and costs while entering new markets due to outsourcer knowledge of geographical features of the territories served. The main disadvantages of logistic outsourcing in the activities of industrial enterprises are the following: low level of logistics service quality, leakage of commercial data, schedule overrun in work and service provision, etc. However, it is worth noting that there are more advantages of this type of activity, that is why the logistic outsourcing strategy is popular with modern enterprises in all spheres. To sum up, logistic outsourcing is a profitable and efficient tool at manufacturing enterprises in the context of cash savings.

## 4 Discussion

Nowadays, enterprises of various sectors of economy, including industrial ones, have to choose between two options in production development: 1) own production facilities development (insourcing) or 2) outsourcing of services, including logistic ones. Insourcing is based on using company internal resources [11]. The majority of scientists agree that outsourcing is a procedure of transferring some internal business processes to a supplier on the basis of a long-term contract [2, 6, 8, 11, 13].

Outsourcing, including logistic one, is able to increase industrial enterprise efficiency by minimizing costs, developing enterprise flexibility, reducing production costs, attracting external resources, knowledge or know-how, and sharing risks with logistics providers. The use of logistics provider services in the logistics system of industrial enterprises also leads to an increase in labour productivity and logistics service quality, a reduction in transport costs, as well as an efficient reconstruction of a supply chain [8]. Logistic outsourcing has important incentive features that allow companies to get access to the resource base of a business and benefit from partner's competencies and skills [2]. Various risky situations may arise in the process of interaction between industrial enterprises and logistics providers, and it is necessary to minimize the level of their impact. The following types of risks in logistic outsourcing have been distinguished: managerial, informational, market, financial, and competence-based risks [13]. However, these risks do not reduce a positive effect of logistic outsourcing on industrial enterprises.

## 5 Conclusion

The authors of the study came to the conclusion that the effects of the coronavirus pandemic and restrictive preventive measures had a negative impact on the activity of industrial enterprises. Many manufacturing companies are facing fierce competition and lack of funds, that is why they are looking for new ways to improve operational efficiency and strengthen their sustainable state. The authors believe that logistic outsourcing is currently central tool at the activity of industrial enterprises that contributes to the improvement of all key performance indicators of functioning: reducing costs, improving products and services quality, increasing labour productivity in the main business processes, etc. Logistics providers that are strategic partners of industrial enterprises in the supply chain offer a whole range of logistics services. A complex of logistics services includes shipment, warehousing, cargo handling, insurance, customs clearance, etc. Logistics services also include the introduction of innovative procedures, methods, and tools in order to manage flow processes. Logistic outsourcing allows industrial enterprises to be more flexible and respond to changing market trends. The interaction between industrial enterprises and logistics providers in the supply chain is not without risks [13]. An integrated analysis of the costs and benefits of using logistic outsourcing will help management make a right decision and provide industrial enterprises with sustainable development.

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# Conceptual Organizational Aspects of Innovation Management Processes for Industrial Enterprises

**A. R. Rakhmatullina, T. N. Shatalova, and M. V. Chebykina**

**Abstract** Economic activity of the organization includes many aspects of innovative management which in many respects defines success of his functioning. On the basis of the saved-up base of researches and the analysis of activity and structure of the enterprises the authors offer several types of classification of models of functioning of the enterprise. By criterion of behavioural model the authors divide the organizations on: the organizations which work according to a tactical algorithm, the organizations which regard as of paramount importance the marketing principles, and the so-called "organizations of technological breakthrough"; describe the main properties of these models and difference of behavior of the enterprises of different groups from each other. The formation of managerial innovation processes is associated not only with their behavioral model, but also with the degree of influence of external factors on the enterprise's activities. By this principle of the organization belong either to the open, or closed model. The closed models in turn are divided into functioning on the basis of theoretical postulates of scientific management and guided by aspect of internal social interaction. Open models include the enterprises organizing the economic activity on results of the analysis on the concept of the theory of systems and the enterprise which remind the form and activity public institutes.

**Keywords** Innovative management · Innovative organization models · Management innovations · Open and closed enterprise model · Organization of technological breakthrough · System theory

## 1 Introduction

Classical economic science does not separate innovative management from the process of introducing management innovations in the aspect of applied management

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concepts. These concepts are most clearly reflected in the various structural models of the organization. In this article, we look at the specifics of implementing management innovations in organizations that are structurally appropriate for different models of innovation process management.

Most theories of decision making and implementation consider the organization as a vector set of targeted actions, a non-strict hierarchical system with socio-technical elements under the constant influence of the external environment [1]. The hierarchical structure, templates of actions, the practice of the economic entity and their interdependence are described by various models, the analysis of a significant number of which was carried out by Dziallis and Blind in a 2019 study on innovative indicators, indicators and their relationship with innovative processes [2].

In this scientific survey, we were tasked with considering and structuring different types of classification of business models. By criteria of the general type and also opportunity to develop, implement, introduce, develop and to control development of innovative processes and technologies we make group of various types of models. Analysis of the study of strategic planning functions, issues of the strategic level, including the interaction of companies, were considered by authors such as Carayannis, Dziallis and Blind [2, 3]. We also set and solved the tasks of identifying the most expedient changes in the internal management and foreign policy of the organization in all the types of organization models considered.

Research issues include the classification problems of various business models described in academic sources. We identified a number of key criteria and reviewed the classification typology according to them. Another important issue is the consideration of objective factors for the organization, depending on its type. We believe that the theoretical nature of our classification is important, in practice there is a process of combining different models, as well as an evolutionary transition between in connection with the change of economic priorities, modification of aspects of activities, etc. We also consider the characteristics of management depending on the nature of the dominant model of the enterprise. It can be said that the basic conceptual models of economic organizations, depending on the type of development and the vector of their innovative solutions, on how organizations create, generalize, develop innovative processes, include:

– so-called classic models, which are described primarily by the functional characteristics of the enterprise, the dominant relationship between the amount of material and intangible resources spent, production factors and their configuration and production results. It is also necessary to mention the significant influence of external factors;
– those models of organizations that can be combined on the basis of their representation as objects of creative initiative. The results and details of the proposed classification will be discussed in the following sections.

We also refer to the objectives of this study:

– classify types of organizations and their behavioral patterns;

– develop adequate approaches to the introduction of innovative systems and the development of correct innovation management policies in organizations;
– evaluate the organization according to its commitment to the principles of innovative development, indicating as a criterion the importance of innovation and interest in them in the strategic development plan of the company.

## 2 Methodology

This study used general scientific methods of cognition. In this study, general scientific methods include: theoretical and empirical. The theoretical level involves research based on conclusions and reasoning. The authors analyzed the scientific literature, decomposed the scientific problem into parts or elements for detailed study. They also resorted to synthesis—a common system is formed from different elements of the subject, which the researcher studies. In terms of the empirical function of economic science, observation and data collection were used. The researchers reviewed and analyzed different types of organizations and their behavioral models. They formed a new approach to the introduction of innovative systems and the development of a correct innovative management policy in organizations. The authors developed a model for evaluating the organization according to its commitment to the principles of innovative development. The authors systematized the data and made reasoned conclusions.

## 3 Results

Based on the socio-economic environment, the characteristics of technological and personnel equipment, the historically conditioned decision-making regime, any organization chooses the optimal model for it, the type of behavior, and the way in which the selected strategies are implemented.

We can classify the types of organizations and their behavioral patterns as follows:

(A) “classic (conjuncture algorithm)”;
(B) “marketing”;
(C) “organization of technological breakthrough”.

Consider the above types and models and their features in more detail, as well as explicitly denote their fundamental differences from each other. Simply based on the name, we can understand the peculiarities of the activities of organizations allocated by us to subgroup (A): all enterprises falling into this group are characterized by a monoplexal connection with the market, that is, all innovative and technological solutions being introduced have the so-called catch-up background, that is, they are aimed at synchronizing with current technologies and current changes in the external market environment affecting the production process of the company [3].

The marketing enterprises (that is allocated with us in group (B), differ in emergence of a certain expected mechanism, i.e. attempt to foresee and orient on future requirements of the market, making preparation for introduction of innovations in advance. Thanks to it such organizations have an important opportunity to influence the market environment, to change the market, focusing it on themselves.

The organizations which can be carried to group of technological breakthrough (innovative attack) (C) continuously rely in the activity on research and development developments, carry out monitoring of achievements of a scientific and technological revolution and sometimes even interact with her driving forces, for ensuring preservation of the leading positions in the market. However this strategy has also a number of negative features connected first of all with high risks (for example, an investment of the significant sums on a research or implementation of new technologies which success and profitability isn't guaranteed).

The above classification allows you to evaluate the organization according to its commitment to the principles of innovative development, indicating as a criterion the importance of innovation and interest in them in the strategic development plan of the company. However, the degree of dependence on the external environment and the peculiarities of relations with external entities can be put at the forefront, in which case the classification will be different.

According to the above-mentioned criterion, as well as according to the management concept used, the organization can be divided into four main types:

- enterprises operating on the basis of theoretical postulates of scientific management;
- enterprises focusing on the aspect of internal social interaction;
- enterprises that organize business activities based on the results of analysis on the concept of system theory;
- enterprises that are a form of public institution or have most of the characteristics characteristic of them.

The first approach can be called mechanistic or classical, since it combines most basic ideas about the norms of management models. This approach has a large theoretical basis, a significant amount of scientific literature was devoted to its analysis. With this approach, the enterprise is considered as an interconnected complex of resource potential, production factors with the leading role of technical and economic ties within production, that is, here we observe typically the legacy of industrial production. Despite the seemingly archaic approaches and views on the production process, this model has not lost relevance, although it is mainly applicable to large industrial production. One of the main features of this model is focusing on internal optimization, maximizing the effective use of all available resources and increasing efficiency within organizational management. Accordingly, the place for the introduction of managerial innovation remains only in the field of optimizing and rationalizing the internal infrastructure of the organization, improving metalogical approaches and progressive evolution and the information production process.

The next approach to the management of the innovation process is the social orientation of the internal management of the enterprise. In this case, we consider an enterprise primarily as a set of human resources, that is, a team of people engaged in various activities, but having common goals. With this approach, it is important to pay attention to employees, control their level of motivation, investigate the impact of various types and mutual communications on the effectiveness of their activities, and also increase loyalty. Of course, the main factor here is the chosen management style—authoritarian or democratic. Despite the fact that most researchers point to the greatest effectiveness of the democratic style, characterized by the presence of complex mutual ties between management and subordinates, which in turn increases their involvement and interest in business processes and even involves the possible participation of employees in the management decision-making process (including innovative), the authoritarian style of management still remains relevant, especially in cases of strong influence of the external environment on work and production processes, that is, for example, in the event of an economic crisis, etc. In both cases, the main task of the manager is to achieve the goals set for the structural unit in general or the enterprise as a whole, to fulfill all the developed strategic innovation plan. Thus, the main indicator of the success of the described approach is the improvement of performance as a result of the incentive impact on the staff of the organization [2].

Note some similarities with the first approach, which consists in focusing on internal reserves, the importance of analyzing internal factors of the enterprise and, if not ignoring, then taking into account the role and significance of external factors and the external environment only in the second place. Thus, both described models can be called "conditionally closed" or partially closed, since they are dominated by an internal strategy. The basic approaches to implementing management innovations in the organization, which we will consider below, can be conditionally attributed to "open" models.

In the case of the third model, the enterprise is considered as a complex complex of interconnected subsystems with a hierarchical nature of relations, while closely related to the environment. This model is based on the developments of the general theory of systems, the main idea of which is to represent any object (organization) as a composite whose elements are connected to each other and revealing the significance of the relations of this object with the external environment, a conditional external environment (industry or market in general) can also be represented as a complex object, the components of which will be the subjects under study, for example, a number of enterprises, including the one considered initially.

The criterion for the success of enterprises of this type is efficiency in both areas of activity:

- from the external sphere the enterprise can and should receive various types of resources, including information or innovative technological processes,
- the internal sphere is identical to the main field of activity of closed systems, taking into account the fact that efficiency in the internal sphere is responsible for the quality of the transformation of external resources into manufactured products and services [4].

The main role in innovative implementations in this case is taken by strategic management, the development of strategic plans and the success of its implementation according to the criteria of completeness and urgency). The fourth model proposed by us involves an analysis of the organization based on an understanding of its basis as a public education, an institution. Economic activity in this case is of interest both for groups both within the organization and groups external to it, and we consider it important to note that formally the content and composition of these groups can intersect [5]. Consensus among these groups in dealing with different issues or simply reconciling their interests tends to be at the forefront. The activities of such an organization are determined not only by the typical content of economic relations, that is, the production of products, its sale or the provision of services, but also by the observance of the non-economic interests of counterparties, as well as, for example, the fulfillment by the company of a number of social obligations. Managing innovations in an organization of this type is the most time-consuming and complex process, since the result of effective management should be profitability of production, but also respect for the multidirectional interests of business entities, that is, the achievement of any of the set goals is hindered by a number of restrictions related to the obligations and requirements for the fulfillment of other, unrelated goals that have the same resource base.

It should be noted the theoretical nature of the classification we give, in practice there is a process of combining different models, as well as the evolutionary transition between in connection with the change of economic priorities, modification of aspects of activity, etc. Management features depending on the nature of the dominant model of the enterprise are presented in Table 1 and Fig. 1 [6–8].

**Table 1** Management features in different organization models

| Control characteristics | Management objectives | Nature of communication with the external environment | The principle of adaptation to the external environment |
|---|---|---|---|
| Organizations coming classically (conjuncture algorithm) | Short-term (profit growth and profitability) | Monoplex | Passive response |
| Marketing organizations | Long Term | Duplex (link in both directions) | Active response |
| Organization of technological breakthrough | Strategic (leadership on market) | Duplex | Creative and innovative behavior |

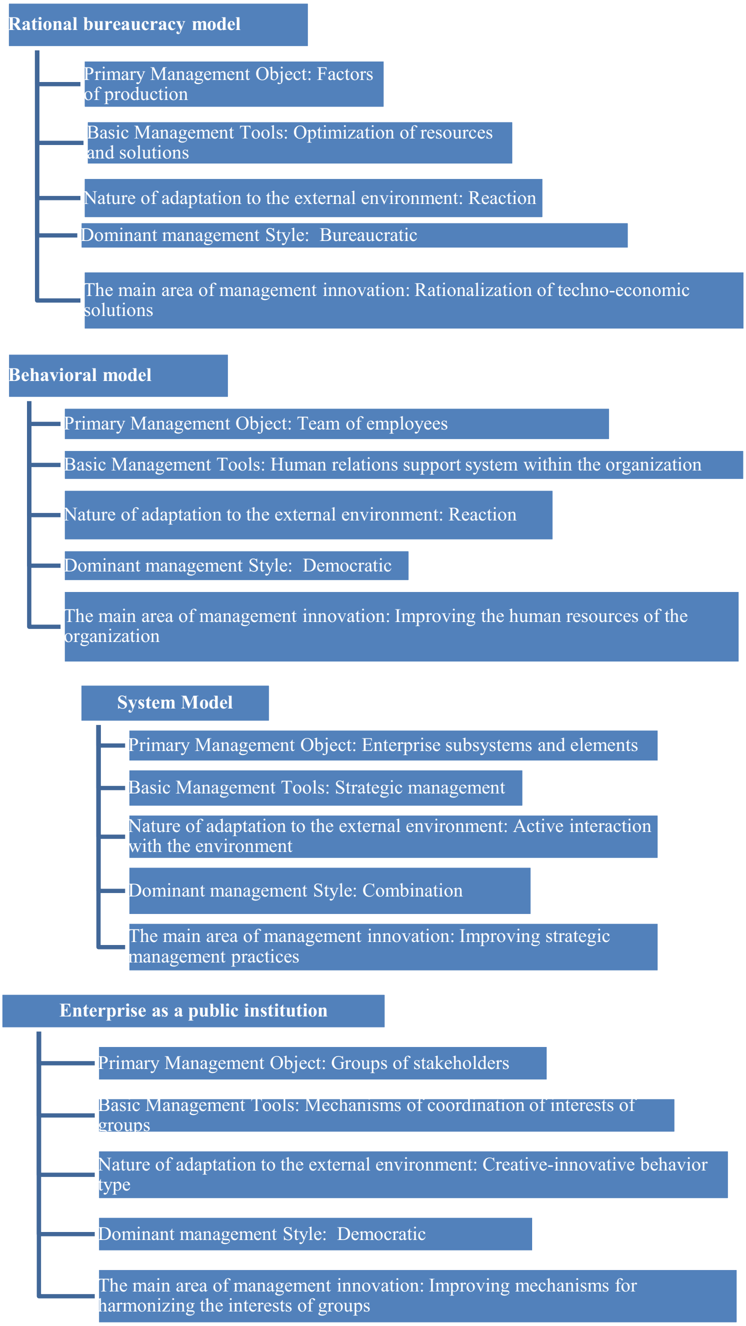


**Fig. 1** Peculiarities of the enterprise organization in models of various types taking into account the main areas of management innovations

## 4 Conclusion

In the process of analyzing the activities of most organizations, researchers usually note the presence of characteristic properties for all the listed models, in each particular case the share of a particular concept is determined on the one hand by the appropriateness of its use, and on the other hand by objective factors (for open models these are environmental factors, for closed ones—the state of internal resource potential). To create adequate approaches to the introduction of innovative systems and the development of a correct innovative management policy in organizations, it is considered right to first of all carry out diagnostics to identify features characteristic of a particular model of the enterprise. Thus, it is possible to identify the most appropriate areas of change in the internal management of the organization. Even in the case of a closed model, we consider it important to pay attention to those innovative methods that are characteristic of models with a greater share of external participation, that is, an increase in this share in one form or another is a manifestation of the development vector of the modern innovative post-industrial economy.

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# Mathematical Models for Information Flow Processes Management

**A. Korablev, M. Petrushova, and K. Kornilova**

**Abstract** In the modern conditions of the digital economy, the efficiency of the enterprise management system is based on the constant optimization of the movement of information flows. Enterprise management activity is a set of business processes, the functioning of which is based on the movement of information. The information resource management system is allocated within the framework of a single complex of information support for the management system. The development and implementation of a complex of information flow management in a particular enterprise depends on various factors: the organizational structure, the field of activity, the significance of specific information. The main criterion for the quality of management is the efficiency of processing stream processes. Reducing the processing time of documents can be a problem of queuing theory. It is necessary to implement this task under the condition of a systematic construction of information support. To effectively manage the quality of the service provided, it is necessary to build a mathematical model that describes the operator's work on collecting and processing information flows, based on the mathematical apparatus of the theory of queuing in systems with expectation. The most important problem remains the integration of the information support system of management processes into a single information management system of the organization. These issues can be solved when designing the information support of the information flow management system based on the process approach.

**Keywords** Distribution law · Information flow · Information management system · Mathematical expectation · Variance

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## 1 Introduction

The allocation of information flows as a separate object for research appeared in the last stages of the development of science with the appearance of the first automated control systems. Their implementation made it possible to determine the sources of occurrence, direction and receivers of information flows in control systems. It was at this time that the concept of information management support emerged. Foreign researchers define information support as an effective system of organization, the use of information systems to ensure economic processes [1].

It is obvious that information support plays a leading role among all subsystems that provide management of the organization, since the effectiveness of the organization's activities directly depends on its information relations, both with the external environment and with internal management objects. The subsystem of information support of management processes performs a large functional and, accordingly, has a complex organizational structure, while being, in accordance with the methodology of the system approach, a complex system. The formation of information support should be based on a systematic approach. It is necessary to base the construction of a system of information support for the processes of all types of activities of the organization: planning, management and control. Despite the increasing role of the information resource in modern society, the concept of information management is still not precisely defined.

In contrast to the previous technocratic approach, information management is beginning to be seen as a new discipline in its infancy. Information activity is not only an interconnected group of functions for receiving and moving information, but also the ability to influence the capital and funds of an organization. One of the main goals of information management is beginning to be called improving the competitiveness of the organization, the ability to quickly and efficiently implement new technologies in the organization's activities [1]. The choice of promising technologies should be based on economic analysis and synthesis of external information.

The analysis of existing systems showed that there are the following prerequisites for improving the efficiency of information flows: reengineering of the information process, setting up technological equipment, and implementing an information platform. In practice, the following set of technological platforms is possible: a universal workplace, from the point of view of a queuing system—a single-phase, single-line system; a set of several specialized operating operator stations—two-phase, single-line; a set of several universal operating operator stations—multi-line, single-phase [2]. The functional purpose of the operator stations determines the different complexity and duration of the technological procedures, which affects the probability of a queue among the elements of the flow for processing.

The appearance of a queue of flow elements during customer service can lead to undesirable consequences: reputational risks; reduction of income due to the refusal of customers to increase cash turnover on the current account; increase in the number of errors in the work of the staff. For example, when providing cash and settlement services to customers, it is possible to reduce the time for processing payment documents by solving the following issues: professional development of operational personnel; the most complete provision of information to customers about services and rules, high-quality training of customers; minimization of operations performed by the personnel of the cash and settlement division in manual mode (increasing the level of automation of business processes); improving the process of collecting and processing documents; optimal routing of information flows when working with documents.

## 2 Methodology

When designing information support for a service management system, it is necessary to integrate various system modules (personnel, equipment, technologies) into a single information space. At the same time, the main task is to choose a mathematical model for collecting and processing payment documents. Let's consider a mathematical model of a single-line queuing system with waiting, which includes: elements of the information flow (in the form of a Poisson flow) with intensity X, the time of processing documents in the form of an arbitrary distribution P. The queue is served according to the rule: first come—first served. The queue length may not be formally limited, but there are limitations, such as the operational time of operation.

The state of the model, expressed in qualitative indicators, is calculated using the Pollacek-Khinchin formula [3]. There is a modification of this formula that allows you to determine the average time of finding documents in the information system, the total time of waiting in the queue and processing.

$$M(\bar{t}) = \bar{t}_m + \frac{p * \bar{t}_m}{2(1-p)}\left[1 + \left(\frac{\sigma}{\bar{t}_m}\right)^2\right] \quad (1)$$

$\bar{t}_m$ —average time spent on documents in the system;
$p$ —workplace utilization rate;
$\sigma$ —the standard deviation of the time when the documents are in the system.

The parameters $\bar{t}_m$ and $\sigma$ can take different values, and the value p is limited to the scope of the formula, $p$ can not take values greater than one. The presented one-line model can describe the operation of the following operator stations: universal workplace, specialized workplace. At the same time, each of the operator's operating modes corresponds to a certain law of service time distribution. Depending on the ratio of the intensity of various document processing processes and the functions of the operator stations, the service time may vary according to the laws of distribution: uniform distribution law-a specialized operator station for processing documents in electronic form; the normal distribution law is a specialized workstation for receiving documents; the exponential distribution law, the gamma distribution, or the Weibul-Gnedenko distribution is a universal operator station.

In the queuing system, it is determined that a constant (uniform) service time is optimal, and an exponential distribution is unacceptable, despite the fact that the gamma distribution can take values of the standard deviation greater than a random variable [4].

With an exponential distribution of the document processing time ($\sigma = 1$), the formula (1) will take the form:

$$m(\bar{t}) = \bar{t}_m + \frac{p * \bar{t}_m}{1 - p} \tag{2}$$

The average processing time of the flow element according to the results of testing the information support system is in the range of 90–560 s. To determine the average waiting time of a work item in the queue with exponential processing time ($\sigma = 1$), we use the formula derived from the formula of Pollaczek-Khinchin:

$$T_M = \frac{p * \bar{t}_m}{1 - p} \tag{3}$$

The nature of the dependencies in the studied parameters were calculated based on Eqs. (2) and (3) shows that the value of p = 0.8 revealed a monotonic growth functions [5]. The probability of a queue for processing from documents is determined by the Poisson formula.

$$P_k(t) = \frac{(\lambda t)^k}{k!} e^{-\lambda t} \tag{4}$$

t—time; λ—the intensity of the document stream;

k is the number of documents in the information system.

For a system with a single operator station, the probability of a queue is determined by the formula (5)

$$P_r = 1 - \sum_{k=0}^{1} P_k(t) \tag{5}$$

The calculation results are presented in the Table 1.

As you can see, the probability of a queue in the control system increases with the number of flow elements. It is necessary to determine how the average time of the flow element's stay in the information support system will change with a decrease

**Table 1** The probability of a queue of documents appearing in the information system

| p | 0,1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|
| P(t) | 0.003 | 0.02 | 0.04 | 0.07 | 0.11 | 0.13 | 0.14 | 0.18 | 0.3 |

**Table 2** Average time spent by applications in the information system for exponential distribution

| Reduction percentage | 5% | 10% | 15% | 20% | 25% |
|---|---|---|---|---|---|
| $\bar{t}_m$ | 285.0 | 270.0 | 255.0 | 240.0 | 225.0 |
| p | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 |
| $m(\bar{t}, p)$ | 542.9 | 490.9 | 443.5 | 400.0 | 360.0 |
| Efficiency improvement, % | 9.5 | 18.2 | 26.1 | 33.3 | 40.0 |

in the time that the operator spends on processing the flow element (with a decrease in the intensity of the flow elements ‘ arrival and the operator’s workload).

Let’s use the formula (2) $\bar{t}_m = 300$, p = 0.5, $m(\bar{t}, p) = 600$ (Table 2).

Reducing tm and p by 15%, will reduce the processing time of the document $m(\bar{t}, p)$ by 43.1%, a qualitative jump in the provision of the service.

$$Q_r = \frac{(M_0(t) - M_c(t))}{M_0(t)} \tag{6}$$

$Q_r$ is a value that characterizes the reduction in the residence time of the flow element.

It is important to know the absolute value of the ratio of the residence time of the flow element in the information support system for the existing and new service method, which is calculated by the formula (7).

$$Q_a = \frac{M_0(t)}{M_c(t)} \tag{7}$$

The existing theoretical possibility to reduce the absolute value of the ratio of the residence time of the flow element in the information support system by 5.5 times with the utilization factor. It is possible to use a workstation with a coefficient from 0.8 to 0.9 as much as possible.

The processes of working with flow elements depend on a large number of external and internal factors, so the distribution of work time may differ from the uniform and exponential distribution laws, so let’s compare the time dependence with the distributions: normal; the gamma distribution; the Weibull-Gnedenko distribution.

Normal distribution. A random variable X obeys the normal distribution law if the distribution of its reduced value is F(x). The definition of the normal distribution is presented in the form [6]:

$$Y = \sigma \times X + M \tag{8}$$

X is a random variable with the distribution F(x);

$$M = M(Y)$$

The normal distribution is used in various management decision-making methods (statistical processing of customer service processes, resource base analysis, etc.).

When processing flow elements, by default, we enter that for the normal distribution:

$$\sigma = \bar{t}_m * 20\% \tag{9}$$

Gamma distribution. Distributions of this type are used in the study of distributed economic systems [7].

For the study of documentary systems, the variance is determined by the formula (10).

$$D = \frac{\alpha}{p^2} \tag{10}$$

$\alpha$—determines the significance of the value used to calculate the variance. By default, we assume that the parameter is 0.07.

It should be taken into account that the gamma distribution at $\alpha = 1$ is an exponential distribution. Weibull distribution. The distribution of this type is used to determine the reliability of the systems under study, to determine the time of stable operation of the system elements [8].

The variance of the distribution is calculated by the formula (11).

$$D = p^{\frac{2}{\alpha}} \left[ \frac{2}{\alpha} \tilde{A}\left(\frac{2}{\alpha}\right) - \frac{1}{\alpha^2} (\tilde{A}\left(\frac{1}{\alpha}\right))^2 \right] \tag{11}$$

$\tilde{A}(\alpha)$ is a gamma function, by default we assume $\alpha = 2$.

The average time spent by the flow element in the information system, which consists of the waiting time of the flow element in the queue and the processing time of the flow element, is determined by the Pollacek-Hinchin formula:

$$m(\bar{t}) = \bar{t}_m + \frac{p * \bar{t}_m}{2(1-p)} \left(1 + \left(\frac{\sigma}{\bar{t}_m}\right)^2\right) \tag{12}$$

## 3 Findings

The efficiency of working with the elements of the information flow depends on the intensity of the service. When it increases, the power of the flow or receipt of documents decreases. Changing the service intensity is allowed in the following ways: routing organizational processes by describing and then optimizing information flows; automating procedures with maximum frequency, as well as phase transitions

**Table 3** Average time spent by documents in the information system

| Type of distribution law | p | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| Exponential | 0.80 | 1.22 | 1.66 | 2 | 2.5 | 3.33 | 5 | 10 |
| Uniform | 0.90 | 1.11 | 1.33 | 1.5 | 1.75 | 2.16 | 3 | 5.5 |
| Normal | 0.85 | 1.16 | 1.49 | 1.74 | 2.11 | 2.73 | 3.98 | 7.70 |
| Gamma | 1.04 | 1.25 | 1.47 | 1.64 | 1.89 | 2.33 | 3.21 | 5.88 |
| Weibull | 0.98 | 1.24 | 1.51 | 1.71 | 2.01 | 2.52 | 3.53 | 6.57 |

between them; replacing outdated technological equipment with modern analogues with improved characteristics; improving the scanning procedure (encoding content in the form of a barcode), which will reduce the number of errors due to distortion of the scanned information; transfer of operational and cash work on the receipt of payment documents to the remote service system. The results of the study are presented in the Table 3.

It should be noted that the results obtained, reflecting the change in service time, are located in the numerical range characteristic of a uniform and exponential distribution. At the same time, there is a possibility that at certain values of the studied parameters, the worst dependence of the time spent by the flow element in the information system on the operator station utilization factor (gamma distribution) will appear, in terms of the quality of the service provided. This may occur due to the movement of the average service speed value to the region of large values, there is a shift in the load of operator stations. It is advisable to consider the uniform and exponential distribution as borderline service options, the minimum queues of documents in the information system will be at a constant service time, and the maximum queues will be at the implementation of the service according to the exponential law.

It is revealed that reducing the time for processing the information flow gives a significant effect in the form of reducing the stay of the flow element in the queue. It should be noted that the number of threads in the queue depends minimally on the law of distribution of service time and on the average duration of service. These options (non-linear dependencies) should be taken into account when improving the software.

## 4 Conclusion

The results obtained, reflecting the change in service time, are located in the numerical range characteristic of a uniform and exponential distribution. At the same time, there is a possibility that at certain values of the parameters under study, the worst dependence of the time spent in the information system on the utilization rate of the operator station (gamma distribution) will appear, in terms of the quality of the service provided. This may occur due to the movement of the average service speed value to the region of large values, and the load of operator stations is shifted. It is advisable to consider uniform and exponential distribution as borderline service options, i.e. the minimum queues of documents in the information system will be at a constant service time, and the maximum queues will be at the implementation of the service according to the exponential law.

It was found that reducing the time for processing documents has a significant effect in the form of reducing the document's stay in the queue. It should be noted that the document's stay in the queue minimally depends on the law of distribution of service time and on the average duration of service. These options (non-linear dependencies) should be taken into account when improving the software.

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# Innovations in the Industrial Sector: Modernization of the Country's Economic Space

**Yu. V. Sharikova, E. S. Popova, and A. K. Titov**

**Abstract** The article investigates the actual issue of innovative modernization of the industrial sector and the degree of its influence on the economic space of the country. The aim was to study innovations in the industrial sector with the subsequent modernization of the country's economic space. For this, the following tasks were solved: the role of industry is shown, since it provides 40% of the country's GDP; describes the most popular areas of innovation at manufacturing enterprises; the significance of the industrial sector from the point of view of its historical formation is given. The works on the innovative economy and the economic spatial sector were studied. The role of industry is shown because it provides 40% of the country's GDP. The most popular directions of innovation in manufacturing plants are described. The significance of the industrial sector is proved from the point of view of its historical formation. The newest industrial sector industries are given. The three main directions of the development of technologies will be described, which will allow industry to recover faster in 2021.

**Keywords** Artificial intelligence · Country's economic space · Digitalization · Industrial revolution · Industry 4.0. · Production

## 1 Introduction

Innovations today find their application in all areas of activity. The industrial sector has not exceeded. This is the most important segment of the economy, because its share in the country's GDP has about 40%. About 32% of the population is employed in this sector, at enterprises that are engaged in raw materials, products and production of labor instruments [1]. The most popular areas of innovation in manufacturing enterprises in 2019–2020 were the acquisition of advanced equipment and machines (58%); personnel training for advanced technologies and innovations (54%) and the acquisition of technologies (42%). Almost half of the companies (43–46%) plans

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to introduce large data, robotization of business processes and artificial intelligence, although at the moment they are found in the manufacturing sector quite rarely—only 14–16% of companies. Also, industrial enterprises are planning to introduce smart production (56%), fully automate business processes (55%) and use energy saving technologies (48%) [2]. Innovations passing under the auspices of the "Industry 4.0" are conjugate with the digitalization of enterprises, the Internet of things, video analytics, artificial intelligence, virtual reality and machine learning. The development and modernization of the industrial sector affects the indicators of the economic sector, thereby strengthening the position of the country in international markets. Developed countries spend billions of dollars to support breakthrough technologies, including in industry. This allows the economies of these states to remain competitive and improve the standard of living of their citizens.

## 2 Methodology

The industrial sector is represented by heavy and easy industries. Heavy includes mining, part of the industries of mechanical engineering, chemical industry, as well as energy, metallurgical and building materials. Light industry consists of all types of light and food industry [3]. With the development of capitalist society, the role of industry has constantly increased, which was especially manifested during the industrial revolution at the end of the XVIII-XIX centuries, at the time of the greatest activity and development of the mining industry, the construction of new factories and plants, as well as rapid capacity building, an unprecedented increase in energy consumption of any species, and as a result—brewing environmental problems. The industrial revolution was noted in the invention of the steam engine, the mass production of textile products, the construction of railway tracks, invention of the telegraph and many others.

The rapid growth of industry at the end of the XIX and the first half of the XX century, allowed it to take a key place among the industrial production sectors in terms of product cost. It is important to note, in terms of the value of products, the industry exceeded agriculture by 1950 twice, and by the end of the century—by 7–8 times. By the beginning of the XXI century, the largest share of industry - at the level of 50–60% of GDP is characteristic of developing countries that have reserves of minerals of world importance. It is based on the fact that these countries are developing export-oriented mining industry. It is also typical for some countries with economies in transition.

The share of industry in the economy gradually decreased, it was provoked by the search for alternative types of energy, the intensification of production, a decrease in its energy intensiveness, and what is the most important—active development of the scope of services. The share of industry decreased to 20–40%. This trend has become characteristic for the beginning of the XXI century [4]. The industry is the most material consumption of the global chain, which annually gives several tens of billions of tons of various types of fossil and a large number of ores of black and non-ferrous metals, building materials, etc. However, it is worth noting the fact that the number of mined minerals at the beginning of the XXI century twice increased compared to 1970. At the same time, the cost of producing industry products is only 10% of the global industry, since the price of extracted raw materials in most cases is quite low.

At least 1% of gross global products account for the development of quarries and mining of minerals. Mineral consumption is concentrated in total in several regions of the world. There are countries such as USA, Canada, EU, Japan, Australia, in which at least 15% of the entire population of the Earth live, together they consume most of the metals that are produced in the world. Thus, the industry is a complex of organizations, institutions, enterprises producing the same type of goods and services, applying similar technologies that satisfy the need for nature.

The newest industries include: microelectronics, computing technique, robot buildings, atomic production, aerospace production, microbiological industry, industry of informatics. The most developed sectors of the Russian industry are the oil and gas sector, black and non-ferrous metallurgy, general and transport engineering, food production. The characteristic feature of the industrial sector is the regional and complex-forming functions. The high level of the manufacturing industry provides a worthy standard of living and serves as the basis for positive public changes (availability of housing, motorization, development of infrastructure elements), thereby improving the ecosystem of the country's economic space.

## 3 Results

The new technologies can help to speed up this process and ensure the sustainability of the industry to future crises. There are three main directions for the development of technologies that will allow industry to recover faster in 2021 [5]. Production companies will use more and more technologies that will allow to manage objects remotely. This will reduce the number of personnel in the workplace. The use of automation and other technologies in the fourth industrial revolution, such as a supplemented and virtual reality, as well as analytics, will ensure the effectiveness of production with minimal impact. This will affect both gross income and the net profit of organizations. Remote control becomes a new norm. With these technologies, equipment, such as forklifts, can be controlled remotely. Specialists can work together with places operators through the AR-headsets without the need for personal presence.

5G network will become the most important element of the next generation enterprises [5]. They will provide a reliable connection with a minimum delay, which is necessary for the fourth industrial revolution. The speed and reliability of 5G networks will allow manufacturers to approach the creation of an intelligent enterprise and realize the full potential of digital technologies [6]. Artificial intelligence will be more widely embedded in the production and supply chains. It will allow you to better predict risks and quickly solve them [7]. The Basic Tools can provide automated solutions literally per second. For example, manage the logistics network, change the transport route and select the delivery method. Technologies such as 3D printing and blockchain will also be actively distributed, since organizations seek to prepare for similar unforeseen events in the future [5]. Engineering will also be given the most important role in the development and effective introduction of innovation in various sectors of the economy. The needs of industry in engineering services are growing, since there is a need for a more accurate configuration of engineering development mechanics as a branch. For example, in Russia, 83 engineering centers were created at universities in 2013, which over the years have managed to become quite noticeable players in the innovation market. The overall revenue of university engineering centers exceeded 26.4 billion rubles, annually the centers are implemented over 2000 contracts for various Russian and international companies [8].

The United States also has a Manufacturing USA Industry Program. It unites 14 private institutions and three ministries (trade, defense and energy) that they finance. In addition, the participants of the program are over 1900 organizations representing small and large manufacturers, scientific circles and other associations [5]. Each institution specializes in a separate area of advanced production technologies. However, they have one goal—to ensure the future of the country with the help of innovation, education, collaboration and production of products. Institutions communicate between the participants of the Program, conduct joint research and development in order to resolve the most complex tasks facing the sectors, as well as to train residents of the country with advanced professional manufacturing skills. The contribution of industry in the country's GDP amounted to 20.2%. At the same time, the share of spending on research and development in the United States is assessed by UNESCO specialists in 2.7% of GDP [5].

China places great emphasis on innovation. The companies from 2009 to 2019 sent over 1.8 trillion US dollars to R&D. The financing of R & D and improving its structure serves as a good help in implementing innovative development strategies, believed in the country's statistical office. At the same time, the areas where the PRC is noticeably lagging behind the developed countries, - in the proportion of fundamental research costs [5]. There is a very high probability that the country will reduce the gap with leading foreign powers. The PRC has created several funds to help local manufacturers. For example, the Industry Assistance Fund has a capital of $ 21 billion. The funds are allocated by the Ministry of Finance of the country and several government organizations. As for the share of industry in China's GDP, in 2019, according to statista.com, it amounted to 39%.

## 4 Discussion

About 80% of financial directors in the field of industrial production expect a pandemic to continue to affect their business. This opinion is separated by 48% of representatives of inter-sectoral companies [2]. Industry has significantly suffered for two reasons: most of the job cannot be done remotely; the slowdown in the economy reduced the demand for industrial products worldwide. To support business during the uncertainty and ensure its sustainability for future crises, enterprises need to be investing in new technologies [9]. At the same time, the restoration of domestic demand from the removal of restrictions has been exhausted. It is known how and when the non-sireless export will be held a third wave of coronavirus. In 2020, the cause of the growth of a number of positions is not oil and gas exports served as possible on the supply of traditional exporters (in which the negative effect of quarantine restrictions was more explicitly and durable than in the Russian Federation). Considering that large-scale restrictions remain in the global economy, this effect will continue to support non-oil and gas exports for some time, and then Russian exports will support the active recovery of global demand.

On the other hand, there is the second side of the medal that in the conditions of the company's pandemic industry turned out to be much more resistant to the service sector. The most significant contribution to the increase in industrial production was able to make those industries that worked for opposition "COVID-19". This is the pharmaceuticals, the medical industry, the production of protection products. Also, the beginning of 2021 was marked by a sharp increase in demand for many Russian export goods in the global market [2]. The fourth industrial revolution slowed down under the influence of a pandemic. The economic downturn did not allow some industrial representatives to invest in new technologies. However, in 2021, this development will accelerate and the industry will try to return to the pre-crisis level.

## 5 Conclusion

The future of humanity is inextricably linked with the improvement and distribution of digital technologies. They will determine all aspects of the life and functioning of society as a whole. The accelerable digital transformation in the coming year promises us big changes. Thus, manufacturing companies will use more and more technologies that will allow managed objects remotely. Artificial intelligence will be widely embedded in production and supply chains. It will allow to better predict risks and quickly solve them. 5G networks also become an essential element of the development of enterprises of the new innovation generation. They will provide a reliable connection with a minimum delay, which is necessary for the fourth industrial revolution. Technologies such as 3D printing and blockchain will not force digitalization. They will actively spread, because organizations seek to prepare for any unforeseen events in the future and is much easier to react to uncertainty. As the pandemic showed, the most important factor for enterprises and institutions today is the readiness to respond quickly to unforeseen situations and implement innovations to improve business efficiency [10]. The basis of such innovation is a smart and scalable network infrastructure that ensures the security and flexibility of business processes.

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# Conducting Special Tracer Researches for Selecting Technologies to Increase the Oil Recovery

**I. V. Pavlov and G. S. Mozgovoy**

**Abstract** The article presents the results of integrated tracer, photocolorimetric and potentiometric studies of oil and associated water produced at the Baytugan field, which made it possible to assess the uniformity and current state of the development of reserves in one of the areas, propose an optimal design of the enhanced oil recovery technology, assess the overall efficiency of the work, and the contribution of various mechanisms for increasing the oil recovery factor (ORF), individually for wells to outline further promising geological and technical measures (GTM). The "fast" filtration channels discovered at the first stage of research during the first 20 days predetermined the need for the use of low-viscosity gel-forming compositions with Newtonian rheological behavior, which, when injected into the formation, maximally repeat the injectivity profile of injection wells and are capable of deep penetration into channels with LFR with their subsequent isolation. A complex of special tracer studies performed at the Baytuganskoye field, combined with photocolorimetric analysis of oil and determination of salinity of produced water, made it possible to clarify the general hydrodynamic relationship between wells, identify "fast" filtration channels, their direction and filtration-capacitive characteristics, and assess the relative distribution of drained reserves, identify sources of water cut in wells, propose EOR technology and optimize its design, clarify the subsequent mechanism of oil recovery factor and the overall achieved efficiency.

**Keywords** Tracer studies · Oil absorption coefficient · Salinity of produced water · Enhanced oil recovery · Sweep efficiency · Displacement coefficient

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## 1 Introduction

The implementation of enhanced oil recovery technologies is almost always accompanied by a lack of initial knowledge about the hydrodynamic relationship between injection and production wells, the features of the waterflooding front propagation and reservoir properties (reservoir properties) of specific areas of the field, while the choice of the technologies themselves, as well as the management of the technological parameters of their implementation, such as the volume of injected formulations or the level of residual hydrodynamic resistance created, is carried out on the basis of only general information. In order to increase the efficiency of the planned geological and technical measures and the existing development system as a whole, hydrodynamic, geophysical, geochemical and many other types of studies of wells and developed formations are carried out at the fields [1]. One of the most informative methods for studying the interwell space are tracer studies based on marking filtration flows from injection wells with various substances—indicators that are not found in natural reservoir conditions, followed by mathematical interpretation of the results of detecting these substances in the production of surrounding production wells [2].

In the general case, computer modeling of the conditions of mass transfer and the calculation of the corresponding characteristics of the identified groups of channels participating in this process allows us to establish:

- hydrodynamic connection between wells;
- productivity of the identified channels, their contribution to the water cut and the operation of production wells;
- distribution of filtration rates of the pumped liquid;
- permeability of the corresponding groups of channels, their volume and cross-sectional area;
- fracture parameters and flow type;
- the share of non-productive water injection of the reservoir pressure maintenance system (PMS);
- the presence of interstratal and behind the casing flows, lithological replacements, tectonic faults, etc.

Nevertheless, tracer studies with a short monitoring period make it possible to identify only the "fastest" channels with the so-called abnormally low filtration resistance (LFR), the flow of water through which from injection wells in the classical view occurs without performing useful work to displace oil [3]. The implementation of studies of longer duration, when monitoring is carried out for several years and there is a significantly greater coverage of the reservoir by study, is more laborious and costly, therefore, according to the analysis, the vast majority of tracer studies performed in Russia cover less than 0.5–5.0% the specific volume of the collector in the corresponding areas of work [4]. To ensure greater reliability and information content of tracer studies, especially in the conditions of short monitoring sessions, the experts of Expert Technology LLC have developed the following recommendations:

- the indicators used must have good solubility in the injected water and be stable, must not be sorbed by the rock and dissolve in oil, must be reliably detected by the analytical methods used at minimum concentrations, and must also be absent from the natural background of formation waters and water of the reservoir pressure maintenance system [5];
- the monitoring period, in the general case, should ensure the accumulated removal of the indicator from the used amount of at least 0.1%, preferably >1%;
- for short-term studies (up to 3 months), the concentration of the injected indicator solution must exceed the minimum detection threshold of the tracer by at least 5 orders of magnitude; in the case of longer studies, an additional increase in concentration by 10–30 times is recommended;
- the determining factor in identifying the hydrodynamic connection between wells is the average daily volume of water injection into the investigated injection well, as well as the distance to the producing wells, and not their productivity [6];
- ceteris paribus, the lower the injectivity of the injection wells and the productivity of the production wells, the more the concentration of the labeled rims should be increased and their volume reduced.

Separate opportunities are provided by the integration of tracer studies of the reservoir pressure maintenance system with photocolorimetric studies of oil produced by wells, as well as analysis of the composition and salinity of the produced water [7]. The considered complex provides not only additional information necessary for a reasonable selection of impact areas and planning of enhanced oil recovery technologies, but also allows assessing their effectiveness, since it is implemented before and after work on changing filtration flows in two stages, respectively [8]. It should be noted that it is quite convenient to combine these studies, since the costs associated with sampling well products, their separation and delivery to the laboratory remain unchanged and are already included in the production cycle for tracing filtration flows.

## 2 Methodology

Let us consider a specific example of the implementation of such studies and the results of the implementation of an integrated EOR technology performed at the end of 2019 at the Baytuganskoye field at the section of injection well No. 85. The Baytuganskoye oil field is located 60 km north of the town of Buguruslan on the border of the Orenburg and Samara regions. In the regional tectonic plan, the field is confined to the Baytuganskiy swell of the same name—a structure of the second order located on the Soksko-Sheshminskaya system of swells on the southwestern slope of the South Tatar arch. The Baytugan fold is an intricately constructed trap of a combined type and contains fragments of all forms of paleorelief that existed on its territory at various stages of geological development [9]. Commercial oil-bearing capacity at the Baytuganskoye field was established in the deposits of the Lower and

Middle Carboniferous in the formations B2 of the Bobrikovsky horizon, C1S of the Serpukhovsky, B1 of the Tournaisian and A4 of the Bashkirian stages. Formation B1 is the main development target, represented by porous, cavernous-porous and dense limestones, less often dolomites. The B1 oil deposit belongs to the reservoir type, however, practically over the entire area it is underlain by water, pure oil zones are distinguished only in the very arch part of the structure and locally in the area of single wells. Also, a feature of the geological structure of the B1 formation is the absence of dense interlayers of rocks that are consistent over the area and the presence of decompaction zones with increased fracturing of rocks formed as a result of complex structural-tectonic processes during the formation of the trap.

The average depth of the B1 formation top is –912.6 m at the absolute elevation, the oil–water contact (OWC) is taken at a depth of -941.0 m. The total thickness of the formation varies from 36.5 to 43 m, the effective thickness—from 6.1 to 31, 6 m, oil-saturated—from 3.3 to 29.1 m. The average value of the reservoir permeability coefficient is 11.0 mD, porosity—0.11 unit fraction, net-to-gross ratio—0.57 unit fraction, dissection coefficient—10.7 units, while individual wells penetrate up to 34 interlayers with a thickness of 0.3–9.8 m. The main geological and physical characteristics and physicochemical properties of reservoir fluids are presented in Table 1.

To identify potential candidate wells and areas for work on changing filtration flows in order to increase oil recovery, a simultaneous sampling was carried out according to the following criteria:

- injection wells should have an uneven injectivity profile, and the partition coefficient should be $\geq$2 units;
- the permeability of productive layers should not be lower than the standard values, and the coefficient of variation of permeability $\geq$50%;
- residual recoverable oil reserves at the work sites must be $\geq$5000 tons;
- the average water cut of wells by the impact areas should be 40–90%, and the current fluid rates should ensure a cost-effective level of additional oil production after the works;
- the rate of increase in water cut should be high, typically $\geq$2% / month.
- injectivity of injection wells should ensure the possibility of injecting the planned volume of compositions with the recommended modes and volumetric flow rates;
- desirable areal heterogeneity of reservoir properties and current reservoir pressure;
- in order to more objectively assess the technological efficiency of the work carried out in the target areas, other geological and technical measures should not be carried out, nevertheless, in a number of cases, an integrated approach allows achieving a greater synergistic effect, but requires factor analysis.

Other criteria not noted above for the selection of candidate wells to a greater extent determine the choice of an effective stimulation technology, rather than the effectiveness or prospects of EOR operations in general. To assess the hydrodynamic picture and monitor the existing filtration flows from the side of injection well No. 85, ammonium nitrate in the amount of 600 kg was chosen as the base indicator (stage I of research), as a control indicator pumped in after the EOR (stage II) was Urea was

**Table 1** Geological and physical characteristics of the B1 reservoir Baytugan deposit

| No | Parameters | Values |
|---|---|---|
| 1 | Deposit type | reservoir |
| 2 | Collector type | carbonate |
| 3 | Average depth of the roof / absolute mark, m | 1191.4/-912.6 |
| 4 | Average total thickness, m | 40.6 |
| 5 | Average net oil pay, m | 15.1 |
| 6 | Average effective water-saturated thickness, m | 6.5 |
| 7 | Porosity coefficient, unit fraction | 0.11 |
| 8 | Permeability coefficient, $10^{-3}$ $\mu m^2$ | 11.0 |
| 9 | Oil saturation coefficient, unit fraction | 0.81 |
| 10 | Net-to-gross ratio, unit fraction | 0.57 |
| 11 | Dismemberment coefficient, units | 10.7 |
| 12 | Initial reservoir temperature, ºC | 27 |
| 13 | Initial reservoir pressure, MPa | 10.8 |
| 14 | Oil viscosity in reservoir conditions, mPa s | 20.3 |
| 15 | Density of oil in reservoir conditions, t / $m^3$ | 0.8775 |
| 16 | Density of oil in surface conditions, t / $m^3$ | 0.890 |
| 17 | Absolute mark OWC, m | – 941.0 |
| 18 | Volumetric coefficient of oil, unit fraction | 1.031 |
| 19 | Sulfur content in oil,% | 3.21 |
| 20 | Paraffin content in oil,% | 4.50 |
| 21 | Oil saturation pressure with gas, MPa | 4.13 |
| 22 | Gas factor, $m^3$/t | 15.1 |
| 23 | Hydrogen sulfide content,% | 2.40 |
| 24 | Water viscosity at reservoir conditions, mPa s | 1.37 |
| 25 | Density of water in surface conditions, t/$m^3$ | 1.157 |
| 26 | Formation water salinity, g/l | 237.95 |
| 27 | Displacement coefficient, unit fraction | 0.561 |

selected in the amount of 1000 kg, while, based on the principle of correspondence, the volume of injected tagged rims was 6 m3 in both cases. Additionally, before the start of the work, tests were carried out for the compatibility of these indicators with formation water and water of the reservoir pressure maintenance system, the value of sorption by hydrocarbons was estimated, as well as the presence of so-called masking substances or noise that could introduce an error in the quantitative determination of indicators in the samples taken. The presented indicators fully met all the requirements and geological and physical conditions of application at the Baytuganskoye field.

a) «Neogel»; b) «Polytech-EOR»; c) «DiSAV»

**Fig. 1** Gel-forming compositions "Neogel" and "Polytech-EOR", oil-washing solution "DiSAV"

Modeling of research design (preliminary selection of indicators, their quantity, volumes of labeled rims, representative sampling frequency of production wells, etc.), as well as processing of the results with the calculation of geological and technical parameters and construction of maps of their distribution were carried out in the specialized computer program TRACERS 2.0 ".

The "fast" filtration channels discovered at the first stage of research during the first 20 days predetermined the need for the use of low-viscosity gel-forming compositions with Newtonian rheological behavior, which, when injected into the formation, maximally repeat the injectivity profile of injection wells and are capable of deep penetration into channels with LFR with their subsequent isolation. For leveling the permeability inhomogeneity in the near-wellbore zone and the injectivity profile, gel-forming compositions based on medium and high molecular weight acrylamide polymers are more suitable—the pseudoplastic nature of the flow of solutions, high viscosity, as well as adsorption and mechanical retention of polymer particles by the rock provide a more compact placement of the flow deflecting screen and efficient redistribution of filtration flows in the near region. Since both considered gel-forming systems are aimed at increasing the sweep efficiency of the reservoir by waterflooding and do not affect the coefficient of displacement Kwith of oil by water, in order to combine the effects, it was decided to inject a concentrated rim of oil-washing micellar solution into the well at the end of the gelation period (Fig. 1).

Thus, the design of the implemented EOR technology at injection well No. 85 included the following sequence of works: (1) injection of a low-viscosity gel-forming solution "Neogel" based on modified sodium silicates in a volume of 200 m3; (2) injection of a gel-forming composition "Polytech-EOR" based on medium hydrolyzed acrylamide polymers with an average molecular weight in a volume of 100 m3; (3) holding for the period of gelation and hardening within 48 h; (4) injection of a salting-out-resistant oil-washing micellar rim "DiSAV" in a volume of 700 m3. The implementation of the complex EOR technology led to a decrease in the water cut of the produced products by 4.5–6.5% and made it possible not only to stabilize, but also to increase oil production even in conditions of a general falling fluid production.

Taking into account the calculated basic trend of the increase in water cut in production (1.13% / month) and the actually obtained decrease, the additional oil production in only the first 3 months after the work was 457.6 tons, and at the time

**Table 2** Summary results of special tracer studies

| No | No. wells | Number of channel groups with LFS | | Average weight. filtration rate, m / day | | Average weight. permeable, μm² | | Volume of a group of channels with LFS, *10⁻³ m³ | | Produces. groups of channels with LFS, *10⁻³ m³/day | | Extracted mass indicators, *10⁻³ kg | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | A | B | A | B | A | B | A | B | A | B | A |
| 1 | 359 | 2 | 0 | 154.6 | – | 98.1 | – | 5 | 0 | 2.0 | 0.0 | 7.1 | 0.0 |
| 2 | 361 | 8 | 0 | 31.2 | – | 17.4 | – | 812 | 0 | 61.0 | 0.0 | 384.8 | 0.0 |
| 3 | 1536 | 8 | 5 | 19.4 | 18.3 | 4.5 | 3.9 | 93 | 31 | 11.0 | 6.0 | 39.0 | 22.4 |
| 4 | 1731 | 5 | 1 | 62.7 | 40.3 | 48.5 | 39.9 | 15 | 1 | 5.0 | 1.0 | 6.3 | 0.3 |
| 5 | 1733 | 5 | 1 | 176.2 | 28.2 | 96.6 | 14.2 | 56 | 4 | 16.0 | 1.0 | 97.7 | 2.1 |
| 6 | 1734 | 2 | 1 | 99.3 | 29.4 | 46.0 | 12.6 | 7 | 8.0 | 2.0 | 1.0 | 8.3 | 5.2 |
| 7 | 1736 | 7 | 2 | 54.0 | 49.4 | 27.5 | 22.3 | 386 | 46 | 40.0 | 6.0 | 241.8 | 43.9 |
| 8 | 1738 | 4 | 4 | 87.4 | 36.9 | 29.1 | 11.3 | 78 | 28 | 10.0 | 4.0 | 65.7 | 19.9 |

*B—before, A—after

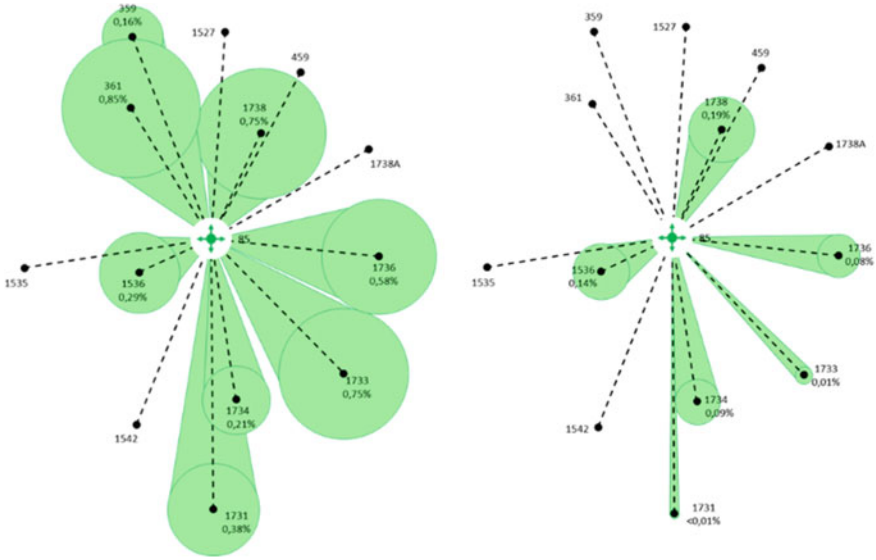
of the predicted end of the effect it may exceed 2000 tons. After putting injection well 85 into operation, after 3 days, the second indicator was injected and samples of production from production wells were taken during an equal monitoring period. Table 2 shows the combined results of special tracer studies of stages I and II.

## 3 Results

During the first period of the monitoring of channels that significantly contribute to watering, no channels were identified, however, their well-developed orientation, short arrival times to production wells (from 0.3 to 3 days) and a fairly uniform nature of accumulation of the removed indicator, a high frequency of occurrence and relatively equal peak concentration values made it possible to conclude that there is a general rather high hydrodynamic connection between the production environment and injection well No. 85 (Figs. 2 and 3).

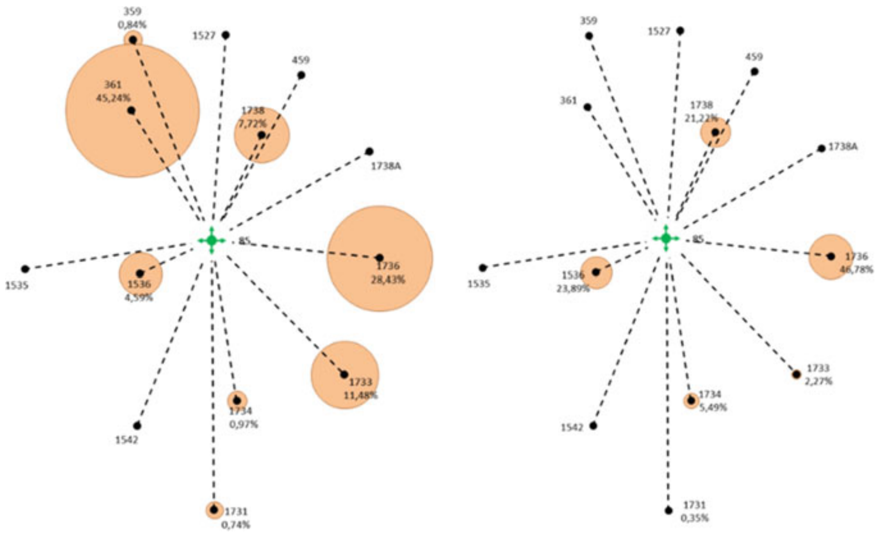
As can be seen from the presented data, after the EOR, the contribution of the channels with LFR to the water cut of the produced products decreased by 7.5 times, and the mass transfer of the indicator decreased by more than 15 times, which is significantly higher than the average indicators when implementing enhanced oil recovery technologies [10]. Additional information confirming the unevenness of oil displacement by water from the side of injection well No. 85 was obtained by analyzing the distribution over the area of the considered area of the salinity of the produced water and the light absorption coefficient (CSP) of oil in the near ultraviolet range.

Since the waterflooding of the B1 formation is carried out by the produced water of lower salinity (about 76.5 g/1) than the formation water, the desalination of the




a) Before *EOR* b) After *EOR*

**Fig. 2** Contribution of the identified system of channels with LFR to well watering



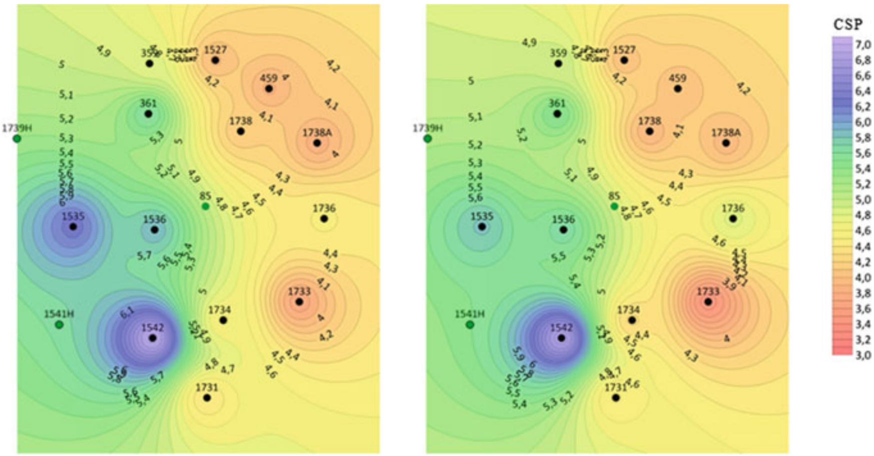

a) Before *EOR* b) After *EOR*

**Fig. 3** Distribution of masses of indicators to be removed produced water through the wells reflects the total contribution of the filtration channels through which the injected water breaks through. The distribution of the CSP values as a complex parameter reflecting the relative proportions of the content of light and heavy components in the produced oil, adjusted for the cumulative production and the current performance of wells, makes it possible to assess the uniformity of reserves recovery. In the case under consideration, the enlarged section of injection well No. 85 was characterized by the presence of developed highly permeable channels, a low coefficient of coverage by the process of oil displacement by water, and uneven advancement of the waterflooding front, outstripping the development of individual zones and weak drainage of other areas, which was the reason for carrying out work on the above complex technology of increasing oil recovery.

For all wells that responded to the performed EOR work with a decrease in the water cut of the produced product, either a decrease in the optical density of oil in the target wavelength range (wells No. 361, 1535, 1536, 1733, 1734 and 1738), or a decrease in the No. 1731 and 1738A), which indicates the active involvement in the development of previously uncovered reserves with unchanged initial state and relative fractional composition of hydrocarbons (Fig. 4).

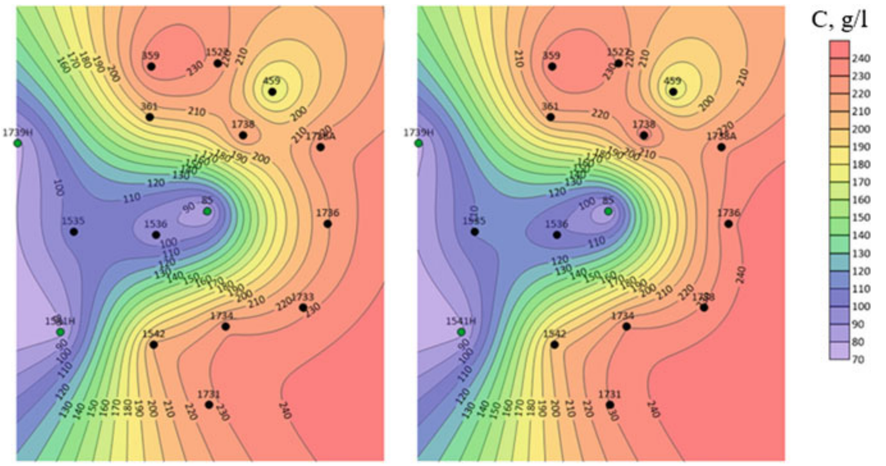
An increase in the salinity of the produced water practically in the entire area under consideration also indicates a decrease in the influence of the flushed channels from the side of injection well No. 85, but here wells No. 459, 1736 and 1542 should be distinguished (Fig. 5).

Despite the significant mutual distance between wells No. 459 and 85, the low salinity of the produced water with an overall low water cut (about 7%), even in the absence of injected indicators in the samples taken, still speaks of the existing hydrodynamic relationship between the considered pair of wells and the predominant nature watering the reservoir with water, but along more “long” filtration channels




a) Before *EOR* b) After *EOR*

**Fig. 4** Distribution of the values of the normalized CSP of oil over the area of the study area




a) Before *EOR* b) After *EOR*

**Fig. 5** Distribution of water salinity values over the area of the study area

that are not detected by tracer studies in a limited observation period, which is confirmed by the subsequent increase in salinity (by 1.6% within three months) after the EOR. For the edge well No. 1736, the decrease in the mass of the removed indicator, presumably, indicates not only the isolation of the breakthrough filtration channels, but also a decrease in the actual pressure gradient from the side of the injection well No. 85, since the subsequent increase in the water cut and salinity of the produced product with a simultaneous increase in the CSP of oil is caused by an increase in the volume of formation water inflow due to the OWC contour and an increase in production, as a rule, of more oxidized and heavy oil. Thus, for this well, a slight decrease in total production is recommended, which will allow to equalize the existing pressure gradients and reduce the water cut.

## 4 Conclusion

A complex of special tracer studies performed at the Baytuganskoye field, combined with photocolorimetric analysis of oil and determination of salinity of produced water, made it possible to clarify the general hydrodynamic relationship between wells, identify "fast" filtration channels, their direction and filtration-capacitive characteristics, and assess the relative distribution of drained reserves, identify sources of water cut in wells, propose EOR technology and optimize its design, clarify the subsequent mechanism of oil recovery factor and the overall achieved efficiency.

In the implemented complex EOR technology, first of all, a mechanism for increasing the sweep of the reservoir by waterflooding was clearly manifested, associated both with the deep isolation of the breakthrough filtration channels and the installation of a stationary flow diverting screen in the near area of injection well No. 85, and with the formation of a mobile but viscous water–oil rim, also preventing the breakthrough advancement of the injected water and leveling the waterflood front as a whole. Additional oil production as a result of the introduction of the proposed EOR technology in the first 3 months of observation exceeded 450 tons with a decrease in the water cut of the produced products by 4.5–6.5%, and at the time of the predicted end of the effect, it can reach more than 2000 tons.

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# Introduction of Lean Thinking by Russian Manufacturing Enterprises: Challenges and Prospects

**N. A. Kryuchkova**

**Abstract** The concept of lean production appeared in the 1940s of the XX century, the term itself appeared much later in 1988 and began to be introduced into the theory and practice of Russian enterprises in 2003. The crisis in economic development, accompanied by a record decline in the price of Brent crude oil in March 2020, affected the activities of enterprises producing machinery and equipment for mining. An urgent problem for organizations engaged in this type of economic activity is to increase productivity, as well as reduce costs, restoring order and organization in the workplace, which requires the use of effective methods. The application of lean manufacturing concept and one of its main tools—the 5S system—helps improve productivity. However, there are challenges associated with the implementation of the concept that need to be addressed in order to achieve sustainable results. Given that the 5S method is aimed at ensuring order in the arrangement of resources, reducing the degree of faulty work, improving the comfort of staff work and rationalizing the work flow, there is a need for quantitative measurement of performance indicators for implementing this system. Moreover, these indicators are specific for enterprises that produce machinery and equipment for mining. Quantitative assessment, identification of factors that hinder the implementation of the concept of lean production, and their degree of influence contributed to the creation of a model for implementing lean thinking.

**Keywords** 5S system · Lean production · Lean thinking · Mining machinery and equipment manufacturing enterprise

## 1 Introduction

One of the key problems of research highlighted in literature is that the application of lean thinking at enterprises producing machinery and equipment for mining is limited, most publications are devoted to the optimization of transport services [1,

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2] at industrial enterprises. Only about 3% of foreign studies analyze the issues of lean thinking in mechanical engineering, metallurgy, and furniture industries [3]. These conditions necessitate an in-depth study of the practice of using lean thinking in mechanical engineering, namely in the production of equipment for mining. In general, the motivations for implementing lean practices are to increase efficiency, use space and restore order and organization in the workplace [4]. According to the national standard of the Russian Federation, lean production (LP) is a business organization concept focused on creating attractive value for the consumer by forming a continuous flow of value creation covering all the organization's processes and constantly improving them through the involvement of personnel and eliminating all types of losses [5]. The founders of the lean manufacturing concept identify seven types of waste that most often cause losses to the enterprise: transportation, inventory, movement, overproduction, defects and flaws, waiting, unused talents [6]. To get rid of the listed losses and comply with the principles in management and production, the lean concept includes the 5 S tool, using which you can increase the efficiency of the enterprise by improving the organization of the work area. However, research on the application of the 5S system is often descriptive [7], although it is known that process optimization is impossible without the use of quantitative methods, determining the stages of application of the concept.

## 2 Methodology

The subject of this article is the study of barriers and relevant tools in the process of implementing the principles of lean production at enterprises that produce equipment for mining. Experimental study of objects was carried out using observation and survey in the form of questionnaires and interviews. The collected data were then analyzed according to standard scores on the desirability scale, as well as taking into account a differentiated approach to the results of respondents ' responses. When summing up the results of the study, the author used mathematical methods, namely the data visualization method. The graphical method made it possible to clearly demonstrate the sequence of management actions for applying the concept of lean thinking at enterprises in the field under consideration. The combination of these methods ensured the validity of the results. When studying the literature on the research topic, such methods as analysis and synthesis were used.

## 3 Results and Discussion

In order to determine a tool for eliminating existing waste at enterprise, it is necessary to address the issue of development and periodization of the concept of lean production, where the opinions of researchers are divided. Some researchers propose to distinguish two periods in the development of the concept and its two types: "basic lean enterprise system" (BLES) and "contemporary lean enterprise system" (CLES). According to the author, this approach is greatly simplified; we adhere to an alternative paradigm consisting of 3 stages [8]. The first stage is the creation of a concept with practical use of the principles of scientific production management, which appeared at the beginning of the XX century in the USA and other countries. The second stage is the popularization of the Toyota production system, which lasted from the 1990s to the beginning of the XXI century. The beginning of the third (current) stage dates back to Russia in 2003, when enterprises using the principles and tools of lean thinking appeared. This period is characterized by the dissemination of ideas of lean thinking in the economic activities of enterprises and authorities of countries with different levels of economic development. At the stage of spreading lean thinking in the Russian Federation, the ideas of this concept are specified, applied not only by commercial enterprises and the social sphere (education, healthcare), but also popularized in the activities of state authorities.

The author suggests a periodization of the current stage of development of the concept of lean thinking based on the degree of saturation of economic activities, cartographic generalization and extension of the principles to the social sphere (Fig. 1). Note that during the third stage lean production ideas are combined with other methods to improve efficiency. According to the research conducted by the author, enterprises producing equipment for mining began to actively apply the principles of lean production in the second period of the concept's dissemination stage. The market of equipment offers for the oil industry demonstrates high competition not only between domestic manufacturers, but also between foreign companies. The success of conducting economic activity is not always present, because some enterprises of the considered type of economic activity are in the process of reorganization, while a temporary manager has been appointed for the others by arbitration court.

The survey conducted by the questionnaire method among the enterprises of the considered type of economic activity, helped to identify the complication factors of implementing the principles of lean production. The questionnaire was sent to enterprises using e-mail addresses published on official websites. Initially, the conversion rate of responses was very low. In order to increase the indicator and sample size, a telephone survey was used with the interviewer fixing the position. With a conversion rate of 0.19, both businesses using lean thinking and those planning to implement it took part in the survey. Employees of enterprises had to assess the degree of influence of factors on the success (possibility) of implementing the lean production concept.

The survey results are presented in Table 1. The analysis of the degree of influence of factors was carried out according to standard estimates on the desirability scale, as well as taking into account a differentiated approach to analyzing the responses of respondents of two types of enterprises that apply lean thinking and do not use it. The author suggests dividing the complication factors into 3 groups:

- unique—received a high degree of influence, the maximum number of respondents;
- variable—having a multidirectional assessment of respondents of two types of enterprises;

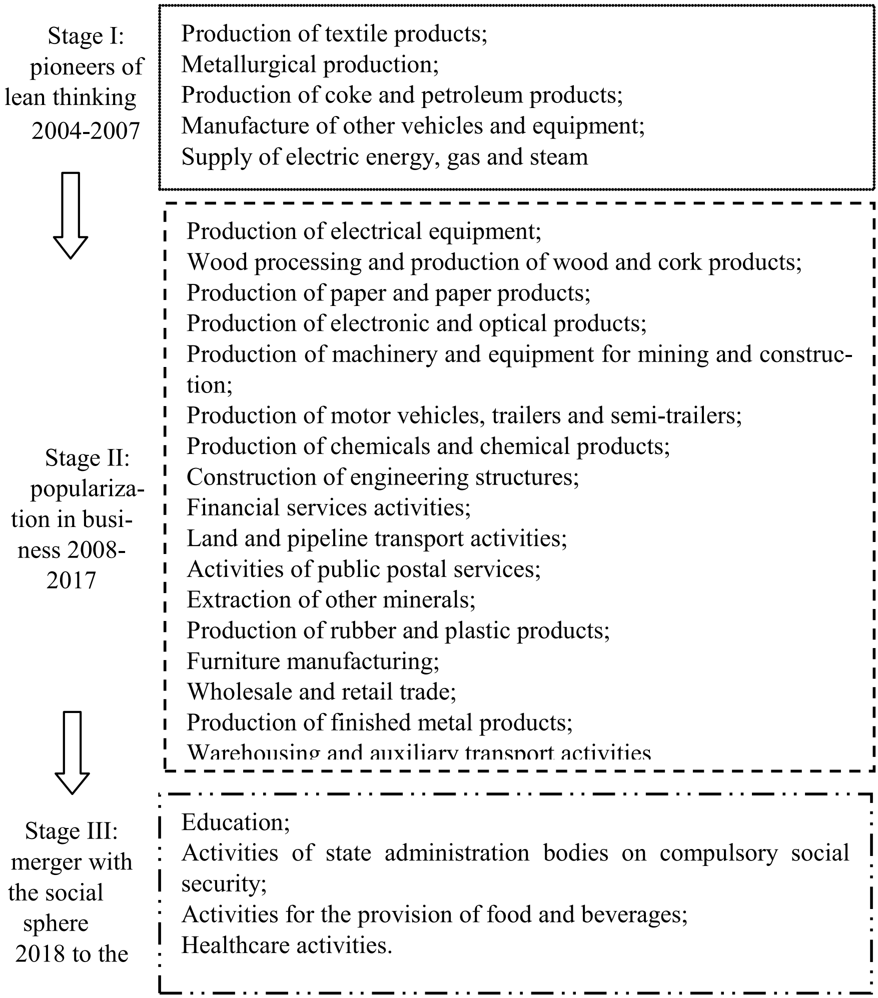


**Fig. 1** The evolution of lean thinking dissemination stage in the Russian Federation

- common factors that have the highest percentage in the medium and/or low degree of influence.

Despite preliminary evidence of the benefits of implementing lean production, there are a number of obstacles at the macro level: low awareness of the practical application of LP tools and a shortage of qualified specialists. The introduction of national standards contributes to the elimination of the first factor; for a unified approach to the system of professional development of employees, as well as the structure and content of competencies, GOST R 57,523–2017 «Lean production. Guide for personnel training system» is applied [9].

**Table 1** Impact assessment of complication factors in implementing the lean production concept at enterprises that produce mining equipment, %

| Name of the factor | Low degree of influence | Average degree of influence | High degree of influence | Factor Group |
|---|---|---|---|---|
| | *Macro-level* | | | |
| Low awareness of the practical application of tools LP | 14.3 | 28.6 | 71.4 | Unique |
| Shortage of qualified specialists | 14.3 | 28.6 | 57.1 | Unique |
| Decrease in business activity in the area | 28.6 | 42.9 | 28.6 | Variable |
| | *Micro-level* | | | |
| Duration and consistency of getting the effect | 42.9 | 42.9 | 14.3 | Common |
| Insufficient financial resources | 14.3 | 28.6 | 57.1 | Unique |
| Lack of involvement of the company's management | 57.1 | 28.6 | 14.3 | Common |
| Lack of time for employees | 28.6 | 28.6 | 42.9 | Unique |
| Staff resistance to change | 42.9 | 14.3 | 42.9 | Variable |
| Production culture | 57.1 | 14.3 | 28.6 | Variable |

Let us turn to the consideration of the influence of unique factors at the micro level, which was carried out at the enterprise of the sphere under consideration located geographically in the Samara region. Based on open data sources, the type of financial stability of a legal entity was determined—the third type, which is characterized by an unstable financial situation. The financial condition of organizations is unstable and was below the standard value, the absolute amount of profit decreased. To determine the combined impact of the above unique complication factor and the factor "Lack of time for employees" it is necessary to identify the loss of time during the execution of the order by enterprises. The norm of the order completion time is presented in Eq. (1), which has the form:

$$\mathrm{Nt} = \mathrm{t\,prod} + \mathrm{t\,del} + \mathrm{t\,proc} + \mathrm{t\,sr} + \mathrm{t\,ed} \tag{1}$$

where N t is the unit norm of order completion time; t prod is the time of equipment production; t del is the product delivery time; t proc is the time for processing the consumer's request; t sr is the staff rest time; t ed is the equipment downtime caused by the organization of the production process by personnel.

The largest share is taken by the equipment delivery time (85%), which is explained by the use of railway transport and remoteness from the company's product consumption areas, since the leading regions in crude oil production in the Russian Federation are the Khanty-Mansiysk, Yamalo-Nenets Autonomous Okrugs, Krasnoyarsk Territory and Sakhalin Region. Reducing the equipment delivery time must be performed at the meso-level. The production time of drilling equipment is 15 h (7.5%), which depends on the condition and updatability of fixed assets of the enterprise, and at the moment there is no possibility of reducing of the last standard due to the unstable financial situation. Time for rest and personal needs of workers takes up 1.5% in the structure of the norm of order completion time, the amount of time is established by the law of the Russian Federation. Equipment downtime is 4.5%, the indicator includes the time spent by an employee to find parts for further production of equipment. The data was taken from personal observation of the production process, as well as through employee surveys. Causes of equipment downtime have been identified:

- cluttering up the space of industrial premises with tools and components;
- location of unnecessary materials in a disorderly position between workplaces;
- storing excess inventory on the floor;
- difficulty in finding the necessary parts.

As the study showed, a sufficient part of the time in the production of the necessary drilling equipment falls on "downtime". There are a lot of lean thinking tools, and some of them are very specific to a particular enterprise, for example, the Andon concept is not suitable for implementation, because many production processes are separated geographically and employees do not have the opportunity to visualize the process. It can be concluded that the enterprise needs to implement one of the components of lean manufacturing, the 5S system, since it is the most suitable one when improving the mechanisms of equipment production to the end user.

The main reasons for using the 5S system at the enterprise in question to improve the production process were:

- simplification of the production process as a result of cleaning, sorting, ordering;
- creating the infrastructure needed for enterprise-wide improvements;
- the importance of setting up the process flow and redeveloping the workspace;
- increasing staff motivation and dedication;
- creating a clean production environment;
- the need to implement safety measures and reduce the number of accidents at work;
- a method of reducing the amount of waste by minimizing its amount and reusability.

**Table 2** Optimization of equipment downtime losses

| Reasons for equipment downtime | Suggested solutions |
|---|---|
| Consultation with the workshop master takes place orally | Mandatory distribution of shift tasks to staff at the beginning of the working day |
| Unregulated breaks | Regulation of the duration and number of breaks according to the internal labor schedule |
| Equipment contamination | Compliance with the equipment cleaning and maintenance schedule |
| Difficulty in finding tools | Storage of necessary tools near the machine, as well as the location of each tool should be outlined, all markings should be made and visible |
| Storing excess inventory on the floor | Removal of inventory from the aisle, employees' compliance with safety standards |

Suggestions for optimizing equipment downtime identified during the drill bit manufacturing process are presented in Table 2.

According to the identified complication factors of implementing the lean production concept, a phased application of the "5S" system at the enterprise was proposed:

- explaining the principles of the "5S" system to the company's staff;
- creating a base for motivating workers;
- general cleaning of industrial premises and surrounding areas;
- freeing the area of industrial premises from clutter;
- using the control check card for implementing the "5S " system
- reducing large amounts of waste;
- creating a cleaner and safer production environment.

The application of the 5S system as part of the implementation of the lean thinking concept at the enterprise during the annual period allowed reducing equipment downtime by 77.8%. Based on the above research results, we propose a model for implementing lean production at enterprises that produce machinery and equipment for mining, which was created on the basis of drivers and complication factors (Fig. 2).

Shortcomings need to be identified earlier so that businesses can assess their capabilities, better prepare for lean production implementation, and be prepared for systematic processes. In addition, the implementation of lean thinking requires changes in the structure, system, process and behavior of personnel at all levels in accordance with the applied tools of the concept. Also, the success of the implementation stage is not related to the ideological nature of the management, but rather to its knowledge. When choosing tools and the sequence of their implementation, the following goals should be taken into account: avoiding waste, reducing additional costs and prevention of time losses.

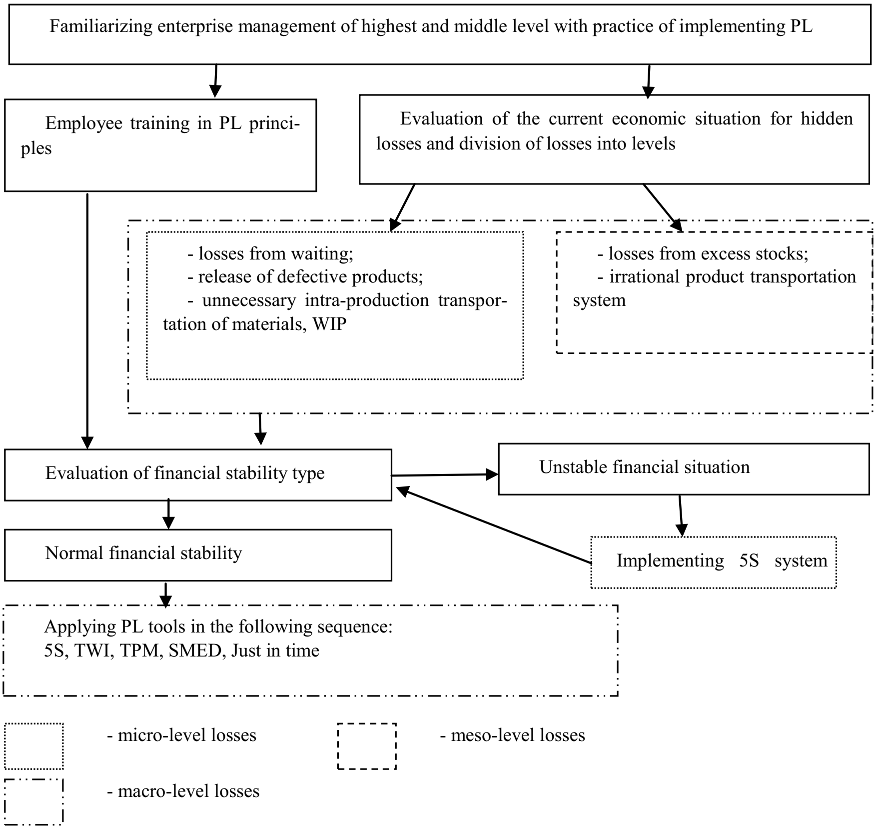


**Fig. 2** A model for introducing lean thinking to enterprises producing machinery and equipment for mining

## 4 Conclusion

According to the results obtained, Russia has been actively implementing lean thinking at enterprises of various types of economic activity since 2003. But the application of this concept in organizations that produce equipment for mining is not an easy task, since it is heavily burdened by complication factors associated with the availability of implementation experience results and available resources of various types. Enterprises that use the principles of lean thinking in their operations and plan to apply them believe that one of the main problems is qualified specialists. At the moment, higher education institutions do not train bachelors in this program, and structural subdivisions independently retrain employees. The lack of knowledge about lean production has not allowed companies to successfully apply lean thinking, so today annual competitions and grants in the field of project management are particularly popular. The use of the 5S system is possible when the financial situation is unstable, which is typical for enterprises that produce equipment for mining. The lean thinking tool is used to increase productive space by cleaning and organizing the workplace. The proposed model for implementing lean production encourages enterprises to understand the principles of the concept and the stages of using tools, which depend on the degree of influence of complication factors.

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# Industry 4.0 Technology in the Digital Economy

**N. A. Zaychikova**

**Abstract** The innovative development of the economy is closely connected with its digitalization. The modernization of technological cycles makes it necessary to turn to new business methods and modernize existing business models. One of the factors contributing to the IT development was the Coronavirus pandemic in 2019–2020. When the restrictions were adopted, there was a massive transition to the digital environment. The positive attitude to digital changes has increased significantly, in particular in the Russian Federation, companies have realized advantages of the digital transformation. In the course of the study, the authors analyzed publications of domestic and foreign authors, as well as popular media on the topic of digitalization of the economy in a changing external environment. The main purpose of the study was to consider the Industry 4.0 technology for the digital transformation of the economy and the modernization of business models. It was concluded that the main obstacles to successful digital transformation are the human factor, outdated IT systems, as well as the lack of knowledge and habits of the population in the area.

**Keywords** Digital economy · Digital technologies · Industry 4.0 · Business innovations

## 1 Introduction

In recent decades, a new technological cycle has been observed in the world, technologies are rapidly developing, companies are adapting to new conditions, revising strategies and changing their business models in order to maintain their competitiveness. Old business models are becoming ineffective, new ones are replacing them. In the course of digital development, not only companies are changing, but also consumers, which means that the customer behavior is also changing, new ways of consuming products and services are emerging. One of the factors contributing to the IT development was the Coronavirus pandemic in 2019–2020. When the

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restrictions were adopted, there was a massive transition to the digital environment. The Russian companies have realized the digital advantages; as a result the priority areas of digital transformation have become digitalization of processes; obtaining, processing and analyzing data for solving operational and strategic tasks; customer experience management. One of the success factors of the digital transformation is a developed «digital culture», since it is not enough only to digitalize processes, it is necessary to change the consciousness of the participants in these processes. Lack of competencies, lack of resources, as well as resistance to change can become obstacles to the implementation of the digital transformation strategy. To reduce this resistance, it is necessary to understand advantages of digital transformations, goals and objectives of their implementation. The uniqueness of digital transformation is expressed in the growth of integration and harmonization of a large number of different scientific discoveries and technologies [1].

## 2 Literature Review

In the modern world, the digital economy is associated with a rapidly developing sphere of the economy, which absolutely changes the existing business models [2]. In 2016 The World Bank has published a document «World Development Report 2016: Digital Dividends» [3], it presents the results of an analysis of the state of the world digital economy. The report notes that the economy digitalization is not only a local consequence of the IT development, it is a phenomenon that deeply transforms the entire economic system.

The digitalization of the economy is manifested in the following aspects: the trade expansion, the competition development, increasing labor productivity by reducing costs, the improved quality of provided services, increasing job number and expanding employment opportunities for people with disabilities, etc. [4]. Speaking about the specific features of the digital economy in 2021, the following aspects can be distinguished:

- due to the increased ubiquity of the Internet access, the opportunities and scope of companies' activities are expanding;
- the most important resource that allows you to build a highly efficient company is the organized information resources;
- information is transmitted and distributed at an increasingly high speed;
- previously effective business models are dying out, new ones are appearing, a platform is recognized as the dominant business model;
- economy elements are not individual companies, but entire business ecosystems.

One of the contemporary economy trends is digitalization which causes a change in traditional formats, the translation of information into the digital form. Digitalization provides fundamental transformations in all life spheres. The digital economy sets a direction for the transformation of traditional sectors of the economy, the emergence of new markets and niches. New business models are emerging basing on their increasing customer orientation. The digital transformation of business is becoming a necessary condition for survival in the new realities. Digital products are increasingly spreading to the service sector and are becoming a part of large information services.

To become a modern market company and maintain its competitiveness, it is necessary to develop continuously. In order to optimize or reengineer processes, information technologies and IT resources are applied. For a more effective use of new technologies and their rapid implementation in all key areas of the economic activity, companies should abandon the previous foundations and completely transform their processes and work models, since maintaining the accumulated experience can incur additional costs.

Digital transformation is designed to ensure the preservation of the competitiveness in a changing external environment, increase the productivity, sales and the market share, transform the culture and thinking of the company's personnel, as well as reduce costs through the introduction of new technologies. In the process of implementing digital transformation projects, the company can expect success or failure. To achieve success, such qualities as flexibility and speed are important, it is necessary to start making changes based on the need, not on the possibilities. Digital transformation is aimed at rapid decision-making, rapid adaptation to current requirements, as well as meeting the changing needs of customers [5]. The goals of digital transformation are:

1. Decision-making based on data, digital decision support systems and predictive analytics.
2. Connectivity with customers, suppliers, colleagues.
3. Stimulating innovations.

Among the main principles of organizing the work of companies undergoing the path of digital transformation, there is a principle of «customer-centricity». In the client-centered model, the product is built around the client and his needs, in contrast to the traditional approach, where products are created based on the needs of the market in general. Consequently, during the digital transformation, customer needs are personalized [6], that becomes possible due to the digitalization of processes and the application of modern analytics systems. Companies also have additional means of maintaining interaction with customers—through the use of mobile applications, websites, social networks and messengers. It is the need to understand individual consumers and study behavioral characteristics that is one of the key directions of the digital transformation. The client makes a choice in favor of the company that will most fully satisfy his needs, providing the product in a timely, fast and convenient manner. The product of the present time is not just a product or service, but the whole process of interaction with the organization. Working with data is becoming an important area of digital transformation. The availability of data allows you to model the customer behavior, optimize production chains, predict demand, as well as determine preferences and, as a result, adapt products and services to individual customers.

The development of digital infrastructure enables to make any integration processes flexible. Building open systems provides limitless opportunities not only for enriching data from external sources, but also for finding completely new product ideas, in this regard, many companies join forces by creating a digital partnership or collaboration. This allows them not to waste resources on creating additional missing parts of the infrastructure within themselves when integrating with the partner's infrastructure, so they can effectively test hypotheses and bring completely new joint products to the market. By creating an open infrastructure, companies have the opportunity to attract startups by testing pilot projects on their real data and processes which allows them to make better decisions about launching innovative products. One of the features of the economy of 2021 was the construction of business ecosystems.

Under the business ecosystem, you can define a modern technological platform that has certain elements—services that meet various customer needs. The ideal ecosystem is based on meeting all the needs of customers by providing the own services in order to make a profit from each service. Services can be provided in various directions, for example:

1. Communications. The basis of the services of this direction is the communication means: Internet, mobile communications, social networks.
2. Information support. These services are based on cloud services, search engines, voice assistants, and information resources.
3. Financial services that have a common payment system.
4. Loyalty system. Here you can select services that are related to offline and online sales.
5. Other areas of services related to entertainment, travel, education, health, work, transport, geolocation, etc [7].

The use of digital technologies allows you to manage the value of the product for the client, for example, to adapt and personalize, to enter dynamic parameters depending on the behavior and context of events. It becomes especially important for a modern client to be able to purchase products or services fully and remotely, to receive operational support around the clock and without visiting offices, to be able to integrate and connect different products with each other.

The main obstacle to the successful digital transformation of business entities in some cases is the team's unavailability, as a result of lack of motivation and insufficient expertise. This causes internal resistance to change. Thus, people are at the heart of any effective transformation. It is important to understand which specific people with what competencies, in what quantity and at what point of time will be required in the process of implementing strategic plans of the company.

The digital transformation process is characterized by several key stages, regardless of the scale and direction of the company's activities.

The first stage is the creation of a plan that takes into account all the business needs of the company. When planning a digital transformation, it is necessary to determine development directions, as well as choose technologies that will help in this development. To solve this task, it is necessary to conduct an inventory of available resources highlighting those that require modernization. At the planning stage, it may be necessary to change priorities in the implemented projects taking into account the identified additional business needs, as well as limitations and shortcomings, since they can have a negative impact on the digital transformation process.

At the second stage, it is necessary to train the employees' skills of working with new technologies, while difficulties may arise including due to the staff resistance to changes, unwillingness to accept new technologies. For a successful digital transformation, employees have to be ready for all changes to existing workflows, if changes are necessary and intended to improve the efficiency.

At the third stage, it is necessary to abandon outdated technologies. The preservation of old technologies that are not able to support modern digital processes limits the development of the company. If old inefficient technologies are used (and valuable resources are periodically spent on servicing them), it is necessary to identify them and replace them with new, easier-to-use ones that improve the quality of customer service and accelerate the data analysis [8].

Studying the issue of digital transformation, we can distinguish three areas of its implementation: customer experience, operational processes, company's business model. Understanding the differences between the transformation of the company's operational processes and its business model is important for maintaining and increasing the competitive advantages. It should be noted here that the transformation of operational processes is aimed at achieving success and improving the efficiency of current operating activities, while the company's management focuses on a longer-term perspective when transforming business models. When working out the issues of transformation of operational models, not enough attention is paid to the business model. That hinders the company development in the digital environment of the modern world.

Often, companies do not immediately begin to transform in all three areas, but choose one as the most priority. Which of the three areas to choose is determined by the company's management based on the activity specifics and the current state. You can direct your efforts to digital transformation of the customer experience by increasing the contact points with customers, or by reengineering internal processes in order to increase the productivity, and, finally, you can change the business model by creating digital services and products, launching a new product on the market.

One of the most attractive and promising areas of digital transformation is the change of the company's business model. The formation of a digital business model has a number of advantages, among the main ones are: easier asset management due to the lack of a burden, another advantage is the possibility of embedding direct interactions with investment and innovation partners in the business communications.

Customer expectations are growing in terms of the speed and quality of service provision. A high level of service becomes the default requirement. Consumers are increasingly valuing their time, they need instant feedback, as well as a clear and user-friendly interface to meet their needs. A good design of information resources, the availability of online chats, an individual approach—this is a world that customers have already managed to get used to. To ensure readiness and meet the high expectations of customers, companies should accelerate the digitization of their business processes [9].

## 3 Results

The fourth industrial revolution, called Industry 4.0, represents a new level of the production organization and value chain management throughout the entire product lifecycle. Industry 4.0 is associated with the transition to fully automated production, which is controlled by intelligent systems in real time when interacting with the external environment [10].

The term "Industry 4.0" appeared in 2011 at the Hanover Fair in Germany, the concept of industrial development was presented under Industry 4.0. Unlike the Industry 3.0 stage, when efforts were focused on automation and robotization of processes, the tools of the digital economy became the basis of the Industry 4.0 stage. We present a brief description of the industrial revolutions that took place (from the first to the fourth) in Table 1.

Industry 4.0 includes many new technologies that contribute to the creation of value which leads to the rapid transfer, receipt and analysis of data [11]. Modern companies have to adapt to new conditions in order to maintain their viability and gain competitive advantages. In order to build and organize a modern digital company in Industry 4.0, it is necessary to take actions in the following areas:

1. Review and change the strategy and the business model. Reviewing the development strategy, understanding the company's goals allows you to understand which business model will most fully meet short-and long-term goals.

Speaking about the prevailing business models of the Industry 4.0 stage, it should be noted that platform-based solutions are increasingly developing that allow maintaining the efficient interaction with customers, obtaining the necessary data and personalizing offers based on the customer needs. The principle of «client-centricity» is implemented.

2. Digitalization of the company's processes, products and value chains. To obtain the final result, companies have end-to-end processes, both internal and external ones, that forms the value of the product. Each process has its own «inputs» and «outputs», the results of one stage of the process are required to start the next stage of the process or start a completely different process, so all the company's processes are interconnected and the occurrence of failures within any process can lead to undesirable final results. It is necessary to implement a unified system for ensuring and controlling the company's processes in order to detect deviations in a timely manner and take measures to eliminate them. It is also important to ensure the collection, analysis, and storage of data. The use of the obtained data on an ongoing basis can contribute to decision-making related to the revision and improvement of business management strategies.
3. Another important area is the training of personnel, the development of competencies necessary for the introduction and use of new technologies and approaches. The application of new technologies will be accompanied by resistance on the part of employees, the reason may be misunderstanding of changes,

**Table 1** Contents of 1–4 industrial revolutions

| Industrial revolution | Period | Content (achievements for the period) |
|---|---|---|
| The First Industrial Revolution (Industry 1.0) | The end of the XVIII century.—The beginning of the XIV century | Agrarian revolution, mechanization of manual labor, transition to industrial production, increase in labor productivity<br>Achievements: steam engine, weaving and spinning machines in the industry, lathes and milling machines in metallurgy, agricultural machines, etc |
| The Second Industrial Revolution (Industry 2.0) | The second half of the XIV century.—The beginning of the XX century | Electrification, the use of electric energy, the use of a conveyor in mass production, the development of petrochemicals, the construction of railways and other transport networks, etc |
| The Third Industrial Revolution (Industry 3.0) | The end of the XX century—present time | Programming, creation of industrial robots, introduction and application in the production of electronic computing complexes and information systems, automation and robotization of processes, etc |
| The Fourth Industrial Revolution (Industry 4.0) | Nowadays: the appearance of the term—2011 | Access to information resources, cyber-physical production systems, development and distribution of Internet commerce, personalized approach in interaction with customers, cybersecurity, "digital enterprise", large amounts of data, artificial intelligence, virtual reality, cloud technologies, 3D printing, etc |

each of the interested and influential persons should be aware of the role of new technologies in maintaining the competitiveness.

The use of Industry 4.0 technology requires the availability of personnel competencies, significant financial investments, while in the medium term it contributes to strengthening the competitiveness of companies, increasing market share and entering new markets, in the long term it can be assumed that such tools will allow the company to survive in the new digital world. The application of Industry 4.0 technology requires a digital transformation of business, a revision of existing business methods and the introduction of new ones using modern management tools.

## 4 Conclusion

The increasing role of information and knowledge in business, the need to reduce production costs, the rapid development of digital technologies have given rise to a new economy type called the digital economy [7]. One of the main factors contributing to the development of the digital economy is innovation, while the innovative breakthroughs of the last decade are associated with the transformation of business models. Digital transformation occurs both in the economy as a whole and in individual business areas, these processes are interrelated [9]. At the global level, digital transformation is the next stage in the development of the digital economy (after digitalization). The business model, as well as the operational management model, is being transformed when using technologies that allow creating fundamentally new value chains, producing more profitable products and services, this contributes to the growth of the company's profit and its investment attractiveness.

Thus, the term «digital transformation» is associated not only with the introduction of digital management tools and improving the efficiency of processes in the company, but also with structural changes in thinking and approaches to management. The main obstacles to successful digital transformation are the human factor, outdated IT systems, as well as lack of knowledge and customer habits [11]. Corporations are applying new technologies and implementing digital transformation of business models in order to maintain the positions of industry leaders, creating technological barriers that competitors will not be able to overcome.

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# Innovations in the Construction and Transport Sectors

# Innovations in Production of Moscow Underground Railway Carriages

**S. V. Bespalko, V. N. Tarasova, and V. V. Degtyareva**

**Abstract** The article discusses the main directions of development of the design and technical characteristics of the Moscow underground railway carriages from the beginning of the 1930s to the present time in connection with the construction of the subway in large metropolises of Europe, Asia and the United States. The influence of changes in railway carriages building on passenger traffic is analyzed. Five generations of equipment were traced by the design of the railway carriage and bogie; the shape of the driver's cab; engines, drive, control and other electrical equipment; ventilation and air conditioning; brakes; auto-coupling device; protective devices; passenger comfort. Manufacturers of second-generation equipment achieved a smooth start-up and reduced amount of electrical equipment repairs. During the creation of the third-generation equipment, the improvement of the rolling stock went in the direction of increasing the capacity of the railway carriage. The lightening of the body, bogie and auto coupling due to changes in the load-bearing structure, materials and finishes led to an improvement in the smoothness of the ride and a reduction in the weight of the railway carriage. The fourth-generation equipment was created with the aim of increasing the reliability of components and parts, carrying capacity, increasing the average and structural speed, and reducing operating costs. The modernization of equipment in the fifth generation of rolling stock equipment was aimed at providing comfort and increased passenger capacity.

**Keywords** Innovations · Moscow underground · Railway carriage · Technology generations

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## 1 Introduction

In the first half of the 1930s, railway carriages were built for the Moscow underground, which was opened in 1935 [1]. The capital of the USSR was not the first to choose this type of transport. The operation of the subway began in England in 1863 [2], in Boston—in 1898 [3], in New York-in 1904 [4] and others. Modern trends in the development of high-tech underground in recent years are reflected in the achievements of China [5, 6]. Over the decades since the opening of the Moscow underground, five generations of railway carriages have been replaced, which have been improved in terms of technical characteristics, travel conditions for passengers, technological production and service in accordance with the best design traditions used in the metro technology of densely populated megacities of the world [7, 8] (Table 1).

This process continues today, which is associated with the release of the innovative carriage model "Moscow 2020". Modeling of transport preferences in countries is

**Table 1** The change in generations of the Moscow underground equipment

| No | Types, models | Years of construction | Years of operation | Passenger traffic, million people/year |
|---|---|---|---|---|
| 1 | A<br>B | 1934–1937<br>1937–1939 | 1935–1975<br>1941–1983 | 1938/212,6<br>1939–1945/616,5<br>1946–1950/628,9 |
| 2 | G, Y, UM, UM-5 | 1939,1940,<br>1947–1955 | 1941–1983 | 1951–1960/1307,9<br>1961–1970/1628,1 |
| 3 | D<br>E<br>Ezh/Ezh1<br>Em508/Em509 | 1949–1963<br>1959–1969<br>1970–1973<br>1973–1979 | 1955–1995<br>1959–1969<br>1970–2010 | 1971–1980/2318,2 |
| 4 | I, 81–717/714<br>81–717.5/714.5<br>81–717. 5 m/714.5 m<br>81–717. 6 k, 81.717.6<br>81–720/721 "Yauza";<br>81–720. 1/721. 1<br>"Yauza" | 1973, 1980–1981,<br>1985; 1976–1988<br>1987–1995<br>1993–2010<br>2009, 2011<br>1991–2002; 2004 | 1970–1980<br>1980–1990<br>1990–2000 | 1981–1990/3182,5<br>1991–2000/3202,7 |
| 5 | 81–740/741,<br>81–740. 1/741. 1<br>"Rusich»<br>81–760/761 "Oka"<br>(two carriages end<br>sections) | 2002–2004; 2004,<br>2005–2009;<br>2010–2016 | 2003–2009<br>since 2012 | 2001–2010/2348,3 |
| 5a | 81–765/766/767<br>81–5.2/766.2/767.2,<br>81–65.3/766.3/767.3<br>81–65.4/766.4/767.4<br>Moscow 2020 | since 2016<br>since 2017<br>since 2018<br>since 2019 | since 2017<br>since 2018<br>since 2019<br>since 2020 | 2011–2020/2560,7 |

increasingly based on more environmentally friendly, safe and affordable transport [9]. In turn, the global process of metro construction is on the verge of introducing a smart underground [10]. This approach requires evaluating the development of urban infrastructure through the introduction of digital technologies [11]. On the other hand, the introduction of new technologies requires a constant assessment of the factors that hinder innovative development [12]. Thus, this article will provide a retrospective analysis of the design features and technical characteristics of the Moscow underground carriages, as well as suggestions for their improvement, taking into account the current development of technologies and the impact of digitalization.

## 2 Methodology

The following methods are to be used in the article:

- methods of empirical research;
- methods of theoretical knowledge;
- general logical methods and techniques of research.
- The methods of empirical research will be as follows:
- observation, that is, the process in which the change in the design and technical characteristics of the Moscow underground carriages is studied in the historical aspect;
- comparison, which consists in identifying the similarities or differences of the same type objects in the carriages of the Moscow underground of different generations;
- description, that is, the knowledge of the system, the fixation of the data obtained as a result of observing any objects or systems.

The methods of theoretical knowledge will be as follows: formalization, that is, the representation of the system in meaningful knowledge, which allows to exclude inaccuracies in the interpretation of any phenomena or circumstances. General logical methods and techniques of research include such traditional methods as analysis, synthesis, abstraction, generalization, idealization, analogy, modeling, historical, logical, structural and functional methods and approaches, and system analysis.

## 3 The Main Directions of Development of the Design and Technical Characteristics of Underground Carriages

The analysis of various aspects of the improvement of domestic underground railway carriages allows to identify trends in the history of the development of the underground car fleet. Let's analyze them in relation to the main nodes and systems.

## 3.1 Body Structure

The structural design of the bodies of underground railway carriages underwent the most significant changes in the process of their development. First of all, the changes in the load-bearing structure should be noted. Here, the main trends were, on the one hand, the simplification of the structure, on the other hand, the increase in load-bearing capacity associated with increased productivity (the number of seats for passengers, more powerful equipment).

Lightening and strengthening of the construction of underground railway carriages was achieved through the use of the following design solutions [13]: (a) changing the shape of the body; (b) corrugated sheets of skin instead of smooth (3rd generation) to increase rigidity; (c) stiffeners for the side walls (3rd generation cars) also to increase rigidity and strength; (d) a smaller thickness of siding (type E-3rd generation); (e) all-welded load–bearing structure (from the 4th generation); (e) new materials, including aluminum alloys (starting with type E-3rd generation), low-carbon (4th generation) and stainless steel (4th and 5th generation). Another significant trend that requires separate consideration is in the change of shape, size of the body, and internal layout, which leads to an increase in the performance of the railway carriage (Fig. 1).

The following areas should be noted here: (a) increasing the length of the railway carriage; (b) improving the layout, including seats for sedentary passengers (see Fig. 2); (c) changing the number of doors (from 3 to 6), increasing their width and structural design (from double-leaf to lean-sliding and double-leaf sliding), which

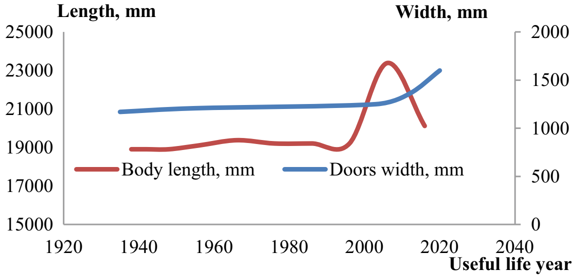



**Fig. 1** Schedule of changes in the size of the body interior in years

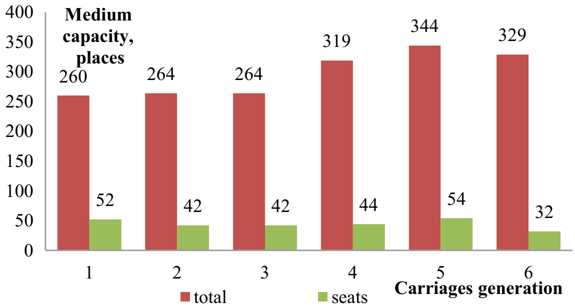



**Fig. 2** Histogram of changes in railway carriages capacity

facilitates the entry and exit of passengers; (d) using new forms of side walls and roofs; (e) changing the end walls of intermediate carriages (blind walls-doors with transition platforms—through inter-carriages transitions throughout the composition in carriages of the 5th generation from narrow to wide with standing places for passengers).

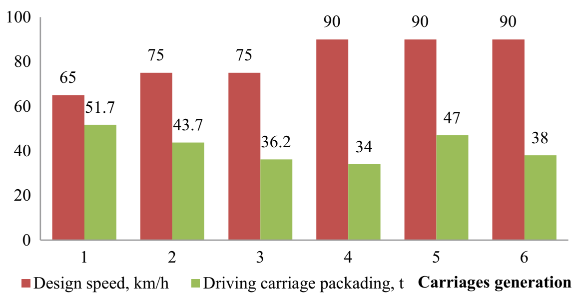
## 3.2 Bogie Design

Improving the design of the trolley concerned mainly the characteristics of the frame: (a) strengthening of the frame beams (in carriages of the 4th generation) to prevent cracks, especially in the joints of the beams; (b) replacing the cast brackets for fixing the box leads with welded-stamped ones when strengthening the frame; (c) changing the design of the electric motor suspension brackets to the cross beam—the most loaded part of the bogie frame (in cars of the 5th generation), introducing jet traction; (d) improving the welding technology in the manufacture of the frame (density and complete welding of seams), the use of direct current welding of reverse polarity, inert gases, and subsequent heat treatment of the frame, strengthening of welded joints by riveting; (e) changing the design and characteristics of the spring suspension, using air springs (5th generation) instead of springs, which allows to adjust the height of the floor level depending on the load of passengers; (f) changing the body support schemes, in particular, the use of a two carriage section supported by three bogies (5th generation) to facilitate the passage of small-radius curves (light and mini-metro).

In general, all the upgrades provided improved dynamic performance, increased strength and reliability of the undercarriages. Figure 3 shows a histogram of changes in the structural speed and tare weight of motor carriages.

For generations of underground carriages, the design speed was increased twice—to 75 and 90 km/h. The packaging weight has a general tendency to decreasing, the increase in the packaging in the 5th generation is due to the fact that it belongs to the two-carriage section, in addition, there is a tendency to increase the weight of the equipment, which was expressed in a certain increase in the packaging since 2017.

**Fig. 3** Change in structural speed and packaging



### 3.3 Driver's Cab Shape

The shape of the front part of the car largely determines the aesthetic perception of the train as a whole. In addition, it affects the technical characteristics, including traffic safety. Modernization of the driver's cab was carried out in the following areas: (a) changing the shape of the frontal part, which changed from a flat rounded with a central emergency end door (1st generation) to a prismatic (of three planes, type I1, 4th generation), then a flat without an emergency door (type I3, 4th generation), a convex rounded shape with an emergency door (models 81–717.6 K/714.6 K and 81–717.6/714.6, 4th generation), an inclined shape with smooth vertical side and end walls (5th generation); (b) the number, location and design of buffer lamps from two at the edges (1st generation) to the layout of several lamps in the form of a single line in the center (4th generation) and the use of halogen and LED headlights (5th generation); (c) increasing the area of the driver's cab by lengthening the frontal part (mainly starting from the 4th generation); (d) the use of a crash system in the frontal part (models of carriages of the 5th generation). Comparing the main forms of the front part of the train, typical for carriages of different generations [13], we can conclude that the fundamental change in shape is common only to cars of the fifth generation.

### 3.4 Motors, Drive, Control and Other Electrical Equipment

The main elements of the electrical equipment of underground railway carriages are driving motors with a drive. The main directions of changes of the electric underground carriages: (a) the type of traction motors from DC motors [14] (the carriages 1st-3rd and partially 4th generations) to three-phase asynchronous motors (latest model 4th generation), which have greater efficiency, smoother acceleration and deceleration engines (instead of the brakeblocks); (b) in the power and weight of a traction engine, which is possible by the presence of the trailer carriages; (c) some models have used regenerative braking—the motor when braking in generator mode; (d) improving traction drive, including the use of a clutch (in the carriages of the third generation), rotation sensors, mount and engine and speed transformer on the frame, which corresponds to the traction transmission of the third class (in the carriages of the fifth generation); (e) introduction to the control system, from the trains of the type E (3rd generation) systems ARS-ALS ("Automatic speed control and automatic locomotive speed—the System of Underground of the Russian Federation") and means of the driver vigilance, application of tiristor-pulse control system for smooth starting and braking (the fourth generation), microprocessor control and diagnostics (starting with 81–720.1 model of the fourth generation), automatic driving system of the train (the train "Moscow 2020" 5th generation); (f) improvement of accumulator batteries to power the control lines; g) change in the type of lighting fixtures from incandescent electric lamps to fluorescent, number and location of lamps (in the cabin), the use of halogen and LED headlights of high efficiency; h) the emergence of radio in the front carriage, direct communication with the driver (4th generation), public address system, including route information displays and monitors in carriages, CCTV systems, USB connectors for mobile devices, diagram panel on the outside of the train (5th generation). The development of electric equipment of underground railway carriages was carried out both in the direction of the development of power (traction) equipment, and in the direction of improving the convenience of passengers, including improving safety measures.

### *3.5 Ventilation and Air Conditioning*

The ventilation and air conditioning system underwent significant changes: (a) starting from the fourth generation—the use of a forced ventilation system instead of the previously used supply and exhaust system, and starting from the fifth generation of carriages-the air conditioning system in all carriages (in the 4th generation, the driver's cab air conditioning system was introduced); (b) in the fifth generation of cars, a modified climate system for ground metro lines was introduced; (c) starting with the "Oka" models (5th generation), an air disinfection system was introduced. Obviously, the improvement of ventilation and air conditioning systems required changes in both the electrical equipment and the body structure.

### *3.6 Brakes*

In the brake system of the modification, the following technical solutions were used: (a) rheostatic braking (type B, 1st generation), including self-excitation of traction motors (2nd generation), with a multi-position drive of the Reshetov design controller (third generation); (b) regenerative braking (in some models, in particular, I1 of the fourth generation); (c) thyristor-pulse control system, which provides, among other things, smooth braking (type I1); (d) electropneumatic braking system (model "Moscow 2020", 5th generation).

### *3.7 Automatic Coupling Device*

Starting with the first generation of underground railway carriages, the Scharfenberg automatic coupling was used. The disadvantages of this type of automatic couplers include a tendency to self-coupling, which requires additional fixing elements, as well as difficulties in coupling carriages in curves.

In the innovative fifth-generation railway carriages (the Moscow series), gap-less coupling devices are used, which improve the longitudinal dynamics of the train due to the absence of gaps, eliminate the need for buffers for sampling gaps, have smaller dimensions and weight, and make it possible to automatically connect the highways. At the same time, there are problems with the coupling of carriages in curves and the passage of curves of small radius.

### 3.8 Protective Devices

Transportation safety issues began to be paid attention from the first years of the underground operation. In recent years, new technologies and design solutions have emerged to improve the level of safety. Note the main technical solutions in underground carriages related to safety issues: (a) emergency door in the driver's cab of many models; (b) current removal from the lower part of the contact rail; (c) safe design of the entrance doors; (d) communication with the driver from the carriages; (e) increase in the area of the driver's cab due to elongation, which increases the safety of the driver in emergency collisions; (f) microprocessor control and diagnostics system; (g) increase in the width and number of doorways, which facilitates the exit of passengers in emergency situations; (h) passive protection system of the head car (crash systems); (i) a wide through passage along the train; (j) emergency door opening buttons; (k) a door anti-pressing system; (l) a driver's vigilance control system; (m) fencing of the inter-car space in the latest models of trains; (n) non-flammable materials in the interior of the cabin (hard-to-burn plastic in carriages of the 4th generation); (o) safety devices for elements that have the possibility of falling on the track.

### 3.9 Passengers Comfort

In recent years, more and more attention has been paid to ensuring comfortable conditions for underground passengers. Consider the technical solutions that have a positive impact on the level of comfort in underground carriages: (a) improvement of the ventilation and air conditioning system; (b) thyristor-pulse control system of the electric drive, which ensures smooth starting and braking of the train; (c) passenger notification systems, including sound and visual; (d) the possibility of direct communication between passengers and the driver; (e) increased heat and noise insulation of the cabins (carriages of the 4th generation); (f) improvement of the design of both the interior and the appearance of the train; (g) improvement of the internal layout, including increasing the total area, width and number of doors, ensuring through passage along the train, improving the conditions for passengers to pass from the doors deep into the train, optimizing the number of seats; (h) seats for disabled people; (i) USB sockets; (j) free Internet.

## 4 Discussion

This article presents the rationale for the development of the Moscow underground rolling stock. The importance of the problem lies in the formation of future reserves and innovations in this area. Comfort and passenger capacity are two important characteristics that design engineers are currently paying attention to. Foreign authors raise this problem in their works [14, 15]. These characteristics are especially relevant for capitals and cities with millions of inhabitants. The features of Chinese and Japanese technological developments play an important role in the development of this industry. The participation of the Russian side in exhibitions and joint projects is reflected in the modern rolling stock, which is increasingly found on the lines of the Moscow underground. The limitations of this study are built due to the closeness of the information. In future research, the authors will compare modern underground carriages in different countries of the world.

## 5 Conclusion

The rolling stock of the Moscow underground has passed a long way of development to serve the ever-increasing passenger traffic in the capital per year from 212,645 people in 1938 to 320,2694 people in 2000 (Fig. 4). The decrease in this indicator to 2,348,300 people in 2010 and a slight increase to 2,560,700 in 2020 is due to the increased volumes of public and private passenger transport.

The reduction in the size of the Moscow underground carriage in the 1930s compared to the passenger carriage in railway transport required further efforts to increase its capacity. This was achieved by increasing the indoor length of railway carriage, reducing seats, changing the number, size and design of doors, end walls of intermediate carriages, using new forms of side walls and roof.

In the second generation of the Moscow underground rolling stock, along with a reduction in the weight of the body packaging, it was possible to achieve a smooth start due to slowdown with the help of rheostatic braking, as well as reducing the amount of electrical equipment repairs.

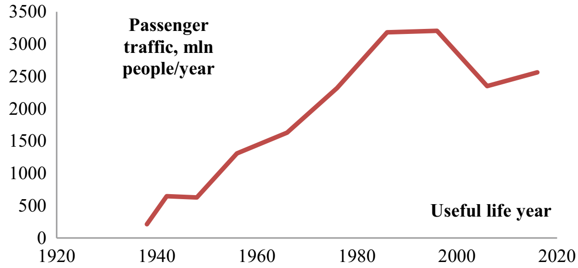



**Fig. 4** Change in passenger traffic of the Moscow underground in years

In the third generation of rolling stock technology, the tendency to lighten the body, bogie, traction drive, and carriage auto coupling was preserved due to changes in the load-bearing structure, materials, and finishes. This resulted in improved ride smoothness, reduced wagon weight, and reduced traction consumption.

In the fourth generation of rolling stock equipment, the reliability of minor components was increased and, as a result, the carrying capacity was increased, the average and structural speed of movement was increased, and operating costs were reduced.

The fifth generation of rolling stock equipment, which is operated, including on open metro lines, is aimed at providing comfort and increased passenger capacity.

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# Mathematical Modeling of the Process for Assessing Innovative Potential of Machine-Building Complex

**N. A. Dubrovina and A. G. Lukin**

**Abstract** The paper investigates issues on the innovative potential and the main approaches to its assessment in the engineering sphere. The machine-building complex is a very complicated socio-economic production system, which is influenced by a huge number of factors (both external and internal), and it is impossible to take into account all of them, based on the assessment of the impact of each factor with their subsequent summation. Just as it is difficult to identify the most significant factors, the impact of which would be the strongest for any conditions of the system's existence. As a result, the assessment of the innovative potential of the machine-building enterprise and the industry as a whole faces similar problems. This article is aimed at synthesizing the main theoretical aspects in the field of assessing the innovative potential and to form on this basis the author's vision of solving this problem. The main result of the study was the creation of a mathematical model of the process of assessing the innovative potential of a machine-building enterprise, based on the cybernetic principle of the "black box". The suggested model takes into account the conjuncture of the innovation potential as a whole, allowing not to consider it as a sum of assessments of each of its constituent factors impact.

**Keywords** Innovations · Innovation potential · Machine-building complex · Machine-building enterprise

## 1 Introduction

### 1.1 Establishing a Context

Since the creating of a term "innovations" by Schumpeter, more than 100 years has passed [1]. During this period, the innovative theory has given many directions for

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research. Took over the whole world. Almost completely replaced the Soviet term "scientific and technological progress". It has reached the state level, although it was developed by the author exclusively for entrepreneurs. The most prominent followers of the innovative theory of Schumpeter are Freeman [2], Drucker [3], Dundon [4]. Copeland, Kooler and Murrin [5], Bright [6], and others have explored the issues of innovation theory in their works. An important place in the innovation theory is given to the concept of "innovation potential". It is believed that the first scientific use of this concept was introduced by Freeman, who considered it as a set of measures to implement the accumulated production, economic and organizational potential, which leads to the emergence of innovations [2]. Drucker believed that innovative development is possible only after a detailed analysis of the existing potential of an economic entity and an assessment of the prospects for its effective use [3]. That is, the innovation potential is considered as a controlled activity to transform the entire accumulated potential, including the socio-economic aspect, into an innovation.

### *1.2 Reviewing the Literature*

Today, we can probably talk about the school that developed in the Russian Federation within the framework of innovation theory. The analysis of the works of domestic scientists on the study of innovation potential shows that the main focus in studies is on the quantitative and qualitative assessment of the ability of an economic entity to develop and implement any innovation. Thus, Gureev and Grishin note that in the Russian scientific literature, the concept of "innovation potential" is most often associated with: the scientific and technical background (the presence of research, discoveries, inventions) of an economic entity; the availability of new developments that contribute to solving new problems; the availability of opportunities for the company to effectively attract new technologies and other innovations [7]. And they consider the innovation potential as a sign of the socio-economic system, which characterizes the acceptability (feasibility) and the maximum possible result of purposeful activities to change the structural and functional properties of this system [7]. Izmaikina considers the nature of the innovation potential somewhat broadly and identifies four characteristics of the nature of innovation potential:

- enterprise development goals;
- resources that are required for the implementation of these goals (human, material, financial);
- necessary for this development assets (property and investments, intellectual resources);
- skills and abilities (technologies, knowledge, equipment, etc.) for the effective use of resources [8].

The nature of the innovation potential in its modern view in Russia was most clearly formulated by Shubina. This researcher considers two factors of the innovative development: innovative activity and innovation potential. Shubina expresses the sum of these factors with the Eq. (1):

$$R = aID + \delta IPP \tag{1}$$

where $a$ and б are weighting factors, they determine the relative importance of each factor and should amount to 1 [9]. It is easy to see that in the formula, the innovation potential is separated from the concept of innovation activity. Thus, in contrast to the Western school, Russian scientists consider the innovation potential not as a set of actions of entrepreneurs to turn the accumulated resource into an innovation, but rather as a process of accumulating various types of resources to enable the development and implementation of such an innovation, effectively separating innovation activity from innovation potential.

Based on this concept, research approaches to the assessment of innovative potential are also implemented. As Shubina writes, there is no single methodology nowadays for assessing the innovation potential, which seemed to be the most objective [9]. This is due to the following reasons. First, the innovation potential is considered not only for industrial and other enterprises, but also for clusters, industries, etc. Each of these economic entities has its own characteristics of the formation and accounting of the property and intellectual complex, which cannot be evaluated uniformly. In addition, there are various factors that need to be taken into account when assessing the innovation potential. Secondly, the innovation potential is also evaluated in the regional and territorial context. This is how the innovation potential of regions, countries, cities, etc. is evaluated. In this case, there are also different approaches to understanding the category of innovative potential and, accordingly, the evaluated criteria, which increases the diversity in the solution of this problem.

Nevertheless, the methods of assessing the innovation potential offered by Russian scientists and practitioners are based on two main approaches, determined by the understanding of its nature. The first approach is mainly a quantitative, but also a qualitative assessment of various production, human and financial potentials and the summation of the resulting estimates into a single integral indicator, which is then considered in the dynamics of changes. So, for example, Kalev offers the following mathematical model of the efficiency of using the innovation potential of the enterprise, Eq. (2):

$$Eip = \frac{PR}{\sum_{i-1}^{I} Ri + \sum\limits_{j-1}^{J} Pj + \sum_{z-1}^{Z} Cz + \sum_{l-1}^{L} Ml} \tag{2}$$

where *Eip*—efficiency of innovation potential use; *PR*—profit; *Ri*—indicators of the potential of research and development (R&D); *Pj*—indicators of production potential; *Cz*—indicators characterizing the cost on servicing innovative products (financial potential); *Ml*-indicators evaluating the marketing potential of the enterprise; *I*, *J*, *Z*, *L*—the number of indicators used in the model to assess each component of innovation potential [10].

The second approach, a factor approach, is based on the assessment of internal and external factors impact on the innovative capabilities of an enterprise. Based on the analysis of the Russian scientists' works, we can talk about the typology of factors that affect the enterprise innovative potential. Let's consider the main types of factors.

The development of the innovation infrastructure, shifts in the consumption structure, development trends of a particular economy sector, and others belong to the external factors, at the same time, the totality of the enterprise's potentials is an internal factor, for example [9]. At the same time, external factors in terms of the level of occurrence can be global (relations with other businesses in the global context while implementg innovative projects, the need for innovative products to be integrated with the products and technological processes of the relevant field), meso-level—the state, the region (financial support for research and development, insufficient support for young scientists, weak protection of intellectual property, etc.) and micro-level- enterprise [11].

Internal, in turn, can be divided into economic (the availability of own funds directed to the field of innovation, the level of costs for the production of innovative products, a long payback period for innovations), production (production potential, availability of personnel, reliability, timeliness and completeness of available information, the possibility of cooperation with scientific organizations and innovation-active partners, etc.) and organizational (the development of the innovation market) [12].

On the basis of factors contributing to the development of innovative potential, state factors (the need for innovation, the cost of innovation, economic risks) and change factors (demand for new products, the state of the market segment, the balance of production capacities, the availability of material resources, the qualification of personnel, the financial independence of the innovation project) are considered [9]. On the basis of factors hindering the development of innovative potential, there are transformational factors that affect the quality content of innovative potential and transactional ones that characterize the readiness of a business entity to carry out innovative activities [11].

It is quite difficult to take into account the impact of all the factors mentioned and not mentioned in this work. Assessing the impact of external factors is almost impossible to solve, since there is a high degree of uncertainty of market factors. Therefore, scientific papers usually describe some ideal model that works for certain conditions. So Lukashov studies the impact on the innovation potential of enterprises of the national innovation system, which, as a product of state and joint public–private structures needs to solve the task of modernization of the economy of the state [13], and Chertykovtsev and Lukin offer a methodology for assessing investment risks in the modernization of production [14].

The largest number of studies is devoted to methods of assessing the impact of internal factors on the formation of the innovative potential of the enterprise.

For example, Izmaikina suggests evaluating the innovative capabilities of an enterprise through an integral indicator of innovation potential, which includes a set of assessments of the structural components of innovation potential, taking into account weight coefficients [8]. The evaluation of each factor is made by calculating the corresponding coefficient, and the evaluation of the structural component is made by calculating the arithmetic mean of the sum of the factor coefficients of its components. As a result, the formula for assessing the innovation potential is proposed, Eq. (3):

$$IP = 0,3PI + 0,15PNI + 0,25PPT + 0,15PF + 0,1PM + 0,05POU \tag{3}$$

where IP is an integral indicator reflecting the enterprise innovative potential; PI is a private indicator of the intellectual component of this potential; PNI is a private indicator of the research component of the potential; PPT is a private indicator of the production and technical component of the potential; PF is a private indicator of the financial component of the potential; PM is a private indicator of the marketing component of the potential; POU is a private one. The weight coefficients reflect the share of the number of factors that make up each component in the total number of components that make up all 6 factors [8].

## 2 Methodology

Using these examples, we have shown the complexity of various methods for assessing innovation potential. Without criticizing the proposed methods in any way, it is impossible not to notice that they reflect mainly one side of the nature of the innovation potential. And most importantly, in our opinion, they do not answer the question of how the accumulated opportunities are used, and with what efficiency. Russian scientists agree that, despite the fact that the impact of the innovations application may include non-financial indicators, the main result of the innovative activity of the entrepreneur is still the profit or other income received by the firm in financial terms [15]. The basis of this study was the enterprises of the machine-building complex, which are inherently complex socio-economic systems [16]. Given this, their innovation activity and innovation development are influenced by a very large number of factors. In addition, it is quite difficult to assess the totality of their potentials. We get a large amount of calculations, which is almost impossible to reduce to a single integral indicator that can clearly and simply demonstrate both the level of innovation potential and the effectiveness of its application.

In order to minimize routine calculations and get as accurate as possible data on the potential innovative capabilities of the machine-building complex enterprise, it is proposed to apply the cybernetic principle “Black Box”. This is based on the study of the system’s responses to known input effects [17]. Considering that the most significant resource component of the innovation potential is the cost of technological innovations, as input actions we will mean the amount of investments in the innovative development of the enterprise, recorded in accounting or statistical accounting, denoting them as X (in the machine-building complex as a whole).

The black box itself will represent a set of factors that affect the innovation potential or the environment of the innovation potential. Taking into account that the environment of innovative potential plays the role of a mechanism for converting provided investments into a finished innovative product, we will call it the transfer function of the machine-building complex (hereinafter referred to as the transfer function) and denote it by the letter W.

At the exit from the black box, we will consider the result of the innovative activity of the machine-building enterprise (the machine-building complex as a whole), in the form of the cost of the shipped or sold innovative products of the enterprise, also reflected in the corresponding accounting register. Let's denote it as Y. The transfer function shows the value of the finished product produced per one ruble of investments. Therefore, it represents the ratio of the output-Y of the system to the input-X, Eq. (4):

$$W = \frac{Y}{X} \tag{4}$$

However, given that the positive effect of the provided investments can be postponed for some time, and can be cumulative in nature, it is proposed to calculate another indicator—the rate of change in the transfer function V, which is expressed by the ratio of the change in the value of the transfer function over time, Eq. (5):

$$V = \frac{\Delta W}{\Delta t} \tag{5}$$

To illustrate the suggested methodology, we will use statistical data on the innovative activity of the machine-building complex of the Russian Federation for 2010–2017 (Table 1).

## 3 Results and Discussion

Based on the data in the table, we will build a linear trend of the transfer function of the innovation potential. The linear approximation of the transfer function of the innovation process is represented by Eq. (6).

$$W\iota = Vt + b \tag{6}$$

where: $W_l$ is a linear approximation of the transfer function of the innovation process intensity, V-coefficient characterizing the rate of change in the transfer function of

**Table 1** Indicators of the innovative potential of the machine-building complex in the Russian Federation in 2012–2018

| Indicators | Years | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| ***Y***—Volume of goods shipped, works performed, services rendered, billion rubles | 47.3 | 58.4 | 62.3 | 68.8 | 56.2 | 56.6 | 97.0 | 68.2 |
| ***X***—Costs of technological innovations by types of economic activity (billion rubles) | 10.6 | 11.7 | 12.3 | 14.6 | 19.2 | 18.0 | 18.6 | 13.9 |
| ***W***—Transfer function of the structure of the innovative potential of mechanical engineering | 4.5 | 4.9 | 5.0 | 4.7 | 2.9 | 3.1 | 5.2 | 4.9 |
| ***V***—The rate of change in the transfer function of the structure of the innovative potential of mechanical engineering | – | 0.4 | 0.1 | −0.3 | −1.8 | 0.2 | 2.1 | −0.3 |

the innovation process (1/year), b is the value of the transfer function at the reference point.

As can be seen from Fig. 1, the impact of the innovation potential in the estimated period is insignificant, but it fades. Although, this may be due to the delayed effect of innovative investments. Thus, by controlling the rate of change in the transfer function, it is possible to influence the efficiency of investments in the formation of innovative potential. We study another aspect of the suggested methodology. This is a question of the stability of the formed innovation potential, as a system of factors influencing innovation activity, to various negative impacts on it. To do this, we consider the mechanical engineering transfer function-W on stability. A nonlinear system can be stable in a small way, but unstable in a large way. Stability in the small

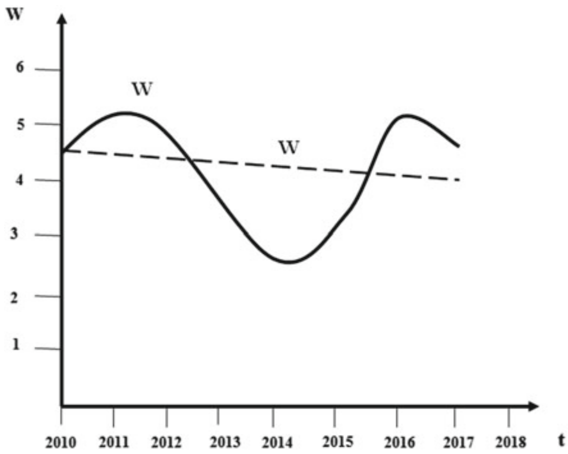


**Fig. 1** Transfer function of the innovative potential of mechanical engineering in time

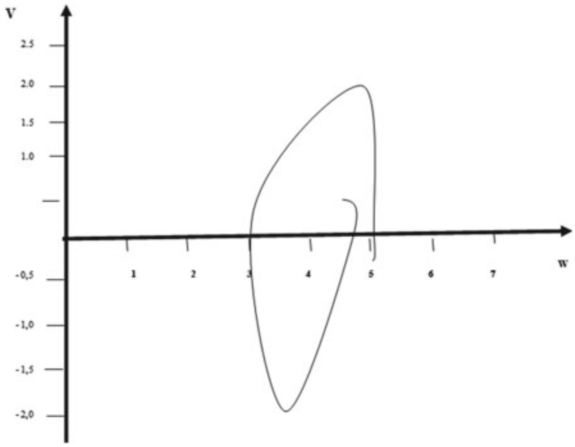


**Fig. 2** Phase portrait of the innovation potential of mechanical engineering

way is the stability of the system at infinitesimal deviations from the initial mode. Stability in a large way is stability under the finite deviations possible in a given system under its conditions [18].

In the qualitative analysis of processes in nonlinear systems, a geometric representation based on the concept of phase space is used. For second-order systems, the two-dimensional phase space is a phase plane. When the state of the system changes, the trajectory of the system is displayed on the phase plane, which is called the phase trajectory. The phase trajectory gives a complete idea of the nature of the process in the system. Images of phase trajectories are called phase portraits of the system. In the presence of stability, the phase trajectories contract to the origin, and in the instability, they diverge to infinity. In an oscillatory transition process, the phase trajectories wind around the origin. The phase portrait of the innovative potential of the machine-building complex corresponds to a nonlinear system that is stable in small, but unstable in large (Fig. 2).

That is, under the influence of factors that cause small fluctuations in the system, for example, the gradual obsolescence of equipment or a lack of marketing efforts of the company or the industry as a whole, the system will tend to a stability. However, with a more powerful impact, such as the actions of the state in terms of strengthening environmental requirements, a sharp obsolescence of products, due to the emergence of more technological products from competitors, etc., the system can go out of balance and, despite the investments, do not lead to the desired results.

## 4 Conclusion

The study showed that Western and Russian schools have some differences in their approaches to determining the nature of innovation potential. The Western school considers innovation potential as an emerging action—a set of measures to transform existing opportunities into innovation. The Russian school sees it as a potential opportunity for such a transformation, regardless of whether it has begun or not. But at the same time, both schools emphasize that it is necessary to assess the existing capabilities of an economic entity to implement innovative activities. The suggested assessment methodology is closer to the Western point of view. In the framework of this approach to assessing the innovation potential, it is stated that the invested financial resources initiate the impact of influencing factors and lead to some intermediate results by themselves. Therefore, this methodology can be used to assess the effectiveness of the innovative potential use, and to predict the results of this application, as well as for other purposes.

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# Features of Bonded Zones

**R. V. Fedorenko, O. D. Pokrovskaya, and T. Czegledy**

**Abstract** The intensification of transactions in electronic cross-border trade has led to the formation of innovative bond logistics ecosystems. The main term for these ecosystems is bond zones. They are located in large multimodal transport hubs and concentrate terminal, customs, logistics and production services for cross-border trade goods. The authors examine the business model of bonded areas using methods of logistics, terminalistics, regional economics, transport geography, marketing analysis, system and cluster approach. The authors study main features of bonded zones and its impact on individual regions integration in the world economic system. Most of the previous studies analyze and give an idea of the internal layout and technological solutions of logistics facilities. Unfortunately, few studies consider a complex of interrelated problems of organizing the functioning of bonded zones and their role in regional development. The purpose of the article is to study the features of the organization of the transport and logistics business in the format of bonded zones, the principles and stages of their development. The study tries to fill the gap in analytical research and is aimed at scientific substantiation of the preconditions for the organization and development of bonded zones in the market of the Russian Federation for effective transport and logistics.

**Keywords** Bonded logistics · Bonded zones · E-commerce · Regional integration · Terminal and warehousing infrastructure

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## 1 Introduction

2020 has been a disruptive year for e-commerce. A significant growth in electronic transactions was noted in the world as a whole. According to forecasts of the Ministry of Economic Development of the Russian Federation and the Data Insight agency, within five years, the average annual growth of electronic cross-border trade may reach 33%. At the same time, the main barrier to the development of cross-border trade is a poorly developed terminal and logistics infrastructure. The country's government sees the organization of bond zones as a new instrument to regulate international trade and accelerate individual regions integration in the world economic system.

A well-developed transport and logistics area will be considered a bond zone, in which there is a special tax and customs regime for imported goods, which are stored free of customs duties, VAT and excise taxes. The complexity of organizing bonded zones is associated with a format of geographically concentrated business. One place, one brand, in synergy, with a unique service—this are the main principles of bond zone. The number of bond zones in the world continues to grow. Only in China, according to the Association of Bonded Zones, there are 120 of them. It is not surprising that the global logistics business is looking for new tools to manage bonded logistics in cross-border trade. Bond logistics is an applied methodology for managing various flows of cross-border trade—cargo, information, finance. This is an efficient technology of interaction between regional business structures, government bodies and the entities of customs and logistics infrastructure, providing services for the support of export–import commodity flows.

The study is based on works devoted to the development of logistics facilities in terms of transport geography (Rodrigue [1]), intermodal technologies (Nguyen and Notteboom [2]), digital technologies (Poenicke, Groneberg, and Richter [3]), the development of new logistics paradigms (Xiao, Yuan, Sun, and Sun [4], Liu and Wu [5]), configuring cross-border supply chains (Alizadeh Afrouzy, Nasseri, Mahdavi and Paydar [6]). The authors use results of their previous works [7], devoted to the creation of a customs and logistics framework for sustainable development of border regions. The purpose of the article is to study the features of the organization of the transport and logistics business in the format of bonded zones, the principles and stages of their development.

## 2 Methodology

The authors performed a thorough analysis of scientific literature in the field of transport, logistics and economics. It is seen that today's scientific trends show mutual distribution, or integration of scientific research, and that the research has an interdisciplinary nature. The authors used methods of logistics, terminalistics [8], regional economics, transport geography, marketing analysis, system approach.

## 3 Results

The growing intensity of cross-border e-commerce has determined the genesis of logistic objects of a completely new type. Such logistics facilities—bonded zones—not only process online shopping goods, but also serve as multifunctional hubs for comprehensive service of international trade flows. According to the National Distance Selling Association, Russia is in 11th place in the world in cross-border trade rating. The bonded zones provide opportunities for increasing cross-border trade flows and integrate individual regions in the world economic system. The bonded zones have special customs status that makes it possible not to pay customs duties and taxes when storing imported goods until the final buyer purchases them.

Figure 1 shows that the organization of a bonded zone in the St. Petersburg transport hub can reduce the delivery time of goods from abroad from 45 to 35 days by sea routes to 14 days by rail transport.

The advantages of organizing a bonded zone on the territory of the existing transport and logistics hub Bronka are the following:

- this is the port area and a well-developed point of distribution / redemption of commodity flows;
- Bronka is adjoining the railway, maritime and automobile infrastructure;
- the new bonded zone is proximate of the European Union;
- there is no any land encumbrances.

The authors assume that it is possible to realize the transit potential by optimizing the formats of conducting transport and logistics business and organizing a terminal and logistics framework corresponding to the pace of cross-border trade.

Understanding the principles and stages of bonded zones development will allow solving the problems of effective transport and logistics services for consumers of e-commerce goods.

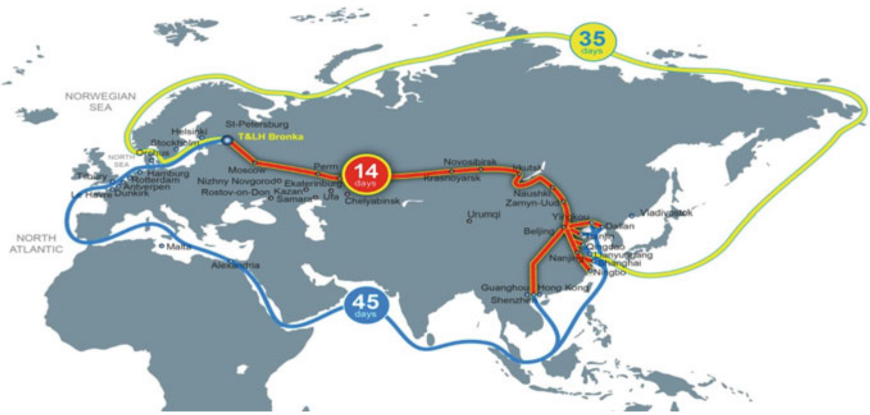


**Fig.1** Comparison of delivery times of good

The authors formulated the principles of the bonded zone development:

1. Consistency—manifests itself in the consideration of all elements as a complex to achieve development mission.
2. Total costs—accounting and minimization of costs associated with design, construction and operation of logistics facilities.
3. Logistics integration and coordination—the bonded zone maximizes the benefit of the goods due to the combined actions of the participants. It aggregates and synthesizes services into a unique package service.
4. Integrated virtual support—the bonded zone provides a single information field for the interaction of supply chains participants. All interaction is organized using blockchain technology.
5. Openness—the bonded zone is a platform for all types of business.

The authors propose the following enlarged stages of the development of the bonded zone, Table 1.

It is known that the main advantages of the functioning of bonded zones are:

1. Preferential taxation based on the complete cancellation or partial replacement of individual payments to the budget with a special bond tax.
2. Duty-free trade—the possibility of free import, export and movement of goods within the zone without paying customs duties.
3. Transfer of the usual tax regulation beyond the perimeter of the bonded zone—customs duty, VAT and consumption tax at standard rates will be charged only in case of export of duty-free imported goods to other territories.

**Table 1** Stages of development of the bonded zone

| Stage | The essence of the stage |
|---|---|
| Genesis | Exploration and marketing research, pre-design feasibility studies |
| Structure | Formation of the structure of the bonded area according to the concept of spatial development and the functionality of the participants |
| Investment | Defining the business model and financing mechanism |
| Production | Construction start |
| Launch | Commissioning, interaction with global marketplaces, building your own supply chains |
| Setting up work technology | Debugging the regulatory framework, the concept of strategic development of the territory |
| Profiting | Reaching the planned profitability indicators |
| Efficiency | Obtaining main and multiplier effects and achieving strategic objectives |
| Metamorphoses and self-determination | Making a decision on the vector of further development (expansion, absorption, reorganization, etc.) |

4. Special regime of currency regulation—the possibility of concluding and paying for contracts for the supply of goods in foreign currency.

To realize the benefits, it is necessary to solve a number of problems when organizing bonded zones:

1. Design of logistics facilities as part of bonded areas according to international standards.
2. Planning the bonded territory integrated development, understanding the typology and development prospects of the seaport.
3. Methodological support for the organization of rational supply chains in cross-border trade.
4. Improving the legal framework in the field of tax and customs regimes.
5. Development of ways to improve the interaction of transport modes in bonded areas.
6. Developing a typical model of participants composition and their actions in the bonded area mechanism.
7. Improvement of design methods, modeling and optimization of bonded areas.

The authors formulate functional purpose of the bonded zone as follows: Ensuring the profitability of transport and warehouse processes with a multiplier effect. The bonded zones provide flexible management of synergistic interaction in the complex service of e-commerce goods. Clients can get import, export and transit cargo flows on a localized territory with a special tax and customs regime with a full range of fulfillment, surface treatment and other "near-transport" services.

## 4 Discussion

Bonded zones are an innovative mechanism to reduce transaction costs for international trade. The authors investigated the possibilities of preferential regimes and their impact on the region's economy in their early works [9]. Many researchers note the importance of cost reduction in the course of international trade [10, 11]. Innovations in logistics are usual tools to reduce such costs [12, 13] and bonded zone is one of this modern tools. Border regions use bonded zones to attract additional flows of goods. The literature concerned about bonded zone developed rapidly in recent years. Scientists from China [14, 15] carry out a significant number of studies of the results of the work of bond zones. The authors of the presented article rely on the experience of foreign researchers and note that the active introduction of bonded zones in Russian regions can create preconditions for their further involvement in the system of world economic relations.

## 5 Conclusion

This research is aimed at scientific substantiation of the peculiarities of the development of bonded zones. In modern Russia, bonded zones gain growing interest due to rapid development of international e-commerce market. The development of bonded logistics in terms of the concentration of logistics activities in a spatially localized multifunctional hub makes it possible to perform a full-fledged fulfillment service for goods arriving in export–import directions. For Russia, the bonded logistics business format is relatively new. The unique geopolitical position of the country allows working with powerful transit trade flows of different directions. Therefore, in order to extend the depth of controlled logistics chains, Russian companies should consider the prospects for including the "bonded logistics" format for generating new complex transport products. The launch of bonded zones based on railway freight yards will make it possible to develop tools to increase the profitability of the transport and logistics business at the breakpoints of logistics chains. It will also help to configure rational terminal network. One of the main possible winners of introducing this innovative mechanism is Russian Railways Holding. The national pro-state carrier will achieve the following positions: an increase in transshipment capacities; optimization of warehouse logistics activities; "switching" of cross-border trade to the network of freight terminals of the Russian Railways Holding. The research results can help to choose the methods of organizing bonded zones on the territory of the country and assess the transit potential and cross-border trade in electronic format. In-depth research deserves the issues of modeling the operation of bonded zones and predicting their development, calculating the parameters of bonded zones and their elements.

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# Transportation by Rail of Chemical Enterprise Products Based on Lean Thinking

**N. A. Kryuchkova and T. A. Ilyina**

**Abstract** The article discusses the peculiarities of product transportation development at chemical production enterprises. Despite the rapid development of interactive communication between sellers and buyers in the framework of online commerce in other economic activities and the reorientation from rail to road transport, chemical manufacturers consider railway transport as one of the main due to the significant export component in sales. Current conditions as of the beginning of 2021: rolling stock surplus and reduction in universal carriage rates highlight the need to consider the optimal use of private rail transport. The relevant information of the definition of this area is sufficiently determined and contains several indicators: the type of rolling stock, the cost of preparing the car for loading, the carriage fee for using the railway infrastructure and its differentiation according to transportation distance of the cargo, as well as checking the need to take into account the carriage fee for empty mileage of the private car. To determine the area of rational use of private cars, the degree of influence of each indicator on its border is taken into account. The article justifies the need to create digital technologies aimed at prompt administrative decision-making and presents a model for determining the area of optimal use of the operator's own transport and rolling stock on the basis of lean thinking.

**Keywords** Chemical production enterprise · Lean thinking · Lean transport · Railway transport · Value of transportation process

## 1 Introduction

The proposed mechanism for creating the value of transport services is based on identifying the hidden reserves for reducing its resource intensity. This approach was

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called lean transport [1]. Modern researches of lean thinking use different resource-saving approaches in the formation of the supply chain mainly involving road transport, and unfortunately do not fully take into account the sectoral aspect [2–4]. It should be noted that the entire flow of value creation consists of two parts: information and resources. Lean thinking requires the analysis of all the costs involved in transportation. According to the authors' research, the transport component reaches 15% of the total costs of the enterprise. About 60% is payment of railway transport carrier tariffs. Taking into account the positive dynamics of the volume of transportation for 2015–2020 of chemical and mineral fertilizers by 11316.5 thousand tons [5] and increasing the range of cargo transportation, the problem arises of determining the field of rational use of a private rolling stock. The changes taking place in the national economy encourage the main freight railway carrier, OJSC Russian Railways, to revise the parameters of the long-term program for the development of monopolies until 2025: abolition of the lowering factor of 0.4 per carriage range, elimination of discounts on empty mileage for innovative cars, 4% indexation of the tariff for transportation in containers [6]. The use of a private fleet of vehicles leads to payment for the empty unproductive run of the car to the home station, and when using the operator's car this is not necessary. The basic principles of lean thinking state the need for continuous efforts to improve production processes and the dependence of the volume of transport services provided on the consumer (chemical production enterprise). The achievement of continuity of the value of transport services to the consumer can be realized using digital technologies.

At the moment, the Russian market for information transport services lacks software products that take into account the sectoral aspect of the industrial enterprise. Online calculators, digital platforms for calculating the cost of railway transportation and specialized program products (CTM Rail-Tariff, CTM Rail-Info, CTM Rail-Tariff Russia and others) take into account such parameters as the type of dispatch, the type of rolling stock, the weight of cargo in one car, the tariff class of cargo, the ownership of the car, the need to accompany the cargo; but the cost of preparing cars for loading, which is a relevant indicator, is not taken into account.

The creation of a model for prompt determination of the feasibility of using a private railway fleet of vehicles or an operator's fleet and its implementation on the basis of digital technology with the possibility of generation with existing software products is an important task when applying lean thinking in chemical production enterprises. The application of this model will realize the essence of lean thinking: creating the value of a service based on its reliability and accuracy.

## 2 Methodology

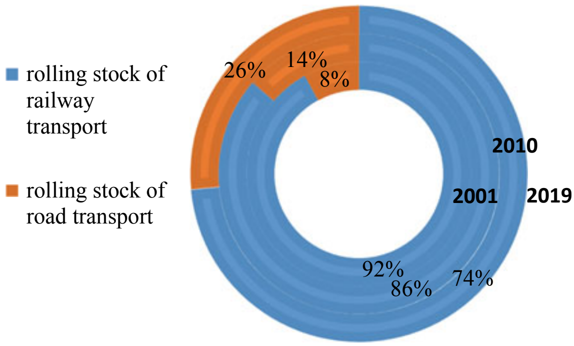
The subject of this article is the process of creating the value of transportation by rail of products of chemical production enterprises. Using the dynamic series method, the mode of transport in question was defined as dominant. By axiological method, were revealed the factors influencing the field of rational use of the railway rolling stock of the enterprise and its boundaries were determined. Due to the overwhelming effect of railway tariffs on the creation of the value of transport, their components were diagnosed by the least squares method. In order to determine the relationship of the received tariff values, paired correlation coefficients were calculated. Methods of analysis, induction and mathematical modeling are used to form a criterion for optimizing rail transportation based on lean thinking. The graphical method made it possible to clearly demonstrate the sequence of management actions to form the value of the process of transporting products of the chemical production enterprise. The combination of the above methods ensured the validity of the results.

## 3 Results and Discussion

Chemical production enterprises are located in all federal districts. Processes of territorial concentration of production were widely developed. Agglomerations of chemical production were formed in the Republics of Tatarstan and Bashkortostan, Altai, Perm and Krasnoyarsk Territories, Tula, Tyumen, Yaroslavl, Nizhny Novgorod, Volgograd, Samara, Kemerovo and Irkutsk regions. More than 30% of chemical products produced in Russia are exported; the imbalance in the supply of mineral fertilizers and solvent demand from their consumers brought this production to the export-oriented sector of the chemical complex.

Despite a decline in production in 2020 in a number of industries, the physical volume of chemical export increased due to China's active demand. However, revenue decreased significantly due to falling prices. As a result, the transport arm of the sold products increased. Due to the seasonality of inland water transport, railway is dominating in terms of transportation of chemical production products throughout the Russian Federation. Considering the structure of the transport fleet of chemical production enterprises by the absolute amount of rolling stock (Fig. 1), we note a significant advantage of railway transport. In order to improve profitability,

**Fig. 1** Dynamics of the structure of the rolling stock of chemical production enterprises of Samara region



balance the interests of chemical production enterprises (customers) and transportation service providers, according to the lean transport approach, various types of outsourcing and insourcing of the transport function are used [1, 2].

But applying this process to rail transport is quite difficult due to the practical absence of intra-species competition. Within the territory of the Russian Federation, freight railway transportation is carried out by no more than 6 enterprises, for example: OJSC Russian Railways, JSC Railways of Yakutia, JSC Yamal Railway, FSUE Crimean Railway. All Russian railway carriers, except Russian Railways, do not take part in international transportation. Given the export orientation of chemical production enterprises, cooperation occurs mainly with the latter.

At the moment, several concepts of lean thinking are distinguished, which determine the value and need of the product and service for the consumer, as well as the continuity and improvement of production processes [7]. Transport is of particular importance in the value creation process. Its task is to ensure consumption, which requires improving not only physical transportation, but also the entire process of providing transportation services. The main criteria for optimizing transport services should be the degree of satisfaction of transportation needs and the quality of the transportation process. But meeting needs and improving quality is impossible without enterprise expenditures and investing part of the funds in the maintenance and development of transport infrastructure.

Lean thinking requires careful and consistent analysis of all the cost elements associated with product transportation. As a result, the total general production costs should be minimal. Thus, a combined assessment of the following indicators should be made to determine the value and improve the rail transportation process [8]:

- the size of expenditures of the production enterprise from transportation by private transport;
- providing shippers with rolling stock;
- cost of transportation by private transport for the shipper in comparison with the cost of transportation in the carrier's rolling stock;
- average time of cargo delivery in private cars, including in directions;
- number of violations of delivery time by private transport;
- volume and dynamics of the transport of goods by private transport, including by type of cargo and type of links.

According to the authors' research, in total transport costs up to 60% is the payment of tariffs of railway carriers, therefore, we will initially analyze these costs by determining the dependence of tariff calculation on distance and on the owner of rolling stock. As a result of the studies carried out, the ratio of the carriage charge to its distance has the form of a linear correlation between the two variables under consideration, which is graphically represented the more accurately the larger the sample size of the charge. The relation of the tariff to haulage distance is presented in Eq. (1). In general, this relation has the form:

$$\mathrm{Tariff}_{\mathrm{pl}} = \mathrm{A} + \mathrm{BS};$$

$$\begin{aligned} \text{Tariff}_{pe} &= C + DS; \\ \text{Tariff}_{p} &= E + FS \end{aligned} \tag{1}$$

where: $\text{tariff}_{pl}$—carriage charge for the transport of private loaded cars in the rolling stock of the chemical production enterprise; $\text{tariff}_{pe}$—carriage charge for the return of private empty cars of the enterprise to the home station; $\text{tariff}_{p}$—carriage charge for the use of infrastructure and carriage fleet of the service provider (OJSC Russian Railway); S—haulage distance; A, B, C, D, E, F—constants.

To confirm the convergence of the presented relationships, paired correlation coefficients having a value greater than 0.9 were calculated, which indicates the accuracy of the calculations. One of the main indicators affecting the value of transport services for the chemical production enterprise is the amount of payment for the use of the carrier's engaged cars. During the stay of federal railway cars with shippers, owners of railway access roads, chemical production enterprises pay railways for the use of cars.

The procedure for making payments for the use of wagons with railways is determined in contracts related to the operation of railway access roads and contracts related to the supply and cleaning of cars. To calculate the fee for the use of cars, the base rate and paid time of use are determined. The intervals of paid time for the use of cars are differentiated by the duration of their use in the range from 0 to 12 h inclusive, from 13 to 24 h inclusive and over 24 h.

The paid time of use of wagons in the case of maintenance of railway access roads by a locomotive belonging to chemical enterprises is calculated from the moment of transfer to the owners of railway access roads of cars, containers on railway dead end tracks until their return to these railways.

Another parameter affecting the value of transportation of chemical production enterprises is the cost of preparing cars for loading, arising independently of the owner of the rolling stock. The list of costs considered includes: (1) salary, which includes piecemeal payment for work performed, payment for combining professions, payment for night work; (2) social insurance contributions; (3) shop expenses which include keeping of management personnel, depreciation of buildings, the maintenance of buildings, maintenance of buildings, expenses on fire safety, workwear, special meals and milk, other expenses on transport, depreciation of equipment, operation of equipment and tools, operation of transport; (4) cost of materials for car upholstery; (5) payment for internal repair and welding units.

The cost of preparing private cars and cars of the operator's inventory fleet varies somewhat due to the higher cost of preparing the latter. Private cars are thoroughly prepared once for the transportation of a certain type of product and are operated for a long time, and inventory cars must be prepared thoroughly each time, which is associated with a high cost of factors of production. The authors studied the costs of preparing cars for loading over several years. During the study, the consistency of the ratio of the costs of preparation for loading of private wagons and wagons of the inventory fleet was revealed. Table 1 shows the dynamics of the ratio of changes in

**Table 1** Impact of train car preparation costs on rolling stock outsourcing

| Indicator | Rolling stock of chemical production enterprise | | Rolling stock of the provider | | |
|---|---|---|---|---|---|
| Cost of preparation growth rate, % | 110 | 90 | 82 | 70 | 108 |
| Outsourcing area boundary, km | 2300 | 2600 | 2198 | 1700 | 2590 |

the cost of preparing railway cars and the boundaries of the field of rational use of rolling stock.

It is worth noting that the variables for calculating the cost of transportation by private cars mainly depend on the distance and speed of turnover of rolling stock. Based on the above information, there is a model for determining the value of transporting products of a chemical production enterprise by rail (Fig. 2.).

Based on the basic concept of lean transport: improvement of production processes should occur continuously [7], the authors consider the possibility of digitizing the proposed model and its integration with existing software products, calculating the carriage charge for the transportation of goods in the rolling stock of the enterprise, carriage charge for the return of empty cars of the enterprise to the home station, carriage charge for use of freight carrier infrastructure and rolling stock operator's carriage fleet.

Synergy between lean thinking concepts and Industry 4.0 [9] will help create continuity in the flow of value by better locating a private fleet of vehicles. Achieving an absolutely correct determination of the return time of private empty rolling stock is allowed by built-in GPS devices in each car. When entering the car number, information will be automatically generated in the integrated model about the type of departure, type and weight of cargo in the rolling stock.

The possibility of using the RFID tag, it is desirable to form RFID gateways [10], for the railway rolling stock of the chemical production enterprise will reduce the risk of management error. The identified factors and the degree of their influence on the field of rational use of private rolling stock contributed to the development of the model. Incoming model information flows are generated at different levels of the chemical industry and by third-party supply chain participants. Due to the fact that information is variable in nature, and its value varies in the degree of influence on the optimized indicator of the transportation process, it is necessary to switch to a coordinated information flows and reserves of rolling stock management. Coordinated management will ensure that the interests of the supply chain participants are compromised in order to optimize overall costs and create the greatest value of transportation for the consumer.

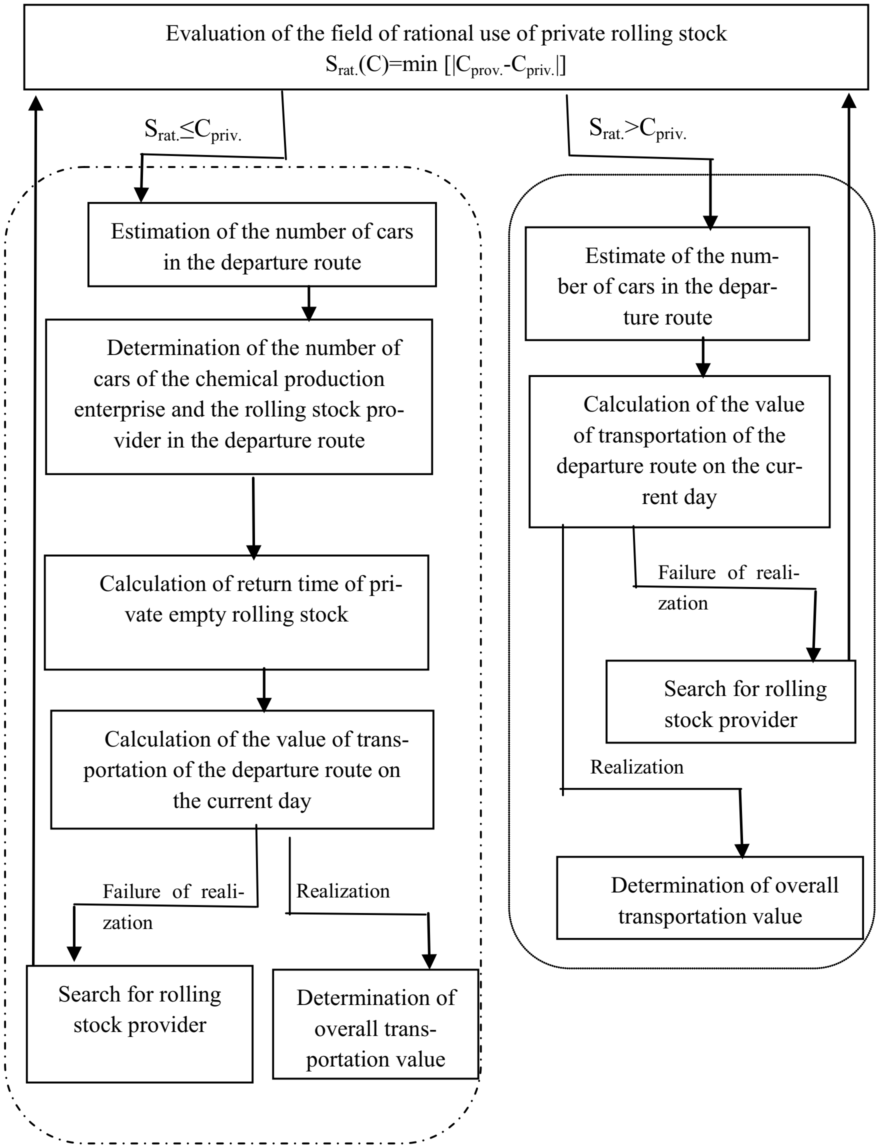



**Fig. 2** Model of creation of value of transportation by rail of products of chemical production enterprise

## 4 Conclusion

Today, chemical production enterprises due to the long transportation range by rail, changes in the parameters of the long-term program for the development of monopolies until 2025, a limited number of railway carriers are forced to optimize the transportation process. The authors propose on the basis of the concepts of lean thinking to create the value of transportation by rail by determining the rational area of using their own rolling stock. The proposed model takes into account the following indicators: the amount of costs of transportation by the shipper's own transport in comparison with the costs of transportation in the rolling stock of the operator, provision of chemical production enterprises with cars; average time of cargo delivery in private cars, including in directions. Lean transportation requires coordinated movement management of material and information resources to minimize costs, and the integration of lean thinking concepts and Industry 4.0 will contribute to the accuracy of determining the boundary of optimal application of private rail transport and the speed of management decision-making. These proposals will ensure that the interests of the participants in the supply chain coincide and compromise between them in order to optimize costs and create an economical process in transport.

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# New River Liners—A Factor in the Development of Russian Cruise Tourism

**G. V. Aleksushin, I. J. Solomina, and M. S. Filatova**

**Abstract** This article research the state of river cruise tourism in Russia. The materials of this study proved that the development of cruise tourism is one of the priority modern tasks for Russia. The most important factor in the development of cruise tourism is the state of cruise ships, which is now characterized by a high degree of wear and tear, which reduces the safety of tourists and their demand. The article presents material not only about new cruise ships, but also about the impact of this factor on the development of domestic cruise tourism. The article analyzes different types of new cruise ships: hydrofoils, with a cavern in the bottom, different classes and different shipyards. The technical data of new cruise ships and their cruise routes were studied. The mechanism of solving the problem with the outdated cruise fleet, which was implemented and allowed to start the construction of new cruise ships, is investigated.

**Keywords** Cruise route · Cruise ship · Cruise tourism · National tourism forum «Rivers of Russia» · National tourist rating · Shipbuilding

## 1 Introduction

The tourism and hospitality industry is experiencing a deep crisis due to the COVID-19 pandemic. According to the forecasts of the World Tourism Organization (UNWTO), international tourism revenues in 2021 will decrease by 320 billion US dollars, which is more than 3 times higher than the losses from the global economic crisis of 2009 [1]. They try to overcome the problems of the crisis with the help of innovative approaches in different directions [2]. Due to the problems in the international tourism market, Russia is trying to develop domestic tourism. From January 1, 2020, the Tourism Development Strategy in the Russian Federation for the Period

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up to 2035 (hereinafter referred to as the Strategy) came into force, in which, among other tasks, the problem of the development of inland water cruise tourism is also solved [3]. This document sets out the priority directions of tourism development, including cruise tourism. The authors of this article have identified the needs for the development of river cruise tourism in Russia as a basic factor in the revival of the construction of river cruise ships.

## 2 Methodology

The main scientific methods in the article were content analysis and comparison. Methods of classification and quantitative analysis were also used. For the scientific forecast, the correlation method was used. To improve the quality of the forecast, the authors also used the expert method of forecasting. Content analysis helped to analyze scientific articles, statistical and analytical reports on the development of cruise tourism, materials of the National Tourism Forum «Rivers of Russia». The comparative method is used in the analysis of cruise tourism on different types of ships, at different shipyards, and in the tactical and technical data of different ship series. The classification method made it possible to create a system of data on the cruise ship, allowing them to be compared. The method of quantitative analysis has become the main one in the formation of the complex of river vessels built recently in Russia. The correlation method made it possible to detect the relationship between statistical data. The method of collective expert assessment is used in the analysis of the forum materials.

## 3 Results

The mechanism for updating the Russian river cruise fleet was revealed based on the materials of the National Tourism Forum «Rivers of Russia» [4, 5]. It was the International forum of river tourism, and since 2016—the National tourist forum «Rivers of Russia». Since 2013, this forum has been held annually in Zavidovo, Tver region, with the informational, organizational and financial support of the Federal Agency for Tourism (Rosturizm) (everytime in the conference halls of the Radisson Zavidovo Hotel (Konakovsky District, Tver Region). This forum is organized by the Government of the Tver region (all Forums—Governor I. M. Rudenya), the company «Zavidovo Development» and the group of companies «Concord» (all Forums-Sergey Bachin, Chairman of the Board of Directors of the Agranta Group of Companies and the Board of Directors of Zavidovo Development LLC). Partners of all Forums were the National Chamber of Shipping, the Russian Union of the Tourism Industry (RUT), the PRDF «Region PR» and the Environmental Chamber of Russia. General Information Partner of Forum—Publishing House «Tourbusiness». The forum is focused on an open polemic of the principles of the development of inland waterways in Russia, the search for effective ways to increase the features of Russian regions in the international market of water cruise tourism, demonstration of unique practices of cruise tourism, promotion of companies actively developing these areas. Over the past years, the Forum has become one of the main federal platforms for discussing the problems of tourism development and river tourist transport, a meeting place for professionals of the tourism and transport industry. Table 1 presents an analysis of the Forum in 2016–2019.

Analysis of the conclusions of the National Tourism Forum «Rivers of Russia» 2016–2019 shows that representatives of the cruise industry expect the authorities to develop tools to stimulate the construction of a new fleet (including leasing and subsidizing interest rates on loans for companies building cruise liners), eliminate infrastructure restrictions on inland waterways.

**Table 1** Analysis of the National tourism forum «Rivers of Russia» 2016–2019

| Participants | Results |
|---|---|
| *June 24–25, 2016* | |
| More than 500 guests from 22 regions, including Assistant to the President, Secretary of the State Council Igor Levitin, Presidential Representative in the CFD A. D. Beglov, Head of the Federal Agency for Sea and River Transport, Deputy Minister of Transport RF V. Olersky, Deputy Head of the Rosturism S. Korneev | The 1st half of June 24 was devoted to general issues of water tourism and water transport.<br>The 2nd session was held in sections: cruise companies were brought together with shipbuilders, local managers shared their experience with each other on the organization of work on the reception and service of tourists, on attracting new people and companies to their regions<br>The decisions and materials of the forum formed the basis for discussions at the meeting of the State Council on the development of Inland Waterways, which was chaired by President of the RF V. Putin on August 15, 2016 in Volgograd |
| *June 23–24, 2017* | |
| More than 500 guests from 40 regions, including Presidential Representative in the CFD A. D. Beglov, the Governor of the Tver region I. M. Rudenya, the Head of Rosturism O. P. Safonov<br>The forum's partner is the Tourist Association of the Regions of Russia (TARR) | They discussed the status and prospects of inland waterways, the revival of cruise shipbuilding, the creation of favorable conditions for attracting investors on the terms of public–private partnership, the organization and promotion of new cruise routes, the role of the media and media communities in the promotion of cruise tourism products, the development of yacht tourism, and more<br>At the Forum, the Government of the Tver Region signed an agreement on strategic cooperation with the association of the leading river cruise companies of Russia «River Alliance», which includes the companies «Vodohod», «Mosturflot» and «Infoflot» |

(continued)

**Table 1** (continued)

| Participants | Results |
|---|---|
| *October 5, 2018* | |
| More than 600 guests, including Deputy Prime Minister of the RF O. Golodets, Deputy Head of Rosturism N. Korolev, Deputy Chairman of the Committee of the Federation Council of the RF on Social Policy I. Fomin, Minister of Tourism of the Tver Region I. Egorov, Deputy General Director for Tourism of the cruise company «Mosturflot» S. Goncharova, regional executive authorities of the Yaroslavl, Vologda, Ulyanovsk regions, the Komi Republic, industry experts. The session was moderated by President of the Russian Union of Tourism Industry S. P. Shpilko and V. Kruzhalin, Head of the Department of Recreational Geography and Tourism, Faculty of Geography of the MSU | They discussed the key areas of work on the creation of tourist clusters within the framework of the new federal target program «Development of domestic and inbound tourism in the Russian Federation (2019–2025)» (hereinafter referred to as the FTP), the prospects of cruise tourism in the Russian regions, measures to support the development of river yacht tourism<br>They discussed the state of the cruise fleet in Russia and potentially attractive regions for the development of cruise tourism, the creation of the Volga Sea cruise tourism and recreation cluster in the Tver Region, priority areas for attracting investment to unlock the tourist and recreational potential of the Moscow Canal, the company's activities, the composition of the cruise fleet, proposed routes and development plans, and best international practices for the development of cruise tourism<br>We outlined the main vectors for the development and support of cruise tourism, and defined the main provisions for the creation, development and support of river tourism infrastructure in the regions |
| *July 2, 2019* | |
| Several hundred guests, including the head of the Rosturism Z. Doguzova, Deputy Prime Minister of the Russian Federation Olga Golodets, Presidential Representative in the CFD I. Shchegolev. The forum's partner is the NGO «Foundation for the Development of Small Historical Cities» | They discussed strategies and models for the development of river tourism companies, the decline in profitability due to seasonality, the reduction in the cost of vouchers and the increase in the cost of diesel fuel, subsidies for the purchase of fuel, the marketing approach to the promotion of Russian tourism in general<br>They recognized the need to increase the river fleet by building new vessels, create new cruise routes, develop a set of measures to promote interregional river tourist routes in Russia on the international market and among Russian tourists (especially through high-quality information platforms), further develop the Zavidovo complex, design and build the Nizhny Novgorod low-pressure hydroelectric complex |

## 4 Discussion

The Concept of the federal target program «Development of Domestic and Inbound Tourism in the Russian Federation (2019–2025)» [6] and the Tourism Development Strategy in the Russian Federation for the Period up to 2035 [3], identifies cruise tourism as a priority. According to these documents, «cruise tourism is a trip on the water on a cruise ship along a designated route for cultural and educational, leisure and recreational, health, professional and business, research and expedition and other purposes». It is planned to expand the development zones of cruise tourism in the Azov-Black Sea, Caspian and Baltic basins, in the Arctic and in the Republic of Crimea. The decrease in the profitability of the business of shipping tour operators in 2008–2018 from 9 to 2.4% confirms the increase in spending on the operation of old ships and the need to create new ones. Indicators of modernization of cruise tourism see the doubling of the cruise tourism market by 2035 and the creation of a mechanism for intensive fleet renewal. «Russia is the only country in Europe whose river fleet has declined over the past 10 years. According to the Russian Chamber of Shipping, more than 120 cruise ships are registered in our country, of which about 100 liners are operated. The average age of the fleet is 40 years, 50 ships are older than 60 years, the rest—from 30 to 45 years. In Europe, the river cruise fleet consists of 346 liners and is the largest in the world, with 19 ships planned for construction in 2019»—said S. Korneev, Deputy Head of the Rostourism [4]. The condition of the liners is important for the development of cruise tourism. Liners are complexes or even destinations for tourists: a means of accommodation, food, entertainment, transportation and a tour desk. We will analyze the new liners and their opportunities for the development of cruise tourism in Russia [7].

**Hydrofoils**

1. «Comet-120 M». In 2013, the Vympel Shipyard in Rybinsk laid down a new-generation hydrofoil, the «Comet–120 M» (M—marine), of project 2316.0, a deep modernization of the «Comet» hydrofoil (1962). The hydrofoil carries up to 120 passengers in the coastal sea zone at a speed of up to 35 knots (65 km/h). 2 MTU 16V2000 M72 diesel engines (Germany). On October 20, 2017, the 1st Comet-120 M was launched on water. Now this shipyard has built 3 hydrofoils of this series. Negotiations are underway on the construction of 4 hydrofoils for import at the Vympel shipyard and 2 for Russia at the shipyard «Sea». They can walk in river mouths, on lakes, and in reservoirs. During the holiday season, 4 cruises a day are planned. The number of hydrofoils will grow, there will be routes to Feodosia and Yevpatoria.
2. «Valdai-45R». On the basis of the hydrofoil «Polesie» (1983) of the project 1709.1, a new hydrofoil «Valdai-45R» (R—river) of the project 2138.0 was developed. Passenger capacity—45 people, speed—65 km/h, cruising range—400 km. In 2018, the lead ship was launched, in 2019—5 more, in 2020, the construction of several more hydrofoils continued. 5 «Valdai» is operated in the Nizhny Novgorod region, 2—in the Ob-Irtysh river basin. Deliveries to

customers from Southeast Asia are planned, 10 of them have already been laid in 2020.

3. «Meteor-120R». Hydrofoil «Meteor-120R» of the project 0.358.0 of the Central Design Bureau (CDB) named after Alekseev is a deep modernization of hydrofoil «Meteor» (1960), laid on December 23, 2019 and is under construction, commissioning is planned for the summer of 2021. JSC «Severrechflot» will acquire it, and 3 more under construction in 2022.
4. Projects of hydrofoils. In addition to the above, there are 4 more hydrofoils projects: 2319 «Dawn-120R» and 2319.0 «Albatros-120R» as a deep modernization of the SPK «Sunrise» (1973), «Meteor-2020»of the Ak-Bars Shipbuilding Corporation, 2317.0 «Cyclone-250 M» as a deep modernization of the marine hydrofoil «Cyclone» (1986). Thus, 7 projects of new hydrofoils were developed: 4—river and 3—sea. According to them, 3 marine and 7 river hydrofoils of 2 projects have already been built. Another 14 river hydrofoils are under construction. 1 shipyard was involved in their production and they plan to attract 2 more shipyards.

**Passenger fastcrafts**

1. «Linda». The most promising now—fastcrafts. In 1993, the first one in Russia was put into operation—the project 1420.0 «Linda» for the transport of 70 passengers at a speed of 55 km/h. In total, 14 such fastcrafts were built, and 3 more, not completed, were dismantled due to the economic crisis.
2. A-45. In 2006, on the Zelenodolsk shipyard a new fastcraft of the project A-45 «Lena» («Lena-1») was built. Passenger capacity—100 people. Speed—70 km/h.
3. A-45-1. In 2006–2009, 4 serial fastcraft were built according to the A-45-1 project («Yeniseisk», «Krasnoyarsk», «Mikhail Godenko», «Ivan Nazarov») on the Zelenodolsk shipyard for the transport of 100 passengers at a speed of 70 km/h.
4. A-45-2. In 2016–2018, 3 fastcrafts were built on Khabarovsk shipyard according to the upgraded A-45-2 project. One of them is «70 Years of Victory», 2 still under construction. It carries the same 100 passengers at the same speed of 70 km/h.
5. A-145. In 2013–2020, 5 fastcrafts of the enlarged A-145 project were built at the Zelenodolsk shipyard to transport 150 passengers at a speed of 40 knots («Rem Vyakhirev» and «Viktor Chernomyrdin» (2013), «AkBars» (2016), «Rovach» for Turkmenistan (2019) and «Rakhat» (2020)). One ship of this project was built in the cruise version.

So, over the past 24 years, we have built 26 fastcrafts and 5 projects.

**Cruise liners**

In 1958–1959, the last cruise river liners were built in the USSR on the Krasny Sormovo shipyard, after which they were purchased in Hungary, the DDR, Austria and Czechoslovakia.

Gama company built a small cruise ship PKS-40 «Sura» for tours on the «Golden Ring» at the Gorodets shipyard in Nizhny Novgorod region in 2012 with 19 cabins for

40 passengers. But, its exploitation has shown that tickets for it will not be in demand due to high prices. And the company turned it into a «banquet boat» (so humorously called small liners for events on the water). His «sister ships» «Kolesov» (2014) and «Dobrokhod» (2015), did not immediately begin to be equipped with cabins, but were already built as «banquet ships». The maximum passenger capacity in the walking version is 120 people on the «Sura», 200—on the «Dobrokhod» and 250—on the «Kolesov». However, «Sura» is still capable of short tours of 1–3 days.

The lead ship of the PV300VD project of the river-sea class was the liner «Peter the Great» (Fig. 1), laid down in August 2016 at the «Lotus» shipyard in the Astrakhan region for the Moscow River Shipping Company, and its subsidiary cruise company «Mosturflot» will be to operate the ship [8].

This liner is being created primarily for cruises on the Caspian Sea, in the navigation of 2021, it should take the first 310 passengers. It is planned to cruise on long-distance routes Moscow-Astrakhan, Moscow-St. Petersburg with crossings on the Ladoga and Onega Lakes and Moscow-Rostov-on-Don with the passage of the Volga-Don Shipping Channel, with the possibility of access to the Black, Azov and Caspian seas (with calls at the ports of 5 states: Russia, Azerbaijan, Iran, Kazakhstan and Turkmenistan) with calls at the ports of Sochi, Yalta, Sevastopol, and other cities on the Black Sea coast.

Now we have developed programs for 3 cruises:

«Treasures of the East» (11 days/10 nights), with stops in ports Baku (Azerbaijan)—Bandar-Enzali (Iran)—Nowshahr (Iran)—Turkmenbashi (Turkmenistan)—Aktau (Kazakhstan)—Astrakhan—Makhachkala/Derbent—Baku;
«Adventures on three seas» (14 days/13 nights) with stops in ports: Baku (Azerbaijan)—Makhachkala—Astrakhan—Nikolskoye—Volgograd—Volgodonsk—Rostov-on-Don—Azov—Kerch—Novorossiysk—Sochi;
«Opening of the Great Silk Road» with departure for the winter to the Black Sea and return in March by the same route back to the Caspian Sea, where it will perform cruises on the Caspian Sea under the 1st program, and then will pass the 3rd route «Opening of the Great Silk Road» (12 days/11 nights) from Baku to Moscow with stops: Baku (Azerbaijan)—Derbent—Astrakhan—Volgograd—Saratov—Ulyanovsk—Kazan—Nizhny Novgorod—Yaroslavl—Uglich—Moscow.

**Fig. 1** «Peter the Great» in the completion afloat

**Fig. 2** «Mustai Karim»

In March 2017, the 2nd liner of this series «Mustai Karim» (Fig. 2) of the PV300 project of the river-sea class for the Vodohod company was laid down at the Krasnoe Sormovo shipyard in Nizhny Novgorod, and it was put into navigation in 2020. It is designed to carry 342 passengers in much more comfortable conditions than in the river liners available in Russia [9]. Its cost is 4 billion rubles.

In the first full navigation of 2021, the ship is scheduled for 15 ring and 15 open cruises (with support for Moscow (14), Rostov-on-Don (7), Anapa (3), Kazan (3), St. Petersburg (2) and Nizhny Novgorod (1)).

Since January 2018, the 1st of a series of 2-wheeled liners of the PKS-180 «Golden Ring» (Fig. 3) project for the Gama company has been built at the «Lotus» shipyard. With a small draft and wheels for driving, it can carry 144 + 36 tourists in Luxury and 1st class cabins along shallow rivers to the towns of the Golden Ring—previously, Russian tourism could not afford this. The crew is small—only 56 people. In early July 2020, the «Golden Ring» launched on water in November 2019 with the «Lotus» shipyard was towed up the Volga river to the berth near the «Volga» hotel (Balakhninsky district of the Nizhny Novgorod region) for completion.

The route of its cruises is supposed to be as follows: Moscow (NRS)—crossing through the center of Moscow, under all bridges—Southern River Station—Oka to Nizhny Novgorod—Kostroma—Yaroslavl—Moscow (NRS).

On June 21, 2018, the 2nd ship of the PKS-180 project was laid down at the «Lotus» shipyard.

For river cruises on the Yenisei River, on July 31, 2020, the lead ship «Andrey Dubensky» (Fig. 4) of the A-45-90.2 series of liners was laid down at the Sredne-Nevsky shipyard in pursuance of the signed agreement in April 2020 with the «State

**Fig. 3** Transfer of the «Golden Ring» from the «Lotus» shipyard to Balakhna

**Fig. 4** Project A-45-90.2 of liner

Transport Leasing Company». The first serial (the second in the series) liner of this type was named «Viktor Astafyev». These ships are a development of the A-45 and A-145 series of fastcrafts. The liners are due to be delivered to the customer in 2023 and 2024. The total price of the contract at the time of conclusion is 5 270 million rubles (at the cost of one liner of 2 635 million rubles). Passenger capacity—220–245 people. Speed—12.4 knots.

The project includes a PV500 liner (Fig. 5) with a capacity of 550 passengers and a speed of 20 km/h. It is planned to use it on the cruise lines Moscow-St. Petersburg with crossings on the Ladoga and Onega Lakes, Moscow-Astrakhan, with access to the Caspian Sea and the Gulf of Finland. It remains to properly integrate modern innovative excursion products into river cruises [2]. Thus, starting with the «banquet boats», modern Russian shipbuilding, with the support of the Russian Government [10], began to revive the river cruise fleet. 3 new liners were built on one shipyard. The construction of 6 cruise liners on 3 shipyard ships is a successful return to the construction of liners after a 60-year hiatus.

**Fig. 5** Project PV500 of liner

## 5 Conclusion

It is safe to say that 2019 was a turning point for the development of cruise tourism in Russia. It is recognized as an important direction of tourism development in all official documents in Russia. Especially important in the development of cruise tourism is the construction of new ships, as having a huge potential in the form of river and sea space, it is difficult to organize cruise tourism without the rotation of the ship's composition. The renewal of the cruise ship fleet will bring the development of cruise tourism to a new level and become competitive in the global tourist market.

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# Innovation in the Construction Sector: Ensuring the Development of the Spatial Economy

**E. E. Dozhdeva, S. E. Afonin, and M. A. Korkin**

**Abstract** This article discusses the construction sphere, which is closely interacting with the spatial economy, strengthening the position of the state in the market by introducing innovative technologies. The purpose of the article was to study the applied information technologies in the construction sector with their adaptation to it, as well as to study the degree of influence on the spatial economy. For this, the following tasks were completed: the important conditions that the spatial economy observes were described; the classification of the construction sector according to the purpose of the objects being built has been studied; It shows how the construction industry has become more dynamically integrating innovation and technological solutions thanks to the growth of cities and population, a new format for the level of human communications, economic growth and human well-being in the era of Big data. The methodology consisted of researching the works on the artificial intelligence and information technology. The technology "BIM" is presented, which implies the inclusion of cloud services for data exchange, real-time information. A virtual reality is described, which creates a "real" world in a digital environment using photographs, rendering and video 360°.

**Keywords** Artificial intelligence · Construction · Digitalization · Innovation · Spatial economy

## 1 Introduction

Modern technologies in the era of digitalization are becoming increasingly adapted under all areas of the population. The construction industry does not become an exception where more than a dozen technologies are already used today. Progressive and demanded information technologies and artificial intelligence are based on the creation of innovative materials and development methods that are firmly integrated into the industry and implement the most advanced ideas of the future [1]. The

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construction sphere is one of the most conservative, at first glance, where there is clear standardization and bureaucracy. Since it is necessary to comply with serious security requirements, the introduction of innovative technologies is more difficult to introduce innovative technologies than any others [2]. That is, the introduction is based on three pillars: the regulatory framework, standardization and self-sufficiency. Any technology requires a whole complex of design and work of the progress—managers led by quality control and highly qualified specialists.

The spatial economy relies on theoretical and experimental achievements of leading specialists in the field of placement and territorial organization of economic activity, regional economic policies, on the patterns and problems of the functioning of economic agents in these systems, includes zoning, systemic analytics and prediction of the development of regional economic complexes [3]. That is, it is closely conjugate with innovation in the construction sector, because before all market participants there is a task to create an innovative object according to the requirements of time and under the peculiarities of the area, taking into account the necessary regulatory features and safety requirements, as well as under regional innovative construction policies.

## 2 Methodology

The spatial economy has a goal of creating mutually beneficial conditions for all economic entities with the timely detection and use of the potential of business entities. To do this, it is necessary to observe certain conditions:

- favorable location of business subjects: It should be equally convenient for both consumers and manufacturers. Resources for production must be close as possible;
- the territory (area) of placing enterprises should be used as efficiently as possible to create business projects, development sites, etc.;
- reducing market zones and a clear distribution between them.

How does the spatial economy interact with the construction sphere? Enterprises create innovative goods and services, demonstrate with high efficiency. Around the highly efficient organizations, firms, infrastructure begins to line up, supports auxiliary production. As a result, such an enterprise becomes a certain pole of attraction for other entities of the economy and a new economic zone. That is, manufacturers and consumers (subjects) will become tied to a certain place in space [4]. The effect on the distribution of subjects in space will be exerted costs and demand. The spatial economy is characterized by erasing the boundaries between the development centers, their transparency. Freedom of the movement of capital, labor resources, services and goods, efficient division of labor are all the model in question.

The construction industry is part of the economy associated with the complex town planning activities of enterprises, organizations and individual entrepreneurs, including the preparation of urban-planning solutions, territorial planning, urban

**Table 1** Classification of the construction sector for the purpose of the subjects of objects

| Type of construction | Description |
|---|---|
| Civic | The objects of this category are houses, low-rise and multi-storey, as well as various public, public, office, trade and administrative buildings |
| Industrial | This category includes work related to the construction of workshops, factory factories and plants |
| Agricultural | The construction of industrial facilities on farms and for large agricultural and livestock companies |
| Transport | Construction of bridges, tunnels and roads, and overpass |
| Hydrotechnical | Erect dams and canals, reservoirs and dams |
| Military | Construction of military facilities |

planning zoning, planning of the territory, the performance of survey work and architectural and construction design [4]. The construction industry ensures the reproduction of fixed assets in all sectors of the economy and the social sphere, has a high multiplicative effect and numerous intersectoral connections. There are certain types of construction, based on the appointment of buildings. This classification is presented in Table 1. Over time, the construction industry has become more dynamically integrated in innovation and technological solutions due to the growth of cities and the number of people, the new format of the level of human communications, the growth of economies and well-being in the era of Big Data. Therefore, new technologies in construction are actively moving and used throughout the world.

## 3 Results

The speed of technology development leads to a large-scale digitization of the construction industry. The use of IT technologies is already a matter of competitiveness [5]. Innovations in construction modify the construction site and increase profits, and also help win design tenders. Since the innovation is to bring economic benefits and increase the competi tiveness of a particular construction company, and also ultimately implement the client's request with maximum efficiency.

Today, BIM technology is actively used, which has become the main "whale" in modern design. This technology will be mandatory in Russia from 2021 for the construction of budgetary facilities, and from 2023—everywhere in the country. It implies not just a virtual modeling of the building; this is a comprehensive representation in the digital form of the physical and functional characteristics of the object. "BIM" takes into account not just the construction, but also equipment, management, operation of the facility, the prospect of repair or demolition, that is, covering the entire life cycle of the object in the complex. All components and nuances in the design, which are related to the object, are necessarily taken into account and are considered in a single project. When you delete or replace some element or addition, the entire model is recalculated with this adjustment [6].

Thanks to the BIM, the created virtual model of the object allows specialists:

– see all problems and inconsistencies;
– approve the alleged advantages of the object;
– the ability to use the model to all project participants;
– make adjustments;
– calculate the estimate;
– monitor the work process;
– anticipate the risks of the future design;
– calculate resources.

Unfortunately, according to the Ministry of Construction of Russia, only 5–7% of companies use "BIM" (mainly in metropolis and large companies), other new technologies in construction in Russia are more common [7]. The BIM model work implies the inclusion of cloud services for the exchange of data, real-time information. The clouds can be the most different segmented information and tools, ranging from the tools for architects, ending the project management system that are available to any project participant at any time from a mobile device—the effect of cooperation increases. Cloud services provide:

– high mobility (all information is available from any device with internet connection);
– the volume of stored information in the cloud is not limited, as well as the computing power of the servers where the data is stored;
– scaling in accordance with the needs of the construction project—is flexibly configured under the need, it is not extended, the performance does not fall;
– affordable services—the creation of its own IT infrastructure is much more expensive than using a cloud service provider;
– instant access to the information of all project participants, the entire team;
– simplify communications and collaboration in real time;
– the ability to manage multiple building sites without loss of quality control—the cloud helps in synchronization;
– ability to reduce expenditures on large offices—hosting on third-party servers, you do not need to serve your own;
– maximum data protection.

New building technologies will not cost without machine learning and AI. In fact, this is an invisible assistant who analyzes the terabytes of data, finding the problems. It can be like routine filtration of unnecessary information and vice versa, a search for specific data [8]. Programs where the AI engine is used for:

1. Predictive analysts:

   (1) forecasting the safety threat, based on past data;
   (2) recognition of important attributes and elements at a construction site;

(3) control of the territory, the number of people at the facility, compliance with PPE.

2. Project Planning and Design:

   (1) collected and modeled data will help avoid budget recalculation;
   (2) Tracking and reducing risks, definition of priorities.

3. Robotic mechanisms, automation of processes:

   (1) fulfillment of routine, simple, but labor-intensive operations at a construction site, replacement of human force:
   (2) Optimization of works where high-performance needs.

Among the new technologies in architecture and construction, it is especially worth allocating virtual reality (VR). She creates a "real" world in a digital environment using photographs, rendering and video 360° [7]. The possibilities of technology provide navigation in a realistic Digital environment, where you can also interact with real-time objects. Additional reality is already separate digital elements imposed on a real environment that completing the final intended model [9].

VR further gives the integrity and globality to a virtual object, where in fact digital information "comes to life" with physical. Virtual reality is much larger, which only enhances the created multidimensional models. This is a special experience of first person who adds more professional decisions, expert assessment. It modifies a way to build infrastructure as a whole.

## 4 Discussion

The construction industry has a number of restrictions that influenced the cost of construction and business developers in 2020 [10]. Among them are the following: ban on the construction of apartments, increase in the cost of construction and installation work (CMR), changes in the law on the types of permitted use of land, tightening the norms of urban planning design, lagging of the development of transport and social infrastructure in cities, etc. Most developers call an important problem this year the deficit of personnel. This problem is directly related to the pandemic and will affect the market and next year. The shortage of labor resources on construction sites arose due to the fact that potential workers from near abroad cannot enter Russia due to anti-epidemic measures. The replenishment of this deficit is one of the priorities that developers have to be solved.

Frame deficit is felt serious, especially in the regions, and has already led to the growth of wages of builders and the appreciation of both construction work and building materials that will have to compensate for buyers of apartments. The deficit of builders at the company's facilities is 20–25%, on average, the market has a lack of workers in 40–50%, it is already clear that the lack of labor affects the reduction of supply in the market, and tomorrow will begin to influence the cost of construction [10].

The cost of construction has grown throughout the year, the growth led to high rates of inflation, the continuing transition to project financing and jump rates of currencies. In addition to the listed factors of cost growth, by the end of the year, another one is added a sharp rise in reinforcement prices, one of the key materials of construction. Experts note that from mid-November, reinforcement prices increased by 40% over the last month [10]. But at the same time, the business looks at 2021 with careful optimism: high hopes are associated with the removal of most restrictive measures in the regions and, as a result, demand recovery. At the same time, the upcoming cancellation of AD (A single tax on imputed income), the fall in real disposable incomes of the population, the completion of many preferential programs and support measures, as well as the alarming public expectations regarding the further spread of coronavirus in the world do not allow to talk about any breakthrough growth of enterprises and organizations in the following year.

## 5 Conclusion

Obviously, large-scale digitalization and the introduction of BIM-technologies in the construction industry will progress—this is a market request, where efficiency and reduction of time, costs become priority. Therefore, construction becomes smart not only in computer design, but also in the direct process of creating an object using robots, 3D printing, sensors, smart materials and technologies. Finally, new technologies will definitely affect the profit of the construction business, since they are aimed at optimizing and the effectiveness of all stages of the project, ranging from engineering surveys, ending with operation.

The construction industry is closely interconnected with a spatial economy, which is characterized by erasing the boundaries between the development centers, their transparency. Freedom of capital movement, labor resources, services and goods, efficient division of labor—this all defines this type of economy. The spatial economy has a goal of creating mutually beneficial conditions for all economic entities with the timely detection and use of the potential of business entities. The construction sphere helps at the expense of innovative technologies, new features that provide navigation in a realistic Digital environment where you can also interact with real-time objects. New building technologies will not cost without machine learning and AI. In fact, this is an invisible assistant who analyzes the terabytes of data, finding the problems. It can be like routine filtration of unnecessary information and vice versa, a search for specific data.

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# Problems of Assessing the Sustainable Development of the Russian Construction Complex

**A. V. Shepelev**

**Abstract** The article examines approaches to assessing the sustainable development of the Russian construction industry. The results of a comparative analysis of statistical data, non-financial reports of Russian companies and analytical materials of external research were used in this study. Common and different characteristics of assessment methodologies in Russia and abroad are identified. The author comes to the conclusion that industry affiliation influences the choice of priority development goals by companies. The results of qualitative research are considered, indicating a low level of awareness of the construction industry managers about the sustainable development goals (SDGs) and their low involvement in this issue compared to similar assessment results for other industries. At the same time, the analysis does not allow us to say that the state of the industry depends on the involvement level in the implementation of the SDGs. It is advisable to assess the sustainable development of the construction complex in the context of the macro-, meso-and micro-levels of management.

**Keywords** Assessment of the development of enterprises and industries · Economy of the construction sector · Sustainable development

## 1 Introduction

The construction sphere is represented by a complex structure of inter-corporate and inter-industry relations between its participants. This largely determines a number of problems associated with the assessment of the sustainable development of both the industry as a whole and enterprises included in it. The assessment should be carried out at different levels. At the macroeconomic level, the sustainable construction goals are most actively implemented in industrial countries, but the share of construction there is declining. The world's experience in assessing sustainable development is

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focused on international systems and methodologies, such as Global 100, RobecoSAM, and GRI [1]. At the meso-economic level, the construction sector depends on the implementation of the sustainable development goals of the national economy as a whole. Supply chains cover the industries of mining and production of building materials, production of construction equipment, design, construction and installation works, operational and technical maintenance, etc. End-to-end monitoring of the chain is not always possible, disagreements and conflicts between participants often arise, and the implementation of common standards, rules and procedures is problematic. Moreover, it relates to the mission, corporate culture and goals of sustainable development.

Menoka, Bryde, Fearon, and Ochieng note the relevance of assessing the attitudes of construction stakeholders towards the sustainable development goals [2]. Prioritization, management, performance measurement, and goal setting are also important. Lukichev, Romanovich propose to evaluate the sustainable development of construction companies through a quality management system [3]. Special attention should be paid to certification (including the voluntary type), which not only opens up new market opportunities for business, but also brings together partners, promotes awareness and incentives for managers regarding sustainable development issues. It is also important to assess the relationship between corporate social responsibility (CSR) and sustainable development. Xia, Olanipekun, Chan, Xie, and Liu suggest some ways to increase CSR's contribution to the sustainable development and the sustainable development goals (SDGs) in the construction industry, including changing traditional procurement practices, improving the environmental responsibility legislation, integrating CSR aspects, and expanding CSR adoption in the small and medium-sized enterprises [4]. Kiani and Standing consider possibilities of assessing sustainable development in the construction industry through the project evaluation [5], Berardi works with the same topic through the evaluation of construction objects (for example, buildings) [6]. The most common and well-founded approach to the sustainable development assessment is based on the Triple Bottom Line (TBL) concept. Its universality requires taking into account the specifics of sustainable construction, which is manifested in the nature of the interrelationships of social, environmental and economic aspects [7]. A good example is the study by Wen et al., which shows how the components of TBL are changing in the assessment of sustainable development in green building rating tools [8].

## 2 Methodology

The study is based on a comparative analysis of Russian statistics, data from non-financial reports of Russian companies, and analytical materials from external research. The study covers the period 2018–2020. To assess the dynamics of changes in the number of companies in certain industrial sectors of the Russian economy, data from Corporate Knights are used. The assessment of the involvement of companies in the implementation of the sustainable development goals is based on the results of contemporary research [9]. In the course of the study, the assessment of the manufacturing and construction industries is given in comparison with the extractive industries, energy complex and service sphere. The first stage of the sustainable development assessment is to determine the level of involvement of construction companies in the implementation of SDGs. The assessment is carried out in comparison with other industries.

## 3 Results

The dynamics of the number of organizations in Russia over the past 3 years shows a decrease in the number of enterprises in general and by industries (Table 1). The COVID-19 pandemic has certainly had an impact on many industries, but the negative dynamics are also observed in the pre-pandemic period. The largest reduction in the number of organizations is observed in the service sector, construction and the manufacturing industry. At the same time, the significant difference between the service sector and other industries is mainly due to the impact of the pandemic. Thus, changes in the number of companies as a trend is typical for all the industries under consideration. However, are there sectoral differences in attitudes towards the SDGs?

According to the results of the study on the current level and prospects of the involvement of Russian companies in the implementation of the SDGs, industry affiliation influences the choice of priority goals of companies [10]. Improving the quality of products and services in accordance with the requirements of the SDGs is mentioned by 60% of representatives of the manufacturing industry. 43% of manufacturing and construction companies participate in events on the issues of sustainable development. For comparison, among the companies of the mining and metallurgical industries, as well as the energy industry, 94% and 80%, respectively, take part in such events.

The development of the company's non-financial reporting with the inclusion of information on the SDGs as an effective measure is noted by more than a third of companies in the service sector, mining and metallurgical industries, and only

**Table 1** Dynamics of the growth rate of the organizations number in Russia in the period 2018–2020

| Industries | Growth rate, % | | |
|---|---|---|---|
| | 2018/2017 | 2019/2018 | 2020/2019 |
| Total | 92.4 | 90.8 | 73.7 |
| Manufacturing industry | 93.4 | 92.5 | 88.4 |
| Construction | 96.3 | 92.4 | 88.2 |
| Extractive production | 97.7 | 98.3 | 90.5 |
| Electric power industry | 94.1 | 93.8 | 94.1 |
| Service sector | 91.9 | 90.4 | 70.3 |

less than 10% of companies in the manufacturing industry. In manufacturing and construction organizations, there is a minimum level of awareness of managers about the sustainable development goals (13%). The motive for improving the reputation and strengthening the company's brand plays an important role primarily for representatives of state-owned companies, and only representatives of private companies indicated obtaining competitive advantages as an incentive of their activities.

Representatives of manufacturing and construction companies have never indicated ensuring compliance with the requirements of investors and partners as a motive, but they pointed more than other respondents to the possibility of obtaining competitive advantages. 58% mentioned new growth opportunities as an incentive.

The SDGs related to water resources management are relevant for the vast majority of companies in the commodity sector and manufacturing (67%). Providing access to low-cost, reliable, sustainable and modern energy sources is relevant for 40% of representatives of manufacturing companies, compared to 75% of companies in the mining, metallurgical and energy industries.

Manufacturing companies demonstrate a high level of integration of the strategy related to the SDGs, the consistency of the goals and key performance indicators for them with other strategic goals, the implementation plan for the sustainable development strategy, etc. Representatives of the service sector, mining and metallurgical industries (62%), the energy sector (60%), and significantly less often representatives of the manufacturing industry (13%) report misunderstandings about the SDGs. Only 33% of manufacturing and construction companies are interested in educational programs and projects, which is significantly less than the estimate for the service sector (71%). These data indicate that in certain aspects of the sustainable development assessment, manufacturing and construction companies are inferior to representatives of other industries. However, this does not allow us to say that the state of the industry depends on the level of involvement in the implementation of the SDGs. It should also be noted that the survey was conducted in the period before the outbreak of the coronavirus epidemic, the negative consequences of which for the economy and the environment are considered by the entire world community. Of particular concern is the fact that the crisis will slow down the achievement of the sustainable development goals, and in some countries, certain indicators may even roll back to the figures preceding 2015. This is evidenced by the results of the latest progress study on the SDGs [11].

In general, it is necessary to note the progress of Russian business, including the construction sector, in understanding the specifics of their involvement in the processes of sustainable development. At the same time, for the subsequent movement, it is necessary to transit from discussing priorities to implementing a methodology for achieving them, transform business models in the interests of the SDGs, as well as to measure practical results in terms of their social, environmental impact and the development of Russian business in the global economy. Since there is no single methodology for assessing the sustainable development, it is advisable to compare the approaches currently used in Russia and abroad (Table 2). An example of the Russian approach is the methodology developed by the credit rating agency

**Table 2** Comparison of the methodology for assessing the sustainable development in Russia and abroad

| Comparison criteria | ESG rating methodology | Corporate Knights rating methodology |
|---|---|---|
| Applied infromation | Data provided by the company (questionnaire, company charter, non-financial statements, internal documents, regulations and reports, website, information from open sources) | Publicly-disclosed data (e.g., financial filings, sustainability reports, company websites) |
| Number of factors to evaluate | 21 | 24 |
| Components | Environmental metrics, social metrics, governance metrics, stress and support factors | Environmental metrics, social metrics, governance metrics, economic metrics |
| Evaluated companies | All companies, except for those, one of the most significant activities of which is the production of products or services, the consumption of which has a critical negative impact on the society | All companies that had a gross revenue in excess of \$PPP-currency \$1 billion during the fiscal year<br>Except for companies involved in certain products or services and their behavior is counterproductive to sustainable development |
| Evaluation | All parameters, except for stress factors and support factors, are scaled and evaluated on a scale from 1 to −1. The weights of all factors are fixed, except for the stress factors and the support factor | Of the 23 weighted indicators (fines deductions [5%] are not weighted), 14 are weighted according to their relative impact, and nine are assigned predetermined fixed weights. The weights of the 14 relative indicators are calculated through impact ratios |

RAExpert [12], the methodology used abroad is the global 100 Corporate Knights [1].

## 4 Discussion

The world practice is familiar with various approaches to the assessment of the sustainable business development [13, 14]. In this study, it was possible to compare the methodologies for assessing the sustainable development in Russia and abroad. The question of choosing the optimal methodological approach, taking into account the specifics of the construction industry in Russia, remains open. Any research of an evaluative nature is carried out on someone's initiative and should solve specific tasks. At the beginning of the article, the importance of assessing the sustainable business development of the construction complex at various levels was noted: macro, meso, micro levels. It is important for the state to know what the contribution of the construction industry to the sustainable development of the region or the national economy is, investors and business partners are focused on the business efficiency, corporate culture and compliance with the agreements, the client expects a product created on the principles of sustainability. Accordingly, it is advisable to distinguish between initiatives, tasks, methods and tools of research. The problem of building an information and management model for assessing the sustainable development of the construction complex is relevant. The similarity of the methodologies is determined by the focus on the documents developed in the sustainability field, but there are differences in the used sources, the identified factors, and the assessment of their significance and magnitude. The choice of the methodological approach and the assessment of the sustainable development of the construction industry enterprises in Russia is the subject of further research.

## 5 Conclusion

In the course of the study, various approaches were used to assess the sustainable development of the Russian construction complex. The author started from the accumulated data and materials, revealing the specifics of the information sources and making conclusions obtained on the basis of its analysis. The evaluation of Russian statistical data allows conducting a dynamic analysis of the number of enterprises by industries. However, taking into account the complexity of inter-corporate and inter-industry relations between the participants of the Russian construction complex, it is difficult to identify the nature of the patterns in their development. At the same time, it was found that industry affiliation influences the choice of priority goals in companies. Surveys of companies on the current level and prospects of their involvement in the implementation of the UN Sustainable Development Goals provide a more detailed picture. Qualitative research allows us to assess the level of managers' awareness about the sustainable development goals, their interest, motivation and willingness to participate in events on the issues of sustainable development. In general, the construction sector of Russia (in this research, the emphasis was on the organization of construction and manufacturing industry) shows low values of these indicators, which are largely inferior to the corresponding assessment results for the mining and metallurgical industries, and the service sector. The differences between the most common methodologies for assessing the sustainable development in Russia and abroad are analyzed, they relate to the used sources, the factors for assessing the significance of their values. This also has an impact on the diversity of views and goals on the part of business leaders.

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# Calculation of Saturation and Depth of Filtrate Penetration in the Primary Opening

**V. I. Nikitin, V. V. Zhivaeva, and G. S. Mozgovoy**

**Abstract** When reservoirs are penetrated using water-base drilling fluids, the permeability of the formation to oil is reduced by the permeability of the formation. Conducting experiments to determine the effect of leachate on the formation is time-consuming and not always feasible due to the need for specialized filtration equipment, as well as the need for representative core material. The invasion radius and filtrate and oil saturation is critical to the multiphase flow when the well is put on production. This paper presents a method for determining the saturation of the bottomhole formation zone with the filtrate of the drilling wash fluid in the process of primary penetration. The calculation methods include fundamental formulas from the theory of two-phase filtration. For calculations the authors used a package of symbolic calculations Wolfram Mathematica. Comparison of calculated and experimental data is presented. The results of application of this technique can be recommended for use in selection of fluid for productive formation penetration.

**Keywords** Calculation methodology · Drilling fluid filtrate · Permeability recovery · Productive formation opening · Saturation

## 1 Introduction

Filtration processes, occurring in the bottomhole zone of the productive formation during its initial drilling-in, lead to consequences in the process of further well operation. Thus, when reservoirs are penetrated using water-based drilling fluids, filtrate penetration into the formation reduces effective porosity and, consequently, the permeability of the rock to oil. When designing drilling flushing fluids, it is possible to evaluate its impact on the payzone. In this case the significant parameters are the filtrate saturation and the radius of its penetration into the reservoir [1]. The conduction of experiments in determining the effect of filtrate flushing fluid on the formation is time-consuming and not always a feasible task due to the need for

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specialized filtration equipment, as well as the need for the presence of representative core material [2]. There are mathematical and experimental methods for determining the effect of the water phase on the core sample. Bilardo, Alimonti, Chiarabelli, and Caetani consider the formation water saturation from drilling fluid filtrate invasion. Their work investigates the comparison of displacement modeling and induction of well log response [3]. They also present a numerical model that aids in the interpretation of log results from thinly-layered formations, giving water saturation curves for the units of interest. This actual problem is considered in the work by Iscan, Civan, and Kok [4]. In this work permeability impairment caused by drilling fluids and subsequent cleaning and permeability enhancement by backflow are investigated by means of experimental and simulation studies. Damage caused by two different drilling fluids is measured experimentally by core tests as a function of the filtration pressure and analyzed using a simulator describing the fines migration and retention in porous media. Drilling fluid invasion into hydrate-bearing sediments could induce hydrate dissociation and complicate heat and mass transfer around wellbore, and further affect mechanical strength of hydrate-bearing sediments and accurateness of wellbore logging interpretations. A cylindrical numerical model was established by Huang, Zhang, Li, Li, and Chen to study the characteristics of drilling fluid invasion into hydrate-bearing sediments and the effects of permeability on this process [5]. In this work, we develop a methodology for determining the saturation of the bottomhole formation zone by drilling fluid filtrate during primary penetration.

## 2 Methodology

The process of interaction of drilling fluid filtrate with formation fluid during primary penetration of productive formation is well enough described by the theory of two-phase filtration [6, 7]. According to Fanchi [7], interaction of water and oil phase during joint filtration can be described by Buckley-Leverett function in terms of "filtrate-oil":

$$f = \frac{k_f}{k_f + \frac{\mu_f}{\mu_o} k_o}, \tag{1}$$

where $k_f, k_o, \mu_f, \mu_o$—relative phase permeabilities and viscosities for filtrate and oil, respectively.

The frontal saturation is calculated using one of the following formulas:

$$df'(S_{front}) = \frac{f(S_{front}) - f(S_0)}{S_{front} - S_0}, \tag{2}$$

or

$$\Phi = \frac{f(S_{front}) - f(S_0)}{S_{front} - S_0} \to \max, \tag{3}$$

where $S_{front}$,$S_0$,—frontal and initial saturation of the water phase in the pore space of the formation.

The average saturation is calculated considering the initial saturation and the value of the derivative of the Buckley-Leverett function when substituting the frontal saturation:

$$\overline{S} = S_0 + \frac{1}{df'(S_{front})} \tag{4}$$

With the known flow rate and filtration time we can calculate to what depth in the radial direction from the wall of the well the leachate spreads with average saturation $\overline{S}$:

$$r_f = \sqrt{r_{well}^2 + v_f At/\pi mh\overline{S}_f} - r_{well}, \tag{5}$$

where $r_{well}$—well radius, $v_f$—speed of filtration, $A$—square of filtration, $t$—time of filtration, $m$—rock porosity, $h$—thickness of the part of the reservoir involved in the filtration process. Equation (5) applies to vertical drilling, but can be adapted to the case of horizontal drilling.

To implement this methodology, calculations are made sequentially from Eqs. (1), to (5), where the frontal saturation is calculated using Eqs. (2) or (Eq. 3). It is important to note that $k_f$, $k_o$– relative phase permeabilities included in the Buckley-Leverett function (Eq. 1) are functions of the filtrate saturation $k_f(S_f)$ and reflect changes in permeability taking into account the dynamics of the filtration process. In this regard, their correct choice or construction is an important task, largely affecting the result of the calculation. As a model case, the authors propose the use of the well-known Chen-Zhong-Siang model [6], which describes the interaction of the water and oil phase.

## 3 Results and Discussion

In the presence of experimental data, approximating functions continuously differentiable on the interval of change in saturation can be used. Choice of functions $k_f$, $k_o$ to a greater extent affects the realization of Eqs. (2) and (3), namely the numerical solution or the existence of a local maximum function at intervals corresponding to physically possible values of saturation. Also as an alternative to the classical Formula (1), its analogue taking into account capillary pressure can be recommended [8]. $v_f$– filtration rate, can be selected from laboratory studies under reservoir-like conditions or from analysis of the dynamics of penetration of filtrate of water-based

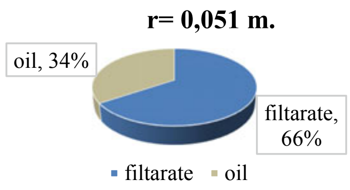


**Fig. 1** Example of calculation visualization

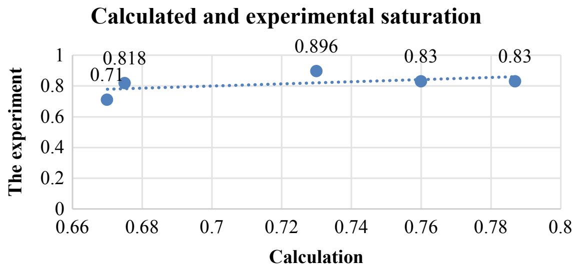


**Fig. 2** Comparison of calculated and experimental saturation

drilling flushing systems into the formation [9, 10]. For calculations the authors used a package of symbolic calculations Wolfram Mathematica. This software environment has all the necessary set of mathematical functions necessary for the implementation of calculations, including the solution of differential equations. As a result, the program displays a report and a pie chart of the ratio of filtrate and oil saturation in the bottomhole zone of the reservoir (Fig. 1). Calculations for five flushing fluids were made on the program: №1—Clay mud; №2—Polymer clay mud; №3—Chloralkalium; №4—Resin-containing mud; №5—Polymer drilling mud. For filtrates of these muds there is information about saturation in consequence of filtration experiment on core with approximately 4–14% porosity [11]. To obtain experimental points, we used filtrates of drilling fluids, oil, and natural core samples. The main equipment was a filtration unit with a core holder simulating reservoir conditions. Dean and Stark water phase quantification apparatus was used to determine the residual saturation. The result of comparing experimental and calculated data is shown in the graph in Fig. 2. The correlation coefficient of this relationship is 0.6, which confirms the presence of a positive relationship.

## 4 Conclusion

Based on the theory of two-phase filtration, a method for determining the frontal and average saturation of the drilling fluid filtrate in the bottomhole formation zone was developed. The authors used a package of symbolic calculations Wolfram Mathematica. The software was written based on the methodology. Experimental and calculated data are compared. The developed software and calculation method can be recommended for use in calculating the saturation and depth of filtrate penetration into the formation. These indicators can be used to estimate the degree of decrease in filtration-volumetric properties of the reservoir in the process of primary penetration. The results of such studies can be useful in studying the mechanism of reducing the formation permeability for oil due to the penetration of the water phase. Optimization of the parameters of the drilling fluid and its filtrate can help to reduce the negative impact on the formation during drilling. Determination of the pore volume occupied by filtrate in the process of oil production and the permeability recovery factor also carry significant information in the design of the opening fluid and in the assessment of oil production. It can also be noted that, similarly to the experimental technique used, it is possible to assess the degree of primary saturation of the core material with the drilling fluid filtrate. This parameter can also be useful for carrying out special calculations, according to which, taking into account the depth of penetration of filtrate into the formation, it is possible to assess the quality of the formation penetration and select the opening fluid.

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# Optimization of Innovative Solutions in Oil Refining: Methodology and Mathematical Support

**A. P. Sizikov**

**Abstract** The article investigates the issues of innovative management in oil refining. We consider the situation when there are several options for investment projects, from which we need to choose the best one. The analysis and comparison of options is carried out on the basis of a methodology that regulates a set of key project performance indicators. To calculate these indicators, you need to know the elements of the cost and result flow of each project. In other words, we need to know how certain technological changes will affect the main technical and economic indicators of production. In the oil refining production, this is quite a difficult task, since changes in one link of the technological process affect other links and the results of the entire production. To determine how the modernization of installations affects the intensity and quality characteristics of material flows, the costs of fuel, electricity and other ingredients, and, ultimately, the economic indicators, a comprehensive optimization model is proposed. On the basis of this model, a computer program has been developed to calculate the dynamics of the main technical and economic indicators as a result of the phased reconstruction of existing or newly entered production facilities. An example of the use of the suggested software for the analysis of options for the reconstruction of an oil refinery is given.

**Keywords** Innovation management · Mathematical support · Oil refining · Optimization · System modeling

## 1 Introduction

At the oil refinery, reconstruction is underway, the purpose of which is the transition to new standards of product quality. An important aspect of innovation management is the evaluation of the quality of projects. According to the existing methodology governing the stages and procedure of this work [1], the basic assessment of the investment project is the net present value (Eq. 1):

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$$NPV = \sum_{t=0}^{T} C_t (1 + r)^{-t} \tag{1}$$

where $C_t$ is the cost of the project's cash flows, $r$—the discount rate. In addition, derivates from $NPV$ are used, namely $PI$ and $IRR$—respectively, the reduced income per ruble of the reduced costs and the internal rate of return.

As we can see, to calculate the estimated indicators, we need to know the elements of the financial flow $C_t$, $t = 1, 2, \ldots, T$. Determining these values presents a certain difficulty. Especially if we are talking about the elements of the return flow [2]. Oil refining production is a complex system of installations connected by material flows, through which one technological process affects another. Changes in one link inevitably affect others and, ultimately, the final production indicators. To determine how changes in the parameters of technological equipment affect the intensity and quality characteristics of material flows, the cost of fuel, electricity and other ingredients, and, ultimately, the economic indicators, a comprehensive model of oil refining production is proposed.

## 2 Model

Oil refining production can be represented as a network directed graph. The set of nodes of this graph $K = U \cup S$, where $U$ is the set of installations, $S$ is the set of mixed pools. The set of arcs reflects the flows of petroleum products. Each product from the set $I$ can be represented by one or more flows. If $J_i$ is the set of flows representing the product $i \in I$, then the set of all flows is $J = \bigcup_{i \in I} J_i$. Material balance equations (Eqs. 2–6):

$$\sum_{j \in J_i^+} x_j - \sum_{j \in J_i^-} x_j = 0, \quad i \in \mathrm{I}, \tag{2}$$

where $x_j$ is the intensity of the $j$ flow; $J_i^+(J_i^-)$—the set of flows replenishing (consuming) the $i$ product.

Restrictions on the supply of raw materials and semi-finished products from:

$$P_i^- \le \sum_{j \in J_i^+} x_j \le P_i^+, \quad i \in I^+ \tag{3}$$

where $I^+$—the set of products coming from the outside; $P_i^-(P_i^+)$—delivery limits.

Requirements for the shipment of commercial products:

$$V_i^- \leq \sum_{j \in J_i^-} x_j \leq V_i^+ \quad i \in I^-, \tag{4}$$

where $I^-$—the set of commodity products; $V_i^-(V_i^+)$—the limits of the shipment of the commodity product.

Material balances of nodes:

$$\sum_{j \in J_k^+} x_j - \sum_{j \in J_k^-} x_j = 0, \quad k \in K, \tag{5}$$

where $J_k^+(J_k^-)$—the set of input (output) flows of the $k$ node.

Node loading restrictions:

$$L_k^- \leq \sum_{j \in J_k^+} x_j \leq L_k^+, \quad k \in K, \tag{6}$$

where $L_k^-$, $L_k^+$—the loading limits (potential) of the $k$ node.

The installation, as a node of the network model, is represented by a finite set $R_k$ of technological modes. Accordingly, variables are introduced $\{x_{jr}, r \in R_k\}$, where $x_{jr}$ is the intensity of the $j$ flow for the mode $r$. For each technical regime $r \in R_k$, restrictions can be set in the form of acceptable intervals of variation of input flows—$[\delta_{jr}^-, \delta_{jr}^+]$, $j \in J_k^+$ where $\delta_{jr}^-$, $\delta_{jr}^+$—respectively, the lower and upper limits of the flow share in the total load of the installation. The outputs of the installation are defined as follows, Eq. (7):

$$x_{ir} = \sum_{j \in J_k^+} a_{ijr} x_{jr}, \quad i \in J_k^-, \tag{7}$$

where $a$ is the coefficient of the linear transformation.

To connect the newly introduced variables with the variables of the main group, the balance equations are introduced, Eqs. (8)–(10):

$$x_j - \sum_{r \in R_k} x_{jr} = 0, \quad j \in J_k^+ \cup J_k^-, \tag{8}$$

and a block is entered $r \in R_k$ for each one

$$\begin{cases} \sum_{j \in J_k^+} \alpha_{ijr}^- x_{jr} \geq 0, i \in J_k^+, \\ \sum_{j \in J_k^+} \alpha_{ijr}^+ x_{jr} \leq 0, i \in J_k^+, \\ \sum_{j \in J_k^+} a_{ijr} x_{jr} - x_{ir} = 0, i \in J_k^-, \\ x_{jr} \geq 0, j \in J_k^+ \cup J_k^-, \end{cases} \tag{9}$$

where $\alpha_{ijr}^{-} = \begin{cases} 1-\delta_{ir}^{-}, i=j, \\ -\delta_{ir}^{-}, i \neq j, \end{cases}$ $\alpha_{ijr}^{+} = \begin{cases} 1-\delta_{ir}^{+}, i=j, \\ -\delta_{ir}^{+}, i \neq j. \end{cases}$

A mixing pool can be considered as a node with several incoming flows (mixing components) and one outgoing flow (mixing product). The proportions of the mixing components are determined by the quality requirements of commercial mixtures, which can be presented in the first approximating as follows [3]:

$$I\left(p_q^{-}\right)\sum_{j\in J_k^{+}}\frac{x_j}{p_{oj}} \le \sum_{j\in J_k^{+}} I\left(p_{qj}\right)\frac{x_j}{p_{oj}} \le I\left(p_q^{+}\right)\sum_{j\in J_k^{+}}\frac{x_j}{p_{oj}}, \quad q\in Q_k \tag{10}$$

where $Q_k$ is the set of quality parameters for the $k$ mixing product; $p_{qj}$ is the value of the $q$ parameter of the $j$ component; $p_q^{-}$, $p_q^{+}$ are the lower and upper bounds of the parameter for the product; $p_{oj}$ is the basic parameter for converting the meaning of the value $p_{qj}$ per unit of mass; $I(p)$ is parameter index (index transformations are performed for some parameters to ensure the additivity of the mixing model for these parameters).

Representing the restrictions in Eq. (10) in the form in which all the variables are on the left side, for each $k \in S$ we write (Eq. 11):

$$\begin{cases} \sum_{j\in J_k^{+}} \alpha_{ij}^{-}x_j \ge 0, i \in J_k^{+}, \\ \sum_{j\in J_k^{+}} \alpha_{ij}^{+}x_j \le 0, i \in J_k^{+}, \\ \sum_{j\in J_k^{+}} \beta_{qj}^{-}x_j \ge 0, q \in Q_k, \\ \sum_{j\in J_k^{+}} \beta_{qj}^{+}x_j \le 0, q \in Q_k, \end{cases} \tag{11}$$

where $\alpha_{ij}^{-} = \begin{cases} 1-\delta_{kj}^{-}, i=j, \\ -\delta_{kj}^{-}, i \neq j, \end{cases}$ $\alpha_{ij}^{+} = \begin{cases} 1-\delta_{kj}^{+}, i=j, \\ -\delta_{kj}^{+}, i \neq j, \end{cases}$ $\beta_{qj}^{-} = \frac{I(p_{qj})-I(p_q^{-})}{p_{oq}}$, $\beta_{qj}^{+} = \frac{I(p_{qj})-I(p_q^{+})}{p_{oq}}$.

Economic indicators are calculated based on the intensity of flows. In the context of the task under consideration, we are primarily interested in marginal profit, Eq. (12):

$$P = \sum_{i\in I^{-}} c_i \sum_{j\in J_i^{-}} x_j - \left(\sum_{i\in I^{+}} c_i \sum_{j\in J_i^{+}} x_j + \sum_{k\in K} \varsigma_k \sum_{j\in J_k^{+}} x_j\right), \tag{12}$$

where $c_i$—the price of the $i$ product (for intermediate products, this value is zero); $\varsigma_k$—the unit costs associated with the loading of the $k$ node (the cost of fuel, electricity, consumed ingredients).

In addition to margin profit, flow rates are used to calculate indicators specific to oil refining—the output of light oil products, the depth of oil refining, and others. All indicators are reduced to a comparable dimensionless form and normalized relatively to any target or nominal values. Then, taking into account the weight coefficients, a multi-level convolution is formed from them, which is taken as a criterion [4]. In the generalized matrix–vector form, the problem (1)–(12) looks like this—Eq. (13):

$$(\mathbf{p}, \delta) \to \min,$$
$$\begin{cases} \delta = (\mathbf{Eg})^{-1}(\mathbf{Ax} - \mathbf{g}) \\ \mathbf{b}^{-} \le \mathbf{Bx} \le \mathbf{b}^{+} \\ \mathbf{x} = \mathbf{0}, \end{cases} \tag{13}$$

where $\mathbf{x}$ is the vector of material flow intensities; $\mathbf{g}$ is the vector of target indicators; $\mathbf{A}$ is the matrix of linear transformation of the vector of variables into the vector of indicators; $\mathbf{B}$ is the matrix of production and technological parameters; $\mathbf{b}^{-}$, $\mathbf{b}^{+}$—the vectors of production and technological restrictions; $\delta$ is the vector of relative deviations of the calculated values of indicators from the specified ones; $\mathbf{p}$—the vector of priorities of indicators; $\mathbf{E}$ is the unity matrix.

The model (13) allows to determine the connection between the technological parameters of production and its technical and economic indicators through the intensity of material flows. On the basis of this model, a computer program has been developed [5], which is used as follows. At the initial stage, the parameters of the existing enterprise are introduced. The nominal loads of installations, the coefficients of selection of petroleum products, standard specifications of commercial products, and standard energy costs are taken. The indicators of the introduced processes are taken from the technical documentation of the manufacturers. Then, for each project, the optimal development trajectory of the enterprise is calculated by year, taking into account the commissioning of new installations or the reconstruction of existing ones [6].

## 3 Example

Below are the results of a study of four reconstruction options, which consisted in the commissioning of various new installations. (1) Vacuum tube installation with a capacity of 1.8 million tons/year. (2) Deasphalting installation (1.6 million tons/year), flexicoking installation (1.0 million tons/year). (3) Deasphalting installation (1.6 million tons/year) and delayed coking installation (1.0 million tons/year). (4) Hydrocracking installation (1.7 million tons/year), hydrogen production installation (65 thousand tons/year) and sulfur production installation with capacity (30 thousand tons/year). Investments in projects for all options, broken down by year, are shown in Table 1.

For the current production and reconstruction options, the material balances, expanded and consolidated, are calculated. They are used to calculate the installation loads and the required resources. As well as production results—the cost of

**Table 1** Investments in projects

| Cost items, million rubles | Projects options | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Installation works | 6429.4 | 6517.7 | 7769.7 | 16,634.2 |
| Cost of equipment | 6497.2 | 8688.8 | 6887.5 | 21,106.4 |
| Other expenses | 2084.8 | 3311.9 | 2596.6 | 8473.5 |
| Total | 14,914.4 | 18,509.7 | 17,253.8 | 45,827.1 |
| Investment stages | Capital investments | | | |
| 0 | 147.90 | 186.3 | 173.6 | 457.9 |
| 1 | 597.45 | 744.5 | 687.9 | 1833.8 |
| 2 | 1487.34 | 1855.7 | 1725.6 | 4584.8 |
| 3 | 3728.32 | 4626.4 | 4315.4 | 11,456.6 |
| 4 | 4771.54 | 5934.6 | 5527.6 | 14,754.7 |
| 5 | 4173.54 | 5187.8 | 4837.8 | 12,837.9 |

**Table 2** Results of implementation of investment projects

| Cost–benefit items, million ruble | Projects options | | | | |
|---|---|---|---|---|---|
| | Base | 1 | 2 | 3 | 4 |
| Raw materials | 28,885 | 29,088 | 29,166 | 29,074 | 30,753 |
| Materials | 12,709 | 14,670 | 14,180 | 14,129 | 12,958 |
| Commercial products | 90,723 | 98,629 | 96,419 | 97,178 | 109,626 |
| Total revenue | 48,949 | 54,813 | 53,274 | 53,985 | 63,941 |
| Revenue to base | 0 | 6143 | 4426 | 5157 | 17,192 |

commercial products, profit, and others. The financial results of the projects under consideration are presented in Table 2.

An example of the calculation of the 1st option is given in Table 3, where 1-investments in the project by year, 2-return by year, 3-discount coefficient, 4-discounted costs, 5-discounted results, 6-$NPV$ increment total.

Project totals: $NPV = 2367.18$; $PI = 1.32$;$IRR \approx 0.28$.

The indicators of other investment options are calculated using the described method. The results for all variants are presented in Table 4. As we can see, Projects 1 and 4 have the best indicators. The project has the highest value $NPV$ of 4, but it is inferior to the first option in other indicators.

**Table 3** Dynamics of indicators of the 1st project

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 0 | −147.81 | | 1 | −147.81 | | −147.81 |
| 1 | −595.42 | | 0.834 | −498.10 | | −645.88 |
| 2 | −1488.26 | | 0.693 | −1035.27 | | −1679.89 |
| 3 | −3728.22 | | 0.581 | −2157.95 | | −3837.13 |
| 4 | −4771.62 | | 0.483 | −2301.04 | | −6137.61 |
| 5 | −4172.24 | | 0.403 | −1677.03 | | −7814.08 |
| 6 | | 6043.00 | 0.336 | | 2027.16 | −5794.03 |
| 7 | | 6043.00 | 0.278 | | 1687.32 | −4114.19 |
| 8 | | 6043.00 | 0.232 | | 1405.17 | −2696.52 |
| 9 | | 6043.00 | 0.195 | | 1171.87 | −1531.24 |
| 10 | | 6043.00 | 0.163 | | 975.83 | −552.24 |
| 11 | | 6043.00 | 0.136 | | 815.29 | 263.17 |
| 12 | | 6043.00 | 0.114 | | 679.17 | 939.03 |
| 13 | | 6043.00 | 0.094 | | 565.03 | 1513.04 |
| 14 | | 6043.00 | 0.075 | | 471.18 | 1970.14 |
| 15 | | 6043.00 | 0.067 | | 391.97 | 2367.18 |
| | | | | −7815.79 | 10,178.81 | |

**Table 4** Final projects indicators

| Project indicators | Projects options | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| $NPV$ | 2367.18 | −2235.96 | −369.07 | 4781.76 |
| $PI$ | 1.32 | 0.75 | 1.04 | 1.30 |
| $IRR$ | 0.28 | 0.17 | 0.25 | 0.22 |

# 4 Discussion

The presented calculations show that the necessary stage of the procedure for evaluating investment projects in oil refining is the forecast of the impact of technological solutions on economic results. Such a prediction cannot be made without the use of a comprehensive optimization model that allows to determine the dependence of technical and economic indicators on production and technological parameters. In particular, in the example considered, the reconstruction options that are comparable in terms of costs turned out to be completely different in efficiency.

## 5 Conclusion

The article considers the features of the analysis of investment projects in oil refining. The problem of forecasting the impact of innovative solutions on technical and economic indicators is investigated. The problem is that changes in any one link of the technological process have an ambiguous effect on other links and on the results of the entire production. In order to predict the consequences of innovative solutions, a comprehensive optimization model of oil refining production has been developed. The model allows us to determine the relationship between the technological parameters of production and its technical and economic indicators through the intensity of material flows. On the basis of this model, a computer program has been developed, with the help of which, for each investment project, it is possible to calculate the dynamics of the main technical and economic indicators as a result of the phased commissioning of new installations or the modernization of existing ones. An example of the use of the proposed methodology for the analysis of four options for the reconstruction of an oil refinery is presented.

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# Justification of the New Technologies Choice for Repair and Construction Works

**A. D. Kornilova, E. P. Acri, and V. M. Balkin**

**Abstract** Constructed and commissioned buildings are exposed to various external (physical) and internal (technological and functional) influences. Structural elements wear out, become old, and fail. At the same time, the efficiency of the building deteriorates, which leads to the non-compliance of the building to fulfill its purpose. Premature deterioration should not occur because it disrupts working conditions and affects the quality of people life using the building. The operation of buildings on a state scale is regulated by the provisions on planned preventive maintenance systems. They define the principles of the organization of operation of the main types of buildings and structures, are divided into groups and for them the average service life, types, frequency of inspections and repairs, as well as works related to current and major repairs are established. Creating a unified scientific approach to the planning, development and implementation of production works during major repairs is an urgent task, since there are often discrepancies between the necessary and actual volumes of repair works. The use of the methodology for evaluating and selecting solutions based on modern mathematical methods and technical tools makes it possible to model the process of implementing technical and organizational and technological solutions at all stages of repair and construction production, including for evaluating their effectiveness. As a result of the conducted studies, a model of the choice of new technologies was developed, which allowed to justify an appropriate and effective version of the new technology for major repairs of buildings.

**Keywords** Efficiency · Housing maintenance and utilities complex · Major repairs · Mathematical modeling · Technology

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## 1 Introduction

Construction objects play an important role in the life of modern society, influencing the level of civilization, the development of science, culture and production. According to many experts, the development of a society is largely determined by the number and quality of buildings constructed or renovated. The life of people is determined by the presence of the necessary buildings, their compliance with their purpose, technical condition. For a long service life, buildings should be maintained in proper condition, periodically repaired, using new technologies during repair and construction works. Such technologies should help to increase the operational characteristics and service life of building elements, as well as to save private and budgetary funds necessary for carrying out repair works. This, in turn, will have a positive impact on the image of enterprises and will allow increasing the paces of restoration works of buildings in the regions. Enterprises engaged in repair works need a methodological apparatus that allows an affordable and relatively fast way to justify the appropriate version of the new technology, which makes it possible to effectively solve the assigned production tasks. There are many such methods developed by scientists [1–6]. Recently, the approach of complex use of several methods of one direction has gained popularity, due to which an optimal solution search model is obtained. To implement the introduction of new technologies, it is necessary to develop a set of measures for their selection. And these technologies should be applicable to various types of production works.

## 2 Methodology

When studying the system for the introduction of new construction technologies, it is necessary to take a deeper look at the cause-and-effect factors and their interrelationships. A modern system of economic incentives should promote a more efficient use of the resources necessary for the process of introducing new technologies. The creation of long-term comprehensive plans for the development of new technology management systems is closely related to the optimal design of the national economy. For this purpose, mathematical models are used, with the help of which in a relatively short time it is possible to solve: economic and technological problems, optimal hardware design, and the choice of the best ways of working at the enterprise.

When searching for the optimal variant of a new technology using mathematical modeling methods, an important step is the correct informed choice of these technologies, the implementation of which will lead to the most effective result [6]. Modern methods allow to find approximate numerical indicators of technologies, calculated values of general and comparative efficiency, taking into account the time factor and the costs of the production sector. However, in a situation where at the initial stage it is necessary to justify the directions of new technologies, choosing several technologies for their further in-depth study, it is advisable to use the method of expert analysis, which is similar to the method of Ushvitsky. In accordance with its methodology, it is necessary to actively use a simple, accessible and sufficiently effective method of expert assessments, which allows to consider the professional experience of experts to obtain quantitative values of the defining indicators (Xi) by qualitative characteristics (expert assessments) [6].

## 3 Results

Enterprises engaged in repair works need a methodological apparatus that allows an affordable and relatively fast way to justify the appropriate version of a new technology that will effectively solve the set production tasks. Recently, the method of complex use of several methods of one direction has become popular, due to which an optimal solution search model is obtained [7]. The use of mathematical modeling techniques allows to present a model for justifying the choice of a new technology for repair and construction works (Fig. 1).

As follows from Fig. 1, initially, the construction and repair organization that chooses to use a variant of the new technology should determine the goal at this choice stage. If the goal is to study a large number of technologies and choose a general direction of your technology policy with several technologies, it is advisable to use economic and mathematical modeling and move according to this algorithm:

1. Create a system of defining indicators (Xi-technologies) that are of interest to the repair and construction organization.
2. Determine the range of ratings according to their significance in solving the problem of choosing a new technology.
3. Assemble a team of j − x experts to evaluate the indicators—new technologies (Xi) according to their significance in the conditions of mutual independence.
4. Fill in the matrix of implementation of expert assessments in the conditions of independence of their judgments when studying the characteristics of new technologies. Determine the total estimate of the i-th factor (Table 1).

   When it turns out that an expert assigned the same score more than 2 times when evaluating the defining indicators (Xi), such expert assessments are not taken into account, and the matrix remains with a reduced number of experts.
5. Determine the sum of indistinguishable ranks for the j-th expert (1):

$$T_j = \sum_{k=1}^{l} N_k O_k, \tag{1}$$

where $N_k$ is the number of k − x identical assessments ($N_k \leq 2$);

$O_k$ are the same ratings.

Next, find the sum of indistinguishable ranks $\left(\sum_{j=1}^{m} T_j\right)$ for all experts, where m is the number of experts.

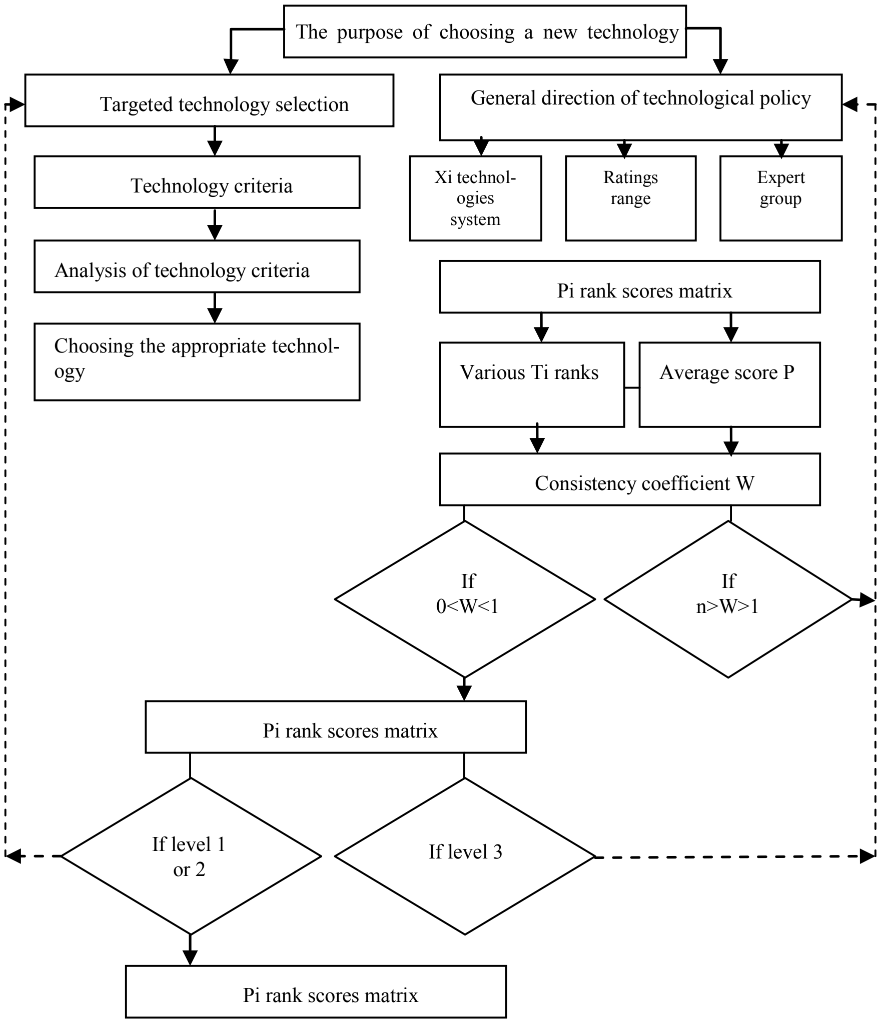


**Fig. 1** Model for justifying the choice of new technologies

6. Determine the average total score for all technologies (2):

$$\overline{P} = \frac{1}{n}\sum_{i=1}^{n} P_i, \tag{2}$$

where i is the technology; n is number of i − x technologies; $P_i$ is the i-th score set by the j-th expert.

7. Calculate the sum of the squared deviations (3):

**Table 1** Formation of the matrix of rank assessments of new technologies of repair and construction buildings works

| Experts | Expert assessments on new technologies (Xi) | | | | | |
|---|---|---|---|---|---|---|
| | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_n$ |
| 1 | $P_{11}$ | $P_{12}$ | $P_{13}$ | $P_{14}$ | $P_{15}$ | $P_{1n}$ |
| 2 | $P_{21}$ | $P_{22}$ | $P_{23}$ | $P_{24}$ | $P_{25}$ | $P_{2n}$ |
| 3 | $P_{31}$ | $P_{32}$ | $P_{33}$ | $P_{34}$ | $P_{35}$ | $P_{3n}$ |
| 4 | $P_{41}$ | $P_{42}$ | $P_{43}$ | $P_{44}$ | $P_{45}$ | $P_{4n}$ |
| 5 | $P_{51}$ | $P_{52}$ | $P_{53}$ | $P_{54}$ | $P_{55}$ | $P_{5n}$ |
| 6 | $P_{61}$ | $P_{62}$ | $P_{63}$ | $P_{64}$ | $P_{65}$ | $P_{6n}$ |
| 7 | $P_{71}$ | $P_{72}$ | $P_{73}$ | $P_{74}$ | $P_{75}$ | $P_{7n}$ |
| 8 | $P_{81}$ | $P_{82}$ | $P_{83}$ | $P_{84}$ | $P_{85}$ | $P_{8n}$ |
| 9 | $P_{91}$ | $P_{92}$ | $P_{93}$ | $P_{94}$ | $P_{95}$ | $P_{9n}$ |
| | $\sum_{j=1}^{m} P_1$ | $\sum_{j=1}^{m} P_2$ | $\sum_{j=1}^{m} P_3$ | $\sum_{j=1}^{m} P_4$ | $\sum_{j=1}^{m} P_5$ | $\sum_{j=1}^{m} P_n$ |

$$\Delta^2 = \sum_{i=1}^{n} (P_i - \overline{P})^2. \tag{3}$$

8. Determine the coefficient of consistency between experts (3.4):

$$W = \frac{\Delta^2}{\frac{1}{2}nm(n^3 - 1) - m\sum_{j=1}^{m} T_j}, \tag{4}$$

It should be between 0 and 1. If W falls in the range from 0 to 1, then we proceed to the next stage of the algorithm. If W does not fall in the range from 0 to 1, then at this stage it is concluded that the expert assessments are incorrect, with a significant difference in opinions, and the search for a new technology is either stopped or carried out anew—with new experts or the same, but with different technologies, in order to form a single expert decision on such an important issue as the justification for the enterprise of a new appropriate technology for repair and construction works.

9. Confidence level of the consistency coefficient (5):

$$X = \frac{\Delta^2}{\frac{1}{12}nm(n^3 - 1) - \frac{1}{n-1}\sum_{j=1}^{m} T_j} \tag{5}$$

10. Compare the confidence level of the consistency coefficient (X) with the statistical value (Xt) for the obtained probability level (consistency coefficient W). There are three levels of confidence:

    (1) X < Xt—the numerical value of the consistency coefficient at a sufficient level of confidence;

(2) $X = Xt$—the numerical value of the consistency coefficient at the boundary of the confidence level;
(3) $X > Xt$—the numerical value of the consistency coefficient is not at the proper level of confidence, i.e. the work of experts is unreliable.

If the first or second level of confidence is obtained, the estimates of experts on new technologies are recognized as reliable. There is a return to the matrix of implementation of expert assessments in the conditions of their judgments independence when evaluating the indicators of new technologies, and, based on the scale of assessments significance, one or more of the best technologies that are appropriate for implementation are selected based on the total values of the matrix. If the enterprise's goal was to select one technology from a small number, after performing a deep expert analysis of the indicators and characteristics of technologies, they should be presented in the form of a table. The criteria for comparison are the features of the device of a particular type of new technology, for example, the environmental component, the operational properties of the building element repaired with the new technology, the likely reduction in labor intensity or manual labor, as well as the features and technical characteristics of the new technology, etc.

## 4 Discussion

In this paper, the question of choosing innovative technologies or materials when performing repair works is considered. We are talking about major repairs of buildings, since this type of repairs implies the improvement of the building structures. According to the major repairs program, residential buildings are being repaired in the following areas: roof repairs, frontage repairs, utility networks repairs.

The listed types of major repairs include a huge complex of works (preparatory, basic). On the basis of tenders, contracting organizations (contractors) are selected [8]. The number and types of works may vary depending on the deprecation of the object, but the cost of all types of work, taking into account material resources, should not exceed the maximum cost of major repairs for this object. Therefore, in order for a contracting organization to receive a profit from performing a set of works, it is necessary to search for such options for performing major repairs, in which the quality of the work performed will not suffer, but their cost will decrease [9]. When concluding a contract, the execution period, objects names, and types of works are determined. Often, the contractor have to independently perform the design works and coordinate the working documentation with the customer. It is at this stage that it is possible to consider the possibility of using a new technology or innovative material. The presented methodology allows to consider several options for implementing the new technology and choose the best option in terms of financial benefits and increasing the operational characteristics of a residential building.

## 5 Conclusion

The article suggests a model that will give organizations performing repair works the opportunity to quickly and efficiently select new technologies for performing repair works from a variety of similar or diverse innovations. The model is based on the principles of economic and mathematical modeling and the method of expert assessments. The development and implementation of models based on modern techniques is a fundamental way to maintain the competitiveness of organizations that perform building repairs, since they: reduce the cost of performed works, increase the operational characteristics of buildings, increase the energy efficiency of buildings, create new and non-standard technical solutions, improve the image of the organization and the region as a whole. Thus, the economic justification of the introduction of new technologies in the repair and construction work of buildings on the basis of the developed model of the choice justification is appropriate.

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# Monitoring Oil and Gas Deposits Using Technologies of Intelligent Avatars and Blockchain

**V. Y. Afanasyev, S. V. Chernyshenko, and V. Mkrttchian**

**Abstract** The objective of the research is to develop an approach to proactive environmental monitoring of events in the environment of oil and gas deposits. The methodology includes following elements: the collection, consolidation and analysis of big data; predictive modelling of environment dynamics and observing direction if this dynamics, forecasting possible negative trends in ecological situation change and risks of emergencies. The issues of developing a decision support system to reduce environmental risks, increase the efficiency of oil and gas production, and ensure the safety of personnel are also discussed. The study used such modern approaches from the field of information technology and the digital economy as blockchain technology, smart avatars, big data, data mining, etc.

**Keywords** Blockchain · Decision-making support · Intelligent avatar · Monitoring · Oil and gas deposit · Predictive modelling

## 1 Introduction

The research is devoted to new forms of intelligent control systems for enterprises in the fuel and energy complex, developing the idea of digital twins. In the context of the digitalization of the economy (the idea and practice of which has existed for more than twenty years [1]), the use of more and more complete information and more and more "intelligent" methods of its processing is the only way to maintain the competitiveness of the economy and solve not only economic, but also social problems. The economy should become not only digital, but also "intelligent" [2].

The main emphasis in the article is made on ensuring the environmental safety of the fuel and energy complex, which is impossible without a well-functioning

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system of permanent monitoring of the environment. In the practical ecology, many approaches to the forming monitoring schemes have been developed [3]. Contrary to the past, when one of the most difficult tasks was to collect a sufficient amount of representative information, nowadays specialists are faced with the opposite problem. It is not difficult now to establish a continuous flow of huge amounts of data—from satellites, from numerous sensors with which modern equipment is equipped, etc. But processing these data (preferably in real time) and even their storage are difficult tasks. For solution of these problems, in different cases, a special area of informatics has been developed: so called "big data" [4, 5]. One of the new approaches to working with big data (aimed mainly at efficient and reliable storage and efficient access to them) is blockchain technology [6, 7]. The latter is developing rapidly, covering new and new applied areas; its theoretical foundations are also under formation [8].

The main element of the computer system for supporting managerial decisions is an intelligent agent-avatar [9], which can be considered as a modern realisation of the classical idea about self-reproducing automata. The technology has become widespread and is used in many fields like public administration [1], human resource management [10], education [11], etc.

An avatar, as a software object, is based on the algorithms of self-learning neural networks and functions in close connection with an automatically forming knowledge base [12]. The latter includes both basic knowledge block and constantly growing experience knowledge block, accumulated new information about observed specific processes and situations. For efficient and reliable operation of the system, the knowledge base must be distributed. As it is shown in articles [13], the most efficient knowledge base's operation is ensured by the blockchain technology [6, 7], which was discussed above.

The system of intelligent twin-avatars in [13] is considered as a tool for development of monitoring systems with application to risk management and predicting environmental force majeure events in such geographically distributed systems as oil and gas deposits. The purpose and objectives of the research correspond to direction H1 from the Strategy of Scientific and Technological Development of the Russian Federation. They relate to developing methods and tools for big data processing using technologies of intelligent analysis; and to machine learning systems for predictive modelling of risks.

## 2 Methodology

The main methodological approaches, used in the research, are the followings:

1. The concept of "proactive" monitoring of the environment in geographically distributed systems based on the collection, consolidation and predictive analysis of big data about the ecological situations. One of the goals is to identify, in the framework of predictive modelling, the main factors, affecting the situation, as well as to assess the risks of negative events. In addition to passive collection

and processing of big data, "proactive" monitoring supposes an ability to control the location and operation modes of the distributed sensors and measuring devices.

2. A method for consolidating large heterogeneous data about critical events, accidents and emergencies with different time and geospatial coordinates. The technique includes algorithms for eliminating duplicates, data validation, filtering information noise, formalizing data in the form of vector and graph models, fixing "event patterns", retrospective analysis to establish correlations with similar incidents in the past.
3. Methods of ensuring information security and protection of big data (in a distributed information storage in sensors or mobile data collection nodes, as well as in the communication channels) in the process of collection, transmission and storage, using distributed register technologies (blockchain).
4. Methodology for presenting information about events in the form of time series (both event indices and external factors) for extrapolation in order to predict and assess the risks of occurrence of negative events.
5. The method of comparative analysis (benchmarking) of time series of event indices with time series of influencing factors to determine possible correlations between them; assessment of sensitivity and influence degree of the factors on the occurrence of accidents and emergency situations.
6. Development of predictive models for assessment of risks of occurrence of critical events, accidents and emergencies.
7. Visualization of results of the proactive monitoring with geospatial and temporal reference on stationary and mobile equipment.

## 3 Results

The scientific novelty of the research is the synthesis of proactive environmental monitoring (at the facilities of complex geographically distributed systems, such as oil and gas deposits), with the latest methods of informatics and digital economy. These methods are the followings: intelligent analysis of big data (in particular, geographically distributed time series); blockchain technology; intelligent avatars with self-learning ability; predictive models that are generated automatically, describing the influence of environmental factors and capable of predicting and assessing the risks of emergency situations. The developed scientific approach, models and methods correspond to the modern level of research in such scientific areas as intelligent monitoring systems; technologies for big data and distributed data processing; machine learning and forecasting. In addition to environmental monitoring, the results can be used as tools for the implementation in Smart City technologies, Smart Manufacturing [14] and the digital economy within the framework of the fourth industrial revolution (Industry 4.0) [15].

The research results are currently being tested in real conditions. The software implementation of a model of the proactive environmental monitoring of events in the environment of a “smart” oil and gas deposit is carried out, based on the collection, consolidation and analysis of big data, as well as the construction, on their basis, of predictive models of the deposit environment. Antenna arrays are considered as one of the main sources of information, the topology of which can be adjusted to the needs of research in the course of the proactive monitoring. Some engineering solutions are shown in Figs. 1, 2, 3, 4 and 5.

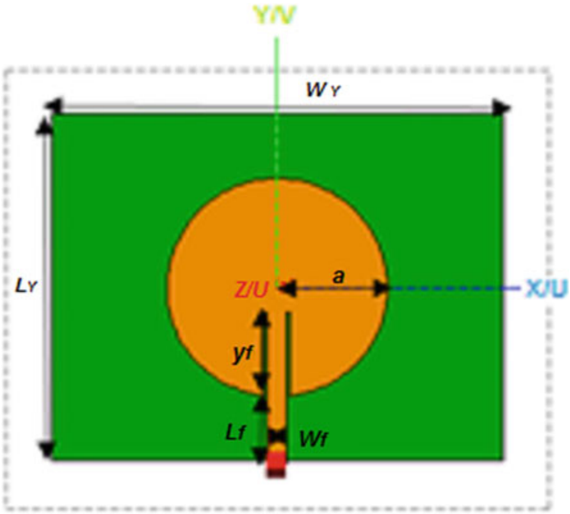



**Fig. 1** Geometry of the designed basic antenna. *Source* Authors

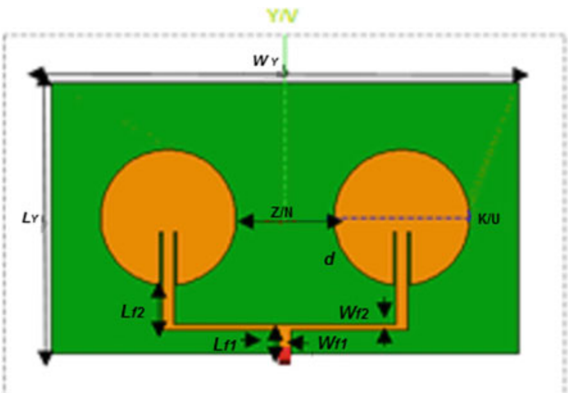



**Fig. 2** Geometry of the designed 2 * 1 array antenna. *Source* Authors

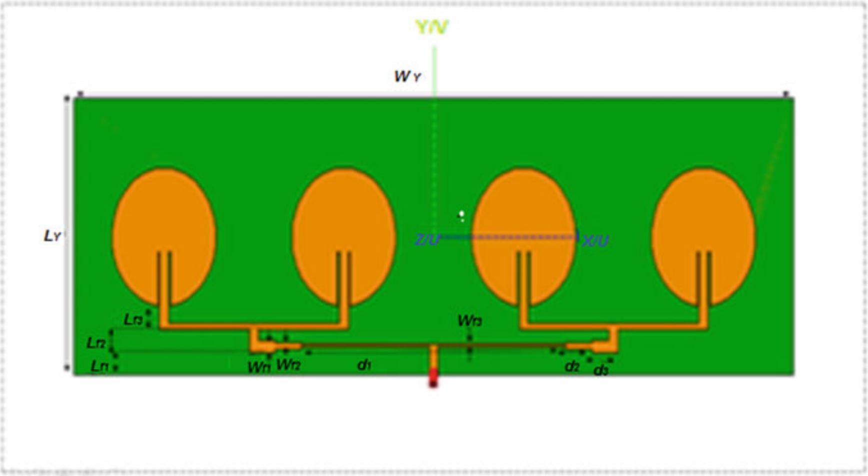
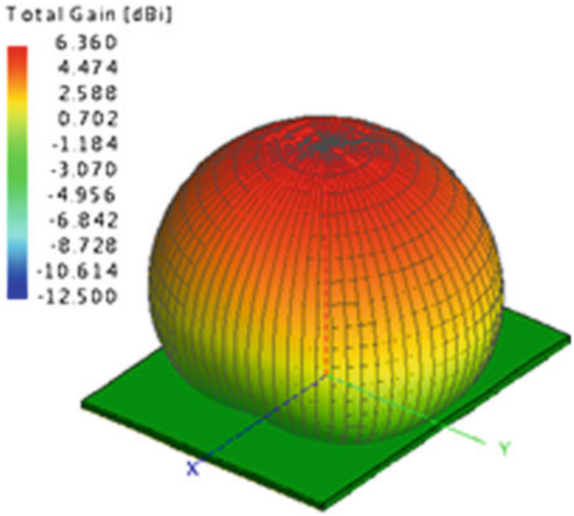



**Fig. 3** 3D radiation pattern of the designed patch antenna. *Source* Authors

**Fig. 4** 3D radiation pattern of the designed 2 * 1 array antenna. *Source* Authors




## 4 Discussion

Within the framework of the concept, it is planned to develop new methods for collecting, consolidating and processing big sensory data for predictive modelling of the risks of the appearance of negative environmental events through not only comparative and predictive analysis of the time series, but also using self-learning avatars, built based on multilevel neural networks, as well as nonlinear differential models.

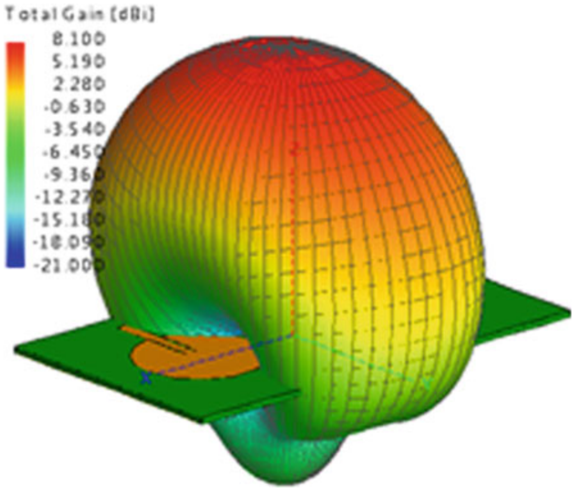



**Fig. 5** 3D radiation pattern of the designed 4 * 1 array antenna. *Source* Authors

Let us mention the following techniques; the use of which has been theoretically worked out, but practical use is only planned:

1. Using, during the consolidation of data from different sources, methods of classification and clustering in the space of attributes and environmental factors.
2. Implementation, for the purpose of reliable storage of large monitoring data and effective access to them, a blockchain model using the resources of several "smart" oil and gas fields.
3. Automatic generation of monitoring reports with graphical information on current trends and potential risks.
4. Construction of a unified model of information sources (satellites, sensors, measuring instruments) with the fixation of the "degrees of freedom" in their setting.
5. Construction of a unified model of critical facilities of a technical and social nature of the deposit and adjacent territories exposed to environmental risks from the deposit.
6. Consolidation of all geo-referenced information into a single geoinformation system of the deposit.

## 5 Conclusion

In general, the aim of the study has been achieved, although the practical implementation of a number of theoretically based approaches is still to be found. The accumulated experience of using proactive monitoring, which consists in registering and identifying events, intelligent analysis of big data (first of all, time series of events) and assessing the risks of occurrence and development of non-standard and emergency situations, proves the correctness of the proposed approach and its prospects.

The universal character of the proposed models, approaches and technologies makes it possible to use the developed tools not only in relation to environmental monitoring of oil and gas deposits, but also to the creation of various geographically distributed monitoring and control systems for cyber-physical objects and processes, such as the followings:

- SCADA-systems;
- systems of automated control of technological processes;
- systems of generation, transportation and consumption of energy, etc.

In the presented form, the public and social significance of the study is determined by the fact that the implementation of its results contributes to reducing the risks of accidents and disasters and ensuring the safety of human life, working in the fields or living in nearby territories.

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# A New Approach to Quantitative Characterization of the Material's Surface Morphological Heterogeneity

**G. O. Rytikov, D. V. Pervoukhin, and V. G. Nazarov**

**Abstract** A new approach to quantifying the degree of the polymer material's morphological heterogeneity is presented. Our technique bases on the analysis of parameters that were calculated for the plane rotation series of the experimental samples' images produced with the scanning electron microscopy. The parameters are mean values, standard deviations and average variation coefficients of variation-rotational picture pixels' brightness. Using the example of low-density polyethylene (LDPE) film that was oxyfluorinated under various surface modification modes, it was shown that even significant observed rotational variations in the average pixel brightness do not significantly affect the functional properties of the considered materials. But the degrees of rotational anisotropy of the standard deviations and the coefficients of pixel brightness variation significantly correlate with the changes in the values of the dispersion component of the experimental samples' free surface energy.

**Keywords** Chemical composition optimization · Oxyfluorination · Polymer modification · Scanning electron microscopy · Surface morphology · Variational analysis

## 1 Introduction

As a part of the implementation of the Decree №204 (May 7, 2018) of the President of the Russian Federation, in order to ensure the accelerated introduction of digital technologies in the economy and social sphere, the Government of the Russian Federation formed the national program "Digital Economy of the Russian Federation". An integral part of the national program "Digital Economy of the Russian Federation" is the federal project "Digital Technologies", aimed at ensuring the

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technological independence of the state, the possibility of commercializing domestic research and development, as well as accelerating the technological development of Russian companies and ensuring the competitiveness of their products and solutions on the global market. According to the Smart Design methodology, it is necessary to carry out a preliminary prediction of the functional properties of such materials, which ensures the implementation of the concept of “smart production”.

This paper presents a new method for characterizing the morphological heterogeneity of the material surface based on the quantitative analysis of variation-rotational patterns of the SEM-images. Currently, high-molecular weight compounds (polymers) are one of the most significant and demanded classes of compounds taking a special place in the development of innovative technologies. The need for new polymer materials creation and development is constantly growing in the modern world. The wide range of applicability of composite polymer materials in various fields indicates the need and priority of research on high-molecular weight compounds with a set of different functional properties [1].

The general approaches to new polymer composite materials creation are the synthesis [2] and the modification [3]. The modification, in contrast to synthesis, provides a wider range of possibilities for creating new materials due to its more versatile orientation and the possibility of varying the combinations of functional properties of the materials being created. One of the most promising ways to modify a material is its surface treatment. The surface modification of polymers is carried out by physical and chemical influences. The main methods for modifying polymers that contribute to changing the surface morphology of polymer matrices include exposure effects, irradiation, deformation, exposure to electromagnetic fields, treatment with chemical reagents, sulfonation, etc. [4].

The surface treatment of high molecular weight compounds allows to improve the properties of materials. For example, fluorination makes it possible to achieve the ultimate hydrophobicity of the surface. Gas-phase sulfonation allows minimizing the amount of sulfuric anhydride and get rid of liquid waste after modification. Plasma-chemical treatment improves the antifriction properties and chemical strength of rubber by creating thin anti-adhesive layers on its surface [5–7].

As a rule, as a result of surface modification, the structure and relief of the polymer are undergoing changes depending on the impact. Under physical action (for example, spraying), the structure of the polymer macromolecules remains the same in contrast to the physics-chemical action (for example, oxidation). Its functional properties and resistance to external atmospheric, chemical and other influences directly depend on the chemical composition and structure of the polymer. Thus, depending on the method of surface modification, such polymer properties as wettability, permeability, adhesion, etc. change [8–10].

## 2 Methodology

The equipment with high spatial resolution is currently used due to the limited possibilities of visual analysis of the investigated surface and polymer structure. Scanning electron microscopy (SEM) is a powerful tool for visualizing the chemical structure and nanotexture of the experimental samples [11]. The results of the physics-chemical properties studying and forecasting directly depend on the quantitative SEM-images analysis. The accuracy of samples' digital image is determined on the number of pixels in the SEM-image and on their brightness (Fig. 1). So the conclusions about the degree of morphological heterogeneity of the studied surface can strongly rely on the details of the corresponding image. The earlier developed original techniques for the quantitative SEM-images analysis are indicated in [12–15].

The digital image of the image is formed as a tabular function $B(x,y)$ of the dependence of the brightness values $B$ of the pixels on their coordinates $(x,y)$.

In order to match the same object with $N$ digital images corresponding to the images of the object in the coordinate systems rotated relative to the original one by some angles $\varphi_k$, it is enough to calculate the pixel coordinates of the original image in the rotated coordinate systems: $\begin{cases} \tilde{x}_k = x \cdot \cos\phi_k + y \cdot \sin\phi_k \\ \tilde{y}_k = -x \cdot \sin\phi_k + y \cdot \cos\phi_k \end{cases}$ and generate digital images $\tilde{B}_k(x, y) = B(\tilde{x}_k, \tilde{y}_k)$.

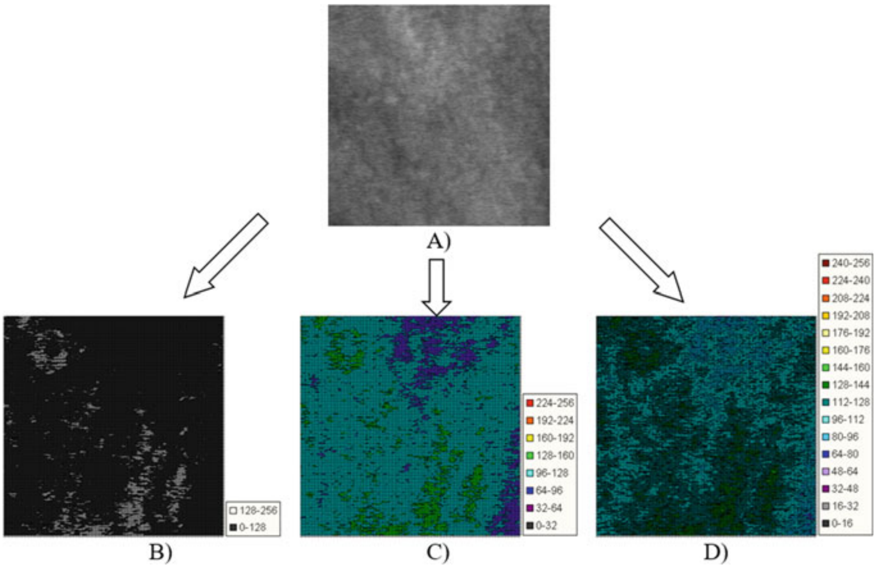


**Fig. 1** Variations in the information capacity of digital models from the standpoint of visual analysis with different amounts of brightness gradations forming the SEM image of pixels. The original SEM image (**a**), "binary" (**b**), 3-bit (**c**) and 4-bit (**d**) digital models. *Source* Authors

By averaging the pixel brightness values over the resulting ensemble of digital realizations and calculating the corresponding standard deviations for each pixel of the standardized image, it is possible to visualize the distributions of the standard deviations $\sigma_B(x,y)$, the average values $\overline{\mathrm{B}}(x,y)$ and the variation coefficients $V_B(x,y)$ of the pixel brightness:

$$\overline{B}(x, y) = \tfrac{1}{N} \cdot \sum_{k=1}^{N} B_k(x, y),$$

$$\sigma_B(x, y) = \sqrt{\tfrac{1}{N-1} \cdot \sum_{k=1}^{N} \left(B_k(x, y) - \overline{B}(x, y)\right)^2},$$

$$V_B(x, y) = \sigma_B(x, y)/\overline{B}(x, y)$$

The main quantitative measure for the analyzed image rotational anisotropy are the average values of the discussed variation coefficients. As calibration tests, it makes sense to consider the results of visualization of two-dimensional samples of random numbers evenly distributed in different ranges of numerical values typical for the analyzed image classes (with $[\overline{B} - \sigma_B, \overline{B} + \sigma_B]$ pixel brightness).

## 3 Results

Samples based on LDPE were subjected to surface modification at various gas mixture compositions ($x\%F_2 + y\%O_2 + 84\%He$). For all samples, SEM images of the corresponding surfaces were obtained. Based on these images, using the developed algorithm, variation-rotational patterns were obtained, shown in Fig. 2.

Figure 3 shows the variation-rotation patterns formed using the above algorithm on the basis of an image given by a two-dimensional sample of pseudorandom numbers uniformly distributed in the interval, and the SEM image of a polymer film treated with a gas mixture with brightness values in the same interval.

## 4 Discussion

We've simulated the variation-rotational picture from two-dimensional set of pseudo-random numbers to demonstrate the sensitivity of the proposed approach. Figure 3 shows images that visualize: (A) two-dimensional sample of pseudo-random numbers that define the brightness of the pixels; (B) variation-rotational picture formed using the above algorithm based on the SEM-image of the modified polymer film surface.

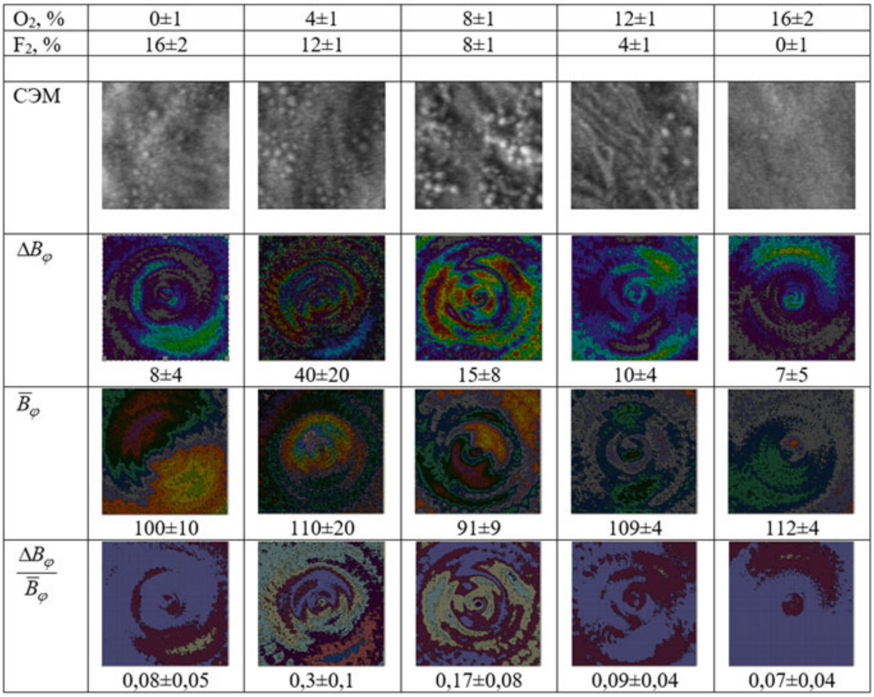


**Fig. 2** Compositions of gas mixtures for various modes of surface modification, maps of distributions of standard deviations, mean values and variation coefficients of the optical inhomogeneities of SEM images of the considered experimental samples. *Source* Authors

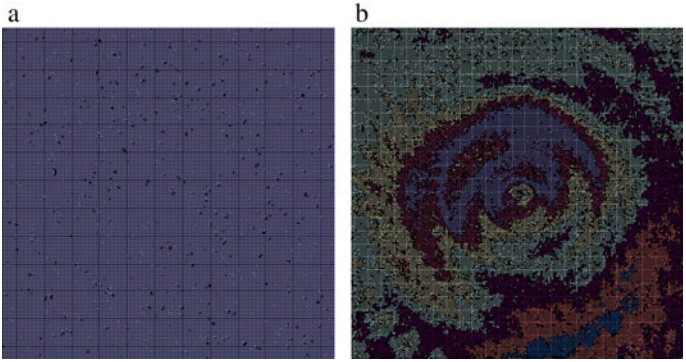


**Fig. 3** The demonstration of variation-rotational isotropy (**a**) and anisotropy (**b**). The image synthesized on the basis of two-dimensional sample of pseudo-random numbers (A) and on the basis of SEM-image of the oxyfluorinated film of low-density polyethylene (LDPE) (B). The average pixel brightness value is 108 and a corresponding standard deviation is 14. *Source* Authors)

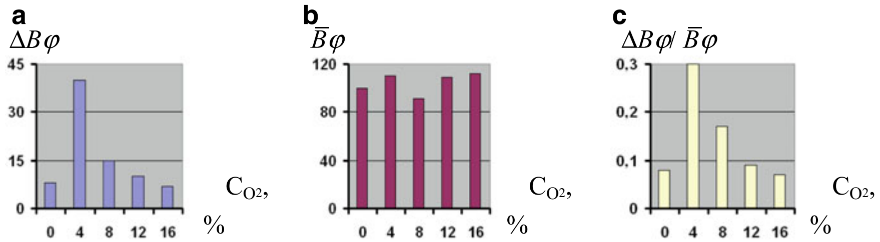


**Fig. 4** Histograms of the dependences of the standard deviations and average values of the pixel brightness of the rotated SEM images of experimental samples on the percentage of oxygen. *Source* Authors

The average value of the variation coefficient for the variation-rotation pattern based on the simulation sample was 0.08 ± 0.01, while for the treated polymer film this value takes the value of 0.3 ± 0.1 (i.e., 3.75 times more). Consequently, the variation-rotational approach can turn out to be a rather effective tool for characterizing the surface morphology, which determines the corresponding group of physicochemical properties of the materials under study.

Based on the calculation results, histograms were constructed to visualize trends in changes in standard deviations, mean values and variation coefficients of the discussed pixel brightness (Fig. 4).

The mean values of pixel brightness vary with changes in the oxygen content within the limits of statistical error, which indicates a high similarity of the conditions in which the formation of the SEM images was carried out.

The variation coefficients and standard deviations depend significantly on the oxygen concentration, and the maximum of the corresponding functions is observed at 5% oxygen content in the modifying mixture.

The Pearson correlation coefficient $R_{xy} = \frac{\sum_{i=1}^{N}(x_i-\overline{x})(y_i-\overline{y})}{\sqrt{\sum_{i=1}^{N}(x_i-\overline{x})^2\sum_{i=1}^{N}(y_i-\overline{y})^2}}$ between the dispersion component of the free surface energy ($\gamma$) and the variation-rotational patterns variation coefficient ($V$) was $R_{V\gamma} = 0.72 \pm 0.08$.

## 5 Conclusion

A significant correlation between the dispersion component of the free surface energy and the coefficient of variation in the pixels brightness of the variation-rotational patterns indicates the potential for predicting a number of physical and chemical surface properties (wettability, permeability, adhesion, etc.) based on the variation-rotational analysis of the corresponding SEM images. The preference for using the average coefficient of variation as a measure of rotational anisotropy in comparison with the standard deviation is due to the «dimensionlessness» of this value and its relative nature. Thus, a new approach to the quantitative characterization of the morphological heterogeneity of the material surface based on the variation analysis of its SEM-image has been developed and tested.

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# Factors and Conditions of Effective Dynamic Innovative Development of Aviation Industry Enterprises

**M. A. Fedotova, V. N. Tarasova, and E. M. Mallaeva**

**Abstract** This work is devoted to an overview of factors and conditions that determine the innovative development directions for aviation industry enterprises. In this regard, the historical development features of the Russian aviation industry, specific features of projects currently being implemented there, digitalization and modern specifics of innovation implementation, state regulation and strategic importance, features of civil and military developments, the role of intersectoral interaction, etc. were considered. Groups of factors often have a joint and complementary impact on the development of enterprises and individual projects. The authors identify specific features of the development and implementation of civil and military projects. According to the research results, the current state and changes in a number of aspects of further development of aviation industry enterprises are indicated.

**Keywords** Aviation industry · Innovations · Factors and changing aspects of development · Transport

## 1 Introduction

A comprehensive understanding of the aviation industry and the transport industry, their interrelation and development tasks is associated with the importance of their role for the Russian economy. The aviation industry is a branch of mechanical engineering represented by hundreds of enterprises with various forms of ownership. In the 2000s, vertically integrated holdings (OAC) were created in the industry, and the Ministry of Industry and Energy of the Russian Federation adopted the "Strategy for the Development of the Russian Aviation Industry for the period up to 2015"

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[1]. The management of corporate structures was changed and a new framework of partnership was built by the state by reducing the tax burden, increasing state orders and the fulfillment level of obligations under budget expenditure items, increasing the volume of bank financing of the high-tech sector, allocating targeted places for training industry specialists, etc. The most active development areas are military aircraft construction, engines, medium-haul aircraft and drones. Within the framework of this study, the authors consider some historical features and the current development state of the industry enterprises. The research tasks are to identify directions for further development of aviation industry enterprises and to identify debatable issues.

## 2 Methodology

The methodological research basis is the principles of dialectical cognition of human society. Their application made it possible to study the information sources in the context of cultural-historical, socio-economic and socio-political processes of the considered period. The cultural-historical process explores the dialectical unity of natural and anthropogenic development factors. Their interaction leads to the rise of society to a higher level. The socio-economic process is changes in society that affect its well-being. These include changes in political and economic stability, and the country's security conditions. Socio-economic processes are based on the "innovation—investment" cycle and affect the wave deployment of economic conjuncture at each of these levels. The socio-political process involves changing the state of socio-political reality under the influence of economic conditions. The inclusion of innovation management problems in the political analysis allows us to trace the success factors of innovations. In the modern world, the speed of changes is increasing, and the role of the state is becoming more significant. It can accelerate the development pace of the Russian aviation industry. To do this, it is necessary to eliminate legislative and infrastructural obstacles to innovations.

## 3 The Role of the Aviation Industry in the Development of the Economy of the Russian Federation

### *3.1 The Impact of Digital Transformation on the Development of Transport and Logistics*

The aviation industry provides innovative sustainable development of the economy and social stability of the Russian Federation. The aviation industry is considered in this work as an independent component of the transport complex according to such criteria as a special defense value, the basis of economic growth for the territory, the industry as a source of important technological innovations, the economic effect of which can affect the entire economy and will give a positive economic effect for other sectors of the economy as a result of the general infrastructure development, an additional innovation effect, industries in which an international competitive advantage can be ensured by achieving special production and organizational solutions [2, 3]. Speaking about the Russian experience, the authors highlight political factors—the special importance of the industry for the national security, and economic factors—the high potential of the industry to ensure the socio-economic development of the state and increase the international competitiveness of the national economy.

The state is a subject that allocates strategically important industries for the formation of an anti-crisis program and provides them with direct targeted support according to such criteria as the number of employees of the enterprise (more than 500 people), tax revenues to the budget (the level of % of the budget revenues of the territory/region), belonging to a life-supporting industry, investment activity (investments over 3 years of more than 1 billion rubles), import substitution, export (the presence of export revenue), the level of average wages, quality standards for management systems and/or products and innovation activity (the share of innovative products in shipment volumes and/or the share of R&D costs in the total cost structure is higher than the average for the economy), etc. Currently, regulatory documents have been developed at the state level, they define the development tasks of the aviation industry [4].

The world economy is turning into digital production [5, 6]. The PWC study [7] highlights new trends in the global market (new driving forces and strong players), changes in demography, high rates of population growth and migration, urbanization and growing demands on the quality of life, progress in science and technology, resource constraints and global climate change. From the perspective of today and taking into account the global experience of the 2020–2021 pandemic, the authors supplement this list with weak predictability of global negative phenomena and the need to be prepared for global crisis events. All this is combined with the processes of digital transformation, which is a new trend in the development of industrial companies in Russia and around the world.

Most industrial companies in the world, including Eastern and Central Europe [8] have included digital transformation in their innovation development strategies. New information technologies (VR/AR—virtual/additional reality, IoT—Internet of Things, cloud technologies, Big Data analysis, ML—machine learning, etc.) have an increasing impact on all industries and sectors of the economy. These technologies affect the transport services sector, including through close and direct communication with customers who quickly change their needs and requirements, and production technologies in mechanical engineering (and aircraft construction, in particular), from the control of the production process to fundamental changes in the production itself.

Russian transport companies are developing their digital transformation strategies aimed at automating production functions: driverless control, automatic control and self-regulating equipment, active monitoring of infrastructure facilities and auxiliary processes, etc. But without optimizing the operational infrastructure, the company's efficiency will decrease, as an increase in the number of working vehicles will create difficulties in driving, reduce the average speed and customer satisfaction.

"Hard" production, including technological innovations should be combined with "soft" infrastructure innovations (planning, modeling, software, sharing in the structure of the transport chain, etc.) [2, 9–11], because the new products of the aviation industry are designed to develop the business of transport companies and meet the needs of customers, ensure the security of the country, etc.

The special importance of "soft" innovations in the digital economy was emphasized by the experts of the Organization for Economic Cooperation and Development [12], who included "product and business process development" in a new group of innovations.

Competition between different transport companies is being replaced by cooperation and partnership relations. Multimodality and collective ownership and use of hubs are becoming increasingly frequent in the field of transport and logistics. Aviation industry enterprises should take these trends into account when making decisions in the field of technological strategies, taking into account a wider coverage of environmental factors. For the development of product/service it is necessary to study and meet the needs of the client/consumer, as well as to educate its culture use in the beginning of the formation of a socially responsible economy (introduction of the requirement for the implementation of the safety rules during the flight, etc.).

The authors considered some groups of factors that determine current conditions and development directions of the aviation industry (Fig. 1).

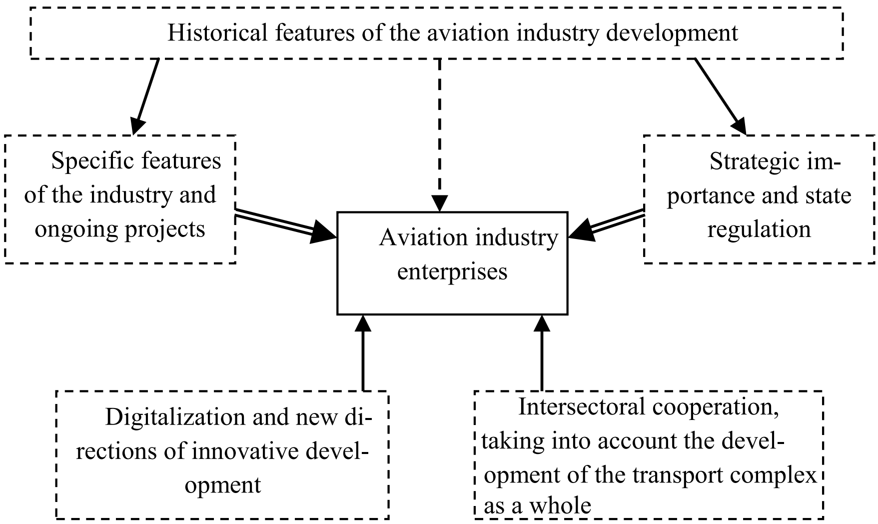


**Fig. 1** Factors and directions of the aviation industry development. *Source* Authors

### 3.2 *The Main Directions of Innovative Development of Aviation Industry Enterprises*

Within the framework of the study, the existing functioning conditions of the Russian aviation industry enterprises as one of the promising and knowledge-intensive industries are analyzed and the directions of their further development are indicated. In the 90s of the twentieth century, the Russian aviation industry lost its former positions on the world and domestic market, air carriers switched to using foreign aircraft at prices based on the recoupment level of the minimum costs for restoration and repair. The domestic market was provided by Airbus, Boeing, etc., despite the fact that the industry of the USSR was largely oriented to the market through the main user—Aeroflot. The main difficulties of the domestic aircraft industry, which have developed historically, since the times of the USSR, are the insufficient maintenance of high-quality serial production, the shortage of qualified workers, the wrong approach to the implementation of long-term investments.

The distinctive features of the aviation industry are the high capital intensity of the industry, the need for product certification, long terms of development and mass production of new aircraft engines and aircraft (up to 10 years), the need to attract highly qualified personnel (for all categories of personnel), the need to use advanced developments in the field of mechanical engineering, electronics, chemistry, information technology and materials science, the influence and participation of the state in decision-making, high risks (including innovative ones), the complexity and high cooperation level of enterprises during the implementation of projects, etc.

The areas of innovative development should include the activation of innovative activities for the development of new design and technological solutions, the effective use of which in new aircraft models will increase the volume of production in this industry (development of new aircraft models and modernization issues), the allocation of tasks for the development of related industries (production of analogues or new developments, for example, in a situation of import substitution), organizational, managerial and infrastructure innovations aimed at promoting products.

In accordance with the Development Strategy for the Aviation Industry of the Russian Federation until 2030 [13], Russia has a strong position in the section of military and special-purpose aviation equipment (about 16% in aircraft construction and 17% in helicopter construction on the world market of final products in the mid—2010s, deliveries of military aviation equipment to China, India, Algeria, Indonesia, Belarus, and other countries) and insignificant indicators for civil products (about 1% in aircraft construction and about 3% in helicopter construction for the same period).

The design of civil and military aircraft is characterized by its focus on innovation. The diversification issues of innovations created in the military sphere in the field of civilian applications and the intersectoral application of individual technologies are debatable. At the stage of forming a new aircraft project, the main technical indicators and requirements for a military aircraft are formulated by the Ministry of Defense through the mechanism of the state defense order, and for a civil aircraft—the demand on the domestic and/or international markets. The launch period for military vessels is 15 years, for civil vessels—5–8 years. For a civil aircraft, the flight range, the number of seats, fuel consumption, quality of service, terms of sale of the aircraft, technology transfer, etc. are important. For military equipment, the decisive role is played by the tactical and technical parameters and the price agreed with the state.

Currently, the Sukhoi Superjet 100 (SSJ 100) is an example of the development of a mass Russian civil aircraft, work on which began in the early 2000s by the Sukhoi Civil Aircraft company with the participation of the American company Boeing, the Italian company Alenia Aermacchi, etc.). The SSJ 100 has not won the aviation market in Europe and remains not in demand worldwide, because it consists of imported components, which creates difficulties in after-sales service. The significant cost of spare parts, their limited quantity and delivery time eventually lead to small indicators of the average flight time (according to Aeroflot—3.5 h, while for Boeing and Airbus—9–10 h).

Russia's position in the production of military aircraft and helicopters is more stable. The composition of orders is influenced by the aggravation of internal and interstate conflicts and threats of their occurrence, terrorist threats, the need for military operations, etc. Thus, the support of allied groups, participation in humanitarian operations and anti-terrorist actions in "hot spots" stimulate the demand for military transport aircraft. By 2020 the program of rearmament of the army (according to which the goal was set to bring the share of modern military equipment and weapons in the troops to 70%) was fulfilled. Currently, there is a saturation of high-ranking units and army aviation with new military equipment.

The peculiarities of the operating conditions of military equipment are that it quickly becomes obsolete, loses its advantages and needs continuous improvement. With the high cost of new modifications of combat aircraft complexes, as well as the frequent financial and other crises, it becomes an expensive pleasure to replace the entire fleet of military aircraft, even for solvent countries, in this regard, the tasks of aircraft modernization arise. The search for new solutions is to complete and equip the existing technical items with the latest developments in the field of engine construction and avionics. Modernization in the amount of 10–15% of the cost of a new aircraft requires retraining of personnel on the basis of the existing infrastructure. The Kronshtadt Group of Companies develops complex solutions for the use of unmanned systems in various fields. They were among the first to develop a line of unmanned aerial vehicles (UAVs) of different dimensions ("Sirius", "Helius", "Thunder", "Orion") with a take-off weight from 1 to 7 t.

The MS-21 medium-haul narrow-body passenger aircraft is a Russian development and a direct technological competitor of the Boeing 737 MAX, it was initially focused on the most popular segment of aircraft in the world. The main user of the new aircraft should be Russian airlines belonging to the Aeroflot group, as well as foreign companies. The increase in the cost and timing of the implementation of the aircraft creation program is explained by the presence of foreign components and the imposed sanctions. For example, the composite "black wing"—the know-how used in the production of an aircraft and forming the necessary competitive advantages for the product—is made from imported composite materials, the supply of which has been suspended. Under these conditions, with the support of the state, the group of companies of the Rosatom holding began to master the production of the necessary chain of raw materials required for aviation composites. Domestic products have already passed the initial inspection stage and are not inferior to their foreign counterparts, according to representatives of the Irkut Corporation. By 2022, the planned level of components localization for the MS-21 should be more than 90%, which, in itself, is unique and important for the promotion of the aircraft at the world level.

Innovative solutions in the aviation engine industry are an example of the development of related industries. For the MS-21, PD-14 engines (Aviadvigatel JSC based on the PS-12) or PW1400G (Pratt & Whitney) can be used. In 2021, the MC-21-310 prototype aircraft with the PD-14 engine is at the stage of factory finishing tests, serial production is planned for 2022.

Organizational, managerial and infrastructural innovations aimed at product promotion include: building multimodal transport chains, logistics tasks, joint operation of aircraft by different airlines, taking into account the specific requirements of a group of customers when designing a specific series of vessels, etc. To use the opportunities of digitalization, the tasks of product and business process development are a priority.

To increase customer satisfaction, transport companies are looking for new technological opportunities that will increase the quality and/or value of products and services, at an acceptable level of costs, with their subsequent reduction. Client solutions are often based on technological innovations as a result of the practical introduction of new knowledge, achievements of science and technology [5, 8]. In the case of a digital transformation of a transport company, all changes are based mainly on the introduction of information technologies called "smart" (if they are linked to the customer) or "infrastructure" (if they indirectly affect the customer satisfaction). Due to the long life cycle of transport services, the main part of digital (infrastructure) innovations is aimed at infrastructure facilities. For the aircraft industry, such conditions should be justified and laid down in the requirements for the production facility. Innovations directly related to the needs of the client include ticket sales services, Internet services on the way, education of the client and the formation of new socio-economic and environmental norms (the formation and explanation of the norms of client behavior, "black lists" of passengers, baggage requirements, etc.).

## 4 Discussion

This contribution shows the impact of digital transformation on the transport development. Transport engineering is analyzed on the example of commercialization of civil projects of Russian aviation industry enterprises. The possibilities of using (diversifying) developments made in the military sphere, in civil aviation, as well as their application in other areas of production are directly related to security issues and limited access to information. Foreign scientists consider this problem in their works [14–16]. Attention is drawn to the need to provide regular reporting on the development of the global aviation industry, the development of business models of civil aviation, taking into account the fleet of vehicles and the portfolio of services, the feasibility of using laser technology for surface treatment of piston aircraft engines, etc.

Interesting, although quite debatable, are issues of developing innovations that are directly related to the needs of the client (for example, ticket sales services, Internet services on the way, etc.). In addition to the appearance of so-called "smart" and "infrastructure" technologies and innovations, it is worth talking about another trend in building relationships with customers. This is, in fact, the education of the client and the formation of new socio-economic and environmental standards. Examples here are the formation and explanation of the norms of customer behavior, baggage requirements, etc. In this regard, the authors believe that solutions will be formed at the intersection of various new norms and needs. These include the needs of the client, social, environmental and other norms laid down at a new level of public relations development, technical and technological opportunities in the structure of transport companies and the industry. And here the discussion can unfold in the direction of how much we should take into account the interests of the client, and whether they can prevail over the security tasks and sustainable society development aspects.

## 5 Conclusion

The authors have identified the following aspects of the further development of aviation industry enterprises.

1. The aviation industry of Russia has its own historically developed features and modern specifics. This determines the development direction of the industry's enterprises at the present time. In the Soviet period, the work of the industry was connected with the customer in the person of the state, including Aeroflot and military structures. In the 1990s, the stable positions of the industry were lost. In the first quarter of the XXI century, there was a restructuring and the formation of vertically integrated holdings, which were tasked with creating new civil aircraft. The enterprises of the industry are distinguished by the participation of the state in decision-making, high capital intensity, the use of advanced technologies in various fields, long terms of development, development and certification of products, the need for highly qualified personnel, the complexity and high level of cooperation between enterprises during the implementation of projects, specific risks, etc. A necessary condition for the further development of the industry is the importance of implementing projects for the development and production of new vehicles in accordance with the strategies and programs for the aviation industry development, the presence of enterprises for the production of aircraft engines and the ability to solve complex production and technical problems at the expense of related industries.

2. State support is important for the civil aircraft industry. It is advisable to implement a project on the basis of Aeroflot to use the fleet of Russian medium-haul civil aircraft MS-21. Potential development areas are the search for opportunities for infrastructure innovations and the implementation of the “product and business process” principle. In the field of aviation engine building, it is necessary to master the production of eco-friendly engines according to the type of HTSP of the SuperOx company. The essence of this development for energy and transport is to reduce the weight and size of machines and power plants based on them through the use of high-temperature superconductors (HTS) in electric motors. New accents for development are the promotion of civil aircraft products on the foreign market and intersectoral cooperation.
3. Decisions on the development of the military aviation industry are made at the state level, are related to the country’s defense capability and security and are implemented through a defense order. Currently, the program of rearmament of the Russian army has been practically implemented, but the peculiarity of military equipment is the need for its constant improvement through modernization and retrofitting of the equipment used in aircraft and helicopter construction, search for original solutions to improve the technical fleet, including for foreign customers, development of drones, making decisions on infrastructure support, implementing the principle of “product and business process” at different stages of the product lifecycle.
4. In order to attract highly qualified personnel to the industry and develop the personnel of enterprises, it is necessary to train personnel with competencies in managing innovative projects, analytical abilities and the ability to use “digital tools”.
5. The high level of variability of the operating environment and new priorities of socio-economic development form new tasks for building relationships with customers of the industry’s products and its end users. The development of new types of vessels should correspond to the digital changes of transport companies and take into account “infrastructure” innovations. Among them, there are training of personnel during the modernization of vehicles, building logistics multimodal chains, providing the necessary conditions for “smart” innovations.

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# Innovations in Construction and Transport

**V. V. Mantulenko and S. V. Domnina**

**Abstract** This work is devoted to the analysis of current trends in the innovative development of the transport and construction sectors in the Russian Federation. The authors consider the impact of global transformation processes on the Russian economy, some features of the application of transport and construction innovations in terms of the geographical location of regions, the state of infrastructure, and other specific characteristics. Methods of analysis, synthesis, and systematization are used. In their research, the authors considered scientific articles on the research issues, reporting data, factual material of expert interviews of curators and consultants of innovative projects in the field of transport and construction.

**Keywords** Construction · Innovation · Innovative development · Transport

## 1 Introduction

"Everything we do turns out to be a Kalashnikov assault rifle," President Putin joked once while inspecting a new domestic industrial development—the Olympic Torch for the Sochi games. Dmitry Medvedev, who actively promoted the modernization of the Russian economy during his presidency, came up with the idea of adopting the best practices of Western countries in combining companies to create innovations [1].

The idea of companies' cooperation for innovative purposes—clusters—had been going to Russia for 40 years. In Europe, local cluster programs began to appear in the 70s of the last century. In the 90s, national cluster development programs were approved in many developed countries. Some of them launched 60% of their projects after 1999. In 2003, there were 500 of innovation clusters worldwide, and in 2005—already 1400. The cluster policy is aimed at supporting biotechnologies, information

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developments and other high-tech sectors of the economy. The real business practice shows that the main beneficiaries of state programs are small and medium-sized enterprises. Nowadays the developed countries face new tasks: to support world-class clusters, to improve the management level and to establish inter-cluster interaction.

In 2012, a competition was announced in Russia to select pilot programs for the development of innovative territorial clusters. In the Concept of long-term socio-economic development, officials clarified that clusters can be of two types: high-tech and innovative or territorial-industrial. Initially, 94 applications were selected. Among accepted applications, there were competitive on the world market and those that had a large number of educational and research organizations. According to the results of the two-stage competition, the creation of 25 clusters was approved-26% of the total number of selected applications.

All clusters work in one of six priority areas: nuclear and radiation technologies, production of aircraft and spacecraft, shipbuilding; pharmaceuticals, biotechnologies, medical industry, new materials, chemistry and petrochemistry, information technologies and electronics. Innovation clusters are mainly concentrated in the European part of the country, seven out of 25 clusters are located in the Asian part [1].

The report "Global Innovation Index" (GII), published annually by the World Intellectual Property Organization (WIPO), provides an overview of the latest global trends in innovation and a rating of innovation activities of 131 countries. The 80 indicators for which the analysis is carried out include, among other things, an assessment of the education development, infrastructure, the political situation and the diversity of the market. The key theme of this year's GII is "Who will finance innovations?" This topic is especially relevant, given the damage caused to humanity and the world economy by the coronavirus pandemic [2].

This year, Russia demonstrates higher results in terms of investment in innovations compared to the return on them. Among the strengths are the presence of a high number of qualified personnel, the development of the research sphere, the availability and quality of higher education, the number of graduates in the field of natural and technical sciences. The Russian economy also received a high assessment of the GII 2020 in terms of the size of the national market and its diversity, including the level of competition. Also, the country took the 17th place in the ranking in terms of the number of national patents issued and the 9th in terms of utility models.

In addition, Russia has shown high results in terms of payments for the use of intellectual property results, the number of women who have received scientific degrees and are employed in the innovation field. In the overall ranking, Russia ranked 6th among countries with an above-average income level and 32nd among European economies. According to the GII 2020, Switzerland, as well as last year, is a world leader in the field of innovations. It is followed by Sweden, the United States of America, the United Kingdom and the Netherlands.

## 2 Innovation in Construction

The modern construction industry already operates with more than a dozen technologies that are most in demand. Our review covers the most advanced and popular IT technologies and innovative materials in construction, which are increasingly integrated into the construction sector every year, implementing the most daring ideas of the future. The construction industry is often criticized for excessive conservatism, standardization and bureaucracy in the document management. However, some experts think that it is not easy to implement the latest technologies in construction, since the main requirements for objects are compliance with safety, i.e. each technology has a regulatory framework, standardization and self-sufficiency: the final cost for its development has to be adequate, and the effectiveness in reducing costs in the future is significant, plus, prolonged in time. Any technology requires appropriate design and a whole range of work of the project team, quality control, as well as staff training.

But the growth of cities and the number of people, as well as the new format of the level of human communications in the era of Big Data, the growth of economies and the well-being of people has activated the construction industry for a more dynamic integration of innovations and technological solutions. Therefore, new technologies in construction are actively promoted and used in the world market. In addition, the very speed of technology development leads to a large-scale digitization of the construction industry. And the issue of using IT technologies is already a matter of competitiveness. Innovations in construction modify the construction site and increase profits, as well as help win project tenders.

Contemporary innovations in the construction sphere are: BIM, Cloud services and mobile technologies, Artificial intelligence, Internet of Things, Virtual and augmented reality, Robotics and exoskeletons, 3D modeling, Big Data, Digital doubles, Blockchain Technology.

It is obvious that large-scale digitalization and the application of BIM technologies in the construction industry will progress—this is a market demand, where efficiency and reduction of time and costs becomes a priority. Therefore, construction becomes smart not only in computer design, but also in the direct process of creating an object using robots, 3d printing, sensors, smart materials and technologies. And finally, new technologies will definitely affect the profit of the construction business, since they are aimed at optimizing and efficiency of all stages of the project, from engineering surveys to operation [3].

## 3 Innovations in Transport

In 2021, the Russian Ministry of Transport named 6 main projects of the transport industry in the regions. These are the following areas:

- drones for passengers and cargos: it is proposed to create a smart secure infrastructure for drones on all types of transport throughout the country, ensuring the use of drones for commercial and personal transportation;
- "green digital passenger corridor": the Ministry of Transport believes that the implementation of such an initiative should ensure the possibility of any trip without paper documents and without cash, taking into account benefits and real traffic;
- seamless cargo logistics: the initiative involves the implementation of the transit potential of Russia, which will have the effect of accelerating transportation, reducing their cost, increasing the revenues of the budget of the Russian Federation and transport companies;
- digital management of the transport system of the Russian Federation: this project is designed to improve the efficiency and safety of the transport complex. The tools for achieving the task are the situational information center of the Ministry of Transport (SIC); online monitoring of vehicles, including drones; online monitoring of transport infrastructure facilities; integration with the national data management system;
- digitalization of transport security: the task is to increase the information security of the transport complex; this will ensure the control and prevention of leaks of personal and biometric data of passengers by analyzing data flows; monitoring and analysis of the security status of the transport complex in online mode;
- digital counterparts of transport infrastructure objects: the task of the initiative is to monitor the state of transport infrastructure facilities. To do this, it is necessary to create 3D models of all transport infrastructure objects; switch to a system for planning the construction and maintenance of transport infrastructure objects using BIM technologies (building information modeling) [4].

## 4 Discussion

As we can see the most promising trend in both industries is digitalization. It relates to the implementation of intelligent transport systems and smart construction, robotization of business processes, preventive maintenance and monitoring etc. [5–8].

There are spheres of great relevance for the whole economy and the most difficult areas for the innovation implementation. That is determined by some reasons. The first is the large scale of the country, in general, the complexity of construction and the transport accessibility of some regions. Sometimes, innovations had to be adapted to specific climate conditions. In particular, this affected electric buses, which have to be heated at the expense of diesel fuel in winter, because there is not enough electric energy. Second, it is the old infrastructure inherited from the Soviet Union, it has not been updated for decades and this significantly hinders the development of territories. The next factor is a clear informal division of territories between business groups that have the support of local governments. The experience of innovative projects shows that this is what prevents deep innovations from penetrating into these areas. For this reason, for example, the use of new materials and technologies that significantly reduce the construction time, make buildings more environmentally friendly and energy efficient is closed or largely blocked for the construction industry, since this is contrary to the interests of major players in regional markets.

## 5 Conclusion

Integrated mobility is the organization of a multimodal transportation system by combining all types of transport and transport services in a single digital space. This is an urgent issue for Russia due to its large area first of all. The further development of electric transport (both personal and public) is also a relevant direction of innovative activities. Autonomous delivery robots, unmanned ground and aerial vehicles are being actively tested in the Moscow region now. Automation of warehouses and supply chains was catalyzed by the pandemic. At the moment, solutions for warehouse robotization and "last mile" delivery services are being actively implemented in big Russian cities, while there are practically no solutions in the field of supply control and cargo tracking based on blockchain and AI. The real practice shows how difficult these processes go in Russia and what tasks should be solved there.

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# Problems of Financing Innovation Processes and State Support for Innovations

# Functioning of Investment Platforms as a Factor of Sustainable Economic Development

**M. N. Zubkova**

**Abstract** Today, when the opportunities for attracting financing to startups are limited, since entrepreneurs' personal funds are usually insufficient, and banks issue loans on strict terms, investment platforms become useful. These are online platforms designed for the interaction between investors and entrepreneurs who need investment, for example, for a startup. This activity is called crowdfunding. In addition, investment platforms also allow ordinary citizens who are not entrepreneurs or qualified investors to invest in assets that are interesting to them. In other words, investment platforms are needed to invest in different sectors of the economy. According to the current regulations, all relationships for receiving and transferring funds for the business development of organizations pass through special open nominal accounts of the operator of the investment platform, which guarantees the fulfillment of obligations by all transaction parties. Thus, the transparency and accessibility of investment through investment platforms creates favorable conditions for the development of business environment, and a clear legislative regulation of activities allows all parties to guarantee the fulfillment of their obligations. This article describes the concepts and requirements for investment platforms, as well as for the operator of the investment platform. It also addresses the issues of how to invest using the investment platform, as well as some restrictions for attracting investment. Specific features of investing by individuals are highlighted.

**Keywords** Investment · Investment platform · Investment platform operator

## 1 Introduction

According to the Russian legislation, an investment platform is an element in the Internet which is considered as a system that is applied for concluding investment contracts. The contracts are concluded with special technical tools of this information system, and the operator of the investment platform provides the users with

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the access to these tools [1]. Users of an investment platform are legal entities or individual citizens, as well as persons attracting investments. Business entities and individual entrepreneurs belong to this category. The operator of the investment platform provides them with services for attracting investments. The investment platform should contain a register of contracts for the provision of investment attraction services, as well as investment assistance services, and on the base of this platform, investment contracts are concluded. The specified register provides information that allows you to identify the parties to the contracts, the essential terms of the contracts and the dates of their conclusion. Information about each concluded agreement should be kept by the investment platform operator until the date of termination of this agreement, as well as during five years from the date of its termination. The investment platform guarantees the safety and reliability of such data throughout the entire period of storage of information about contracts, as well as provides the parties with the opportunity to get these data [2]. The platform operator can be a company that is founded according to the Russian legislation. This company has to be included in a special register established by the Bank of Russia. The amount of the own capital of the investment platform operator should be at least 5 million rubles (the calculation is regulated by the Bank of Russia).

The investment process itself using the investment platform consists of the following main stages: (1) before entering into a contract, the operator has to check participants of this investment contract in relation to the requirements of the Russian law in the area of legalisation of criminally obtained proceeds and terrorism financing before concluding contracts with them, as well as familiarize the investor with the risks that investing through the platform entails, (2) the operator enters into an agreement with the users of the investment platform and provides them with access to the investment platform tools, (3) investment participants transfer funds to a nominal account opened for the operator, (4) the person, who attracts investments, places the investment offer on the platform (the investment offer may be, and in certain cases should be, addressed to specific persons—the so-called closed investment offer), (5) the investor accepts the investment offer using the technical means of the platform and transfers the funds which are held in the nominal account of the operator to the bank account of the person attracting the investment, after that the investment agreement is considered as concluded.

## 2 Methodology

In the course of studying this topic, the following methods were used. The method of comparative law is used to consider the legal regulation of similar social relations. When using this method, both the content and the reasons for the appearance of this institution in a particular legal system are investigated. In addition, this method allows you to identify the characteristics inherent in the object under study, which are both universal and legally specific. As a result, we can form a certain basis for new research in this area and formulate proposals for the subsequent development and improvement of this institute. In addition, the method of complex analysis was applied, along with legal tools and instruments that are also used in other scientific fields. For example, in the framework of this study, it is not possible to consider the question of legal regulation of activities of investment platforms and their operators in isolation from the economic science. Formal and logical methods were also used, in particular, analysis, synthesis and generalization, for example, in determining the concept and requirements for investment platforms, the specifics of regulating investment platforms, and establishing the subject composition of these relations.

## 3 Results

The development of digital technologies has an increasingly significant impact on existing forms of financial relations, including in the field of investment. As it is noted in the scientific literature, today, thanks to fintech companies, financial innovations and hybrid services are emerging, which provide new opportunities and contribute to the quality improvement of the financial services market [3]. Therefore, the importance of crowdfunding in the sustainable development of the modern economy is difficult to overestimate. Investment platforms enable small and medium-sized businesses to find alternative sources of financing to banks, as well as protect the rights of investors and stimulate non-bank lending methods. However, due to the fact that financial interests are involved in these relations, the activities of investment platforms and their operators are strictly regulated by the state. Moreover, the requirements relate not only to the organization and operation of the platform, the persons who manage it, but also to the engineering and technical component of the platform. However, all these legislative measures are designed to protect all market participants from fraud and abuse.

Among the organizational requirements, there is the requirement that investment contracts may be concluded in writing with the information tools and technical decisions of the investment platform. The organizational requirements also include that the acceptance of an investment offer is carried out by expressing the investor's will to get the investment offer with the help of technical tools of the platform. Investments on the base of the platform can only be carried out with non-cash funds. These funds are credited to a nominal account which is opened by the investment platform operator.

There is a list of technical requirements to the investment platform operation:

– there should be so called "nodes of the investment platform": these are technical elements of the platform, they build a space where the investment platform database is stored, they are linked to the united information and telecommunications network, but physically, these elements are separated from each other;

– it should be impossible to add into the information base the data on the transition of a terminated utilitarian digital right (this database contains facts on the emergence, transition and termination of utilitarian digital rights);
– the investment platform database should be operated with software that is placed on the nodes of this investment platform;
– the utilitarian digital right or identical utilitarian digital rights should be provided with unique symbols which allow the users to identify these rights in and (or) outside the investment platform, as well as to distinguish them from each other, without getting access to their content;
– information technologies of the investment platform should maintain the identity of the information contained in the databases of the investment platform at all nodes of the investment platform without human participation (automatically).

In addition, the legislation also provides a number of requirements and restrictions on the amount of investment for a single investment platform. In particular, one entity has the right to attract investments in the amount of no more than one billion rubles during each calendar year using the investment platform. An exception to this requirement is investments in the form of utilitarian digital rights or digital financial assets that attract public joint stock companies.

As for the investment opportunities of individuals, the size of their investments is limited to 600 thousand rubles per year. The platform operator is responsible for monitoring compliance with the specified limit. To circumvent this requirement, you have to obtain the status of a qualified investor. Moreover, the right to recognize individuals as qualified investors is granted directly to the operators of the investment platform themselves, for this you need a statement from the interested person. Individual entrepreneurs and legal entities can also participate in crowdfunding as investors, and there is no investment limit for them. At the moment, you can invest using the investment platform in the following ways:

– by providing loans;
– by purchasing equity securities which are placed using the investment platform (the exception is securities of structural bonds, credit and non-credit financial institutions, and securities for qualified investors);
– by acquiring utilitarian digital rights [4];
– by acquiring digital financial assets.

As for the requirements to the investment platform operator, they are mainly organizational in nature. In particular, subjects who have the right to dispose of ten or more percent of the votes may not be: (1) a legal entity registered in states or regions that do not provide the disclosure and provision of information when conducting financial transactions; (2) a legal entity whose license to operate a credit institution or a non-credit financial institution has been revoked for committing a violation; (3) an organization with respect to which there is information on its involvement in extremist or terrorism activities, as well as the proliferation of weapons of mass destruction; (4) an individual who was convicted for crimes in the economic field, crimes against the state, the interests of public service and local self-government bodies, or was disqualified.

All these restrictions are set in order to protect the interests of investors, as well as to prevent the possibility of a conflict of interest. The investment platform operator, controlling persons, and persons performing the management functions may not be individuals and organisations if they are subjects in relation to which there is information about their involvement in extremist or terrorism activities. The same is in the case when these organizations or individuals are involved in the proliferation of weapons of mass destruction. Besides, the transfer of powers is not allowed from the sole executive body of the investment platform operator to a legal entity (a management organization). One of the main tasks of the investment platform operator is the approval of an internal document to regulate and manage conflicts of interest. The operator should also disclose information on conflicts of interest which were identified and measures that have to be taken to manage such situations.

The investment platform operator is not liable for obligations of individuals who attract investments. The disclosure of the investment platform regulations is a necessary condition for the activities of the investment platform operator. These regulations should be approved by the operator of the investment platform itself. Using investment platforms within one calendar year, a person may attract investments of not more than 1 billion rubles (according to the securities legislation, the preparation and registration of a securities prospectus is not mandatory). These rules do not apply to public joint-stock companies that attract investments while acquiring utilitarian digital rights and/or digital financial assets by investors.

The investment platform operator may provide an individual with the opportunity to invest funds using tools of the investment platform within one calendar year. But it should be emphasized that the investments of this subject on other investment platforms in the same period don't exceed the amount of 600 thousand rubles, unless otherwise restricted by federal laws. The exceptions to this rule relate to:

– individual entrepreneurs and (or) individuals who are recognized by the investment platform operator as qualified investors in accordance with the securities legislation; at the same time, the operator of the investment platform may also recognize an –individual as a qualified investor on the basis of an individual's application;
– individuals when they acquire utilitarian digital rights under investment agreements concluded with a public joint stock company.

## 4 Discussion

As we noted earlier, the essence of crowdfunding is the cooperation of entrepreneurs who need to attract capital, and investors who are its source, and intermediaries—crowdfunding platforms that provide a legal basis and carry out a preliminary selection of viable projects [5]. A significant role of crowdfunding is that it is an instrument to finance projects in case when traditional sources of funding are not available for one or another reason. First of all, it relates to entrepreneurs who develop the own innovative projects. The main advantages of crowdfunding include the attraction of investments from a wide range of investors, and the reduction in costs associated with raising funds. Its positive effect is also created by diversifying investors, speeding up and simplifying operations to raise funds through electronic transactions [6].

At the same time, in the scientific literature, crowdfunding refers to investing, which is not entirely true, since crowdfunding is rather a generalized name for the entire process of raising money, and not just investments. But this aspect could not be considered as a fair one. Since the investment is always carried out exclusively for the investors' purpose to get income from their investments. At the same time, crowdfunding covers both the collection of funds without the obligation to return, and the payment of income [7]. Thus, crowdfunding can be non-financial, that is, not involving a return on investment or the provision of remuneration, and financial. This type, on the contrary, involves the return of funds and, most often, remuneration. As a rule, experts refer to the models of such return crowdfunding the following cases: crowdinvesting: investors receive a share of the capital as a reward (it is still not decided in the science whether crowdinvesting is a type of crowdfunding); crowdlending: investors receive a percentage of the invested amount with the repayment of the principal amount of the loan after the specified period; crowdfactoring: investors acquire accounts receivable through an online platform [8].

Today, reward-based financing is a fairly popular method of financing that allows entrepreneurs to motivate potential consumers to invest in their business, in exchange for non-monetary remuneration, which may represent, for example, the products produced by these entrepreneurs [9]. It should also be noted that foreign law enforcement practice today provides the possibility of extending crowdfunding to real estate transactions [10]. Thus, we can conclude that the scope of investment platforms will continue to expand.

## 5 Conclusion

Investment business on the Internet is significantly different from similar activities in real life. Its main features include the following: the conclusion of contracts within the investment platform does not require the personal presence of participants, there are no time, national or other restrictions, there is no need to invest large funds, you can start with small investments. The current legislation allows small and medium-sized businesses to use alternative sources of financing to banks, at the same time to protect the rights of investors and encourage non-bank lending methods. In addition, the law regulates the activities and imposes restrictions directly or investment platforms, without directly affecting the process of collecting funds. However, these same legislative measures are designed to protect all investment participants from fraud and abuse [11].

Security-based crowdfunding has more recently become a new market that allows small investors to directly participate in the financing of entrepreneurial ventures.

However, understanding and managing these digital finance tools requires a certain level of financial literacy [12]. In the meantime, the circulation of digital rights in the field of crowdfunding is still quite risky operations, since official state regulators, and the legal framework, as well as the technical base are not still able to protect the interests of their participants [13]. Despite the risks, it is difficult to overestimate the importance and role of investment platforms in the economy development. Crowdfunding campaigns lead to new organizations that end up generating billions in non-crowdfunding revenue and employing thousands of people. Individual project creators often use crowdfunding campaigns for the transition or promotion of their careers, as well as for creation of new businesses [14].

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# Tools for Fixed Assets Assessing When Providing State Support for Industrial Companies

**E. A. Evdokimova, E. Yu. Kamchatova, and N. A. Starostina**

**Abstract** The present time is characterized by the development of information technologies and the active saturation of the market with innovations. Many states see the innovative involvement of companies as one of their main tasks and use various support methods. Direct financing is one of its most common forms. The key to the successful implementation of this form of support is high-quality preparatory work, which is based on a multi-factor assessment of the company as an object of financing. The state should have a tooling containing a set of indicators sufficient to generate complete and reliable information that corresponds to the objectives of the assessment. This is necessary to minimize or completely eliminate the possibility of inefficient financing. The article presents suggestions for expanding the state's tooling for evaluating companies in the framework of innovation policy. The expansion of the tooling is suggested on the basis of an assessment of the company's fixed assets' abilities to implementation of innovative technologies. The developed system of indicators meets the high requirements of goal-setting, and also considers the versatility of the state at all stages of innovation activity. The article considers examples of the use of indicators in the performance of various functions from the state.

**Keywords** Digitalization · Financing · Fixed assets · Indicator · Innovations · State

## 1 Introduction

Increased level of digitalization and forming an accessible environment for creating and implementing innovations is a priority of modern states [1]. Currently, many countries adopted national projects, programs, and documented initiatives at various levels to promote information technologies. For example, in Germany, the Industrie 4.0 strategy has been implemented for almost 10 years [2], in Austria, Industrie 4.0

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Österreich has been operating for a shorter period [3], in Sweden, state support for enterprises is provided within the framework of the Smart Industry strategy [4]. The national project “Digital Economy”, launched in 2018, confirms the priority of digitalization development in Russia. It includes such federal projects as “Information Infrastructure”, “Digital Technologies”, “Information Security”, etc. In the Russian Federation, there are such state programs as “Economic development and innovative economy”, “Information Society”, “Development of industry and increase of its competitiveness” [5–7]. The presented state programs are included in the direction of “Innovative development and modernization of the economy”, one of the main goals of which is the mass appearance of innovative companies in all spheres of the economy [8]. Within the framework of programs, projects, strategies, etc. developed in different countries, the state provides companies with multilateral support. Information support is provided through the creation of platforms and forums where information in a particular area is concentrated [9]. Legal support consists in the development of a legal and regulatory framework for regulating relations in this area. Financial support is provided in the form of grants, subsidies, loans, and tax cuts that contribute to increasing in the level of digitalization of companies. Unlike informational and legal types of support, which concern almost all participants at the same time, financial support is targeted. When implementing direct financing, the state should have high-quality tools for evaluating the object of financing to minimize risks and maximize the effect of project implementation [10].

## 2 Methodology

Industrial production is the basis of the GDP of many countries implementing projects and strategies to increase the level of digitalization that forms the basis for effective economic development. In the capital structure of companies in the industrial sector, a significant share is occupied by fixed production assets [11]. In this regard, it seems relevant to highlight the introduction of digitalization in fixed assets as a priority [12]. Providing measures to support innovative projects aimed at improving the efficiency of fixed assets will lead to sustainable development, both for the companies themselves and for the industry as a whole. To achieve the stated result, the primary task is to assess the state and capabilities of fixed assets for the implementation of information technologies. Writing this work, methods of synthesis, analysis, and deduction were used.

## 3 Results

Comprehensive state support is provided at all stages of innovation activity. As a customer of innovations, it creates conditions for their development, promotes their progress, mass distribution, etc. To achieve the overall goal of increasing the level of digitalization and innovative accessibility, depending on the function performed, the state forms a pool of tasks that determine the set of tools for their implementation. At the same time, the state plays two global roles in the process of increasing the level of digitalization of companies. Acting as a customer (participation in the formation of demand), the state, as well as all private companies, is interested in achieving its goals at the lowest cost, which is possible through competent management and maximum use of the resources at its disposal. When setting goals, it is important to correctly assess the capabilities of the available resources involved in achieving them, in order to avoid additional costs and time loss. Acting as an investor (participation in the formation of the offer), the state is called upon to provide assistance to promising and strategically important companies, including at the level of industries and regions. When providing assistance to companies, it is important to ensure that they use all the resources at their disposal correctly and, despite this, they need additional external support. Otherwise, the allocation of funding to such companies can be considered deliberately inefficient, given the limited resources and other priorities of the state. When performing the role of an investor, in order to avoid financial risks, the state also needs to conduct a correct assessment of the resources of companies applying for support. As part of the analyzed direction of increasing the level of digitalization of companies, the state sees it as important to first assess the capabilities of the fixed assets of companies. It is worth considering that fixed assets by definition have a high cost, and, therefore, the most complete and competent assessment of them as a resource will help to avoid the risks of additional financing.

Currently, the most reliable indicator of the evaluation of fixed assets is their depreciation. Despite the large number of factors that determine physical depreciation, its assessment is more accessible and is absolute. Moral depreciation is more difficult to assess. Its evaluation is relative, since it includes a comparison of the fixed asset with advanced analogues. The values of moral and physical depreciation may differ greatly, however, their totality is currently the most informative indicator of the state of fixed assets. Deprecation demonstrates how well a fixed asset can perform its functions. But when evaluating it, as an object of digitalization and other innovative transformations, this indicator is only a factor. For example, IT companies are characterized by a low level of depreciation of fixed assets compared to companies of other industries, but this may not be enough to implement innovations within the framework of the company's chosen innovation policy. At the same time, high deprecation rates do not indicate that the fixed asset cannot be upgraded. To get the maximum effect from the assessment of the fixed asset and the most complete information, first of all it is necessary to determine the purpose for which it is carried out. This article discusses the possibility of fixed assets to participate in the processes of digitalization and other innovative processes defined by the innovation policy of companies, for which it is suggested to use the coefficient of innovative availability of fixed assets ($KID_{os}$):

$$KID_{OS} = \frac{DI_{OS}}{I_{OS}}, \tag{1}$$

where: $DI_{OS}$—all innovations designed for a specific fixed asset, available for implementation; $I_{OS}$—all innovations designed for a specific fixed asset.

The basis of this coefficient is the "fixed asset—innovation" relation. The coefficient demonstrates the presence or absence of this relationship, among the entire set of relationships intended for one fixed asset and a certain number of innovations that make up the innovation field in which it is located. In the practical application of this coefficient, it may be difficult to process a large array of information. This is typical for fixed assets, the innovation field of which contains a large number of innovations.

To reduce the amount of information required for processing during the evaluation, it is suggested to focus on innovations defined by the company's innovation policy and/or other selected priorities to achieve its goals. Reducing the number of innovations will help to eliminate the additional amount of work that involves performing calculations for innovations that knowingly do not meet the requirements and the implementation of which is planned with a minimum degree of probability or is not planned at all. This will help the evaluation results to meet the requirements of the goal setting of its initiators and customers to a greater extent.

To carry out this assessment of fixed assets, it is suggested to introduce an extended coefficient of innovative availability of fixed asset ($RKID_{os}$):

$$RKID_{OS} = \frac{\frac{DI_{OS}^{I-1}}{I_{OC}^{I-1}} + \frac{DI_{OS}^{I}}{I_{OS}^{I}} + \frac{DI_{OS}^{I+1}}{I_{OS}^{I+1}}}{3} \tag{2}$$

where:

$I_{OS}^{I}$—innovations (including analogues) planned for implementation, intended for a specific fixed asset;
$DI_{OS}^{I}$—innovations (including analogues) planned for implementation, designed for a specific fixed asset and available for implementation, taking into account the level of depreciation of this fixed asset;
$I_{OS}^{I-1}$—innovations (including analogues) that precede by 1 step the innovations planned for implementation, intended for a specific fixed asset;
$DI_{OS}^{I-1}$—innovations (including analogues) that precede by 1 step the innovations planned for implementation, designed for a specific fixed asset and available for implementation, taking into account the level of depreciation of this fixed asset;
$I_{OS}^{I+1}$—innovations (including analogues) that follow by 1 step the innovations planned for implementation, intended for a specific fixed asset;
$DI_{OS}^{I-1}$—innovations (including analogues) that follow by 1 step the innovations planned for implementation, are intended for a specific fixed asset and are available for implementation taking into account the level of depreciation of this fixed asset.

To calculate the $RKID_{os}$ from the entire innovation field of the fixed asset, innovations of three groups are taken into account: those planned for implementation, those preceding them, and those following them. Precisely, such a quantitative and qualitative restriction will help to maintain a balance between the completeness of the assessment and the availability of its implementation. Exclusion of innovations that do not meet the goals defined by the initiators and customers of the assessment allows to get a more accurate result compared to the coefficient of innovation availability. For a clear determination of the innovation groups required for the calculation of the coefficient, it is important to give the following definitions. *Planned innovations* are innovations that meet the customer's requirements based on the results of their implementation. *Previous innovations* are innovations, the results of the implementation of which, according to the selected evaluation parameters, lag behind the results planned for the implementation of innovations by 1step. *Following* innovations are innovations, the results from the implementation of which, according to the selected evaluation parameters, have 1step advantage over the results planned for the implementation of innovations.

One step is a selected step for calculating the innovation advantage (both the exact value and the range can be selected). If the innovation accessibility coefficient and the extended innovation accessibility coefficient do not match, the latter is the priority, since its value more closely meets the requirements of the evaluation initiator. The value of the extended innovation availability coefficient can be represented in the range from 0 to 1. Since each of the innovation groups involved in calculating the coefficient is assigned the same significance, we will consider the following three ranges.

$0 \leq \mathrm{RKID_{OS}} \geq 0.33$—the fixed asset used as an object of planned innovative transformations, is technically outdated and cannot fully meet the stated requirements. If there are innovations available for implementation in the group of planned and following ones, it has a low probability of high-quality functioning for the purposes of the chosen innovation policy and has no prospects for further innovative transformations in the chosen aspect.

$0.33 < \mathrm{RKID_{OS}} \geq 0.66$—the fixed asset used as an object of the planned innovative transformations meets the necessary requirements of the selected innovations. If there is a large number of available innovations in the next group, it has prospects for further innovative transformations in the chosen aspect.

$0.66 < \mathrm{RKID_{OS}} \geq 1$—the fixed asset used as an object of planned innovative transformations, meets the necessary requirements of the selected innovations, demonstrates the possibility of conducting a bolder innovation policy with its use.

If the implementation of a single innovation requires the use of several fixed assets, the coefficient is calculated for each fixed asset separately. An exception may be a group of fixed assets that perform the same functionality, acquired in a time period with a small deviation, and operated in similar conditions. In the case where the state acts as the customer, the $\mathrm{RKID_{OS}}$ value in the range from 0 to 0.33 indicates that at the time of the calculations, the introduction of new technologies in relation to this fixed asset or with its use is likely impossible. The lower the coefficient value, the higher the probability of a negative result. A value in this range indicates the occurrence of possible additional financial costs necessary for the implementation of the selected innovation. If several fixed assets are involved in the project, and their values mainly fall in the range from 0 to 0.33, then it may be necessary to change the innovation planned for implementation to a more affordable one. A value in the range from 0.33

to 0.66 indicates comfortable and with a high probability sufficient conditions for the implementation of the selected innovation. A coefficient value in the range from 0.66 to 1 indicates the undervalued capabilities of the fixed asset, as well as the potential for the introduction of technologies from the group of the following. If several fixed assets are involved in the project, and their values mainly fall in the range from 0.66 to 1, then it may be necessary to change the innovation planned for implementation to a more advanced one. In the case where the state acts as an investor, the value of the $RKID_{OS}$ in the range from 0 to 0.33 indicates that it is impossible to implement the selected innovative technologies by the company in whose possession the estimated fixed asset is at the time. This value may indicate: the necessary replacement of the fixed asset, the need to introduce an intermediate innovation to achieve the planned result, the additional costs of time and money. If the company does not have its own sources of financing to replace the estimated fixed assets with similar or with better values, it is worth to consider providing it with the necessary assistance. This decision is presented without taking into account additional factors, such as the company's role in the industry and the region, its financial condition, credit history, etc. The lower the coefficient value in the described range, the more the company needs support to implement the selected innovation. The $RKID_{OS}$ value in the range from 0.33 to 1 indicates the potential ability of the fixed asset to meet all the requirements of the innovation necessary for its implementation. In this case, the company is less in need of additional support. It can be provided in other areas of its functioning, for example, assistance in training employees, legal support, tax benefits, financial support to cover the payroll, purchase of materials, etc. The developed extended coefficient of innovation availability of fixed assets is suitable for assessing fixed assets as a determining factor of the possibility of innovative transformations, including those involving an increase in the level of their digitalization. These examples demonstrate the possibility of considering the coefficient as a modern evaluation tool both from the part of private companies and from the state, which performs the role of the customer.

## 4 Discussion

The proposed extended coefficient of innovative availability of fixed assets is a universal tool for assessing the state and capabilities of fixed assets for the introduction of innovative (information) technologies. These examples demonstrate the diversity of its use. For a correct calculation result, the purpose of the evaluation is important. In this case, the results of the calculations will fully characterize the achievability of the set goal. The advantages of the developed coefficient are the high level of goal setting, simplicity of calculations, accessibility and informative results. The calculation of the coefficient for each fixed asset involved in the implementation of innovations, the composition of which is big in large production companies, can be quite time-consuming. However, performing such detailed calculations increases the accuracy of the evaluation results. The use of the developed tools is relevant in countries whose economic development is determined by the growth of their industrial production. The extended coefficient of innovation availability is equally applicable for assessing the fixed assets of companies with different level of product availability (raw materials, parts, semi-finished products, finished products), different levels of their digitalization in general and in particular the products they produce, taking into account the priorities, goals and selected policies, including innovation one.

## 5 Conclusion

In crisis conditions, it is especially important to exclude the possibility of inefficient investment by the state and to provide direct support to companies whose sustainable development largely depends on their readiness to implement innovative technologies. Fixed assets are one of the main objects of digitalization in industrial companies. In this regard, the tools for assessing their ability to implement the results of scientific and technical developments are of particular importance [13]. Of particular value is the information that corresponds to the goals, contributes to achieving the maximum result using the minimum amount of resources or identifying hidden opportunities. The expanded coefficient of innovative availability of fixed assets meets all modern requirements for the information provided and can take a worthy place in the assessment tools of readiness for digitalization of companies, industries, and the state as a whole.

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# Innovative Approach to Improving Tax Control Methods in the Context of Informatization

**V. S. Charikov and Y. V. Levashova**

**Abstract** A lot of entrepreneurs are faced with the problem of shortage of their own resources of the organization to avoid tax risks and financial losses, in this case, they have to resort to third-party assistance from tax consultants and state regulatory authorities. In this regard, the development and improvement of methods in this area from the point of view of tax control is an urgent issue. The paper analyzes modern methods of tax regulation and control of financial activities of organizations operating in the current conditions. The role of tax control in shaping the sustainable development of the organization and the country's economy as a whole was determined. The authors considered the concept of sustainable economic development and the variety of tax regulation mechanisms that determine the further development of the economic system in the country. The authors considered the features of conducting control measures in the context of digitization of the usual tax processes. The article presents and analyzes the tax control system based on the assessment of tax risks, considering the peculiarities of the environment under the influence of the introduction of innovative technological and information methods.

**Keywords** Economy · Financial management · Risk management system · Tax administration · Tax control · Tax system

## 1 Introduction

Improving the mechanisms of sustainable development is now becoming increasingly important for the country's economy. The concept of sustainable economic development is largely associated with the crisis phenomenon in economic development, primarily with the need to redistribute limited resources to meet the increased needs of society [1]. An integral part of this issue is the tax system and its elements. Currently, there are a number of shortcomings in the development of this system, which are primarily related to the unfair behavior of taxpayers and the lack of ability

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to control these violations. It is worth noting that the development of tax legislation does not keep pace with the rapid development of business processes and changes in the institutional economic environment. Despite this, quite often in the modern practice of taxation there are various kinds of problems in the implementation of the taxation process. It is important to use such a tool as tax control. The relevance of the study of tax control methods is determined by modern trends in institutional economic relations. In conditions of financial instability, the tax authorities need to improve the quality of tax control in relation to taxpayers. At the same time, the task of reducing administrative costs for conscientious taxpayers is urgent. For this purpose, the risk-based approach has often been used in the methodology of tax control, which allows us to assess the effectiveness and possible effects of tax audits and tax control by the tax authorities. This fact helps to identify possible risks and problems caused by the unfair attitude of taxpayers to the tax system. In this regard, we can draw a conclusion about the relevance of this topic in the modern world both for the taxpayers themselves and for the state [2]. This issue is particularly important in the era of digitalization and the introduction of information services into the tax system, which provide a basis for the development of the use of elements of a risk-based approach in the tax system, forming a certain trend in the functioning of the tax system.

## 2 Methodology

We conducted a theoretical analysis of data from the field of tax regulation of the activities of modern organizations. The continuity of the phenomenon under consideration with the tax system is explained by the fact that with the help of tax instruments, the state and enterprises are able to maintain a balance in the environment. To update the available data, a comparative analysis of the available methods of tax control was carried out, the main trends in their formation were identified, and the role of the risk-based approach in the tax system was determined. The authors evaluated the necessity and possible effects of various types of tax control measures. In addition, the concept of tax risks, their classification, risk management of tax control, as well as the procedures for conducting audits in the framework of the implementation of tax control were studied. In order to identify shortcomings in the activities of the tax control, the theoretical and practical aspects of modern methods of conducting tax audits were analyzed. The authors have identified the role of the risk-based approach in the implementation of tax control measures in our country. The authors considered the theoretical features of the implementation of tax control, which are provided for by legislation. The assessment of the possible development of this direction in the economy was carried out and the impact of modern processes on the implementation of tax control was analyzed, based on which elements of the risk-based approach used in modern practice in the implementation of tax control, conclusions were drawn about the impact of this methodology on the development of the economy as a whole, as well as on various stages of the tax process. By identifying the peculiarities of combining various elements of the risk-based approach in the practice of tax control in the country, the authors assessed the trends in the development of the tax system under the influence of information technologies and its elements. Trends in the application of tax risk assessment methodologies are identified by analyzing the theory and practice in the field of tax control.

## 3 Results

Analyzing the theoretical and practical tax base, it is worth considering that during the implementation of tax control, it is worth noting that an important point of its effectiveness is the relationship of the elements in the entire range of methods. In the course of interaction of the parties in this process, the main field for the activities of the parties is a set of legislative acts regulating taxes and fees in the country, they also set the basic rules [3]. Following these rules is important for the effective functioning of the country's economy as a whole, which is why a fairly large number of measures are carried out within the framework of tax control. It was revealed that the following methods of tax control are used in modern tax practice, which are presented below on the basis of the analysis of the theoretical and practical base of research in the tax system and a scientific article by Kobeleva [4] (Table 1).

It is worth noting that this classification is not legally fixed, but is considered in the practice of taxation and is subjective. The methods of tax control listed in the table are widely used in modern practice, but all of them do not fully reflect the processes that are considered tax control in the modern world. Considering these methods, we can see a trend in the development in favor of a risk-based approach. In many respects, this development was set by changes in the system of conducting tax audits in 2007, but it has become widespread only recently. This approach to taxation allows us to take a fresh look at the conduct of the tax control process. The methodology of prioritizing tax risks is innovative, considering the specific features that exist in a particular industry. From the point of view of the elements of the risk-based approach used in

**Table 1** Basic methods of tax control and their classification

| Basic methods of tax control | |
|---|---|
| Documentary<br>control of registry documents, verification of the correctness of the preparation and reliability of reports, verification the legality of the activity, verification of the validity of transactions, etc. | Documentary<br>control of registry documents, verification of the correctness of the preparation and reliability of reports, verification the legality of the activity, verification of the validity of transactions, etc. |
| Complementary methods of tax control | |
| Calculation and analytical economic data analysis, technical calculations, logical estimation, etc. | Calculation and analytical economic data analysis, technical calculations, logical estimation, etc. |

the process of tax control, the following can be distinguished: ranking of taxpayers depending on the specifics of economic development and industry affiliation, priority in conducting tax audits and monitoring the activities of taxpayers, reduction of inspections for certain groups of taxpayers and increase for others, regular analysis of tax risks in the country's economy. These elements can be used in various systems, combined with each other and individualized depending on the industry and the surrounding circumstances.

The tendency to use the considered approach based on risk assessment in the practice of taxation is quite new and partly innovative method of implementing tax control. Having appeared relatively recently, just a couple of years ago, it does not cease to improve in the direction of an increasing transition to the digital format. Analyzing the risk-based approach in the tax system of the Russian Federation, it is necessary, first of all, to consider the advantages and disadvantages of this approach on the basis of an analysis of the theoretical and practical basis for conducting tax control based on a risk-based approach [5] (Table 2). Based on the advantages and disadvantages of the risk-based approach in tax control, it can be concluded that this approach carries a significant number of value elements for the economic system. In addition, in the modern world, it is necessary to consider the impact of digitalization on these processes. So, a number of elements of the approach considered in the work will undergo a number of changes in the future and be modified for those information services that are used in the economy for these processes.

It can be noted that in the modern economy there is a clear tendency to systematize processes, including in the tax system, and there is a clear trend in the formation of the most general approaches to tax control. This trend is largely traced in the application of the approach based on the assessment of tax risks, while the processes of informatization make it possible to simplify and facilitate the process of tax control

**Table 2** Advantages and disadvantages identified in the tax system, considering the application of the risk-based approach

| Advantages | Disadvantages |
|---|---|
| 1. Unity in the system of choosing the priority of controlled entities and the objectives of tax control<br>2. Minimization of tax risks in the country's economy, and, accordingly, increasing the sustainability of its development<br>3. Acceleration of processes in the economy by standardizing the activities of tax authorities<br>4. A unified methodology for conducting tax control in different regions, leading to the simplification of this process<br>5. The ability to manage risks in the country's economy<br>6. Increasing the level of significance of tax audits as a result of determining their necessity for specific taxpayers | 1. Difficulty in determining the characteristics of different industries<br>2. Lack of highly qualified personnel capable of carrying out activities in this format<br>3. Complication of the system of ranking taxpayers according to the degree of risk |

to a greater extent, as well as to increase the level of reliability of such an assessment, and, consequently, to reduce the level of possible tax risks. Innovations in taxation come with the processes of digitization. This process allows you to translate documents into electronic databases, which contributes to the development of openness of counterparties, as well as transparency of tax audits, which is an undoubted plus for both taxpayers and the verifying party.

## 4 Discussion

Lots of economists conducted their research in this direction. One of the authors who considers the risk-based approach in the modern tax system is Artemenko [6]. The author analyzed the modern system of tax control from the perspective of a risk-based approach. In the article "The application of the risk-based approach in the methodology of tax control", one of the methods of ranking tax risks was considered, their classification was proposed, and measures to minimize them were proposed. The author presented arguments in favor of a positive trend in the development of the tax system with the application of the considered approach to the implementation of control over taxpayers, since minimizing tax risks with this method allows to increase the sustainability of the development of both a specific industry and the country's economy as a whole. Another author, who considers this issue in her work is Kobeleva [4]. She analyzed the current forms of tax control in modern tax practice, considering this issue from the perspective of the taxpayer and risks that may arise in the tax system.

The problem of improving the methods of tax control, as well as the elements of the tax system in modern conditions of economic development were also considered in the scientific article by Rybakova and Nazarov [3]. In this article, this aspect was considered from the point of view of entrepreneurship, in addition, the need for such changes was analyzed. This topic is relevant and is considered in modern studies by various authors, who note the importance and significance of the development of a risk-based approach in tax control. This trend, despite its widespread use in modern economic theory, is still relevant and not fully researched, and there are still some inaccuracies and unexplored aspects of this trend in taxation. In addition, the processes of tax control undergo various changes under the influence of various factors of the modern economy.

## 5 Conclusion

The paper considers the main methods of tax control in modern tax practice. It was noted that one of the current trends in the development of the tax system in the field of tax control is the use of a risk-based approach, which contributes to more reliable verification of taxpayers and the tax base, unlike the others. This approach to tax control brings a number of advantages to the activities of the economic system, which contributes to its further stable development and functioning. This topic has recently been quite often considered by experts in the field of taxation, since it has recently undergone a number of changes, despite the already rather long history of its existence and application. We can conclude that the role of tax control in shaping the sustainable development of the country's economy is very large, while a huge advantage in the course of its development is the use of a risk-based approach, especially at the present time. In addition, the further development of tax control is greatly influenced by the processes of digitalization, allowing to expand the capabilities of tax authorities in the process of conducting inspections. Tax control, based on the assessment of tax risks, allows you to increase the degree of reliability and objectivity of tax audits and the use of other tax control tools. Thanks to the formation of digital skills and competencies in the society, the demand for relevant tax services is formed.

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# Venture Capital as a Factor of Innovative Economic Development

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**Abstract** Venture capital contributes to the solution of such an important task as the moving the Russian economy to an innovative way of development; the use of venture investments might contribute to expanded reproduction that is necessary for the formation process of an innovative model of economic growth. There is a comprehensive analysis of Russian venture investments market foundation and development in the article. The purpose of the article that authors had are a research of key theoretical and methodological approaches to the study of venture capital as a factor of innovative companies funding as well as development of practical recommendations for improving an institutional environment. On the basis of an evolutionary approach to the analysis the key stages in the development of the Russian venture capital market were showed. Further trends of its development were identified. Statistical and mathematical methods formed the basis for determining the factors slowing down the growth of the venture capital market in Russia, which made it possible to propose a number of measures to eliminate its institutional imperfections. A special place in the article is occupied by the analysis of various methods of raising funds in the venture capital market including an IPO process. Innovative ways of financing venture capital projects implemented using digital technologies on the basis of crowdfunding platforms are studied.

**Keywords** Crowdfunding platforms · Innovation · Venture capital · Venture funds · Venture investment

## 1 Introduction

At the present stage of economic development the introduction of innovative solutions that can reduce costs is one of the primary tasks the business community and the state face. The venture industry is the main element of the country's innovation structure as one of ways to finance business projects. It contributes to the growth of

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the competitive goods and services production in the high-tech sector. This study is relevant since the venture funding model is one of the most successfully functioning models for the support and development of innovations. World practice shows that only the presence of an effective venture capital ecosystem makes it possible to form the country's venture capital market [1]. There are certain barriers in Russia that impede the development of this market and innovative business in general. Securities market is a direct channel for venture capital financing as most of the investment is made through the stock market. And the correct and effective organization of its work might allow to increase the share of investments in innovative projects and growing companies, which might significantly affect the position of Russia in the international stage, and might also contribute economic development within the country. So, improving the system of venture capital financing with stock market instruments should become a priority task that any state faces. The usage of new digital options for funding venture projects is also an important issue. The establishment of the crowdfunding institution combined with the effective functioning of venture capital funds can stimulate not only to the development of the venture capital market, but also to the innovative growth of the economy as a whole.

## 2 Methodology

The main methodological approaches used in the research are historical, structuralist, rationalistic. The local methods of scientific analysis used in the article are formal logic tools such as analysis, deduction, induction, synthesis of the logical and the historical approaches. Methods of statistical and metamathematical analysis, which made it possible to identify the factors slowing down the development of the venture capital market in Russia, play important role in this article.

## 3 Results

Venture capital is the form of financing of any projects that have significant growth potential in the market. As a rule, the projects of the innovative type are usually become purposes for the venture capital. They cannot guarantee a successful-functioning result that might necessarily bring a stable profit. Venture capital investment is associated with high risks, which are compensated by the possibility of obtaining high income when purchasing a share of a company. Venture financing of projects involves medium and long-term investments in companies with great potential, creating an innovative product [2]. The venture financing mechanism might be described as the process when investor buys a share of the company, rather than receiving a fixed profit, as innovative projects assume the absence of empirical data for analyzing investment prospects. Investors' purpose is to get a company to the market as soon as possible to shorten payback process of the project. In early stages venture projects do not bring any profits. So, there the effect of "burning money" takes place. But venture capitalists earn their income by selling their shares after the startup's significant growth. In cases where the project is scaled up in several stages, venture financing might be attracted several times, and the volume, conditions and guarantees of investment are different. At the moment when the start-up company has completely occupied the market and its development has stopped, the volume of venture capital investments drops significantly because the value of investor shares stops rapidly growing. In this case investors can return their investments in the following ways: sale of a share to the founders (if they have such funds); takeover of a startup by a larger company; organizing an initial public offering (IPO) of the company's shares.

After venture investors exit, the startup turns into an ordinary company operating in the market. Within the study of different theoretical and methodological approaches to definition of venture capital several features of it were detected. Venture capital is invested in existing or just emerging small firms whose activities are innovative and focused on the production of a high-tech science-intensive product, which is characterized by both potential ultra-high profitability and a high risk of capital loss in case of a project launch failure. The financing period for venture capital is medium and long-term, capital withdrawal is not possible until the end of the company's life cycle. Venture capital investment can be viewed as a collateral-free form of long-term credit that does not provide any guarantees for a return on funds. Companies in which venture capital is invested do not have listed securities. As a rule, banks do not invest in projects of this type as venture investment is characterized as mutual investments in shares of developing companies that are not presented on the stock exchange. The interest of venture investors is not only the possibility of obtaining high income, but also is the prestige of participation in the creation of innovative technology that stimulates scientific and technological progress. While investing in innovative companies, the venture capitalist must decide in advance how he intends to get out of this investment: by selling a share in the company on the stock exchange or by selling the entire firm to another company.

It is obvious that venture capital is an important source of innovative organizations funding in the field of advanced technologies. The beginning of the venture investment emergence is considered the period of the 50s of the XX century. It happened on the basis of the American Research and Development company formed at that time, the main goal of which was the commercialization of technologies developed at the Massachusetts Institute of Technology (MIT). Subsequently, the basic principles of venture investing spread to European countries [3]. The growth of interest in this method of investment was linked to the real possibility of obtaining a sufficiently high income, which was higher than the amount of profit received from other types of financial relations. In addition, the principles of building venture financing ensured savings in transaction and transformation costs and contributed to the implementation of innovative ideas of the entrepreneurial community. It is venture capital that has become the main source of such large market players creation as Apple Computers, Microsoft, Intel and Google. Development of the US venture market was evolutionary. There were several stages. The most important of them was a creation of the Silicon Valley. The Centre of technological innovations united companies that develop modern technologies in the field of information systems, telecommunications, medicine, and other strategically important industries and spheres of the economy were founded and developed. The main peak in the development of venture capital is 1978, when the volume of venture capital investment reached $750 million [4]. The subsequent period of the 1980s brought the expected growth in the number of companies using venture capital. In this time range most of the companies known today were born. However, such a rapid growth in the number of participants in the venture capital market was not supported by an equally significant increase in the management efficiency of these companies, which led to the bankruptcy of many firms and a decrease in total income from this type of activity, as a result of which venture funds were forced to cut their costs in order to provide at least some income. The 90s of the twentieth century became a boom period for well-known venture capital companies engaged in information technology. This stage was characterized by a significant volume of IPOs. However, the collapse of the NASDAQ stock exchange in 2000 led to the bankruptcy of many firms, as their value became lower than the invested value, which led to a 50% reduction in the venture capital market [5]. This segment received an impulse for development in the mid-2000s when there was a surge in the realization of venture projects of information and communication technologies development and implementation in economic activity.

As for the Russian economy, venture investment has gained popularity since 1993. At the Tokyo Summit it was decided to accumulate financial resources in Russia for the development of investment projects, the source of which could be venture capital. The period of the 90s of the twentieth century became crucial for the development of venture capital in Russia because at this moment the key institutions of the market system were being formed and consolidated, including investment based on high-risk funding sources. Such a late emergence of a venture capital culture investment led to fundamental differences from the United States and European countries in the mechanism of using venture capital and its infrastructure. In addition, it is important to understand that the institution of venture investment was formed not so much under the influence of economic necessity as under the influence of state regulation aimed at artificially creating a market infrastructure of the Russian economy. As a result of the administrative imposition in the venture financing institution formation its infrastructure has got a rather specific form. In the first stage venture funds were products of the European Bank for Reconstruction and Development (EBRD) that played a role of sup-porter in implementation of market reforms in Russia. The main purpose of these funds is to support and assist in the implementation of the privatization of state-owned companies and the funding of their share capital. The activity of regional venture capital funds was aimed more at increasing the capital of enterprises that were previously state-owned than at modernizing and developing new projects and ideas, which is the very essence of venture investment. Venture funds, created under the influence of the EBRD, pursued a single task that is control over domestic firms and organizations that were attractive to Western Europe. Today the situation has changed. The Russian venture capital market has passed the stage of formation. A large number of players have emerged with real motivation for venture capital investments as a source of innovation. The subject structure of the market is represented by private funds (private, corporate, state), accelerators, business angels, foreign investors. In the first half of 2020 Russian venture market developed with the same dynamics as it had been in 2019. There were 108 deals comparing with 115 in 2019. A drop in the number of deals is noted at almost all stages of development of innovative projects, except for the “start-up” stage, where the number of deals in the first half of the year increased from 22 to 32. At the “seed” stage, a rather insignificant decrease was observed—from 48 up to 42 transactions, and financing of projects at the “growth” stage remained unchanged—at the level of 21 transactions. The dynamics of the number of deals by type of investor showed the activation of business angels, government funds and corporations in the market. It is obvious that there is a big decrease in volumes of the market. There were 183 million dollars comparing with 497.5 million dollars in 2019. This change is primarily linked to a decrease in the volume of transactions with mature companies. The average check of deals decreased in all segments and reached only 1.7 million dollars, while in 2019 this figure was 4.33 million dollars. One of the reasons can be called the outbreak of a pandemic, which has made its adjustments in the activities of the Russian venture market [6].

The key trend of 2019 was the record number of exits made by investors for Russia (14 deals). In 2020, the number of exits amounted to 6 deals. In 2020, there is an increase in the activity of state funds—12 deals. 6 of them took place in the framework of the innovation competition of the Republic of Tatarstan “Start-2”. The largest deal with a state corporation is considered to be an investment of $ 9 million by VEB Ventures in medical equipment and improvement of clinics [7]. By the end of 2020, the market began to stabilize. Competition between companies for start-up shares is growing. Among the largest players in this area are Tinkoff Bank, Severgroup, MTS, Mail.ru Group, Yandex and Sberbank. During this period, corporate accelerators also became active players in the venture capital market, the purpose of which is to search for innovative projects. Among them, Gazprombank (a program for searching for technological solutions), Sberbank (500 Startups, SberUp), Ural-Sib, MTS (Startup Hub), and Build UP stand out. Within the study the mechanism of financing venture projects was studied in detail. Direct investment in Russia is usually carried out by direct investment funds, which are organized, as a rule, in the form of limited liability companies. In world practice, pension funds [8], insurance companies and funds of funds are usually among the most common investors in such funds, but in Russia the situation is different.

There is almost no data on the structure of investors in private funds in Russia, but surveys of financial market participants are regularly conducted. For example, one of them showed that non-state pension funds prefer to invest funds from pension reserves and savings in the least risky instruments with constant returns and do not finance direct investment funds. Insurance companies are not interested in direct investment. They do not have enough investment instruments. The average term of an insurance document in Russia is 1.5 years, and an investment life insurance document is from 3 to 5 years [7]. The lack of interest of such large institutional investors in the venture market is holding back its development in Russia. Other factors hindering the growth of this market segment include: (1) investors have fears associated with high risks of fraud and misappropriation of the invested funds; (2) lack of confidence in the managers of venture funds and private funds, the presence of doubts among investors about their competence in conducting high-quality expertise (it is also associated with the closed nature of such funds, the lack of data to analyze their activities); (3) problems of market institutions including the lack of institution for protection of intellectual property; (4) bad investment climate of the country, leading to a misunderstanding by investors of the final sale of assets possibilities (exit from investment); (5) lack of tools to minimize the risks of investing in private equity funds in comparison with other alternative classes of assets.

## 4 Discussion

The most controversial issue that cause many discussions is whether crowd-funding will be able to compete with other methods of financing venture projects, whether crowdfunding is effective in implementing innovative ideas. We will have to admit, though not yet relying on Russian experience, that the answer will be positive. At the present stage, investment platforms are becoming more and more popular among sources of financing for young companies [9]. Investing through such platforms is subdivided into crowdlending, crowdinvesting and crowdrewarding. These types form crowdfunding—a group collection of small amounts of money and their subsequent investment in projects and companies in the early stages of development using the Internet and social networks. Crowdlending refers to short-term loans issued to individuals and companies. Crowdinvesting means getting a share in a project, crowdrewarding means financing a project in exchange for products or services received during the implementation of the project.

The countries with the most developed crowdfunding markets are the United States, the United Kingdom and Switzerland. The main investors on the platforms there are individuals and institutional investors. One third of US business angels use investment platforms, forming groups with crowdinvestors. By the end of 2019, the crowdfunding market had reached an estimate of $13.9 billion and is expected to have great growth potential [10]. The key factor holding back the development of crowdfunding is the emergence of specific risks when using investment platforms [11]. These include: the possibility of technical failures on the platform, which might lead to the impossibility of the platform to fulfill its obligations to carry out transactions and subsequent losses to clients; the inability of the investor to check the information about the project, its complete dependence on the information provided—the presence of information asymmetry; high probability of the project's insolvency and the impossibility of returning the investment made. It is primarily associated with the placement on platforms of unstable and unreliable projects in the early stages of development. To prevent these risks, platform operators carry out legal check of the project, examination of its financial performance and business model, impose certain restrictions on the amount of investments made in the project, but this is often not enough to neutralize all of the troubles.

The market of investment platforms in Russia is in formation stage today. In the beginning of 2019 its volume was about 172 million dollars. Most of the transactions were in crowdfunding. At the beginning of 2020, the market volume decreased by 53% and amounted to $ 110 million. In the global volume the share of the Russian market did not exceed 0.8% by the end of 2019 [12]. Among the problems that prevent investment platforms from gaining popularity in Russia are: not high level of investment efficiency (below expected); lack of public confidence in such sites; the presence of high risks of non-return of funds; insufficient awareness of investors about the mechanism of the platforms operation, their capabilities and advantages. The process of forming a trusting environment in the field of crowdfunding is taking place in Russia, including increasing its transparency and reducing risks for retail investors. The Federal Law No. 259-FZ defines the rules for investment platforms, the level of information disclosure, establishes requirements for the amount of platform operators' capital, the conditions for their activities, etc. [13]. Another important step in increasing confidence in crowdfunding could be actions to attract large venture capital funds and accelerators as "anchor" investors in investment platforms. These measures will allow the platforms to attract higher quality investment projects, increasing the demand for platforms among retail investors.

## 5 Conclusion

At this stage Russia lags far behind developed countries in terms of the venture capital market development. However, it certainly has good growth potential. Among the main reasons for low demand in this market are the lack of a decent level of awareness and investor confidence, risks associated with law enforcement. The research showed that problems of the venture market functioning in Russia are structural. Their solution is linked to governmental participation in processes of venture market stimulation. It is a key factor of innovative transformation of an economic system. A government is able to adapt a law basis according to economic needs of venture projects realization giving an impulse for innovative activities. A business community also might contribute development, scaling and effective functioning of a venture segment of the market.

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# Financing of Russian Innovation Processes in the Context of Federal Budget Deficit

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**Abstract** The article deals with the issues of financial and budgetary support for the introduction of innovations in the context of a sharp reduction in budget revenues, a limited resource base and the ongoing consequences of the COVID-19 pandemic. Russia's place in the global innovation index is evaluated in comparison with other countries of the world, both in general and in individual indicators that characterize scientific activity and the degree of implementation of information and communication technologies. The raw materials orientation of the Russian economy is noted, which leads to insufficient influence of the results of professional, scientific and technical activities on the volume and structure of GDP. A brief analysis of the budget expenditures of the Russian Federation was carried out, and the changes caused by the coronavirus pandemic were identified, taking into account the factors that affect the reduction of budget resources. The problems that hinder the increase in the investment financing volumes at the expense of budget funds are highlighted. It leads to a decrease in the rate of development of the most important strategic industries necessary in the conditions of recovery from the crisis. The problems of financing innovations at the expense of private business funds are considered and priority areas of investment for stimulating innovation activity are identified.

**Keywords** Budget financing of innovations · Deficit · Federal budget · Financing · Innovations · National welfare fund

## 1 Introduction

The macroeconomic crisis caused by the 2020 pandemic and its consequences affected all sectors of the economy, but the industries that require a high degree of global integration suffered the most. The pandemic created real threats to the international cooperation in the field of innovation, especially in North America, South-East Asia and Western Europe, where was a sharp decline in operations using venture

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capital and intellectual property. The year 2020 clearly demonstrated the importance of timely adaptation of the economy to new scientific and technological challenges. In the conditions of overcoming the crisis in 2021, resources are invested mainly in large projects, and numerous small startups remain without funding. Leaders in the field of innovations spend more money on education, have good financial market indicators, develop operations with the use of venture capital. They are opened to the introduction of the latest technologies, improve the research base, actively use telecommunications, create new organizational and marketing models.

## 2 Methodology

In the course of the study, economic, statistical and information-analytical methods were used, analysis and synthesis, comparison, formalization and concretization of the study results. We used indicators that characterize the international innovation market and innovation indices of countries; data on the volume and structure of the federal budget and the National Welfare Fund (NWF), provided by the Ministry of Finance and the Accounts Chamber of Russia. Using the methods of logic and abstraction, suggestions are developed and conclusions are drawn about the prospects of state participation in the financing of innovations in the Russian Federation.

## 3 Results

The indicators of the global innovation index, calculated based on data for 2020, show that innovations are mainly concentrated in the scientific and technical clusters of individual countries and territories with a high level of income. The largest number (25 clusters) is concentrated in the United States, they followed by China (17 clusters), Germany (10 clusters), and Japan (5 clusters). In 2020, the most productive cluster was Tokyo – Yokagama, followed by Shenzhen – Hong Kong – Guanzhou, as well as Seoul, Beijing and San Jose - San Francisco. In the global Innovation Index, Russia ranks only 47th, behind Bulgaria and Romania. At the same time, according to a number of index indicators, Russia is at higher places. This includes the development of higher education (17), competition and market sizes (18), the quality of universities (21), the quality of scientific publications (22), and information and communication technologies (29). But at the same time, the indicators are significantly lower for a number of parameters. These are environmental sustainability (100), regulatory environment (95), creative goods and services (81) [1]. Despite the fact that the Russian economy is emerging from the crisis, its main focus remains raw materials-based; products with a high degree of added value occupy a small share in the GDP structure, as shown in Fig. 1.

In 2020, as in previous years, the largest contribution to GDP growth is made by mineral extraction (12.6%), wholesale and retail trade (13.7%), construction and

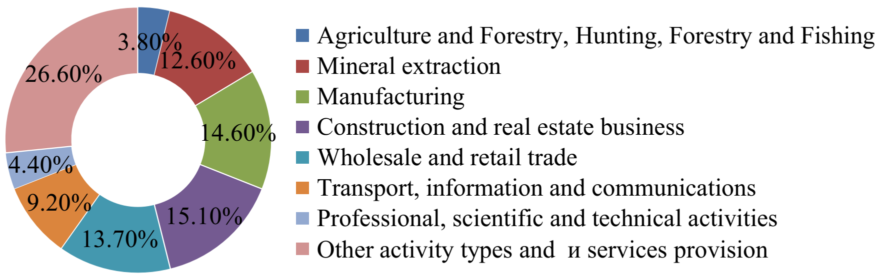


**Fig. 1** GDP structure by economic sectors in 2020 in current prices, in % to the total

real estate operations (15.1%), while manufacturing accounts for 14.6%. The entire sphere of professional, scientific and technical activities brings no more than 4.4% of GDP, which includes, among other things, innovative products. Although a separate article on accounting for GDP growth due to innovations is not even highlighted in the statistical data [2]. The share of innovation expenditures in government spendings is also not sufficient. An analysis of the structure of federal budget expenditures shows that in 2020, the share of expenditures on healthcare, social policy, and inter-budget transfers increased significantly; these structural changes are due to the pandemic, but, as in the pre-crisis years, government expenditures on innovations are not considered as an essential item of expenditure. Due to the losses caused by the global crisis, the federal budget deficit for 2020 amounted to 4.1 trillion rubles, or 3.8% of GDP. In general, in 2020, only 289.8 billion rubles of the National Welfare Fund were spent on financing the budget deficit. The main sources of financing of the budget deficit in 2020 were domestic borrowings, net cash proceeds from which amounted to 4.6 trillion rubles. These funds were sufficient not only to finance the budget deficit, but also to repay the external debt in the amount of 304 billion rubles [3].

The growth of federal budget expenditures in 2020 is also associated with changes in the revenues and expenditures of the budget system as a whole. According to the Ministry of Finance, transfers to the regions increased by 60% [4]. As a result, regional revenues increased by 6.6%, expenditures - by 16%, and expenditures of the consolidated budget of the Russian Federation and extra-budgetary funds - also by 16%. This indicates a significant fiscal stimulation of regions and the economy in 2020, not in innovations, but in terms of current expenditures [3]. At the same time, the growth of federal budget expenditures in 2020 creates certain problems for future years in the context of the expected second and subsequent pandemic recurrences. The following factors influence the reduction of sources of financial resources in the context of the pandemic and the decline in activity in the Russian and global economy: decrease in revenues and profits of oil and gas producing organizations; the growth of the dollar against the ruble under the influence of reduced demand on the hydrocarbon market; narrowing of consumer demand and, as a result, trade turnover; increase in current expenditures due to inflation expectations. Thus, unfavorable conditions are created for investment in fixed assets and financing of innovations. This is due to both production impracticability and financial constraints.

In Russia, the most important strategic industries, including aviation, electronics, rocket and space, radio engineering, robotics, and biotechnology, which determine the innovative orientation of the economy, are insufficiently funded. A relatively high level of innovation activity is typical for such industries as pharmaceuticals, medical equipment production, electronics, chemical products, and vehicles, but the contribution of these industries in GDP remains low – less than 4%. Dependence on imports of high-tech products poses a threat to the national security of the country.

The insufficient level of science and education funding remains one of the problems hindering the introduction of innovations in Russia. The development of science is limited by insufficient integration into the international scientific space, poor training of specialists in breakthrough areas of science and technology. The obstacle is the low prestige of scientific activity and the lack of financial incentives. Innovative development is supported by the demand for new developments from business and state assistance. But most commercial organizations are not sufficiently interested in innovations due to their monopoly position on the market and weak competitive environment. Sources of investment financing can be not only budget funds of all levels of the state budget system, but also private investments, as well as credit resources of the banking system. Nevertheless, the problems of financing investments by attracting funds from private investors are: high cost of credit resources, long payback periods of investments, short planning horizon, high risks of income loss.

In this regard, innovations do not become a significant factor of competitiveness for the majority of Russian entrepreneurs, a priority of the competitive strategy, so we consider it appropriate to strengthen state support for innovations financing. In the context of the country's budget deficit, it is necessary to pay attention to other sources, one of which may be the funds of the National Welfare Fund (NWF). During many years leading up to the crisis, the growth of the NWF continued, both in absolute terms and as a percentage to GDP (Fig. 2). The main function of the National Welfare Fund is to co-finance pension savings, maintain a balanced budget of the pension fund, and in 2020, these tasks were added with covering the federal budget deficit.

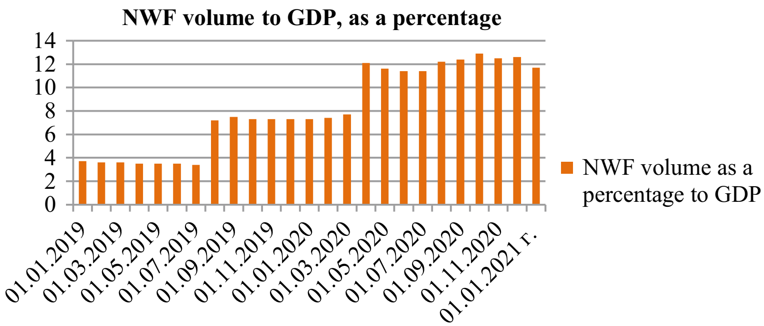


**Fig. 2** The amount of funds of the National Welfare Fund of the Russian Federation, in % to GDP, from 01.01.2019 to 01.01.2021

The existing volume of the National Welfare Fund allows to maintain the balance of the federal budget for several years.

According to the auditors of the Accounts Chamber, in 2020, 241 billion rubles were spent from the National Welfare Fund. Most of it went on reducing the federal budget deficit, and only 3.7 billion rubles - on co-financing of pension savings. Nevertheless, the volume of the NWF funds significantly exceeds the established minimum of 7% of GDP, and in 2020, despite the crisis, it increased many times and now reaches 12% of GDP [5]. In the conditions of the federal budget deficit, it is necessary to attract temporarily free funds of the National Welfare Fund. If the existing mechanisms and tools do not allow to do this directly, then it is necessary to use the money of the National Welfare Fund to finance the federal budget deficit with subsequent targeted use, including for innovative purposes.

## 4 Discussion

The consequences of the 2020 pandemic will be the subject of scientific discussion for a long time. Since the pandemic provokes an economic crisis around the world, it can be contagious both economically and from a medical point of view [6]. Most economists note the positive impact on the economy of urgent government assistance, in the form of package financing and economic incentives, on the example of the United States and other developed countries, including through the budget and special funds [7].

Auditors of the Accounts Chamber of the Russian Federation emphasize that the profitability of the NWF funds employment in the Bank of Russia for 2019, as in previous years, was negative. The current regulatory legal and methodological documents do not fully define the principles of managing the funds of the National Welfare Fund after it reaches the value of 7% of GDP and more. If the liquid part of the NWF exceeds the indicator of 7% of GDP, the government of the Russian Federation has the opportunity to place this amount of funds in assets other than the traditional portfolio of liquid currency instruments with a low level of risk, which allows investing in innovative projects. The use of NWF funds is a necessary and even unavoidable condition for maintaining economic growth [5].

The team of authors of the Primakov National Research Institute of World Economy and International Relations believes that financial incentives, which became one of the key factors of economic recovery in recent years, can be used to support investments in projects that maintain high competitiveness in the current conditions and meet the requirements of import substitution. Public investments in infrastructure objects and innovative technologies create mass demand and increase the safety margin and the potential for further development of the country [2].

## 5 Conclusion

The development of the innovation financing system requires state support, if competition is stimulated and institutional conditions are improved. It is possible to apply special legal regimes that allow removing barriers to entry of innovative small and medium-sized enterprises into the public procurement markets. At present, public financing of innovation activities should focus on the following priority areas: medicine and pharmaceuticals, biotechnologies, communications and telecommunications, transport and logistics, financing of alternative energy sources, marketing innovations in the service sector. Special attention should be paid to the introduction of innovative technologies in industries that produce highly processed products, in eco-friendly activities, in intellectual and human capital. If the state budget resources are insufficient to finance investments, it is necessary to use part of the special budgetary and extra-budgetary funds, including social funds, if this does not contradict their main purpose. This will contribute to the achievement of not only economic, but also social goals, since innovations will improve the quality of population medical services, create opportunities for remote work and make it more convenient to deliver goods and provide services, which in the future means the growth of economic potential and an increase in the efficiency of human capital.

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# State Financing of Innovative Activities in the Russian Federation: Problems and Prospects

**K. S. Chernousova and A. V. Glotova**

**Abstract** The work was aimed to study the problem of state financing of innovative activities in the Russian Federation, as well as to assess the development prospects of this direction. Technological progress is one of the most promising areas of economic development around the world. The greatest interest in investment in the field of innovation, in our opinion, is the experience of countries such as the United States, China and Japan. The relevance of this topic lies in the urgent need to develop technological and innovative processes in Russia, and this is possible only with strong government support. The article will consider the main directions and methods of state support and financing of innovative activities in the Russian Federation, problems and prospects for the development of innovative processes in Russia, as well as an assessment of the place and role of the Russian Federation in the world in terms of total expenditures on innovative activities.

**Keywords** Financial support · Innovative activity · Innovation processes · State support of innovative activity

## 1 Introduction

In the age of information technology, innovations play an increasing role in various spheres of human and state activity. In addition, innovation is one of the most significant factors in the effective functioning of economic entities. They are the most important area of successful, high-quality solutions to commercial, technological and production problems, and they are also an excellent way to ensure the stability of the organization's activities and increase its competitiveness in the market [1]. Despite the fact that there are some positive trends in the development of innovative activity, it can be noted that innovative activity in Russia is developing rather slowly and has a number of problems. One of them is the search for sources of financing for innovation processes. Enterprises, investors, the state can act as such a source.

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In economically developed countries, such as the United States and Japan, the main sources of financing for innovation processes are the state and private sources (enterprises, financial and industrial groups, small innovative businesses, individuals, etc.). This paper will consider the main problems and prospects of government funding and support for innovative activities in Russia.

## 2 Methodology

The subject of the research is the current trends and characteristic features of state financing of innovative activities in Russia. The main objectives of the study are:

- analysis of scientific, regulatory and other information on the research topic;
- study of foreign and Russian experience in investment activities;
- make a comparative analysis of the volume of financing of innovations in Russia and foreign countries, determine the place of Russia among them;
- Theoretical and methodological basis of scientific research;
- scientific articles and methodological developments in the field of taxation, investment and innovation processes, financial support;
- regulatory legal acts in the field of state financing of innovations [2].

The research methods are a systematic analysis of data on the state of the innovation climate of the Russian Federation and foreign countries, statistical and comparative analysis of quantitative indicators for the volume of innovative activities financing in Russia and economically developed countries of the world. For further study of the issue, the following concepts should be disclosed.

Innovation is a new method introduced into the production process, which is designed to increase the efficiency of processes and improve the quality of goods and services that are in high demand in the market.

The innovation process is the process of converting scientific knowledge into innovation, a set of activities, the result of which is the transition of innovation from the stage of an idea to a real product, technology or service and its use in practice.

Innovative activity is an activity that is based on the application of innovative forms of organization, management and financing [3].

## 3 Results

In the course of the study, we made the following conclusions and obtained the following results. Currently, financing innovative activities is a very promising and popular way of investing capital. However, with all the prospects for innovative projects in Russia, they are experiencing a deficit in sources and amounts of funding. This is due to the following factors: (1) a large number of innovative projects have an unfavorable ratio of income and expenses, that is, there is a low correspondence of the results of innovative activity to their costs; (2) intellectual property acts as a condition for the effectiveness of innovative activities, which motivates the state to finance. Intellectual property needs copyright registration, and this is not always the result of innovation [2]; (3) an innovative project is a long-term process of implementing innovations, therefore, innovative activity is not always attractive to investors who are planning to invest capital in the short and medium term.

Innovation is the path to the successful functioning of economic entities. They can act as a means of solving production problems, a way to increase the stability of the operation of an enterprise in the market and increase its competitiveness [4]. The forms of state support for innovative activities are quite diverse: loans, borrowings, tax breaks, information support, and others.

The main problems of financing the innovation process in Russia are the low demand for innovations in the Russian economic system and the ineffective structure of innovations—enterprises are generally inclined to purchase finished equipment and technologies abroad, and not to their own development and implementation [1]. Therefore, neither the private nor the public sector is fully interested in the implementation, and thus in financing, innovations [5]. In Russia, the volume of innovative activity is much lower than in the leading economically developed countries. Figure 1 shows the volume of domestic spending on research and development in % of GDP in the context of economically developed countries of the world [6, 7].

Thus, as of 2018, the Russian Federation ranks 30th in the ranking of R&D expenditures in% of GDP. Since the GDP of different countries can differ significantly from each other, therefore, the amount of R&D funding should be considered in quantitative form. So, as of 2020, the volume of internal R&D costs is presented in Fig. 2 [7].

Thus, the volume of financing for innovative activities in Russia differs significantly from the economically developed countries of the world. In the quantitative form of R&D financing, the Russian Federation ranks 10th in the world with a volume of $39.3 billion, in turn, as in the United States, China and Japan, these indicators correspond to $511.1 billion, $451.2 billion and 168, 6 billion dollars. In terms of

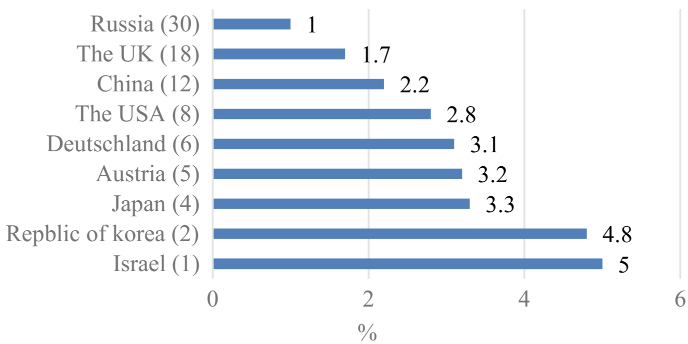


**Fig. 1** Expenditure on R&D, % of GDP (%) for 2020

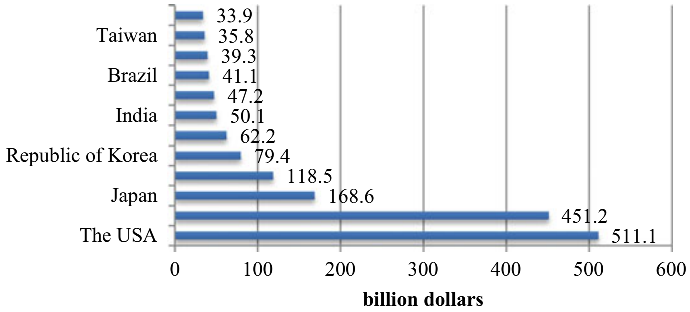


**Fig. 2** R&D expenditures calculated at purchasing power parity of national currencies for 2020

the ratio of the volume of innovations financing to the volume of GDP, the Russian Federation ranks 30th in the world, with a volume of 1% of GDP, and the USA, Japan and China—2.8%, 3.3% and 2.2%, respectively. If we consider the financing of innovative activities exclusively by the state, then the amount of funds should be considered in the context of its sources, presented in Fig. 3 [7].

Based on the schedule, we can say that the financing of innovations in foreign countries is carried out mainly at the expense of enterprises and businesses. In turn, in Russia, 66.3% of all funds invested in innovation are government funding. However, one should not forget that the amount of funds invested in quantitative form in countries such as the United States, Japan, China and Germany, far exceeds the amount of funds in Russia. Thus, we can say that in economically developed countries, both commercial enterprises and the state as a whole are interested in financing innovative activities.

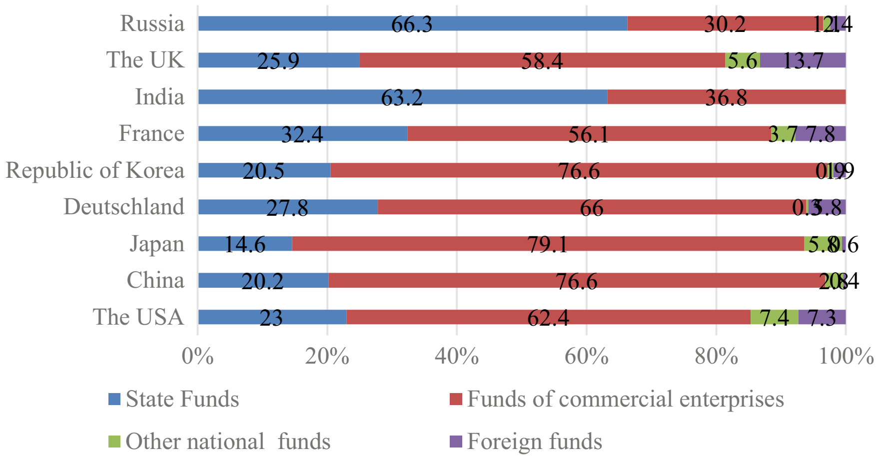


**Fig. 3** Structure of internal expenditures on R&D by sources of funding for 2020

## 4 Discussion

The main problem of financing innovative activities is the lack of interest of economic entities in the development of innovations, since they have a long-term perspective and financial risks. In Russia, there is a low level of investment financing compared to the USA, Japan and China, which are leaders in this area. Also in the Russian investment financing system, the main source is government investment. The problem of state financing of the investment process in the Russian Federation is the limited state budget, the small amount of funds allocated to finance innovation processes. Also, the reason for the low level of innovation in the industry can be the low use of scientific achievements and advanced experience [8, 9]. So, for example, after a number of sanctions introduced in 2014, the Russian Federation began to build up the agro-industrial complex, thereby introducing innovations in this industry. To increase interest in introducing innovations in the agro-industrial complex and to increase the investment attractiveness of the agro-industry, interaction of all levels of government and agricultural business is required, which will be aimed at creating innovations and their infrastructure. This will be possible only with a high interest of both the state and business, which will invest in organizations that determine innovation policy in the agro-industrial complex. An important factor in the development of innovation processes is the financing of an enterprise for the purchase and leasing of innovation. It is also worth remembering the importance of professional training for innovation management in the agro-industrial complex [8, 10]. This example shows the level of influence of state support on the development of the innovation process at an enterprise or even in the industry as a whole.

Based on the above, one can judge the impact of government support on the development of innovations in organizations and even in the industry as a whole. Therefore, the development of innovative processes on the territory of Russia, their stabilization is necessary for the effective functioning of the country's economy as a whole, for the formation of long-term prospects, for the development of enterprises and scientific developments in general [2].

## 5 Conclusion

Currently, the innovative way of development of enterprises determines the future of the entire economic system of the country and the world. Innovative activity allows the organization to be developed technically and technologically, using new high-tech innovations and developments. However, innovative activity requires a high amount of funding, which not every enterprise can afford. Therefore, state support for innovative activities is a necessary phenomenon for the development of the country's economy. In the Russia, in comparison with the leading economically developed countries, state funding for innovation prevails over other sources of funding. However, this does not mean that in the United States, China and Japan, the state is not interested in innovation. For example, in the United States, the volume of public investment in research and development is approximately 23% ($117.5 billion) of the total investment in this area ($511 billion). This indicator is almost 3 times higher than the total volume of internal expenditures on research and development in Russia. Thus, the Russian economic system has prospects in the development of innovative processes in the country by increasing the volume of financing both from public funds and from commercial enterprises.

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# Problems of Innovative Development in Russia and State Support of Innovations

**N. Belanova, E. Trubchaninova, and I. Toropova**

**Abstract** The article studies the innovative development of the Russian economy, and identifies the key problems of innovative development. The strengths of the Russian economy traditionally include human capital and its development. Weaknesses that have a deterrent effect on innovations include: institutions, the quality of regulation; infrastructure and energy efficiency issues; the level of market development, low investment rates and availability of micro-financing, the development of technologies and the knowledge economy, the results of creative activities. The main problems of innovative development of the Russian economy include unbalanced development management, inconsistency of the goals and strategy of innovative development with scientific and technical potential. The authors reveal the main goals and directions of the state innovation policy, analyze the target indicators and indicators of innovative development in their dynamics and compare their planned and actual values, identify the weaknesses and strengths of the Russian economy in the field of innovations. In the process of study and conducting international comparisons, the authors come to the conclusion that it is necessary to intensify the innovation activity of organizations and develop a comprehensive, systematic state policy in the field of innovations.

**Keywords** Innovations · Problems of innovative development · State innovation policy · State program in the field of innovations

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## 1 Introduction

In the Russian Federation, the innovative way of development is defined as a priority direction for the development of the national economy. In the context of globalization and international competition, the innovative version of the Russian economy development has almost no alternative. Therefore, a large number of works by Russian authors are devoted to the formation of an innovation system [1], the analysis of key indicators and characteristics of innovative development [2].

The digital economy and innovations are key areas of development around the world. A large number of foreign studies are devoted to this problem. Most authors consider innovations at the micro level from the perspective of the enterprise [3–7]. They study the automatic drivers of development [8], the features of innovation management in conditions of limited resources [6]. A number of authors study the factors that influence innovations [3, 4]. However, in many works of both domestic and foreign authors, the main attention is paid to the development of innovations at the micro level, while the problems of planning and managing the development of the innovative economy are not sufficiently widely covered.

The purpose of the study is to identify the key problems of innovative development and priority areas of the state innovation policy. Based on the purpose of the study, the following tasks were set:

- to study the state innovation policy in Russia;
- to analyze the dynamics and compare the actual and planned indicators of innovations development;
- to consider the main problems of innovative development of the Russian economy.

## 2 Methodology

The methodological basis of the study is a systematic approach that allows to consider innovation policy as a holistic process that includes many stages and elements. The following research methods were used: formal-logical (deduction, induction, justification, argumentation); abstract-logical, empirical (observation and experiment). Methods of grouping, average values, as well as graphical and tabular methods of presenting the results of the study were used as statistical tooling.

## 3 Literature Review

The study of the innovative development' problems determines the variety of approaches to the study. The concept of technological pressure (pull technology) considers science and fundamental applied studies as the root cause and basis of innovative development. A similar approach is described in the works of Schumpeter [9] and his followers: Nelson [10], Freeman [11]. The other position is held by Mensch [7] and Schmookler [13]. They consider the demand and needs of the market pull as the driving force of innovative development. The concept of innovative development of the leading countries of the world was developed on the basis of the theory of post-industrial society by Bell [1] Galbraith [2]. The study of the foundations of the national innovation system formation is laid down in the works of foreign authors [12] and continued in the works of Russian scientists who conducted a comparative analysis of Russian and foreign national innovation systems (NIS), identified the specifics of the Russian national innovation system. Also, a great contribution to the theory of innovation was made by domestic authors. Publications of domestic and foreign authors give an idea of all the variety of study areas of the innovation process and allow to determine the main approaches to the development of state innovation policy.

## 4 Results

The Coronavirus pandemic and the introduction of a self-isolation regime had a significant impact on the development of the national economies of the world and the world economy as a whole. The probability of a second and third wave of COVID-19 is currently having a negative impact on the development of social and economic processes. However, in recent months, there has been a positive dynamics. The emergence of the vaccine and the formation of collective immunity lead to the gradual stopping of restrictive measures by the state, the revival of the economy, and an increase in the level of business activity. With the development of these processes, the country has the opportunity to go beyond the current anti-crisis policy and focus not only on restoring pre-crisis development indicators, but also on determining the most significant development priorities, among which innovative development is the key [10–15]. In the current conditions, the state should become the locomotive and active regulator of the processes of innovative development. Let's consider the state policy in the field of innovations.

The main powers of state authorities in the field of innovations are:

- providing information support;
- implementation of consulting support, assistance in the formation of project documentation;
- formation of demand for innovative products;
- financial support;
- implementation of target programs, subprograms and activities within the framework of state programs of the Russian Federation;
- export support;
- provision of infrastructure.

The key documents containing the goals, directions and tasks of innovative development and reflecting the state policy in the field of innovations, include:

- Decree of the President of the Russian Federation of May 7, 2018 No. 204 “On the national goals and strategic objectives of the development of the Russian Federation for the period up to 2024” (with amendments and additions of 21.08.2020);
- The main directions of the Government’s activities for the period up to 2024, approved by Resolution No. 8028p-P13 of the Government of the Russian Federation of September 29, 2018;
- The Strategy of innovative development of the Russian Federation up to 2020, approved by the Decree of the Government of the Russian Federation of December 8, 2011 No. 2227-r;
- The Strategy of scientific and technological development of the Russian Federation, approved by Decree of the President of the Russian Federation No. 642 of December 1, 2016 (with amendments and additions of 15.03.2021);
- State Program of the Russian Federation "Economic development and innovative economy", approved by the resolution of Government of the Russian Federation of April 15, 2014 No. 316 (with amendments and additions of 09.02.2021).

Let’s consider sub-program 5 “Stimulation of innovations” of the State Program of the Russian Federation “Economic development and innovative economy” [16]. The goals of the subprogram are to increase the innovative activity of business and accelerate the emergence of new innovative companies. The tasks are:

- creation and development of mechanisms for comprehensive support of innovation activities at the early stages;
- improved coordination between existing and emerging elements and blocks of the innovation system;
- ensuring an increase in the demand for innovations on the part of economic entities;
- development of nanotechnology innovation infrastructure;
- providing training of highly qualified personnel for the digital economy.

Within the framework of this subprogram, the following main activities are being implemented in 2013–2024:

1. Stimulating the demand for innovations.
2. Support for small innovative businesses.
3. Support for regions that are innovative leaders.
4. Creation of a university complex in the Innopolis Innovation Center (2013–2017).
5. Conducting research for the purpose of innovative development of the economy.
6. Development of mechanisms for legal protection and intellectual property protection.

The implementation of these activities and the effectiveness of sub-program 5 GP are evaluated using target indicators. Let's look at their dynamics for 2016–2020 and compare their planned and actual values.

The analysis of the Table 1 shows that during the study period, the target indicators were revised, so it is possible to fully assess the dynamics of changes in values only for individual indicators. In general, it is possible to reflect a fairly high performance of sub-program 5: with the exception of 4 indicators for 2019, all actual indicators have reached or exceed the planned values. The exception is the indicator "The share of organizations that implement technological innovations". For almost the entire period of the study (with the exception of 2017), the actual values for this indicator did not reach the planned ones. Despite this, the state set the target value of this indicator at 50% to 2024. This is not accidental, since comparative international studies show a significant lag between this indicator and global values. The share of small enterprises engaged in technological innovations in foreign countries varies on average in the range of 65–80%. For example, in Italy, this figure is 7.9%, in Sweden—73.4%, in the UK—76.1%, in Greece—78.2%. The analysis of the implementation of the planned indicators and development indicators under the state program generally shows the successful development of innovations, but their comparison with international data indicates a significant lag in the innovative development of Russia from the leading countries of the world. We will make international comparisons based on the study of the Global innovation index (GII). This index has been calculated since 2007 and is formed as the average of two subindices–innovation resources (institutions, human capital and science, infrastructure, level of market and business development) and innovation results (development of technologies and knowledge economy, results of creative activity). The efficiency coefficient is defined as the ratio of two subindices and reflects the effectiveness of innovations at a given level of innovation potential. As can be seen from Fig. 1, GII increased over the study period (the exceptions are 2016 and 2020). In the GII-2020, Russia took the 47th place, falling by one point compared to last year. In the context of the main subindices, the dynamics has the following trend: over the past five years, the positions in the sub-index of innovation resources have significantly improved, but in terms of innovation efficiency and innovation performance, Russia took the lower places. The analysis of this index allows to identify the relatively weak and strong sides of the country. The strengths of the Russian economy traditionally include human capital and its development. Russia takes a leading position in the employment of women with higher education, is among the top twenty countries of the world in terms of the quality of higher education systems, the number of engineering graduates, and the position of universities in the QS rankings. Weaknesses that have a deterrent effect on innovations include: institutions, the quality of regulation; infrastructure and energy efficiency issues; the level of market development, low investment rates and availability of microfinancing; the development of technologies and the knowledge economy, the results of creative activities.

The main problems of innovative development of the Russian economy include unbalanced development management, inconsistency of the goals and strategy of innovative development with scientific and technical potential. The connection

**Table 1** Target indicators of development under sub-program 5 “Stimulating innovations”

| | 2016 | | 2017 | | 2018 | | 2019 | | 2020 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Plan | Fact | Plan | Fact | Plan | Fact | Plan | Fact | Plan | Plan |
| The share of organizations engaged in technological innovations, in % | 9.7 | **7.3** | 7.2 | 7.5 | 7.5 | **6.3** | 15 | **5.9** | 23.6 | 50 |
| Output growth of 1 work. Organizations participating in innovation clusters, in % to the previous year | 2.6 | 2.66 | 3.1 | 14.4 | 3.6 | 11.1 | 4.1 | **3.8** | – | – |
| Number of small innovative companies, units | – | – | – | – | 750 | 770 | 800 | 811 | 805 | 1020 |
| Number of innovative projects of young researchers, units | 1200 | 1349 | 1200 | 1245 | 1200 | 1215 | 1200 | 1206 | 1200 | 1200 |
| The share of applications for state registration of intellectual property submitted in electronic form, in % | 35 | 23.9 | 25 | 33.3 | 70 | 49.25 | 70 | 59.48 | 70 | 75 |
| The average period of application processing for state registration, months | – | – | 11 | 8.9 | 10 | **7.25** | 9 | **5.96** | 6.5 | 5.8 |
| Revenue from infrastructure projects of the Infrastructure Programs Fund and the companies it supports | – - | – - | – | – | 2800 | 5500 | 4160 | 9472 | 7400 | 10,500 |
| The number of medium and large enterprises involved in the NP “Labor productivity and employment support” | – | – | – | – | – | – | 958 | 1283 | 2034 | 10,000 |
| The number of specialists who was retrained in the digital economy competencies, thousand people | – | – | – | – | – | **–** | 30 | **18.51** | 33.4 | 270 |
| Number of infrastructure centers, units | 25 | 25 | 27 | 27 | – | **–** | – | **–** | – | – |

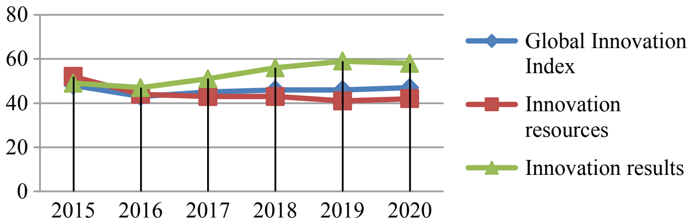


**Fig. 1** Russia's place in the ranking of countries on the Global innovation index (GII)

between science and business, the transformation of scientific ideas into products, and the commercialization of ideas are largely determined by the level of development of institutions and the nature of state regulation. The common efforts of economic entities determine the vector of development. For the successful development of the innovation market, supply and demand are important components. Most Russian companies have little interest in innovations due to low competition on the market and their lack of involvement in export operations. Significant constraints on the demand side of innovations are the high cost of credit resources and the problems of obtaining them, long payback periods and high investment risks. These traditional constraints of innovative development are combined with Russian reality. Russia is among the top ten outsider countries in terms of depreciation of fixed assets. So, in 2020, the depreciation rate of fixed assets for all types of economic activity averaged 38%, the share of fully deprecated fixed assets in commercial organizations is 19.5%. It is difficult to implement innovations on morally and physically outdated equipment. Most small and medium-sized enterprises have an unstable financial situation and face a shortage of their own resources. For them, in the current situation, the first priority is to survive on the market. They choose extensive development instead of innovative and intensive, a short-term strategy for obtaining current profits instead of forming a long-term development strategy. However, there are also supply-side problems on the innovation market. For the most part, Russian science is not ready to effectively interact with business and act as an active player on the market of technologies transfer and innovations. Most of the studies in Russian science are of fundamental nature and are aimed at the development of science as a whole. Applied studies have a scientific novelty, but from a practical point of view, it is often not in demand on the market. This is mainly due to the lack of a well-formed national innovation system. Currently, its separate elements are being created: various development institutions and funds, but they do not have an established mechanism for interaction with all participants of the innovation process. Due to the underdevelopment of the national innovation system, innovative development and technology transfer is carried out mainly using the push model. In advanced countries, an interactive model with a predominance of pull technologies is used. The directions of innovative developments are determined on the basis of market analysis and identification of consumers needs and the business sector. R&D and innovative developments are based on the results of market assessment. In Russia, the primary cause and driving force of innovative development is fundamental and applied studies, and if they are successfully implemented in production, their promotion to the market begins. As a result of using the push model, the needs of potential users of innovations remain unexplored, so there is a high probability that the "output" results of R&D will not be in demand.

## 5 Conclusion

The Russian economy is currently in a state of crisis, and this is due to the influence of exogenous factors. The development of the Coronavirus pandemic had a negative impact on the business and innovation activity of Russian enterprises. The specifics of the Russian economy is that the mechanisms and processes of its formation were not spontaneous, but were systematically integrated and managed by the state. Therefore, they have deformations and require active control and regulation by the state. Currently, the Russian economy has took a "catch-up" path of innovative development, so the state policy for the development of innovations should be comprehensive, systematic, and integrated into the strategy for the development of the country's economy as a whole. The development of legal and organizational measures to support and develop innovations at the present stage is based, on the one hand, on overcoming internal factors that hinder innovative development, on the other hand, on the timely implementation of flexible responses to new economic challenges.

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# Financial Conditions of Innovative Entrepreneurship Development in Modern Conditions

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**Abstract** The article considers some aspects which provide the development of innovative entrepreneurship in modern conditions. A description of the financial features that accompany the process of implementing innovative ideas in the field of economics is given. The essence of state support for entrepreneurship at this stage of development is revealed. The problems and advantages of innovations in business are identified. The current situation in the country is described, examples and statistics are given. It is established that innovations in entrepreneurship are necessary, since they are able to provide the economy to a new level, which is very important in modern competitive conditions. The purpose of this study is to find innovations whose commercial potential should be accurately predicted. In addition, the costs of creating, producing, and distributing products are considered as relevant aspects. The project result is the development of an innovative product, which is further implemented on the market.

**Keywords** Entrepreneurship · Federal program · Innovations · Investment · Technologies · Venture company

## 1 Introduction

It is well known that economic growth in the long term is determined by intensive innovations and business creativity. Today, we can very clearly define the unity of the directions and mechanisms of development of the economies of different countries

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in changing conditions. The main ones include infrastructure development, competitive environment, and readiness for innovations. The practical implementation of this complex indicates the level of entrepreneurial activity in the company. Also, these factors contribute to the formation of an innovative environment. The role of innovative entrepreneurship in the economy is the ability to effectively solve the problems of increasing the competitiveness of business entities on the basis of innovative technologies. Russia's transition to sustainable economic growth is impossible without the formation of a competitive innovations sector.

Funding plays an important role in this case. It is impossible to overcome the constraints on the labor and capital markets without attracting investments in knowledge and new technologies. The quality of economic growth should be associated with the activation of innovations, which are the key to accelerated socio-economic development. The relevance of this topic is obvious, since the current state of the economy needs innovations, their implementation and development. Their successful use can help the Russian economy to reach a new level.

## 2 Methodology

The data of a number of international organizations, as well as domestic agencies, served as an information and statistical base. The methods of macroeconomic analysis, deduction and induction were used as a methodological and methodological basis. The methodological apparatus used in the article is based on the application of causal and statistical analysis. The significance of this contribution for the further theory development is in the study of the financial aspects and their role for the innovative entrepreneurship development in modern conditions. From the practical perspective, this work helps to determine some benefits and opportunities of innovative ideas in the economy, and how to implement them on the basis of the made conclusions.

## 3 Results

The term "innovative entrepreneurship" can be described as risky financial investments in projects. First of all, this applies to the high-tech industry. More specifically, this includes long-term or medium-term investments. They are expressed in the form of loans, investments in shares, etc. Today, we can distinguish two forms of venture (risk-taking) firms. The first one is an independent business, the second one is an internal venture of large companies. Business, as a rule, is represented by small innovative enterprises and financial institutions that provide capital for risky projects. In the latter case, the main initiators of projects are inventors, scientists, engineers and other innovators who strive to bring their ideas to life. Considerable successes in this area among foreign companies became an incentive to create their own structures in Russia, whose activities are aimed at maintaining scientific and technological progress at the world level [1]. The current state of the world economy is characterized by the presence of innovative trends that became actively developed and implemented. Innovative entrepreneurship, as a rule, is a fairly wide range of actions to create innovative products. These actions include the technology development, its promotion, the organizational design to provide clients with new services, the creation of databases in the IT sphere, etc.

It is worth noting that the innovation potential is not fully used in our country nowadays, despite the fact that in recent years there has been an increase in various components of the innovation structure, which can include business incubators, technology parks, etc. Despite the fact that innovation processes can be organized at a high level, there are serious difficulties in this area. The main ones are financial. The problem is the lack of funds, since neither Russian enterprises nor the state can provide them in sufficient quantities. For example, the amounts of funding of the Federal Target Program "Research and development in priority areas of development of the scientific and technological complex of Russia for 2014–2021" do not change [2]. Each year, the amount is about 1.3% of GDP.

At the initial stage of this program, there were some shortcomings. Russia could not reach the necessary level that could meet the demand for innovative products. In addition, less than 10% of the total number of business organizations in the country are involved in the innovative process. At the same time, in European countries, this figure reaches 75% [3]. In the context of financial conditions which are favorable for the innovative entrepreneurship development, it is necessary to mention federal sources of innovation activities financing. These include:

- foundation for Assistance to Small Innovative Enterprises (FASIE). This fund provides support to organizations which create innovative high technology products and lop new technologies [4]. The main fund programs include "Smart Man", "Start", "Development";
- Russian Venture Company (RVC), which is a state-owned fund of all venture funds [5]. Its main task is to encourage venture capital investments and financial support for high technologies. In 2019, there were 22 funds formed by RVC, the total amount of which is 33.2 billion rubles.

In addition, support is provided by the Russian Ministry of Labor, development institutions, which include the Skolkovo Foundation, and OJSC "ROSNANO". Bank for Foreign Economic Activity provides concessional lending and guarantees [6]. To prove these claims, we can cite figures that reflect the level of technological development. In this context, the indicators of the share of high technologies in the volume of production and exports, which in Russia account for less than 26% of the total volume, are relevant. At the same time, in developed countries, these indicators reach 70%. In addition, our country has a rather low level of cluster development, weak cooperation between universities and the industrial sector, and unstable relationships between participants of innovation activities.

As a result of all this, we can observe the poor quality of the innovation environment in Russia. This reality significantly hinders the development of innovative entrepreneurship, as well as impairs the ability to implement the abilities of employees [7]. We see that today, despite the problems, Russia has ambitious strategic development goals. One of them is to ensure a high standard of living of the population, for which many measures aimed at improving the current economic condition are carried out. One of the priority ways for our economy is to solve the task of the transition to an innovative socially-oriented development model.

In modern conditions, this is quite difficult to do, since there are a large number of internal problems and external risks. Good governance requires adequate regulatory mechanisms. In order to save money, various low-cost ways of establishing contacts and cooperation can be used. This includes support for startups, creation and development of incubators, consulting support, etc. Their effective implementation will allow Russia to develop in the trend of global movements of innovative development, even in conditions of financial constraints.

## 4 Discussion

Financial support of innovative entrepreneurship, implemented in recent years, means the satisfaction of various needs of business entities, regardless of their development stage. Today, there are numerous programs developed by the Ministry of Economic Development of Russia, the essence of which is to support small and medium-sized businesses. Guarantee funds were created that provide guarantees for loans. Support is provided in the form of grants, leasing, microfinancing and training. Also, the development of infrastructure to support innovative entrepreneurship should be noted, which is implemented through the creation of business incubators, industrial parks, and technology parks. Lately, their active construction has been observed. In 2020, the volume of investment in the design and construction of this infrastructure is expected to reach 101.8 billion rubles. Thus, the state can receive more than 70 billion rubles of tax payments from enterprises that will operate in industrial parks, which will increase GDP by 1% every year. Industrial parks can help to form domestic demand for investments. Such objects help to localize the production effectively and to achieve economic effect by concentrating resources on a limited territory. There are many industrial parks in Russia. For example, such as “Perspektiva”, “Master”, “Himgrad”, etc. Technology parks are created for the purpose of carrying out activities in the field of high technologies. In particular, the development and implementation of innovative and production projects. Residents of such structures can use numerous services, this helps to develop their innovative potential.

## 5 Conclusion

Nowadays, one of the priorities of the state policy is the support of innovative entrepreneurship. The Government of the Russian Federation has developed a strategy of innovative development which involves the implementation of a large number of measures, which include:

- support of private investors;
- increase in the amounts of financial support;
- helping new innovative companies to enter the global market;
- expanding the range of innovative programs support;
- creating conditions for the emergence of innovative enterprises;
- support for the invention and activities of student organizations;
- development of innovative infrastructure.

The programs of the Ministry of Economic Development of Russia provide financial support in the regions of the country. Recently, such support was provided by development institutions. Namely, the Development Fund of the Center for the Development and Commercialization of New Technologies, Russian Foundation for Technological Development, state corporation "Bank for Foreign Economic Activity", etc. Their activities are mainly aimed at supporting small and medium-sized innovative businesses [8]. Development programs exist in more than 60 state-owned companies. Socially significant areas are particularly highlighted. Thus, a great emphasis is placed on youth entrepreneurship. The government allocates subsidies for carrying out activities to support young entrepreneurs, their competence, and to promote entrepreneurship in general [9].

In this context, assistance is provided in organizing exhibitions and centers for youth innovative creativity [10–12]. About 10 million rubles are allocated from the budget for the creation of one such center. In our country, there are many of them. One of them is the All–Russian Educational Forum "Seliger". An important role here is played by the institutional framework, which is the basis for maintaining the stability of economic legislation and the absence of administrative barriers. It includes the legal component of innovative development.

The Federal law "On amendments to certain legislative acts of the Russian Federation in connection with improving the alienation of immovable property located in the state property of constituent entities of the Russian Federation or municipal ownership and leased subjects of small and medium-sized entrepreneurship" from 02.07.2013N 144-FZ sets for entrepreneurs the advantage of the purchase of the premises, which are owned by the state [13]. This, in turn, contributes to the strengthening of the property basis of entrepreneurship.

In addition, The Tax Code of the Russian Federation establishes many special regimes [14]. This includes the patent system, the simplified tax system. A good incentive for the development of innovative entrepreneurship is tax exemption, as well as the ability to buy property from the subjects of the Russian Federation without paying VAT. Registered individual entrepreneurs have the right to have a tax rate of

0% within two tax periods under the simplified or patent system [15]. Innovative entrepreneurship in our country is developing, but it lags far behind the level of economically developed countries. This is despite the availability of a large amount of resources and labor, as well as the richest reserves of mineral raw materials.

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# Development of Digitalization and Electronic Resources in the Work of Tax Authorities

**A. R. Salkina**

**Abstract** In the modern world, when the informatization of processes in the economy is particularly fast, the tax system is actively functioning and improving the official portal of the Federal Tax Service. Now the official website of the tax authorities provides taxpayers with the opportunity to use more than 20 types of services in electronic format, namely: to get information about their debts on tax payments, check the debt and other aspects of interaction with government department. Since 2020, the tax authorities have developed and put into operation several more modernized electronic services that allow you to answer frequently asked questions of taxpayers, while excluding a personal visit to the tax authority; and to get freely available information about the property tax rate for the subjects of the Russian Federation. In the context of the current digital Russian and international economy, qualitatively new approaches to tax administration are being formed, which has made it possible to practically abandon traditional forms of inspections. All transactions with tax risk automatically come to the attention of the tax authorities through remote monitoring and analytics tools with a clear gradation of taxpayers by risk zones. The article will analyze the main methods of working with electronic resources of tax authorities, identify an approach to the modernization of existing digitalized forms of work of the Federal Tax Service.

**Keywords** Digitalization of tax authorities · Electronic services · Federal tax service · Improving the quality of work of tax authorities

## 1 Introduction

Over the past decades, the work of many government agencies has undergone major changes. Most often this could be due to global digitalization of the economy, which has affected absolutely all spheres of activity. All business structures have moved their work to an electronic environment, or are beginning to work on transforming

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the business into this format. The state authorities could not help but react to such changes. In the Russian Federation, since 2005. A large-scale project on working with electronic resources has been launched to create a more convenient way to track, verify and operate the work of both legal entities and individuals. Starting from the website—"state services", ending with the registration of vehicles. The Federal Tax Service was one of the first to begin work on the transformation of its activities towards digitalization [1].

First of all, any form of work will improve the form of control over the fulfillment of obligations to pay taxes, as well as reduce the problems of the "human factor" in the work. In the course of such transformations, processes were carried out to improve the work of the information portal, as well as to expand electronic services that provide taxpayers with an increasing range of services. In 2010, due to the emergence of the COVID-19 pandemic, the tax authorities were able to transfer the work of their services to an electronic format as soon as possible, which became the foundation for further improving the functioning of the digital environment in this structure.

As mentioned above, in the Russian market, electronic services in the public sector are a relatively young service. However, in Russia, a whole sector of new forms of this kind of activity is developing quite dynamically, which, in turn, are the basis of the system of increasing professional services.

This article will cover the most relevant issues, such as:

- development of digitalization in the state structure;
- provide taxpayers with a number of services without offline visits to offices;
- most of the tax services that work for both individuals and legal entities are illustrated;
- the problem and quality of work of electronic services are analyzed.

The development of the correct approach in the process of forming electronic resources functioning in the tax system is associated with the receipt of funds to the federal budget of the state, and therefore with the systemic development of the Russian economy as a whole. That is why this issue – the timely transition to a digital environment-is so important.

## 2 Methodology

Communication and interaction of citizens with various departments through the use of Internet technologies has long been part of everyday life. The Tax Service currently provides electronic document management with payers through interactive services. To receive a range of public services, it is not necessary to personally contact the inspectorate. Currently, more than 50 services are available on the website of the Federal Tax Service of Russia on a permanent basis to help citizens solve various issues [2]. The most popular services of the tax service today continue to be electronic "Personal Accounts". Through the" Taxpayer's Personal Account for an individual", users can receive a huge amount of useful information about the status of their tax accounts. For example, users of this option get the opportunity to get up-to-date information about the real estate objects listed on their balance sheet, as well as vehicles. In addition, taxpayers have the right to fill out and submit a tax return on Form 3-personal income tax (with supporting documents attached), and then track the status of its internal audit and communicate with any tax authority online. In the future, if necessary, all the documents can be printed out.

Analyzing the available data on the practices listed above in the modern tax system, the following aspects were identified that require more detailed study. These aspects can be presented in the form of related tasks of this study:

- analysis of the functioning of the existing electronic resources of the federal tax authority of the Russian Federation;
- analysis of the opportunities that are provided to individuals and legal entities in connection with the transfer of the work of the Federal Tax Service to the digital environment;
- analysis of the trends that have developed in the modern tax system regarding the use of digital technologies for communication between taxpayers and government agencies.

Based on the tasks set in the course of the study, a theoretical analysis of the available literature in this area was carried out, as well as an empirical analysis in the format of monitoring the activities of the online portal of the Federal Tax Service. In addition, in order to obtain more informative and accurate data, modern practices of using modern technologies to ensure the functioning of these services in the current realities of society's development were studied.

## 3 Results

As mentioned above, electronic services in the work of the Federal Tax Service have become increasingly used. This reduces the risks for taxpayers –it makes it possible to check the completeness and correctness of tax payments already at the stage of filing declarations and forming payments. One of the approaches to reducing the level of risk in the implementation of the taxpayer's functioning and conduct of activities in the era of the introduction of digital technologies is the use of electronic services. These services help to increase the transparency of business on the part of legal entities and individual entrepreneurs, including with the help of the new resource "Transparent Business", which is still in the editorial office of the administrators of this resource. The service allows you to get comprehensive information about the taxpayer-organization and helps to increase security when choosing counterparties. After all, the more information a taxpayer has, the less likely it is that an unscrupulous business entity will become his business partner. Recently, this service was supplemented with a tax burden calculator, which is an additional tool for assessing tax risks [3]. More than a dozen electronic services of the FederalTax Service are already successfully functioning (Table 1).

**Table 1** Current electronic services of the Federal Tax Service of the Russian Federation

| Service name | Structure of the electronic service of the Federal Tax Service |
|---|---|
| Personal account | • Personal account of individuals;<br>• Personal account of the taxpayer of the legal entity;<br>• Personal account for taxpayers on professional income (self-employed);<br>• personal account of an individual entrepreneur;<br>• Personal account of the taxpayer of a foreign organization |
| COVID-19 | • What help can my business get;<br>• List of persons subject to the bankruptcy moratorium;<br>• Checking the possibility of obtaining a deferral/installment plan in connection with the coronavirus;<br>• Verification of eligibility for a COVID-19 grant;<br>• Checking the possibility of tax exemption, in connection with COVID-19;<br>• Verification of the right to receive a subsidy for disinfection measures |
| Business registration | • State registration of legal entities and sole proprietors;<br>• Selection of a standard charter;<br>• Create your own business |
| Information about TIN | • Submission of an individual's application for registration;<br>• Information about the TIN of an individual;<br>• Information about invalid TIN certificates of legal entities and individuals |
| Payment of taxes and duties | • Payment of taxes and duties of individuals;<br>• Payment of taxes and duties of sole proprietors;<br>Payment of taxes and duties of legal entities |
| Business risks | • Transparent business;<br>• Request to provide a person with data on the receipt of information and information on state registration to the tax authority;<br>• Information about legal entities and sole proprietors in respect of which documents for state registration are submitted |
| Tax calculator | • Tax calculator that allows you to calculate the cost of a patent;<br>• Calculator that provides the calculation of the taxpayer's insurance premiums;<br>• Calculator for determining the transport tax for a specific taxpayer, considering individual characteristics;<br>• Calculator for calculating land tax and property tax in relation to individuals;<br>• Calculator that allows you to calculate the tax burden;<br>• Selection of the appropriate tax regime;<br>• Calculator of the effectiveness of the implementation of electronic document management |

Table 1 lists the main and most popular electronic services of the Federal Tax Service of the Russian Federation among taxpayers. It is the work in these areas that the tax authorities receive the biggest requests. For example, the FTS for the Smolensk Region summed up the results of the work of Internet services on the official website of the Federal Tax Service of Russia as of 24.12.2018. Since the beginning of the year, more than 155 thousand user requests to the “Taxpayer’s personal account for individuals” from almost 50 thousand users have been registered. Electronic resource-the leader in the line of services of the tax service [4]. Since January of this year, 23,289 new users have become owners of their own virtual inspection on the site, who were able to compare calculations with the budget, find out up-to-date information about the status of current tax arrears, the presence of real estate objects on the balance sheet of the tax subject, as well as pay existing debts online, about tax arrears, the presence of overpayments, about objects of movable and immovable property, print out receipts for the payment of taxes and pay them online. The total number of individual owners of the personal account is 71,789 people [5]. 49,295 requests from 3362 users were registered from the owners of the keys to the Taxpayer’s Personal Account for Legal Entities. They submitted 13,107 documents to receive state services. Monitoring of the Questionnaire service revealed a generally positive assessment of the tax service’s activities among 96.5% of taxpayers who took part in the survey.

## 4 Discussion

Analyzing the conducted research, it is worth paying attention to the existing practice in the field of the use of digital technologies in taxation, namely in the previously considered electronic services. So, for example, in Russia, namely in its server regions, the declaration campaign is actively gaining momentum—one of the most stressful periods, both for employees of tax authorities and for taxpayers. By April 30, 2015, not only individual entrepreneurs, but also individuals who have received income from the sale of movable and immovable property that has been owned for less than 3 years, in the form of winnings and prizes, as a result of donation, from the rental of property, as well as in cases where the tax on personal income was not withheld by the tax agent, must complete and submit a declaration on the form 3-personal income tax for the previous year. Starting in 2020, after the rapid development of digital technologies, the situation began to improve markedly [6].

For the convenience of payers, the Federal Tax Service has developed a special program—“Declaration 2014”, which greatly simplifies the filling out of the declaration, since repeated data is entered automatically, and all calculations are automated. Distributions for download are available on the website of the Federal Tax Service of Russia www.nalog.ru in the section “Software tools for individuals” [7]. It should be remembered that for 2014, you should submit a declaration of 3-personal income tax in the form approved by the order of the Federal Tax Service of Russia. The electronic service of the website of the Federal Tax Service of Russia opens up huge opportunities for users of its services, in particular for individuals who have passed registration. Among such opportunities, it is possible to highlight filling out the personal income tax declaration in electronic form and tracking the status of its internal audit.

One of the main advantages of filling out the declaration in the personal account is that payers cannot enter some of the information in the reports, which in turn are added automatically. The Federal Tax Service of Russia's Office of Tax Payers recommends paying attention to another service on the website of the Federal Tax Service of Russia. The regional development "Learn about the obligation to submit a declaration of income 3-personal income tax" will help you check whether there is a duty to report income starting in 2014. In order not to waste too much time waiting at the inspection, you can make an appointment virtually through the service of the site "Online appointment at the inspection". You can choose a convenient day and time to visit the tax office in a few minutes [8]. However, mediation between the tax authority and the taxpayer in relation to pre-registration is not the only advantage of these innovations in the functioning of the FTS website at the present time. Next, we will consider some of the electronic resources of the Internet portal available in modern practice, which allow for more comfortable interaction with state authorities in the field of taxation.

For individual entrepreneurs with an electronic signature, a similar resource allows you to find out information about overpayments and outstanding payments, deadlines for paying taxes and filing reports, as well as choose the tax regime, submit applications to the tax authority, track the progress of applications and requests, receive certificates on the status of settlements with the budget, reconciliation reports.

The "Personal Account of a taxpayer of a legal entity" provides enterprises with online services related to state registration, reporting, obtaining certificates and statements of various forms, including on arrears of taxes and fees. To plan your visit to the inspection in advance, the very easy-to-use service "Online appointment to the inspection "will help you. To make an appointment via the Internet, you need to select the day, time and service, and then print out an automatically generated ticket that you need to present to the inspection. Currently, the registration of a legal entity or sole proprietor does not take much time, since it can also be carried out online without a personal visit to the tax authority. This process can be carried out through the Internet service for state registration by submitting electronic copies of the necessary documents. And the section "Providing information from the Unified State Register of Legal Entities/EGRIP" makes it possible to obtain an extract from the Unified State Register of Legal Entities or Individual Entrepreneurs on the basis of a request sent via the Internet [9]. Thus, having identified the main trends in the modern practice of developing information systems in taxation, we can conclude that this practice is quite relevant in the modern world and is quite actively developed and supported by both the state and taxpayers. This topic is often raised in modern research by both Russian and foreign authors. For example, in the work of Moloshnikova and Baitemirova [10], the frequency of appeals of taxpayers to the services of the portal of the Federal Tax Service was analyzed. In addition, the authors identified problem areas in the development of digitalization in the tax system and identified the main directions for improving these services.

## 5 Conclusion

To achieve the greatest convenience of taxpayers in the face of individuals, an approach is currently being implemented that allows you to get timely and up-to-date information about tax arrears and accrued amounts, as well as the history of their payment by using your own personal account. In addition to this information, taxpayers are given the opportunity in real time without visiting the tax authority to obtain data on the presence of movable and immovable property in the accounts of an individual, as well as to pay off current debts online or by receiving and submitting receipts to the bank. In addition, taxpayers can use the service for receiving tax notifications to monitor all tax transactions and overpayments for the purpose of further disposal using the services of the service.

To access the service "Personal Account of the taxpayer", you must obtain a registration card and a primary password from the tax authority. Individual entrepreneurs were offered to use the mobile application of the service, which allows you to perform many actions. For example, in a convenient form, you can get an extract from the USRIP for your business, as well as up-to-date and reliable information about registration with the tax authorities in an online format, information about the current tax arrears, the amounts of accrued and paid tax payments, the presence of overpayments, decisions of the tax authorities on the offset and refund of overpaid or recovered amounts, settled debts, outstanding claims for tax and other mandatory payments, measures of compulsory debt collection.

Thanks to the "Personal Account", organizations can receive about ten services related to state registration, reporting, as well as responses to requests, certificates and statements, including on tax arrears. Representatives of organizations and entrepreneurs were told about the possibility of registering and re-registering cash registers without visiting the tax authority-through the "Personal Account".

In addition to specialized services, the site also offers services for a wide range of users. With their help, make an appointment with the inspectorate, ask a question or contact any tax authority. Of the 50 services on the website of the Federal Tax Service of Russia, the most popular are "Find out about the complaint", "Address and payment details of your inspection", "Pay taxes", etc.

The unification of business processes of tax control with the help of an analytical system allows you to track the entire chain of movement of value added tax, instantly identify inconsistencies and prevent fraudulent actions. And as a result, it encourages taxpayers to create a transparent tax environment and voluntarily clarify their tax obligations. This changes the format of control and supervisory activities, which focus only on potential violators or those who are outside the perimeter of the platform, and reduces the administrative burden on the business. Another area for improving the efficiency of tax control as one of the areas for improving the tax system and integrating information communication into the tax process is the introduction of online sales registers. This project helps to reduce non-production costs of organizations.

More than 1.5 million taxpayers registered more than 3 million cash registers, which is 2.5 times more than the pre-reform fleet. Every month, the Federal Tax Service tracks more than 3 trillion rubles of income in real time. Currently, almost 24 thousand cash registers are registered in the region. Online sales registers are able to send information about transactions to the tax authorities in real time, forming electronic fiscal receipts that are stored in the “cloud” storage. Thereby ensuring the control of all retail sales and increasing the transparency of the economy. In such conditions, there is no need for control in its traditional sense-with the exit of the inspector to the place of sale.

The result of using modern digital tools is a 41% reduction in the number of tax audits in the regions in 2019, while maintaining their effectiveness at the level of last year. Digital document management helps to create a dialogue between the business and the client throughout the interaction between the parties. The business paradigm is becoming more social and customer-oriented. The possibility of rapid communication between the parties increases, which allows for high-quality consultations. Of course, digitization and cloud storage technologies will help in the work of the Federal Tax Service. A single window for storing information will improve the work of tax authorities, simplify the search and analysis of information. Counterparties will be able to receive information about the tax base, the dynamics of taxation in real time and pay bills. The development of these technologies in the modern world is rapidly leading to the modernization of the tax system in the country, as the previous approaches and methods begin to become obsolete very quickly and cease to be effective.

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# Venture Capital Funding of Companies in the Context of Innovative Economic Development

**S. Y. Salomatina**

**Abstract** Venture capital funding is a type of venture capital financing, which in turn is a form of private capital. Investors provide investments to start-up companies that acquire long-term growth potential as a result. The problems of venture capital financing in Russia are associated with many factors, for example, with the relative "youth" of this industry. In Russia, the first venture capital funds began to be created only in 1994 on the initiative of the European Bank for Reconstruction and Development (EBRD). Since venture financing involves the provision of investments to start-up companies, it is necessary to consider this mechanism also as a tool for the development and support of the small and medium entrepreneurship, and, in particular, technological sector. For most Western countries, the state of the SME sector reflects the level of economic development and business activity of the population. Another problem is related to the fact that the Russian economy is mainly raw-material, so it significantly depends on the volume of resource extraction and their cost. Therefore, the development of venture capital investment is becoming one of the priority areas of innovation policy, which determines the relevance of this article. This study examines the main aspects of venture capital funding of companies, as well as the main current trends and parameters of the Russian venture capital market.

**Keywords** Innovative entrepreneurship · High-tech sector · Venture capital · Venture capital funding

## 1 Introduction

The modern economy needs significant financial investments in order to implement innovative development directions. Meanwhile, for innovative companies, most of the traditional sources of funding are inaccessible. This problem has been called the "valley of death" in the economic literature and traditionally arises when a young company moves to the commercialization phase of an innovative project from the

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prototype creation phase [1]. At this stage, the uncertainty is high, and, consequently, the risk of investing. Thus, it is necessary to neutralize many factors of both commercial and technical risk [2]. Traditionally, the source of funding for high-tech small firms at an early stage is venture capital. Venture capital does not always have a monetary form, it can also be provided in the form of technical and managerial expertise. Venture capital is usually distributed among small companies with growth potential or companies that have grown rapidly in the market and continue to grow in value [3].

As a rule, the early stage of technological development is funded by corporations, business angels, in some cases, and the state. According to the National Venture Capital Association of the United States, venture capital is the financial resources provided by professional investors who invest in young, fast – growing companies that can make a significant contribution to the development of the economy in the future. For young companies, it is venture capital that becomes the most important source of funding their own funds and the most effective way to further develop their business [4].

## 2 Methodology

When analyzing the scale and dynamics of the development of the venture capital financing market, the methodology developed by the Russian Venture Investment Association is used [5]. This methodology is aimed at developing a unified approach to assessing the statistical indicators of the Russian private equity and venture capital investment industry. The methodology is aimed at increasing transparency and reflecting the specifics of the domestic industry, as well as ensuring the harmonization of statistics of the Russian direct and venture investment market with the best international practices. In addition, the article uses The MoneyTree Report methodology, developed by PwC with the support of the Russian Venture Capital Company (RVC), based on information provided by the Russian Venture Investment Association (RVIA). The main difference between the MoneyTree methodology and the methodology for collecting and analyzing the main parameters of the activities of Russian private equity and venture capital funds prepared by RVIA is that the RVIA methodology considers the venture capital investment market together with the direct investment market. Venture funding refers to the financing of projects, including innovative ones, on a returnable basis through the acquisition of the authorized or share capital of a young company [6].

## 3 Results

Venture capital is the foundation of the company's innovative development. When considering the basics of venture investment, it is necessary to pay attention to its close connection with such a concept as innovative entrepreneurship, which is extremely important for modern forms of doing business. Private investors, venture funds, credit organizations, elements of the innovative structure of the regions, law firms—this is a far from exhaustive list of institutions with which young companies cooperate [6]. The management of a technological project from the initial stage to the stage of comprehensive implementation depends to a certain extent on the internal and external business environment, the availability of partner assistance, and a favorable investment background. At the heart of the innovation entrepreneurship system itself is the process of creating an environment for the emergence and growth of technology companies [6]. The basis of innovative development is the emergence and growth of technology companies (startups), during which the participant of the system brings the product to the market, receives income, scales and subsequently turns into a sustainable business or goes through the merger procedure with a larger player in the market or investor. The former owner and the investors cooperating with him reinvest part of the funds from these operations, remaining participants of the system and increasing their competencies.

The main disadvantage of venture capital funding for the founders of a company is that investors usually get a stake in this company and thus have a say in making decisions. Therefore, if the founders decide to attract a round of investments, it is important to ensure an adequate distribution of shares and retain a controlling stake. Venture capital as a source of funding is relevant for a project that has at least a prototype or MVP. It is extremely rare that projects at the idea stage are able to attract investment, so resorting to this source, even at the earliest stage, it is important to have the first prototype of the product and preferably the first non-system sales. As a rule, venture capital investments attract high-tech companies with high growth potential. The Russian IT sector is the most active sector, accounting for about 90% of the entire market, both in terms of investment volumes and the number of transactions [7]. The most active sectors funded by venture capital: e-commerce services; services in the field of job search; development and implementation of cloud services, mobile applications, including those related to social networks and recommendation services; telecommunications services; travel services, namely, booking tickets, hotels, reference and recommendation services; educational services; financial technologies; medical services and in the field of personal health; creation and implementation of advanced samples of computer equipment and electronics; services and resources for the accumulation, processing and transmission of audio and video content [6].

## 4 Discussion

Venture capital in Russia is a unique market that provides investors with access to advanced Russian engineering capabilities, bypassing the traditional complexities of Russian public markets, which are mostly illiquid and dominate the natural resources industry. The Russian venture capital market was in a state of retracement throughout

2019 and the first half of 2020. Thus, the volume of venture transactions in 2019 showed a decrease of 2% to $427.1 million from the figure of $433.7 million in 2018. At the same time, the results of the first half of 2020 showed a decrease of 9% to $240 million, compared to $262.8 million in the first half of 2019. The total volume of the Russian venture capital market is estimated at 2.3 billion US dollars in 2019, which is 3.4 times more than in 2018. Much of this growth is due to large investor exit deals [8].

In accordance with the context of the events of the first half of 2020, projects related to the organization and control of remote work, training, as well as projects in the consumer goods segment received venture funding. In 2020, the COVID-19 pandemic disrupted the sustainable operation of many industries, but the venture capital market is traditionally resistant to economic crises and uses them as a foundation for further development. In Russia, the first half of the year predictably showed a serious drop in the number of transactions, but their volume decreased not so dramatically—by 9%. Venture capital investment, first of all, declined in the segment of seed stage transactions, being redirected to projects that have proven their viability. Statistics also confirm the emergence of new favorites-projects in the field of EdTech and consumer goods, which allowed us to cover the basic needs of people during the period of self-isolation and restrictions on movement. At the same time, at the seed stage, the size of the transaction was halved (from $0.7 to $0.3 million). At an early stage, the average transaction amount decreased by 19% (from $2.3 to $1.9 million). At the startup stage, there was a decrease of 39% (from $2.7 to $1.7 million). The average transaction size in 2019 was adjusted by 9% from $3 to $2.7 million in 2018.

The first half of 2020, along with the first half of 2019, was marked by the conclusion of a major transaction with the company Ozon.ru ($150 million in the first half of 2020 versus $119.3 million in the same period in 2019). Despite the fact that the company is at a very mature stage of development for the Russian market, the transaction is classified as a venture type, due to its digitalnative structure and the ability to grow at a faster pace without significantly reducing margins. Other significant deals in 2019 included a $40 million investment in an online movie theater ivi.ru and attracting investment rounds by Dostavista and Wheely in the amount of $15 million for each company [6]. The volume of the TOP 20 deals in the first half of 2020 is $230 million, or 96% of the total market volume of $240 million. In addition to the May transactions with the companies "Doctor Ryadom Holding" and "Kuhnya na rayone", we can highlight the January transactions with the participation of RDIF funds with companies Travelata.ru, CarPrice and Elementaree.

In the first half of 2020, 2,483 grants were issued in the amount of $51 million, which is 10% more in monetary terms ($46.4 million) and 5% more in quantitative terms (2,357 grants issued) than in the first half of 2019. The number of grants issued in 2019 increased to 5,551 against 3,955 in 2018, an increase of 40% in quantitative terms and 55% in monetary terms ($153.5 million in 2019 against $99.3 million in 2018). The Innovation Assistance Fund or Bortnik Foundation is the most active fund-giver for small innovative Russian enterprises [9]. According to the results of the study and the dynamics of 2020, it is believed that, following the global trends, the Russian venture capital market will quickly recoup the decline. Already, there is a rapid increase in the number of venture funding transactions – both new and postponed in 2020.

## 5 Conclusion

Although the Russian venture capital market is still in its early stages, it is gradually growing and expanding. After conducting a comparative analysis of the effectiveness of venture financing in Russia and abroad, it was revealed that the share of venture investments as a percentage of Russia's GDP is 0.007%, which is 11 times less than the average for OECD countries. According to the auditors, Russia is 43 times inferior to the OECD countries in terms of venture capital investments. The share of venture capital investment at the seed and initial stages in Russia is 7% and 20%, respectively, compared to 10.5% and 52.8% in the OECD countries, respectively [10]. In particular, there are no forecasts and scenarios for the development of the venture market, as well as official statistics on the volume and structure of the venture market, which is a risk for making management decisions. There is also no information about the total amount of federal budget expenditures on innovation activities, venture capital and direct financing of innovative projects. It is not possible to make a comprehensive assessment of the effectiveness of the use of state support funds aimed at financing innovative projects. Meanwhile, government subsidies to technology companies are an important source of funding. An analysis of the development of venture capital abroad shows that the need for state participation depends on the degree of maturity of the market at the moment under consideration. The stage of preparing the regulatory and legal framework, creating infrastructure, and popularizing entrepreneurship among the population is characterized by a high level of state participation. This development is unavoidable by nature, and many recognized venture capital leaders have gone through it in their time. Further, it is necessary to reduce state participation and encourage the emergence of private investment players. Greater freedom for independent companies gives them the prospect of diversifying their financial flows, increasing the return on investment. The state here should act as an assistant, ready to prevent the collapse of the market [11]. The driver of the development of venture capital tools is the above-described system of innovative entrepreneurship, its self-replicating component, which is provided by the departure of some and the arrival of other teams on the market. This system is characterized by what is required at the current stage of the formation of the venture market: the state is only engaged in supporting infrastructure and working out international relations to attract foreign partners.

Standardized investment documents are not used in Russian venture capital transactions: first, there is no venture market association like the National Venture Capital Association (NVCA) in the US and the British Private Equity and Venture Capital

Association (BVCA) in the UK that has developed these forms. Secondly, the transaction documentation is determined by the applicable law, which, in turn, is governed by the jurisdiction of the investee company [12].

In 2014–2016, Russian legislation adopted a number of amendments that clarify some existing concepts of Russian law and introduce several new articles regulating transactions into Russian legislation, such as:

- guarantees and compensations;
- put and call options;
- rights of the parties to shareholders agreements, including voting rights, right of first offer (ROFO), right of first refusal (ROFR), partnership and drag-along rights;
- arbitrability of corporate disputes (subject to a number of restrictions provided for by the mandatory accreditation procedures of arbitration institutions).

In general, the amendments to the Russian corporate legislation have given shareholders more freedom in regulating their relations. Although these clauses are common for transactions governed by common law, they are still subject to a number of uncertainties under Russian law. In addition, many tools are still missing or have no legal force in practice (for example, it is difficult to structure the standard provisions on the protection of venture capital investments from blurring in Russian legislation). In order to use the standard set of venture capital instruments, the parties usually incorporate the invested company in a foreign jurisdiction, and this practice is expected to continue in the near future.

Thus, the analysis of the prospects for the development of venture financing allows us to highlight the strengths of Russia in this process. In particular, the country has a strong technical education, and, as a result, many strong technical specialists who are widely in demand abroad. In addition, it was revealed that in Russia there is a positive dynamics of the IT sector. Finally, our country is going through a stage of enhanced institutionalization of the venture sphere. An important driver of venture capital funding for Russian companies can be the formation of a high-quality legal environment, especially in the field of regulating the protection of intellectual property rights.

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# Modeling, Risk Assessment and Efficiency of Infrastructure Projects

**N. A. Arkhipova**

**Abstract** Modeling of infrastructure projects, risk assessment at the design, implementation and application stages is a rather relevant and complicated issue. It is necessary to carefully calculate the elements and parameters of infrastructure project. Economic and financial analysis of infrastructure projects is essential to ensure the viability of the project. The modeling should take into account all possible risks from the moment of design to implementation. The key to effective analysis and control is to timely measure the actual results of the project activities with the help of certain tools, regularly anticipate the necessary adjustments to the project plan and complete it on time. Performance indicators can be applied at each stage of the project, i.e. in terms of product, outcome, or impact. These indicators can provide useful information for project management, monitoring, and evaluation to make or change a project. Infrastructure projects are subject to the influence of negative factors during the crisis, due to the significant impact of infrastructure on the economy of the regions, the analysis of such projects becomes more relevant.

**Keywords** Infrastructure project · Modeling · Project assessment

## 1 Introduction

Modeling of an infrastructure project includes the following elements: detailed study of the physical characteristics of the infrastructure object, its legal status, analysis of its location, analysis of its most effective use, analysis of the functions that are acceptable for the object, forecast investment analysis of the possible development and functioning of the infrastructure project, formation of the concept of building placement by functional capabilities. The life cycle of an infrastructure object is the period during which this object functions as a physical object in a state suitable for carrying out activities for its intended purpose. The parameters of infrastructure projects can be detailed: the level of project implementation, the amount of

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investments, expected investor, as a result of whose initiative is launched, application sphere, agreement term, investment stage, project launch potential [1]. When modeling an infrastructure project, it is important to consider such aspects as: launch dates (long-term or short-term), are they included in the national list of projects or not, probability of implementation (unrealistic, unattractive, high probability of implementation), possible implementation risks.

## 2 Methodology

Among the many risks that accompany the implementation of any infrastructure project, a high probability of occurrence is possible at the operational stage. If we consider the utility industry, then it is possible at the construction stage. Due to the last crisis associated with the spread of coronavirus infection, a huge number of social, transport and other infrastructure facilities are under threat of modeling, construction and implementation, despite many measures taken to prevent the shutdown of projects. 79 infrastructure projects with investments totaling 656.4 billion rubles were in a crisis. Infrastructure projects, when they are modeled and implemented, face risks: unstable economic conditions, delayed negotiations on financing terms, rising interest rates on loans and borrowings, rising prices of commodity stocks and supplies, delayed deliveries, changes in demand, and as a result, a decrease in the number of potential customers, and others. There are many risks that people can face when modeling infrastructure projects [2]. The distribution of risks by stages can be seen in Table 1: A—Transport, B—Telecommunication, C—Energy, D—Communal, E—Social, F—Other.

## 3 Results

It is possible to identify basic indicators that provide quantitative information about the socio-economic conditions on the territory or in the sector, including target groups, and show their initial values. They form the basis for: socio-economic and strategic analysis, on the basis of which the project plan is developed, monitoring the overall context, setting quantifiable target indicators, assessment of the socio-economic consequences of the project implementation.

The initial data for the analysis is developed in accordance with the hierarchy of project goals. In some cases, it is useful to collect specific data on the beneficiaries of the project. More specific indicators by sectors or sizes can provide a complete description of the beneficiaries and make comparisons with previous activities or initiatives in other areas. The initial data allows to set quantitative target indicators and assess the likely consequences (results or impacts) of the planned actions.

**Table 1** Risks of infrastructure projects in the industry level

| Risks | Stage | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| | Preparation for construction | Construction | Operation | Construction + Operation |
| Revision of the terms of the concession agreement | **A B C D E F** | **A C D E F** | *A C D E F* | *E* |
| Delaying the agreement/changing the agreement parameters | *A B C D E* | **A B C D E F** | *A B C D E F* | *E* |
| Increase in project capital expenditures | *A B C D E F* | **A B C D** | | *E* |
| Increased transaction costs | **A B C D E F** | *A D* | *A D* | |
| Project implementation freeze | | **D** | | E |
| Extending the project implementation period | *B C E D* | **B C E D** | | *E* |
| Changes in legislation | *A B C D E F* | *A B C D E F* | *A B C D E F* | *E* |
| Revenue drop due to lower demand | | | **A C D** | **A E** |
| Delayed payments from counterparties | | | **B C D** | **E** |
| Tightening credit conditions | *A B C D E F* | | *A B C D E F* | *A E* |
| Delay in the delivery of equipment or materials from abroad | | *A B C* | | |
| Significant change in the exchange rate | *A B C D E F* | *A B C* | | |
| Number of projects | 12 | 42 | 45 | 34 |

Degree of risk: **High**; *Medium*; No risk

The source for quantifying the project objectives is estimates derived from studies and benchmarks derived from previous observations and assessments. However, this data should be used very carefully and cannot replace monitoring indicators [3].

It is often impossible to quantify the goal of a project because the number of beneficiaries cannot be determined in advance. In these cases, it is advisable to use indirect or qualitative indicators, the values of which can be determined during the implementation of the project.

Software indicators. Program indicators are input indicators, end product indicators, performance indicators, and impact indicators.

Input indicators are linked to the allocated budget at each support level. Financial indicators are used to monitor the progress of financial indicators (negotiating and paying for each relevant expenditure transaction).

End-product indicators relate to activities (for example, road construction). They are measured in physical or monetary units (for example, the length of roads built in kilometers, the increase in traffic flow in a relative proportion).

Performance indicators represent the direct and immediate effects generated by a project. They provide information about changes that affect the behavior of direct beneficiaries. These indicators can also be physical (for example, reduced travel time) or financial (reduced transportation costs).

Impact indicators represent the consequences of a project that go beyond the immediate consequences for its immediate beneficiaries. We can define two concepts of impact—specific and general. Specific impacts occur over a period, but are directly related to the taken actions. General consequences are long-term consequences that affect the general population. Measuring the second type of impact is complex, and it is often difficult to establish clear causal-effect relationships [4].

Considering the importance of the process of selecting, defining, structuring and quantifying indicators, the State Commission periodically develops an approximate list of key indicators for monitoring and evaluation. There are groups of indicators for products, results and impacts in the main areas of structural support by categories (production environment, human resources, basic infrastructure, etc.).

The purpose of implementing key indicators is to create a more reliable summary of comparisons with similar projects and to improve the process of monitoring and evaluating projects. The implementation of the methodology for selecting key indicators is not necessarily a requirement of the Commission, and the executive bodies retain the opportunity to use the classification that is most appropriate for their regional or local situation [5].

Performance indicators measure intermediate results compared to initial quantitative target indicators. They are used to measure the degree of project implementation. Performance indicators address three main issues—efficiency, management quality, and financial performance. Efficiency compares what was done with what was originally planned, i.e. efficiency evaluates how well a project achieves its goals. Efficiency is the ratio between a product, result, or impact, and investments (resources) needed to achieve it [6].

The practical measurement of these correspondences is relatively simple, but there are many difficulties. The concept of efficiency as a trend is focused only on one aspect of project effects—expected positive results. However, projects can also bring unexpected positive and negative results that cannot be captured by pre-established indicators. Performance research includes questions on achieving results with fewer resources and getting more results with the same resources. The problem of comparing the project with its possible alternatives is related to these questions. The most serious difficulty here is to choose the right landmarks. These benchmarks should preferably be set in advance to allow for appropriate comparisons and to refine the quantification of the target indicators at the programming stage [7].

Project implementation is defined in terms of the concept of resources management and efficiency and the context of administrative changes. The choice of a specific model of the criterion proposed below for assessing the public effectiveness of a large-scale investment project is based on an analysis of the current economic situation in Russia, on the one hand, and the specifics of large infrastructure network projects, on the other. The model can provide for a maximum of the real public profit from the project implementation, received at the end of the project implementation, equally from the project profit, and effective investment of funds [8].

Let's calculate the real accrued income (RND):

$$\begin{aligned} \mathrm{RNDi} = \mathrm{Sum}\Big[&\Big(\mathrm{EF}^{\mathrm{int}}_{\mathrm{n+}} \times \left(1 + \mathrm{d}^{\mathrm{i}}_{\mathrm{n}}\right)^{\mathrm{tN-tn}} + \mathrm{EF}^{\mathrm{ext}}_{\mathrm{n+}} \times \left(1 + \mathrm{d}^{\mathrm{i}}_{\mathrm{n}}\right)^{\mathrm{tN-tn}}\Big) \\ &+ \Big(\mathrm{EF}^{\mathrm{int}}_{\mathrm{n-}} \times \left(1 + \mathrm{d}^{\mathrm{i}}_{\mathrm{n}}\right)^{\mathrm{tN-tn}} + \mathrm{EF}^{\mathrm{ext}}_{\mathrm{n-}} \times \left(1 + \mathrm{d}^{\mathrm{i}}_{\mathrm{n}}\right)^{\mathrm{tN-tn}}\Big)\Big] \geq 0 \\ &\mathrm{EF}^{\mathrm{int}}_{\mathrm{n+}} = \mathrm{R}^{\mathrm{int}}_{\mathrm{n}} - \mathrm{S}^{\mathrm{int}}_{\mathrm{n}} \\ &\mathrm{EF}^{\mathrm{ext}}_{\mathrm{n+}} = \mathrm{R}^{\mathrm{ext}}_{\mathrm{n}} - \mathrm{S}^{\mathrm{ext}}_{\mathrm{n}} \\ &\mathrm{EF}^{\mathrm{int}}_{\mathrm{n-}} = \mathrm{S}^{\mathrm{int}}_{\mathrm{n}} - \mathrm{R}^{\mathrm{int}}_{\mathrm{n}} \\ &\mathrm{EF}^{\mathrm{ext}}_{\mathrm{n-}} = \mathrm{S}^{\mathrm{ext}}_{\mathrm{n}} - \mathrm{R}^{\mathrm{ext}}_{\mathrm{n}} \end{aligned}$$

where RADi is real accrued project income, $\mathrm{EF}^{\mathrm{int}}_{\mathrm{n+}}$ $\mathrm{EF}^{\mathrm{int}}_{\mathrm{n-}}$-effects and expances, participants in the year n; $\mathrm{EF}^{\mathrm{ext}}_{\mathrm{n+}}$ $\mathrm{EF}^{\mathrm{ext}}_{\mathrm{n-}}$ effects and expances of external economic entities indirectly related to the implementation of the project in the year n; $\mathrm{R}^{\mathrm{int}}_{\mathrm{n}}$ $\mathrm{S}^{\mathrm{int}}_{\mathrm{n}}$—inflow and outflow of funds of project participants in the year n; $\mathrm{R}^{\mathrm{ext}}_{\mathrm{n}}$ $\mathrm{S}^{\mathrm{ext}}_{\mathrm{n}}$—inflow and outflow of funds of external economic entities, in the year n; N—calculation period; $\mathrm{d}^{\mathrm{i}}_{\mathrm{n}}$ the yield of the generalized deposit accepted for year n; $\mathrm{E}_{\mathrm{n}}$—the discount rate accepted for the year n.

RND can be calculated by subtracting the income received from the implementation of an infrastructure project and the amount of lost profit from an alternative investment of capital. It is assumed that the non-negative part of the net cash inflow is invested in a so-called generalized deposit, the interest rate of which is equal and depends on the direction of investments chosen by the investor and the year of the accounting period. The lost profit from an alternative investment of capital is calculated differently depending on the direction of the alternative investments.

## 4 Discussion

Economic and financial analysis of infrastructure projects is essential for ensuring the viability of the project in terms of defined objectives, adequate returns to private and public stakeholders and to society as a whole. In addition, enabling risk analysis at an early stage ensures better decision-making and better results. However, project risk management is not very often used in infrastructure projects [9]. Infrastructure sustainability modeling programs often consist of projects portfolios that have to be distributed in an appropriate chronological order to maximize the benefits of the program [10]. When modeling an infrastructure project, certain questions arise. What risks should be considered? Which areas of infrastructure projects are at high risk? How should the methodological work with infrastructure projects be carried out? How to evaluate the effectiveness of investments in infrastructure projects? Is it necessary to monitor and evaluate the project? How to calculate the effectiveness of the implementation of an infrastructure project and its further functioning?

The project is evaluated after its completion. The assessment is carried out from the perspective of various aspects related to the relevance, impact, efficiency and results of the project. The certification process identifies the factors that contribute to the success or failure of the project, achievements and results, and identifies best practices, including procedures, methods, and management tools. Assessment is a key function of the project implementation phase, during which progress is assessed, allowing for changes to be made if circumstances change. It is a management tool and represents the follow-up activity to the development of activities, the evaluation of the project implementation in accordance with the approved schedules.

Project assessment identifies existing issues to facilitate timely project implementation and provides ongoing feedback on its implementation. Some authors consider evaluation as a set of methods and forms of continuous monitoring and correction of project activities in the process of project implementation.

In the process of implementing any infrastructure project, it is very important to monitor through agreed reporting procedures, random checks and the creation of special commissions. Monitoring is an ongoing process that regularly controls the progress of a project and evaluates the progress made in terms of resources invested, implemented activities, and direct results [11]. Monitoring is intended for:

- identifying current deviations between the actual development and the project plan;
- identifying the causes of deviations;
- informing the management bodies about the detected deviations;
- assistance in correcting deviations;
- to prevent possible risks in the future states of the observed parameters;
- provide a foundation for effective project implementation.

Key stages of infrastructure project evaluation in the context of the project cycle:

1. The conceptualization of evaluation as an integral part of the project cycle is the result of a more decentralized approach to their management, as well as a clearer definition of responsibilities for evaluating their effectiveness at the national and local levels.
2. Project evaluation is a continuous, gradual process, carried out at different speed and with different implementation degree. In the early stages of a project implementation, its evaluation is seen as a constraint rather than an activity that contributes to the increasing projects effectiveness.
3. As a result of the accumulated experience of project management, the approach to their assessment is changing. Now its advantages are not only beyond doubt,

but its scopes and requirements for the implementation are expanding to ensure the successful implementation of projects and more efficient use of the funds allocated to it.

4. With the increasing role and importance of assessment and monitoring to improve the effectiveness of government programs and projects and to ensure greater transparency and accountability of government activities, the requirements for the design and development of its organization, technology and procedures are increasing.

The indicators for assessment and further project monitoring are physical and financial. They are related to the specifics of the infrastructure project, its goals and the socio-economic situation in the region. The evaluation and monitoring indicators show specific goals—quantitative (as far as possible), achieved stage—physical performance, results and impact, implementation of the financial plan. To monitor the project and assess its implementation, to use a system of indicators that have to be defined in advance or at an early stage of the project implementation, so that data on them could be collected.

## 5 Conclusion

In crisis situations, it is necessary to assess the sustainability of an infrastructure project. First of all, it is necessary to determine the financial status of the project company and the lack of direction of the project indicators revision. The assessment can be carried out according to a variety of criteria: the region, the industry, the financial status of the project company and investors, the attitude of investors to the system-forming ones. According to the study, the highest score on the project's sustainability to the crisis and the first place in the rating were given to two infrastructure projects included in the national list: "Construction and operation of the fourth bridge across the Industrial Logistics Complex Sevastopol" [12].

Due to the ability to model different scenarios in the development of an infrastructure project, it is possible to determine which activities, products and processes have a greater impact on environment and, consequently, potential areas for optimization and improvement of the project [13]. Using financial modeling based on detailed project-level data, it can be found that some of the projects were additional and, therefore, would not have been built without the subsidy [14].

Monitoring of infrastructure projects is considered only as a function performed at the project implementation stage, without presenting the deployment of monitoring activities in time, that is, in a chronological aspect. To eliminate this shortcoming, a methodological procedure for working on infrastructure projects is proposed, through which the main elements of monitoring are considered in the context of the concept of integrated project cycle management. Thanks to this procedure, the stages of project activity are synchronized with the monitoring cycle, that is, they are presented in a time (chronological) and substantive aspect. This approach allows to justify the separation of monitoring activities and their separation from other project management functions. The construction of technological infrastructure and new knowledge or technologies have a greater impact on the successful development of the regional economy. The technological aspect is related to the way of managing the development process. Higher levels of technological risk require longer project development periods and more design cycles [15].

There is much discussion of the growing challenges faced by organizations managing outdated infrastructure that supports society, often with a large lag in intervention due to the fact that financial resources are not always easily available, especially in the case of national, regional or municipal critical infrastructure in the water, energy and transport sectors. It is important that such infrastructure organizations continually improve their asset management capabilities to systematically optimize performance or service level by modeling and predicting infrastructure, lifecycle costs, managing the risk of failure, and finding strategies to finance both short-and long-term investment needs [16].

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# Information and Economic Aspect of Audit for Sustainable Business Development

**T. A. Bityukova**

**Abstract** Financial statements are the main information base for many groups of interested users. Both receiving investments, especially foreign direct investments, and additional financing are welcome steps for business development, bringing it to a new level. But any investor needs information about the investment object and gets it mainly from the audit report. The market of audit services in Russia cannot be considered fully formed, as legislative changes have recently led to a reduction in the number of audit firms and their consolidation. Accordingly, many organizations faced the question of choosing a new auditor to conduct a mandatory audit and calculate the cost of audit services, usually higher. The paper uses the methods of expert analysis of regulatory and legislative documents in the field of legislative regulation of audit activities, comparative analysis and synthesis. The article examines the relationship between the economic information of the primary audit and its necessity for ensuring the sustainable development of the business. An assessment of the possibilities of confirming account balances from the point of view of a possible change of the auditor is carried out. The options for obtaining the economic information necessary for the initial assessment of the business are given. Comparing international auditing standards with the practice of obtaining audit evidence during the initial audit allows us to find common approaches and improve the quality of the audit. This helps to reduce the risks of poor-quality information and contributes to the attractiveness of the business as an investment object.

**Keywords** Business · Economic information · Primary audit

## 1 Introduction

The successful introduction and implementation of the sustainable development goals and objectives largely depends on the participation of business in this process [1]. The Organization for Economic Cooperation and Development (OECD) identifies the

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following areas of business involvement in achieving the goals: foreign direct investments, combined financing, and responsible business conduct. Business becomes the main driver of economic growth, creates jobs, financial flows, creates new technologies and introduces innovations [1]. When developing and enlarging a business, enterprises sooner or later face the need to conduct a mandatory audit. Russia's transition to international auditing standards allows enterprises to obtain an audit report in an international format that is recognized worldwide. This makes it possible to become more investment-attractive, but at the same time imposes responsibility for the quality of the economic information presented in the form of financial statements.

## 2 Methodology

The choice of an audit firm to conduct a mandatory audit is determined by a group of factors and relevant criteria. In an enlarged form, they can be presented as follows: legal factors of mandatory audit, commercial factors of the audit services market, intracompany factors. Legal factors determine the obligation to conduct an audit in accordance with the norms of the current legislation of Russia. The Federal Law on Audit Activities contains mandatory audit criteria, according to which an organization is required to submit an audit report as part of its annual financial statements.

The involvement of an auditor to conduct an audit is accompanied by the selection and evaluation of audit firms represented in the market of audit services. The commercial factors of the audit services market include the rank or rating of each audit firm and the cost range of the works to be performed. However, the financial situation of the organization itself and its internal factors, such as the size of the business, location, and availability of financial resources, do not always allow you choose the desired auditor due to a mismatch of interests and capabilities.

## 3 Results

The proof of responsible business conduct is, from an economic point of view, high-quality and reliable financial statements. At the same time, the choice of an auditor to confirm such reports is responsible and often leads to the need to change the auditor to a new, larger and well-known one, preferably with a world name. Thus, the economic aspect of sustainable development raises two interrelated issues between the enterprise and the auditor:

- how to choose a new auditor and whether it is worth changing it at all, given the possible increase in the cost of works;
- how the auditor conducting this audit for the first time can confirm the initial accounts balance.

For each enterprise, as it grows and expands its business, there is its own “first check”. At the same time, the concept of primary audit can be applied both when changing the auditor, and when there is a sharp change in the direction of the organization’s activities.

The change in the system of legal regulation of audit activities in Russia in terms of increasing the criteria for the cost indicators of mandatory audits to 800 million rubles in terms of revenue and 400 million rubles in sum of assets of the balance sheet leads to a change in the structure of participants of the audit services market. These changes of Federal Law “On Audit Activity” of 30.12.2008N 307-FZ [2] entered into force on January 01, 2021, respectively, small and medium-sized audit firms “leave” and only large participants in the audit process remain. And this process can have a very positive impact on the concept of “responsible business conduct”. In this regard, it is quite natural to change the auditors who conduct the mandatory audit of the annual accounting (financial) statements.

Current business activities conditions and changes in the legal regulation of audit activities oblige auditors and audit firms to follow the international standards of audit (ISA). The practical majority of ISA were translated into Russian and were previously reflected in the federal standards of audit. However, some of the standards were either not fully used, or not used at all. Partly, the problems of introducing ISA into Russian practice are associated with an unclear, “blurred” interpretation of certain terms, the theoretical orientation of the standards and the lack of specific methods that adapt ISA to Russian reality. Individual standards did not find practical application due to the lack of technical feasibility, as they often involve the use of special software products, usually associated with a single computerized accounting system.

Confirmation of balances at the beginning of the first audit combines the requirements of two international standards. Without performing these procedures, the results of the initial audit lose their practical meaning, as they can be greatly distorted due to incorrect initial balances.

When an independent auditor is engaged under a contract to conduct a mandatory audit, he/she reviews the full set of annual financial statements and confirms its reliability by issuing an audit report of the established format. At the same time, the auditor uses the term “reasonable assurance” to justify his opinion. In case of reviews, we can only talk about limited confidence. The auditor simply does not have the necessary time to obtain sufficient audit evidences. Therefore, taking into account the strict time limit, it is extremely important for the auditor to properly allocate his/her forces and correctly compile a list of proposed works. In a certain sense, the review allows to conduct a rapid analysis of the balance. The term “audit” is used in this standard only in connection with the fact that an independent auditor will conduct a review of financial information and even the set of statements here may not be complete, but abbreviated.

International Standard on Auditing 510 (ISA 510) Initial Audit Engagements – Opening Balances [3], is devoted to the problem of confirmability of initial balances. The standard is not completely independent and should be considered together with the ISA 200 Overall Objectives of the Independent Auditor and the Conduct of an Audit in Accordance with International Standards on Auditing [4].

ISA 510 defines that audit assignments conducted for the first time occur if:

- a mandatory audit for this company was not conducted in previous periods;
- or the audit was conducted by another audit firm [3].

Both the first and second circumstance do not provide the auditor with reliable confirmation of the initial balances, without which it is impossible to speak about the reliability of all significant indicators of the confirmed financial statements. Therefore, the auditor conducting the audit for the first time should provide for actions in his audit program to confirm the input balances.

The need for the auditor to verify the correctness of the formation of balances at the beginning of the reporting period is related to the need to ensure comparability of financial statements. If the same auditor performed the previous audit, the risk of incorrect transfer of balances is significantly reduced [5].

The balances at the beginning of the audited confirmable period are formed on the basis of the correct and item-by-item transfer of the balances formed at the end of the previous period, provided that the accounting policy is applied consistently. If the audit was conducted by another auditor in the previous period, the previous auditor's report may be reviewed for reservations and dissenting opinion. The audit report is more informative, but since this document is not included in the system of economic information, the management of the enterprise has every right not to provide it for review to a new auditor, especially if there were indications of the law violations. Contacting the previous auditor is not allowed by the standards of professional ethics and the requirements of maintaining the confidentiality of the client's information.

The auditor's responsibilities should include independently obtaining sufficient and properly executed audit evidences about the presence/absence of significant (material) misstatements of the balance sheet items. As the main methods of obtaining evidence, the auditor uses a request (usually internal) and analytical procedures when confirming the initial balances. For a more rational organization of working hours, the auditor is recommended to determine in advance the number and types of requests in different directions. It is allowed to send pre-prepared requests to the leadership of the audited entity immediately after signing the contract, or even at the stage of approving tasks. The initial inspection procedures may include the following consolidated areas:

1. Getting general information about the organization.
2. Analysis of consolidated items of the balance sheet (statement on financial position) with simultaneous examination of all responses to requests.
3. Preparation of a report and/or an audit report in a special form in accordance with the recommendations of ISRE 2410 [6].

Of the above procedures, the analysis of consolidated balance sheet items is of the greatest interest. Let's consider their possible sequence and the fixed assets of the auditor. We consider it appropriate to start the analysis of the balance sheet asset items with the most liquid items and items that are mostly subjects to distortions:

1. Cash and cash equivalents.
2. Accounts receivable.
3. Inventory items.
4. Financial investments.
5. Fixed assets and depreciation.
6. Intangible assets.

The items of the balance sheet liability can be considered in an enlarged way, taking into account the urgency and urgency of their repayment:

1. Loans and borrowings to be repaid.
2. Accounts payable for settlements with suppliers and contractors.
3. Income tax.
4. Capital.

Let's take a closer look at the procedure for analyzing the above articles and the questions that the auditor should minimally get answers to during the initial audit. For convenience, we will summarize the information in Table 1. The auditor should systematize, document and store the evidences obtained, responses to requests and all other information together with all documents related to this review. The auditor should understand that even the most careful and detailed audit of the current year's operations without confirming the initial balances cannot confirm the reliability of the final statements.

The company itself may suffer from the consequences of falsifying financial statements, as it will lose its attractiveness to potential investors who use open information to make economic decisions. If the auditor could not obtain sufficient and reliable evidences of the correctness of the initial balances, he/she should modify their opinion in the auditor's report, including a special clause in accordance with the requirements of ISA 705 [7]. Thus, taking into account the changes in the market of audit services in 2021, we can expect an increase in the share of modified audit reports based on the results of the mandatory annual audit, especially in the case of conducting an audit for the first time. The procedure and problems of selecting (changing) an auditor are discussed in the discussion.

## 4 Discussion

The quality of the audit depends on the experience and efforts of the audit team to identify and respond to client risks (responsiveness to risks) [8]. First-time audit quality suffers when team members spend more time on other concurrent clients during a busy season [9]. Loss of customer experience and problems with staff retention can further contribute to the decline in audit quality. There may be some improvements in the audit practice when the work of an existing firm will be thoroughly reviewed by a new auditor [10].

**Table 1** Analysis of consolidated balance sheet items during the review audit

| Consolidated balance sheet item | Issue to be solved | Need for request (+, −) | Independent analysis (+, −) |
|---|---|---|---|
| Cash | • Total cash and share in the balance sheet assets structure; | − | + |
| | • Number of payment accounts; | + | + |
| | • Availability of a card file for payment accounts; | + | + |
| | • Availability of foreign currency accounts; | + | + |
| | • Types of cash registers; | + | + |
| | • Structure of cash flows (operating, investing, and financing activities) | − | + |
| Accounts receivable | • Register of debtors; | + | + |
| | • Analysis of past-due debt; | + | + |
| | • Analysis of debt on internal settlements of affiliated entities; | + | + |
| | • Control of debtors according to the degree of reality of collection; | − | + |
| | • Assessment of the total share of accounts receivable in assets and in comparison with accounts payable | − | + |
| Inventory items | • Types of stocks, taking into account the profile of the organization's activities; | + | + |
| | • Dynamics of change in the total amount of margin by years: | − | + |

(continued)

**Table 1** (continued)

| Consolidated balance sheet item | Issue to be solved | Need for request (+, −) | Independent analysis (+, −) |
|---|---|---|---|
| | • Analysis of the exposure of certain categories of stocks to unfair actions; | − | + |
| | • Calculating the share of margin in assets | − | + |
| Financial investments | • Determining the types of financial investments; | + | + |
| | • Division of financial investments into categories (short-term, long-term, equivalent to cash) | + | + |
| | • Control of the reserve for impairment of financial investments | − | + |
| Fixed assets | • Availability of fixed assets in the organization and their share in assets; | + | + |
| | • Groups of fixed assets; | + | + |
| | • Availability of non-depreciable items; | + | + |
| | • The procedure for calculating depreciation; | + | + |
| | • Control of the depreciable value and correct reflection in the balance sheet | − | + |
| Intangible assets | • Availability and types of intangible assets; | + | + |
| | • Legality of placing intangible assets on the balance sheet | − | + |
| Loans and borrowings to be repaid | • Number of loans and their types; | + | + |

(continued)

**Table 1** (continued)

| Consolidated balance sheet item | Issue to be solved | Need for request (+, −) | Independent analysis (+, −) |
|---|---|---|---|
| | • Security of loans and borrowings, taking into account the current balance sheet structure; | − | + |
| | • Urgency of repayment | + | + |
| Accounts payable to suppliers | • Register of accounts payable by suppliers; | + | + |
| | • Analysis of the organization's paying capacity; | − | + |
| | • Comparison of accounts payable with the average balance of materials in the organization | − | + |
| Income tax | • Control of income tax calculations; | − | + |
| | • Analysis of incomes and expenses on the organization's accounting database | + | + |
| Capital of the organization | • Types of capital; | + | + |
| | • Presence/absence of changes in the authorized capital; | − | + |
| | • Compliance with legal regulations in capital transactions; | − | + |
| | • Azvailability of retained incomes (uncovered loss) | − | + |

The review of the working documents of the previous auditor should be used to gain an understanding of the attitude of management personnel to the need to make adjustments to the financial statements based on the results of the audit [5]. This helps to avoid threats to the auditor's independence, reduces the risks of identifying material misstatements, and allows the auditor to determine the degree of confidence in the generated incoming balances.

The application of ISA 510 [3] is a part of a rules-based approach to audit aimed at reducing the legal responsibility of the auditor, but not at improving the quality of the audit. Seeking informal advice (or thinking like a consultant) helps auditors effectively review audit plans in response to the identified risk of fraud—it helps when a clue is present or not, suggesting that it complements rather than simply replaces interventions aimed at improving auditors' judgments and decision-making [11].

The resignation of the previous auditor may be related to disagreements between the auditors and the client. We also found that the Big Four auditors are more likely to disclaim all their responsibility if they disagree with their clients. In addition, we document that successor auditors charge higher fees to firms that have disagreements with their predecessor auditors [12].

The audit fee is significantly higher for clients who report disagreements with their auditor. More importantly, the previous Big Four auditor increases the fee before the organization moves to another auditor, as customers have problems [13]. Since 2011, China has required both predecessor and successor auditors of public companies to disclose the reasons for changing auditors. However, for some companies, there are significant discrepancies between the reasons given by the previous auditor and the reasons given by their successor auditors [14].

External legal regulation affects the quality of the audit, and complements mainly quantitative studies related specifically to the rotation of firms. Audit rotation has several advantages, and one of them is that it can bring a fresh perspective on audit tasks and subsequently improve the quality of the audit [15].

The increase in the cost of the audit may lead to the fact that management will look for cheaper audit options. Firms with poor audit quality are more likely to have internal control issues disclosed by the previous auditor, including accounting issues, financial restatements, and problems with the auditor's report [16]. In addition, they are more likely to receive an audit report with reservations and explanations.

Many studies report that audit fees are discounted in the year of the auditor's change, and regulators have long been concerned that such fee discounting may impair the quality of the audit [17]. Auditors conducting an audit for the first time often offer additional services to a new client, which has a negative impact on the quality of the audit [18]. The audit standards require that auditors consider whether there is "material doubts" that their client will remain a constantly operating enterprise, and modify the audit report [19].

## 5 Conclusion

Thus, the concept of sustainable development is aimed, among other things, at responsible business conduct, which in turn can help attractting foreign direct investments. The change in the system of legal regulation of audit in Russia led to the enlargement of audit firms. At the same time, the total number of players on the audit services market significantly decreased. In 2021, for many Russian organizations, the question of choosing a new auditor, usually with higher professional ratings, is acute. Accordingly, the share of audits conducted for the first time will increase. In order to minimize the negative consequences for information users and potential investors, it is recommended to additionally use the procedures for confirming initial balances. All taken together, it is possible to increase the reliability of the data of the confirmed statements during the initial audit of the organization.

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# The Banking Services Market in the Innovative Economy Development

**D. A. Yuryev, K. N. Ermolaev, and E. S. Nedorezova**

**Abstract** At present, the Russian banking system is transforming and moving to the intensive development model, which is accompanied by active banking innovations, banking services based on modern information technologies, and the banking infrastructure that meets international standards. The study highlights various most significant changes in this area. At present, the development of digital banking services is becoming a promising direction. The development of digital products and technologies is an important competitive advantage of banks, a source of commission income and it allows attracting new highly profitable clients interested in these services. Along with this, digital services create and strengthen the image of a modern dynamic bank and have a positive effect on its reputation. It was found out that there is a significant increase in the provision of banking services through remote banking services. For example, management of bank accounts through the Internet bank, or the Mobile Bank system. In the future, an increasing number of banking services will be provided remotely, with maximum convenience for the client while maintaining his confidentiality. It was also revealed that, in connection with the large-scale increase in the Internet banking, the need to preserve personal data and protect depositors and the bank from cyber-attacks increases significantly, which in turn stimulates banks to develop and introduce innovative products and services, new digital technologies.

**Keywords** Banking innovations · Banking products and services · Credit and financial sector · Information technology

## 1 Introduction

Currently, the development of the banking services market largely determines the special role of the banking system, which acts as one of the main links of the country's economy. In this regard, the growing interest in various aspects of banking, banking products and services, methods of regulation and management of the banking

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services market is urgent. The modern banking services market can be characterized as a combination of classic credit and non-credit products with the latest innovative achievements of FinTech companies. The development of the range of financial products is due to the time, in which all market agents must resort to banks as intermediaries in monetary transactions between counterparties. This circumstance determines the development of mobile gadgets capable of providing access to the Internet and mobile banking to customers without visiting the bank's office. The development of new types of services and the line of banking products is caused by their competition with each other (we'll pay special attention to this issue in this study) and with microfinance organizations [1].

The purpose of this study is to analyze the transformation of providing banking services in the context of the innovative economy development. Identifying new needs of customers based on their use of digital financial assets, domestic and international financial organizations are using Big Data technologies to meet such needs in a timely manner and maintain competitive advantages in the banking services market. The significant relevance of the presented theoretical problems, a rather weak level of research on this issue, the importance of the formed theoretical questions for business have indicated the choice of the research topic.

## 2 Methodology

The main methodological approaches used in the study are historical, structuralist, rationalistic. The local methods of scientific analysis used are formal logic tools such as analysis, deduction, induction, synthesis of the logical and the historical. A special place was taken using methods of statistical and metamathematical analysis, which made it possible to identify the conditions to develop the banking services market in Russia. The study of the FinTech sector, including the determination of the optimal structure of financial products, involves the use of various methodological approaches and local methods. As the main methodological approaches that were used in the work, we can single out the reproductive, institutional-evolutionary and systemic ones. The use of the reproductive approach allows us to determine the essence of the FinTech sector. The institutional-evolutionary approach contributes to the study of the evolution of traditional ideas about the form and content of the category and indicates the role of regulatory and incentive institutions in providing digital goods and services. The systemic methodological approach is based on the study of the entire complex of economic problems as a system consisting of separate elements operating on dialectical principles. The application of this methodological approach allows us to classify practicing financial technologies, showing the distinctive features of each of their types. Methods of analysis of synthesis, deduction, induction, hypothesis, scientific abstraction were used as local research methods, which made it possible to reveal the essence and content of the scientific category under study.

## 3 Results

Some scholars represent the services provided by the bank in the form of specific transactions with counterparties with specific features inherent only to them, among which we can single out the following:

- hedging of operations carried out by law on bank secrecy;
- internal regulatory regulation of the transaction process;
- binding procedural rules [2].

In some cases, banking operations have a subjective composition, a limited range of objects, and special regulation. Banking services can be interpreted not only as specific procedures for the provision of credit and financial services to legal entities or individuals, but also as consulting services, for example, when opening an individual investment account or an impersonal metal account with a bank. In this case, the bank, through indirect control and carrying out transactions on behalf of the client in the financial markets (stock, commodity and raw materials, etc.), provides its client with the opportunity to passively earn and receive income in the form of interest [3].

The modern form of centralization and concentration of loan capital is moving to the global level, being realized in the form of internationalization of bank capital. There is an actively ongoing process of interconnection and integration of banking systems of countries with developed and developing economies, which means the penetration of banks of developed countries into the banking structure of countries with the emerging market, implementing the strategy of acquiring and absorbing national financial institutions. Such operations are carried out by credit institutions due to their exclusive legal capacity.

It is worth noting that banking operations can be carried out not only by a commercial credit organization, which has the right to do so and has the corresponding license. Such operations can be carried out by the Central Bank of Russia, the Deposit Insurance Agency, Vnesheconombank of the Russian Federation. In addition, recently, classic banking operations can be carried out by microfinance organizations, for example, when providing online loans. The latter, in terms of institutions providing them, can be subdivided into:

- Microcredit operations—borrowed funds of short-term repayment with high interest rates. In January 2020, the maximum rate on them was at 1.7% per day. In microfinance organizations, the maximum value of a microloan to an individual (Bystrodengi, MigCredit, Loan Center) is 1 million rubles, in microcredit organizations (Dobrye Dengi, Jet Money Microfinance, Express Credit Agency)—500 thousand rubles;
- A quick loan can be issued for several days or several months. The interest rate ranges from 35 to 55%. The loan has its own characteristics and nuances. The maximum amount of such a loan cannot exceed 1 million rubles (for example, Tinkoff Bank, Bank HomeCredit, UralSib).

Lending for a long-term period is to withdraw a loan for a long time, the term of which can extend up to three years. The interest rate on such a loan varies from 7 to 14%. Such a loan can be obtained through electronic services or in person at a bank branch (Sberbank, Gazprombank, VTB, Alfa-Bank). The undoubted advantage of the loan system is the quick response to the borrower's need for funds. You can also get a credit card with the delivery of an employee of a credit institution to a specified place from the borrower, for example, an office or home. This helps to reduce the costs of missed opportunities, as it saves time, replaces a personal appeal to the bank with a courier delivery of the necessary financial instrument [4].

Currently, the segmentation of the banking market and financial services provided on it is deepening. For example, banks have a serious competitor in their traditional sphere of providing services - microfinance and microcredit institutions, which provide lending services according to a simplified procedure for considering a client application. The latter circumstance significantly saves clients' time, and they, despite the significantly inflated interest on forthcoming payments, choose the services of microfinance and microcredit institutions.

We point out that the active development of the banking services market is currently accompanied by the rapid development of information technologies. We will consider this aspect in the context of its impact on the development of the banking products market in more detail in the next study. At this stage of our research, we emphasize the fact that the digital development of the financial environment not only provokes competition between banks, but also objectively contributes to the creation of new financial products [5]. So, for example, the result of the innovative revolution over the past decade has been the spread of such products and services as: Internet banking, mobile banking, video banking, virtual bank cards.

Such a rapid development of banking technologies contributes, as already reflected above, to the development and implementation of information technologies in modern banking. About 95% of current non-cash transactions are carried out by clients of credit institutions using modern electronic technologies. So, in 2020, the volume of such transactions increased compared to 2019 by 30% (up to 18.8 billion order transactions) in a value volume of up to 537 billion rubles. Basically, the key factor of this growth was the growth in operations of servicing transactions of individuals. Individuals made every fourth payment using the Internet or mobile banking.

However, it is worth mentioning the downside of improving innovative banking technologies. And one of the negative results of this process is the growth of risk accepted by credit institutions, both of non-payment by the client and an increase in the range and number of fraudulent transactions. From the latter, the banking system of Russia lost about $100 million in 2020. This circumstance forces banks to spend significant financial resources on improving cybersecurity, which is an inhibiting factor in the development of the banking services market [6].

Studying the technological aspect of financial transactions by banks, we cannot ignore the most important trend of recent times: the impact of the FinTech ecosystem on the transformation of services provided by the banking sector. Under the term "FinTech" we distinguish a set of financial and technological segments represented by investors, business incubators, regulatory bodies, new technologies, as well as end consumers of financial services who use technical and innovative products in the financial field. Soon, there will be the key areas that will undergo a radical technological change in their classic functions over the next five years: banking and capital markets; the sphere of asset and private capital management; insurance market; electronic systems of money transfers and payments. After analyzing the forecast of such changes, we can state that the most significant volatility in their activities will take place in the banking sector of individuals, as well as small businesses; in addition, the technology of work in the segment of brokerage services will be significantly transformed [7].

An important factor contributing to services provided by banks is the growing demand for financial products from the population, which is currently not serviced by banks (to attract this segment), as well as the deterioration in the quality of traditional services provided by banks. In 2019, about 68% of the working-age population had a bank account. Therefore, this entire consumer segment is a target for proliferation in relation to their FinTech technologies, especially in the field of payment transactions. Considering the widespread use of smartphones, this trend is the most realizable. The same applies to the interaction of banks with small businesses. The latter, to save transaction costs, resort to online banking, implemented through the interaction of banking institutions with FinTech companies, which accelerates the process of obtaining banking services, such as issuing credit resources.

We consider that it is important to note the fact that the banks' activity in the market of services they provide has changed. So, among the main trends in the provision of financial services, we can highlight the following:

1. Development and implementation of personalized offers into the Internet banking system. When ordering certificates from the bank to the client at a convenient time for him, using the appropriate menu items, courier delivery of documentation is possible. When showing loyalty to the bank, the client can receive personalized offers of financial services.
2. Transfer of bank branches (self-service zones) and customer support systems to round-the-clock operation. Thus, the bank's clients get the opportunity to manage financial resources, including online, at any time of the day.
3. Use of robots, Big Date technology and the Internet of things. With the help of these technologies, there is a full-fledged analysis of each of the clients about his financial activity, the development of a financial product specifically for him and support at each stage of the life cycle of a financial service (issuance, service, changing conditions, closing).

Thus, the specified range of banking services has recently undergone significant changes, primarily due to the use of innovative technologies by credit institutions.

## 4 Discussion

Considering the rapid transition of the loan's share of banking operations to the digital environment, one of the main trends in the development of digital banking services has become the introduction of a biometric client recognition system and the creation of a digital client profile system when using banking services. Also, in Russia, work has been underway to create a Fast Payment System using the above technologies since 2018. Among the significant trends in the domestic banking system is the piloting of the Masterchain system, developed for the implementation of the following projects:

- implementation of the system to account for electronic mortgages (including accounting and storage of such securities in a decentralized depository system. The first such transaction was carried out in September 2018);
- execution of transactions with digital bank guarantees (the first transactions were carried out in December 2018);
- serving trade finance transactions using digital letters of credit technology.

It should be said that one of the most priority areas in the development of the banking services market for credit and financial institutions is to improve the system of remote banking payments. Considering the rapid development of the mobile Internet and banking, there is an increase in the number of potential users of such operations. In this case, we are talking about contactless payment technologies, the use of bank cards. Over the ten-year period, there has been a significant increase in the number of these digital bank payment instruments [8]. Technologies that are actively being introduced into providing banking products are fundamentally changing the entire financial market. The process of communication between the bank and its customers goes to mobile service channels [9].

For individuals, banks such as Sberbank are introducing intelligent mechanisms for studying consumer behavior in social networks and instant messengers. So, one of the Sberbank applications called Adults and Children allows parents to create certain tasks in the program for their children, for which they receive a certain amount of money, sending a notification about the work done. Children can spend money on purchases on the Internet, and the amount is debited from the parents' account. In addition, Sberbank is actively introducing elements of contextual advertising into programs such as Viber and WhatsApp, to regularly remind users of itself. A few other applications of the bank allow the client to view his brokerage accounts, individual investment accounts, conduct investment operations, analyze quotes, and place orders for various stock market instruments. The quantity and quality of services provided by the Russian banking system is determined, first, by the speed of solving the existing problems of this market (Table 1) [10].

**Table 1** The most significant problems in developing banking services in the national economy

| Problems | Description |
|---|---|
| Low level of regional implementation of banking products | Banks are systemically important; they are mainly engaged in their branch network development in large Russian cities. In the regional centers, except for branches of Sberbank that remained from the Soviet era, large bank gamblers are not represented. There is no full range of banking services in small settlements, for example, such as factoring, the possibility of opening an impersonal metal account |
| Uneven development of IT technologies and Internet penetration into small settlements | Because of this problem, remote banking channels remain inaccessible for a significant part of the population |
| High commission percentage | Currently, for many operations carried out through banks, you must pay a percentage of the transaction being performed |
| High rate of financial illiteracy | Due to a significant percentage of the illiterate population in relation to knowledge about existing financial products, there is no development of lending processes, trading on the stock exchange, and distrust of the domestic banking system remains |

## 5 Conclusion

For the effective development of the banking services market, it is necessary, first, to pay more attention to training bank employees in digital technologies, an equally important aspect is also improving the cybersecurity system. Most experts believe that POS loans are most sensitive to negative dynamics emerging in the banking market. The considered sphere of lending most quickly loses the volume of clients and loans, but at the same time, it can increase the volume of issued loans more quickly than others. We should point out that there are several alternative approaches to find resources financing the national economy. First, it is worth paying attention to financial institutions of China and India, which can provide support and compensate for the lost sources of funding. It should be said that support for the national banking sector can be provided by government funds formed in the period before the active phases of the crisis unfolded. During active phases of the economic crisis, government support measures made it possible to allocate about 860 billion rubles to key important banks of the Russian Federation to lower interest rates and increase deposits. In our opinion, the following statistics are quite interesting: following the direction of globalization of the national banking sector, Russia annually loses dozens of banks a year. The reasons for banks' withdrawal from the market are different: from the inability to compete with TNB and national players, to the revocation of a license by the Central Bank of the Russian Federation. At present, due to various government measures, the national banking system can resist the imposed and maintained sanctions, there are still problems with financing and gaining access to international loans and the situation, based on recent events, takes place to deteriorate. In the emerging paradigm of banking sector institutions, it is necessary to reorient to the internal market—to search for internal clients and actively participate in increasing the profitability of their activities to build up a high-quality high-yield portfolio in the future.

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# Innovation Ecosystem as Efficiency Factor of the National Economy's Transformation

**P. Romanov, V. Perepelkin, and A. Romanova**

**Abstract** The problem of finding the best ways to ensure the effectiveness of innovations has long been one of the most controversial in economic science. The disputes seek solutions to the problems of ensuring the maximum return on investment in research, increasing the effectiveness of state incentives for innovative activities, achieving the best results of R&D with limited resources, stimulating and supporting entrepreneurs to search for Schumpeter's new combinations. The paper is devoted to the study of the impact of the development of the innovation ecosystem on the results of the transformation of the national economy. The article examines the factors that allowed China to achieve leadership in innovation ratings and analyzes the dynamics of indicators of the effectiveness of innovative activities. As a result, the paper concludes that it is necessary to stimulate the formation of an innovation ecosystem that unites the state, entrepreneurs and research institutes.

**Keywords** Innovations · Innovation ecosystem · State innovation policy · Efficiency of innovative activity

## 1 Introduction

The problem of finding the best ways to ensure the effectiveness of innovations has long been one of the most controversial in economic science. The disputes seek solutions to the problems of ensuring the maximum return on investment in research, increasing the effectiveness of state incentives for innovative activities, achieving the best results of R&D with limited resources, stimulating and supporting entrepreneurs to search for Schumpeter's new combinations.

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**Table 1** Dynamics of the number of patent applications depending on the level of income of the applicant country in 2010–2019

| Countries/Year | High-income | Upper middle-income | Lower middle-income | Low-income | Total |
|---|---|---|---|---|---|
| 2010 | 1,395,800 | 530,800 | 61,100 | 9700 | 1,997,400 |
| 2011 | 1,412,700 | 671,700 | 64,100 | 9700 | 2,158,200 |
| 2012 | 1,472,700 | 808,200 | 65,400 | 10,200 | 2,356,500 |
| 2013 | 1,505,400 | 983,300 | 65,400 | 2000 | 2,556,100 |
| 2014 | 1,519,500 | 1,085,100 | 65,100 | 2100 | 2,671,800 |
| 2015 | 1,540,900 | 1,267,300 | 68,100 | 2000 | 2,878,300 |
| 2016 | 1,550,600 | 1,497,300 | 67,400 | 1800 | 3,117,100 |
| 2017 | 1,554,600 | 1,535,000 | 69,800 | 1900 | 3,161,300 |
| 2018 | 1,557,200 | 1,690,500 | 75,600 | 2100 | 3,325,400 |
| 2019 | 1,593,400 | 1,548,200 | 80,600 | 2000 | 3,224,200 |

*Source* Authors based on the WIPO statistics database [1]

There are original solutions to these problems in different countries, taking into account local specifics, at the same time able to influence global trends. Thus, analyzing the dynamics of patent applications' quantity, divided by income groups of the applicant country in 2010–2019 (Table 1), we can see that the global volume of patent applications increased by more than 1.6 times during this period. The number of applications by individual groups of countries has changed as follows: for high-income countries, this figure increased by 14.2%, for upper-middle-income countries it grew by 2.92 times, for lower-middle-income countries it rose by 31.9%, and for low-income countries it decreased by 79.4%.

The high growth rate of patent applications at upper middle-income countries and its falling in low-income countries have led to significant changes in the structure of the global patent application volume (Table 2).

Clearly, the share of high-income countries in global patent applications decreased by 20.46 percentage points between 2010 and 2019, while the specific gravity of applications from upper-middle-income countries increased by 21.45 percentage points. The shares of countries with lower-middle-income and low-income have not changed significantly: they decreased by 0.56 and 0.43% points, respectively. It is obvious that such noticeable changes in the structure of patent applications are largely determined by the influence of China, whose share in this indicator for the countries of this group in 2019 exceeds 90% (Fig. 1).

In the 2020 WIPO Global Innovation Index, China is highlighted as a leader in innovation among the upper middle-income group of countries [2]. The analysis of the factors that contributed to the transformation of China into the leader of innovation ratings will reveal the specifics of national innovation policy that affect its effectiveness and ensure the best results of stimulating innovative activities.

**Table 2** Dynamics of the structure of patent applications, presented depending on the income level of the applicant country in 2010–2019

| Countries/Year | High-income (%) | Upper middle-income (%) | Lower middle-income (%) | Low-income (%) | Total (%) |
|---|---|---|---|---|---|
| 2010 | 69.88 | 26.57 | 3.06 | 0.49 | 100.00 |
| 2011 | 65.46 | 31.12 | 2.97 | 0.45 | 100.00 |
| 2012 | 62.50 | 34.30 | 2.78 | 0.43 | 100.00 |
| 2013 | 58.89 | 38.47 | 2.56 | 0.08 | 100.00 |
| 2014 | 56.87 | 40.61 | 2.44 | 0.08 | 100.00 |
| 2015 | 53.54 | 44.03 | 2.37 | 0.07 | 100.00 |
| 2016 | 49.74 | 48.04 | 2.16 | 0.06 | 100.00 |
| 2017 | 49.18 | 48.56 | 2.21 | 0.06 | 100.00 |
| 2018 | 46.83 | 50.84 | 2.27 | 0.06 | 100.00 |
| 2019 | 49.42 | 48.02 | 2.50 | 0.06 | 100.00 |

*Source* Authors based on the WIPO statistics database [1]

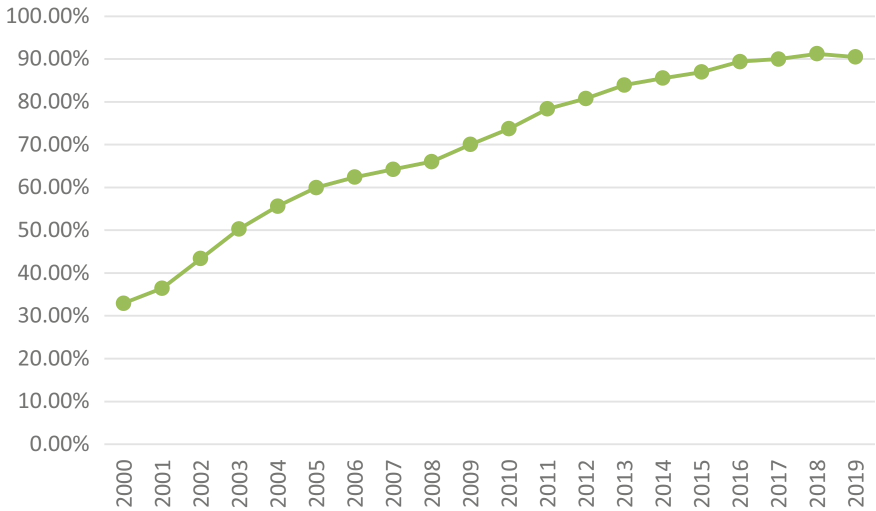


**Fig. 1** Dynamics of the share of China's patent applications in the total volume of applications of upper-middle-income countries in 2000–2019. *Source* Authors based on the WIPO statistics database [1]

## 2 Methodology

Characterizing the specifics of innovation requires a thorough analysis of statistical data. The source of information for this study is the databases of WIPO (World

Intellectual Property Organization) and OECD (Organization for Economic Cooperation and Development), which are publicly available. The time series presented by international organizations are the most comprehensive official global dataset on innovation. In addition, the analysis of the structure and dynamics of the results of innovative activities was carried out on the basis of groupings produced by these organizations.

The article uses methods of processing time series, in particular, the calculation of relative indicators of dynamics, for example, growth rates. These calculations are supplemented by the use of the index method, for example, calculations of average indices. To visualize the levels of the series of dynamics, a graphical method was chosen as an addition to the analytical procedures. To check the tightness of the connection of the series of dynamics, economic and mathematical methods were used, in particular, correlation analysis.

In the course of the study of the features of the development of the innovation ecosystem in China, the case of BGI, a biotech company that managed to become a world leader in this field in a fairly short time, is analyzed. Its history can serve as a vivid illustration of how an effective innovation ecosystem is formed and functions. Analysis of the experience of this company is necessary to find optimal management decisions both at the enterprise level and at the state level. In general, this approach allowed us to substantiate the theoretical basis for identifying a developed innovation ecosystem as the most important factor determining the effectiveness of the transformation of the national economy.

## 3 Results

Today, China's strong influence on the global innovation process is evident, confirmed by the ratings of the WIPO Global Innovation Index [2]. However, even a decade ago, most experts noted a low return on government measures to support innovation in this country. For example, in 2011, The Economist magazine in an article with the offensive title "Bamboo Innovation" noted that China, making "the ability to independently innovate" a priority of its development strategy, often invests resources in dubious projects to the detriment of truly promising new combinations [3]. In 2015, a special report by The Economist noted a significant increase in R&D financing in China, adding that the ratio of these expenditures to GDP exceeded this indicator for the EU and reached 2%. However, while China viewed the country's transformation into an innovation leader as a way to achieve "sustainable and healthy economic development," innovation was often identified only with inventions at the time. Obviously, this approach ignored "new combinations" based on existing technologies and products that only require their adaptation.

It was noted that increased funding for research and subsidies for the development of high technologies were not always a guarantee of the best results. In addition, due to government incentives, there is a sharp increase in patent applications, of which not all are of high quality [4]. Nonetheless, The Economist cited examples of

Chinese companies whose innovations were already well recognized. For example, the Chinese telecommunications equipment manufacturer Huawei then spent about $ 5 billion a year on research, which allowed it to become one of the world's largest holders of valuable patents, successfully competing with Ericsson in promoting 5G mobile technology. In addition, the study noted that Chinese companies have made significant progress in using new combinations in e-commerce and manufacturing.

Currently, the results of innovative activities in China look different—it is obvious that it has reached a qualitatively new level. First of all, the effectiveness of state stimulation of innovations has increased. The flaws in China's state innovation policy that were reported in the early 2010s—the underestimation of "mundane" innovations and the growing number of unsoliciated patents—have largely been overcome.

Primarily, the improvement in the quality of patents should be noted. In the period from 2010 to 2018. China's share in the global volume of patents belonging to Triadic patent families increased from 2.69 to 9.3%, i.e. the proportion of high-quality Chinese patent applications increased by 6.61 percentage points over this period (Fig. 2). The share of the country's inventions in the global volume of patents registered with the three main patent offices (In Europe, USA and Japan) can serve as an objective indicator of the effectiveness of innovative activities.

Moreover, during this period, China significantly increased the volume of gross domestic expenditures on R&D: in 2010–2018, it increased by 2.3 times from 202,280 million US dollars to 464,705 million US dollars, i.e. the average annual growth rate of this indicator was 10.96% (Fig. 2).

By estimating the correlation between changes in China's gross domestic R&D spending and China's share of the world's most valuable patents, it is possible to

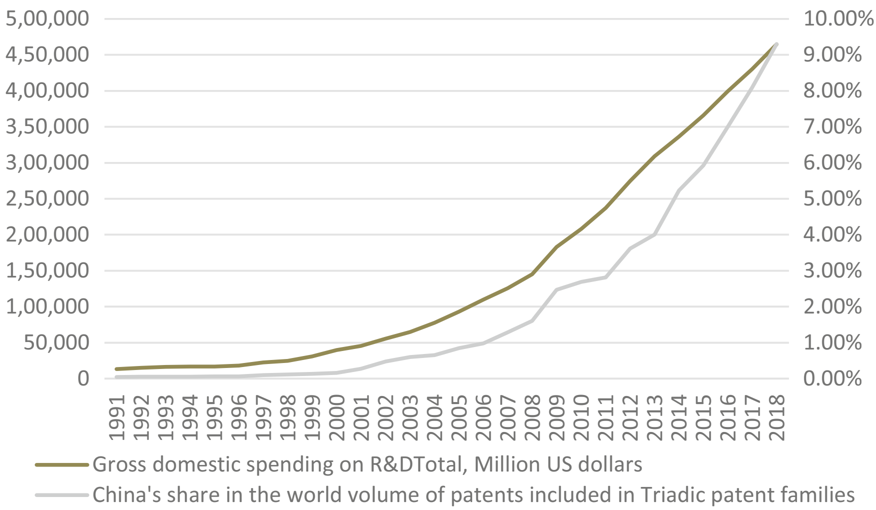


**Fig. 2** Dynamics of Gross domestic spending on R&D in China and China's share in the world volume of patents included in Triadic patent families in 1991–2018. *Source* Authors based on OECD data [5]

**Table 3** Dynamics of the results of innovative activities in China in 2010–2019, units

| Year | Patent | Industrial desing | Utility model |
|---|---|---|---|
| 2010 | 391,177 | 421,273 | 409,836 |
| 2011 | 526,412 | 521,468 | 585,467 |
| 2012 | 652,777 | 657,582 | 740,290 |
| 2013 | 825,136 | 659,563 | 892,362 |
| 2014 | 928,177 | 564,555 | 868,511 |
| 2015 | 1,101,864 | 569,059 | 1,127,577 |
| 2016 | 1,338,503 | 650,344 | 1,475,977 |
| 2017 | 1,381,594 | 628,658 | 1,687,593 |
| 2018 | 1,542,002 | 708,799 | 2,072,311 |
| 2019 | 1,400,661 | 711,617 | 2,268,190 |

*Source* Authors based on the WIPO statistics database [1]

identify a close direct relationship between these time series (correlation coefficient $R = 0.98102$). Consequently, the measures of state stimulation of innovative activity during this period were effective.

It should be noted that the qualitative indicators of innovation results in China have changed (Table 3). The volume of patents in 2010–2019 increased by 3.6 times, industrial designs—by 1.7 times, and utility models—by 5.5 times, and if at the end of the period the number of patents even decreased slightly, the number of registered utility models continues to increase.

The change in the quality of the transformation of the Chinese economy is due to the impact of the emerging innovation ecosystem, which Granstrand and Holgersson consider as a developing set of subjects, activities, artifacts and technologies, as well as institutions and relations that are important for the innovative activity of an entity or group of subjects [6].

The Economist [4] notes that there are examples of successful interaction between the state, entrepreneurs and the scientific community in China. Thus, BGI (now BGI Group), a private biotech research organization headquartered in Shenzhen, Guangdong province, already in 2015 owned half of the world's genome sequencing capabilities and advised major pharmaceutical companies around the world on drug development. The company, whose core values are "curiosity, application of knowledge, work for the benefit of humanity" [7], and whose offices and laboratories are located in more than 100 countries, is the best case describing the creation and development of China's modern innovation ecosystem.

BGI was founded by four scientists as a non-profit research organization and participated in the Human Genome Project on behalf of China. Since 2016, its headquarters has housed the government-funded China National Genetic Bank, a non-profit institution that is a platform for the exchange of information and materials from biobanks, as well as the organization of multidisciplinary scientific research.

BGI has always found the support of government agencies: in 2010, it received a loan of \$1.5 billion from the state China Development Bank, part of which was aimed at purchasing high-tech equipment from the American firm Illumina Inc. Subsequently, its position was further strengthened when China's XII Five-Year Plan (2011–2015) designated biotechnology as a means of solving social problems, stimulating economic growth and creating innovative platforms, and this sector was identified as one of the seven strategic directions of the country's development [8].

The successful development of the company creates prerequisites for expanding its financial base. BGI's transformation into a corporation in 2017 allowed it to conduct an initial public offering (IPO). BGI, listed on the Shenzhen Stock Exchange, raised 547 million yuan ($80.7 million) in an IPO [9].

In 2013, BGI acquired Illumina's largest competitor, Complete Genomics, making it its research arm in the United States. Two years later, BGI released its own gene sequencing equipment. Currently, the company sells manufactured equipment in Asia, Europe and Canada, as well as provides genomic services to researchers and pharmaceutical companies. BGI uses international relations not only to increase sales, but also in the expectation that combining its own resources with external ones will allow creating products and services with high added value.

The company is actively promoting its products in the world market: even before the coronavirus epidemic began, in October 2019, the Ethiopian government announced the creation of a laboratory with equipment donated by BGI. Moreover, it actively participates in the programs of the Chinese government. For example, in Serbia, a member of the One Belt One Road initiative aimed at strengthening trade ties with Chinese enterprises, two laboratories were opened, donated by the Chinese side [10]. The success of BGI is due not only to state support, but also to intensive interaction with other participants in innovative processes. So, this company actively participates in the activities of innovative clusters, in particular, the zone of high-tech industrial development of Urumqi, where it launches a project in the field of biology, involving the creation of centers for genetic research and development, production of reagents, genetic testing and information technology [11].

In turn, the company itself is supporting innovators in its industry by creating Miracle Light, an incubation platform focused on genetics innovation. The goal of creating an open platform is to combine scientific research, technological development achievements and industrial capacities to promote the development of the industry. According to the organizers, Miracle Light seeks to attract human resources, capital and marketing opportunities. “Lack of talent” can be a serious problem for the development of the genetic industry, so “training and encouraging those who have an entrepreneurial spirit to enter the industry” allows you to create the prerequisites for its growth [12]. Thus, the effectiveness of interaction between the state, entrepreneurs, researchers, the possibility of attracting resources (scientific, financial, technological) to a greater extent determined by the development of the country's innovation ecosystem.

## 4 Discussion

The innovation ecosystem' development is the subject of heated discussions, where both the problems of the formation of the national ecosystem and individual aspects of its functioning are discussed. Thus, the study by Arenal, Armuña, Feijoo, Ramos, Xu, and Moreno, dedicated to assessing the state and prospects of the innovation ecosystem of artificial intelligence in China, describes the structure of the national innovation ecosystem, considered as a "triple helix—government, industry and academic/research institutions "linked to flows of skills, knowledge and funding" and also interacting with each other. The results of this study indicate the beneficial effect of competition for capital and talent on the effectiveness of innovation, as well as important role of the innovation ecosystem in ensuring the leadership of the Chinese economy [13].

Researchers can see the development of an innovation ecosystem as the best way to implement innovative developments. So, in the work of Wu, Ye, Ding, Lu, and Euwema, the process of transferring complex interdisciplinary technologies from universities to high-tech companies is analyzed, called by the authors "transplant with the soil", which allows to overcome institutional and structural constraints, simplifying commercialization of university research, and contributes to the formation of an innovation ecosystem [14].

The concept of enriching innovation systems, proposed by Sun, Zhang, Cao, Dong, and Cantwell, implies highlighting the key role of government agencies in ensuring links between universities and industry. This group of relations is seen as central to the development of advanced technologies, and therefore needs "encouragement and support from the state". The authors of this concept note the importance of innovative intermediaries and networks as "conductors of knowledge dissemination and innovation support". Consequently, "government actions and policies play an active role in fostering innovation and enriching the innovation ecosystem" [15].

The most important direction of research of innovation ecosystems is the study of the effectiveness of cooperation between companies that allows you to promote innovation through various "constellations", thereby providing small companies with the opportunity to innovate within networks, and thereby creating the basis for a radical increase in the productivity of innovations [16, 17].

## 5 Conclusion

The task of transforming the national economy into a state of sustainable growth based on innovation involves finding optimal ways to organize innovative activities that ensure its effectiveness. As the case of BGI Group considered in this paper shows, the best results are achieved where an innovative ecosystem is formed that unites the state, entrepreneurs and research institutes. The formation of strong links between the elements of such an ecosystem allows stimulating investment in "new combinations" at all stages of the innovation process: from scientific developments to the dissemination of their results.

Considering the innovation ecosystem as a complex dynamic network of participants in the innovation process, generating and consuming knowledge, it should be noted the importance of managing the interaction of its individual elements. The specifics of roles and relationships in an ecosystem determine its architecture, which is complex, but at the same time capable of adapting to a changing environment. The cooperation of all stakeholders can significantly expand the opportunities for knowledge exchange, creating conditions for easier access to them, and as a result, stimulating a continuous flow of ideas, mutually enriching all participants in the innovation process.

Achieving a synergistic effect within the innovation ecosystem is unthinkable without overcoming existing organizational barriers between the education system, the scientific community and entrepreneurs. As a rule, the state promotes the formation of so-called innovative intermediaries (venture companies, business incubators), whose activities are aimed at creating new and strengthening existing ties between individual elements of the innovation ecosystem. It is obvious that the most difficult task to be solved during the innovative transformation of the economy is to find a balance of opportunities and the need to use state regulation tools, since both excessive influence and insufficient interference in the activities of the innovation ecosystem are ineffective. Its optimal role is determined taking into account the dynamics of innovation processes, the influence of socio-economic factors, as well as the need to adapt the economy to innovative transformation.

The analysis of the peculiarities of the formation of the national innovation system of China allows us to consider the state's interest in the transformation of the national economy based on innovations as the main factor of its development. State support for innovators in this case includes setting priorities for scientific activities, stimulating cooperation between universities and industrial business, and encouraging international cooperation. The successes of innovation policy stem from the stable links of the elements of the innovation ecosystem, providing broad access to modern scientific achievements that generate innovations.

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# Engineering Education in the Era of New Technologies

# Language Training Improvement of Engineering Students Through New Technologies

**L. Kapustina, I. Bakanova, and M. Sergeeva**

**Abstract** Quick changes are very much in evidence in engineering education. They are becoming real challenges and requiring to transform a traditional model of higher education. In the context of Industry 4.0, E-Learning, which was previously one of the possible forms of an educational process, is becoming one of the most significant functional technologies. E-Learning is considered as a knowledge acquisition in electronic form using personal computers, smartphones, and tablets. E-Learning allows to improve engineering students' digital skills and their ability to analyze and manage information. E-Learning develops engineering students' independence and self-control. Moreover, E-Learning contributes to improving an education level in whole. The purpose of this study is to present arguments to prove language training improvement of engineering students on the basis of Foreign Language e-course, designed by the authors of the paper, in Learning Management System Moodle at Samara State Transport University. Flexible usage of e-content and interactive tools of the e-course make it possible to personalize E-Learning and, as a result, contribute to the efficient management of the engineering learning process.

**Keywords** Engineering education · Efficiency improvement · E-learning · Industry 4.0 · Language training · New technologies

## 1 Introduction

Today, quick changes are very much in evidence in engineering education. They are becoming real challenges and requiring to transform a traditional model of higher

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education. In the context of Industry 4.0, E-Learning, which was previously one of the possible forms of an educational process, is becoming one of the most significant functional technologies. E-Learning is considered as a knowledge acquisition in electronic form using personal computers, smartphones, and tablets. E-Learning allows to improve engineering students' digital skills and their ability to analyze and manage information. E-Learning develops students' independence and self-control. Moreover, E-Learning contributes to improving an education level in whole. However, from a scientific point of view, the development and implementation of an integrated paradigm for efficient language training of engineering students through new technologies experiences some issues. The purpose of the study is to present arguments to prove efficiency improvement of the language training of engineers on the basis of Foreign Language e-course, designed by the authors of the paper, in Learning Management System (LMS) Moodle at Samara State Transport University.

## 2 Methodology

The research is based on academic studies analysis on the subject mentioned above. The authors had recourse to inductive and deductive scientific methods, as well. The comparative analysis helped to analyze existing modern approaches to E-Learning. Based on the ideas of Russian and foreign scientists, the deductive method allowed to conduct the own research work under the theme of discussion.

LMS Moodle is the core system of E-Learning in Russian universities. The system has the following opportunities:

- to maintain record of students,
- to present analytical reports,
- to maintain mechanisms for synchronous and asynchronous communication,
- to provide for the training personalization.

Samara State Transport University uses LMS Moodle, which is a part of the University's information environment. However, the provision of high-quality language training of engineers through E-learning is accompanied by a number of difficulties.

## 3 Results

Efficient management of the E-Learning process for engineering education is able to contribute to its qualitative implementation in higher education. The authors of the study developed Foreign Language e-course and tested it at Samara State University of Transport. The purpose of the e-course is to increase the efficiency of language engineering education through new technologies. To reach this goal, the authors identified the following instruments in the e-course (Table 1).

**Table 1** Instruments of Foreign Language e-course

| Instrument | Function |
|---|---|
| Student progress | Tracking tasks completion through electronic simulators |
| Gradebook | Comparing students' results |
| Calendar | Informing students about classes, content, and exercises for individual work |
| Announcement | Sending messages to the group members by e-mail and uploading additional material |

The e-course is characterized by so-called simulators that help gradually build the process of engineers training (Table 2).

The e-course provides for individual and group work of students (Table 3).

Instruments for team work have a great pedagogical potential. They allow to create real communication situations, promote mutual learning and learning autonomy, and provide the opportunity to personalize new material. To practice communication skills, especially for students with a low level of knowledge, it is recommended to use dialogic speech simulators (Table 4).

The e-course that is used as a part of engineering E-Learning, promotes the application of an experimental learning principle, i.e. new information is received through electronic and video presentations, open source web content, but not in the form of traditional lectures and oral presentations [1].

The educational model of engineering E-Learning significantly changes the role of a teacher, who now is increasingly becoming a mentor and a guide, but not just a source of knowledge. It is worth mentioning the e-course feature such as the use of communicative language teaching and three principles of mastering the material: illustration, induction, and interaction.

**Table 2** Simulators in Foreign Language e-course

| Instrument | Function |
|---|---|
| Tests, Reviews | Identifying problems in each part of the discipline under consideration |
| Checkpoints | Improving further study of the material |
| Games | Providing for game content |
| Course | Providing for interactive tasks of the core e-course |
| Workbook | Working on the material by the lesson |

**Table 3** Types of activities in Foreign Language e-course

| Type of activity | Function |
|---|---|
| Individual work | Learning new material, fixing and personalizing knowledge, as well as communicating within the study group when discussing educational topics |
| Team work | Interacting between students within the group and between students and a teacher under online format by sending voice messages, writing blogs, and participating in chats and forums |

**Table 4** Dialogic speech simulators of Foreign Language e-course

| Instrument | Function |
|---|---|
| Record and compare activity | Listening to a question, recording a personal answer, and listening to an approximately correct answer |
| Voice tools activity | Recording an oral response via voice messages available when listening to other students and teachers |
| Video role play activity | Video recording of dialogues in order to create the most realistic communication situation |

**Table 5** Results of the survey

| Point | % |
|---|---|
| Personalization of the training program | +40 |
| Increase of students' interest in learning | +45 |
| Efficiency increase of mastering a foreign language | +52 |
| Efficiency increase of E-learning management in engineering education | +57 |

Upon completing the e-course, students were asked to evaluate this type of E-Learning and identify the points that, in their opinion, contribute to improving the level of engineering education at the University (Table 5).

## 4 Discussion

Analyzing the writings on the research theme, the authors should mention some scientific researchers who worked on E-Learning issues. Yu, Gao, Hou, Hu, Li, Li focused their attention on the latest and most innovative trends in the field, ranging from distance education to co-education, from interactive learning environments to modeling STEM programs (science, technology, mathematics, and engineering) [2].

Klašnja-Milićević, Vesin, Ivanović, Budimac, and Jain presented a comprehensive research review on intelligent methods of personalization of E-Learning systems. The authors offered a new approach to effective personalization based on semantic web technologies which are implemented in a tutoring system [3].

Ventura developed the themes such as alternate reality learning, blended learning, analytics learning, mobile learning, and virtual learning environments [4].

Chenyang considered the following points: virtual reality and alternate reality in entertainment education, gamification for serious play and learning, visualization and applications, and E-Learning and play [5].

Pan, Aylett, Diener, Jin, Göbel, and Li believe that today's world of multimedia games and entertainment is a place where education and entertainment meet. Entertainment education is becoming a challenging research issue that integrate previously separate subjects of education, entertainment, and computer science [6]. However, the issue of improving the efficient language training of engineering students still remains understudied.

## 5 Conclusion

The language training of engineers at Samara State Transport University is implemented through the maximum possible usage of E-Learning instruments for efficient management of students' educational activities and their personalization. The core element of the e-course is the program personalization, which leads to improving students' interest. Due to the familiar context, semantic connections are established within communicative situations, as well as the regularity in the language structures usage contributes to a more efficient use of rules and grammatical units. Moreover, new language structures are trained under the form of group or team work, where the final personalization of the material is observed during the discussion. Exactly the students, but not teachers, are responsible for the success of E-Learning, and they are able to see the results using online learning tools and focusing on detailed exercising. Consequently, flexible usage of e-content and interactive tools make it possible to personalize E-Learning and, as a result, contribute to the efficient management of the engineering learning process.

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# Research of the Competitiveness of Engineering Graduates in the Digital Transformation Context

**O. L. Chulanova and E. S. Bogdan**

**Abstract** Today, powerful economic agents realize that the innovative potential of the enterprise and the efficiency of production are possible not so much due to the equipment, but to the human capital, the employees who work at the enterprise. The management of companies began to be more careful not only in selecting ready specialists who entered the labor market, but they themselves are involved in the process of personnel training in higher school, (prepare specialists "for themselves"), to ensure that, by the time the graduates complete their studies, they possess the competencies required by the employer. The article examines the factors of competitiveness of students in engineering areas of training on the example of Surgut State University, which trains engineers for the regional economy.

**Keywords** Competitiveness · Competencies of engineers · Digital economy · Employment · Graduate · Soft skills

## 1 Introduction

Under conditions of digital transformation, the quality of the workforce becomes a decisive intangible factor of competitiveness of both organizations and the Russian economy as a whole. The labor force is subjected to fundamentally new requirements: readiness of an employee to the process of continuous professional development and mastering new knowledge, universalization of an employee associated with mastering several specialties and even professions, professional mobility, readiness of an employee to quickly master a new profession in accordance with labor market requirements and to perceive changes as a normal mode of modern production. Staff are valued as a determinant of productivity, innovation and economic development at the micro (organization) and macro (economy-wide) levels. The works of many Russian researchers are devoted to the study of the formation and development of the

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competencies of competitive personnel in the modern economy. Researchers focus on the synergy effect of cognitive and non-cognitive skills (soft skills and hard skills.

## 2 Literature Review

We have analyzed the results of studies on the formation and development of key competencies of employees of enterprises [1, 2]. The study of Ukrainian researchers is devoted to the gender aspects of professional self-realization [3]. Along with the study of the problems of recruiting organizations with a quality workforce, the formation and development of professional and managerial competencies among employees [4], we analyzed applied research that highlighted the requirements of employers of industrial enterprises in a number of European countries for the formation and development of competencies among university graduates [5].

Noteworthy are the results of studies devoted to the training of personnel leading the training of engineers and the development of engineering education, sharpened in the context of digital transformation for active innovation [6]. The researchers convincingly prove the importance of effective interaction between the university and specialized enterprises in the training of engineering personnel and, as an option, propose to pay attention to the main areas of interaction between the university and the partner enterprise on the basis of the network cooperation agreement regulating this interaction. The authors of the study note the importance of a comprehensive approach and activities aimed at the implementation of production diversification programs at enterprises of the military-industrial complex, conducting career guidance activities both on the site of the university and enterprise, assistance in employment of university graduates at regional enterprises which are the main employers [6].

In the study of Russian authors, focused on the main problems of modern higher engineering education, including the rapid development of modern technologies. The authors note that the emergence of modern technologies is significantly ahead of the existing terms of training specialists-engineers. As effective solutions to problems, the authors propose a set of measures (the creation of specialized departments of industrial enterprises in universities that train engineers; the organization of scientific and technological clusters; forecasting; a systematic approach (CALS technologies as the basis of engineering education), etc. [7].

Issues affecting the competitiveness of transformational and transactional leadership are reflected in the study and empirically confirmed [8]. An important aspect of the competitiveness of engineering students is the development of soft skills. Time management, as one of the important soft skills, was practiced by both foreign [9] and Russian scientists [10, 11]. Research interest is now significantly shifted towards the formation of soft skills in the learning process. The role of soft skills in the successful employment of university graduates was convincingly proven [12, 13].

Our research is also devoted to the study of the formation of soft skills among engineering students in the process of integration into CDIO [14]. The evaluation of employment skills from the employer's point of view is reflected in the study [15]. The fundamental study provides a conceptual framework for skills development for engineering graduates [16]. The ever-increasing demand for soft skills in the workplace of IT specialists in research is also confirmed.

We have already analyzed the research of Russian and foreign authors, which convincingly prove the soft skills significance in the process of training graduates of engineering specialties (including IT specialists). We conducted a study and published the results regarding the formation of a model of interaction between the university and stakeholders for the formation of the competencies of competitive graduates and the importance of soft skills of engineering personnel as a condition of competitiveness in the digital economy on the example of Khanty-Mansi Autonomous Okrug-Yugra [17], the development of soft skills as an important component of the formation of competencies of competitive engineering graduates [18].

In this article, we present the study results on the competitiveness of universities graduates in engineering areas of training on the example of Surgut State University, which trains engineers for business entities of the Khanty-Mansi Autonomous Okrug-Yugra. The analysis of the authors' works allows us to single out a number of aspects of competitiveness that are significant for graduates of engineering directions. This is, first of all, the importance of universal competencies (soft skills) for achieving demand in the labor market and for further development in professional activity (focus on achieving results, organization, solving non-standard tasks, interpersonal and communication skills, striving for self-development).

## 3 Methodology

Theoretical provisions of domestic and foreign authors devoted to the issues of competitiveness of engineering graduates are also confirmed by the results of a sample online survey of Surgut State University (hereinafter—SurSU) graduates of 2000–2018 engineering training areas. Its purpose was to assess graduates' satisfaction with the education received at the university and the formation of the list of competencies proposed for assessment. The survey was conducted in 2018–2019. It was attended by 1262 respondents (934 specialists, 328 bachelors). Among them are 245 graduates of the SurSU Polytechnic Institute in the following areas of training: applied mathematics and IT, management and IT in technical systems/management in technical systems, software for computer technology and automated systems, automated information processing and control systems, information systems and technologies, IT and computer technology, radio communication, radio broadcasting and television/Info communication technologies and communication systems, etc. The respondents were asked questions regarding the search period and criteria for choosing the first job, respondents' satisfaction with various aspects of the job, as well as significant competencies for successful work. This article will focus on the presentation of the results of the survey of Polytechnic Institute graduates (245 persons) and some comparisons with those of graduates of other disciplines.

## 4 Results

One of the indicators of the demand for graduates in the labor market is the duration of the job search. The answers of the respondents of the Polytechnic Institute were grouped according to the following search periods: got a job right away/got a job while studying at a university; got a job within the first 3 months after graduation; got a job within the first 6 months after graduation; I was looking for more than six months. The respondents' answers were distributed as follows (Fig. 1). The results show that 69% of the respondents were employed either within the first three months after graduation or while still studying at the university. It reflects a fairly high level of competitiveness, but 11.8% of the respondents who have been looking for a job for more than six months suggest that the university should be in constant search of ways to improve graduates' competitiveness and also to study the reasons for graduates looking for work so long. The specifics of the region (Yugra) are such that some graduates leave the region in search of a suitable job that meets the claims of the graduate, but after some time they return back to the region. Considering that many graduates of the Polytechnic Institute are young people, sometimes the search process is delayed due to the settlement of issues with conscription into the ranks of the armed forces.

It is worth noting that 11.8% of graduates who continued their search for work for more than six months included graduates of different years of graduation and different areas of training, which allows us to judge that the reason for such a long search is not so much in the training program in a specific area, but most likely, in the approach

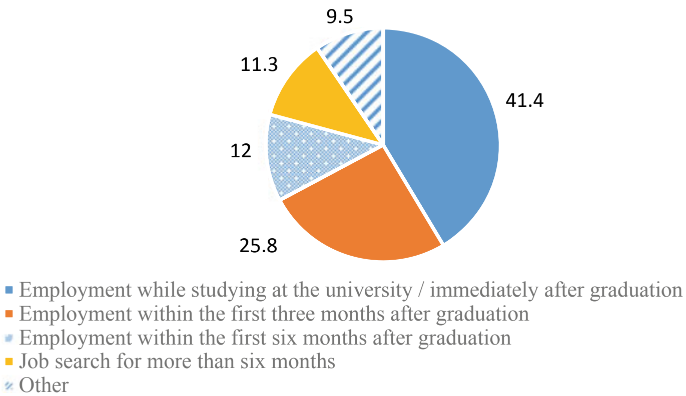


**Fig. 1** Job-seeking period for engineering graduates (%). *Source* Authors

of the graduates themselves to mastering it and developing the competencies of a competitive graduate. At the same time, the majority of the respondents, when choosing their first job, were guided by the search for work in their specialty and are currently satisfied with the salary and the opportunity for career/salary growth.

Due to the fact that the question “How long after graduation did you look for a job?” was open, then the category “other” included such answers as: I didn’t look for it right away as I entered a postgraduate school; long; not very long; almost immediately; fast; I did not search; a few months; individual entrepreneur; immediately after the army; several months (there were questions about military service). It is difficult to attribute these answers to any of the temporary search categories, therefore, these answers are difficult to interpret from the standpoint of competitiveness. An analysis of the criteria for choosing the first job demonstrates that the majority of respondents when searching for a job relied on the correspondence of vacancies to their education (almost 70% of respondents), the possibility of professional self-realization and the level of salary (more than 40% of respondents).

The authors of the study wondered whether the criteria for selecting a job would be different for graduates of the last five years than for the entire sample of respondents. When releasing bachelor and specialist graduates from 2014–2018 into a separate group (62 persons), it was found that the difference in the results of 2 groups of respondents did not exceed 5%.

It draws attention to the fact that such criteria as “where they will take” and “closeness to home” are less significant for graduates in comparison with the others shown in Fig. 2. It may indicate the demonstration of the competitiveness of graduates, choosing a place of work according to their personal preferences.

The level of competitiveness also reflects respondents’ satisfaction with various aspects of the workplace. Respondents’ answers to the question “Which of the listed aspects of your place of work are you satisfied with?” were interpreted on the basis of a sample of respondents who completed undergraduate and graduate programs in 2014–2018 (Table 1).

Respondents are most satisfied with the opportunity for professional development and material security (more than 65% in both groups of respondents). The respondents are least satisfied with the intensity of their work. In order to earn a high salary, respondents have to work intensively. It is worth noting that graduates of the last five years of employment are more satisfied with wages than the representatives of the entire sample of respondents. This can be explained by the fact that wage claims may increase with age and the real increase in accordance with the demands does not occur. The data presented in the article [18] on the significance of universal competencies for achieving demand in the labor market testify the high importance of achieving results, being organized, solving non-standard tasks, as well as interpersonal and communication skills, and striving for self-development for the professional activities of the respondents. Such results can be found in the answers of both engineers and graduates of other fields of study.

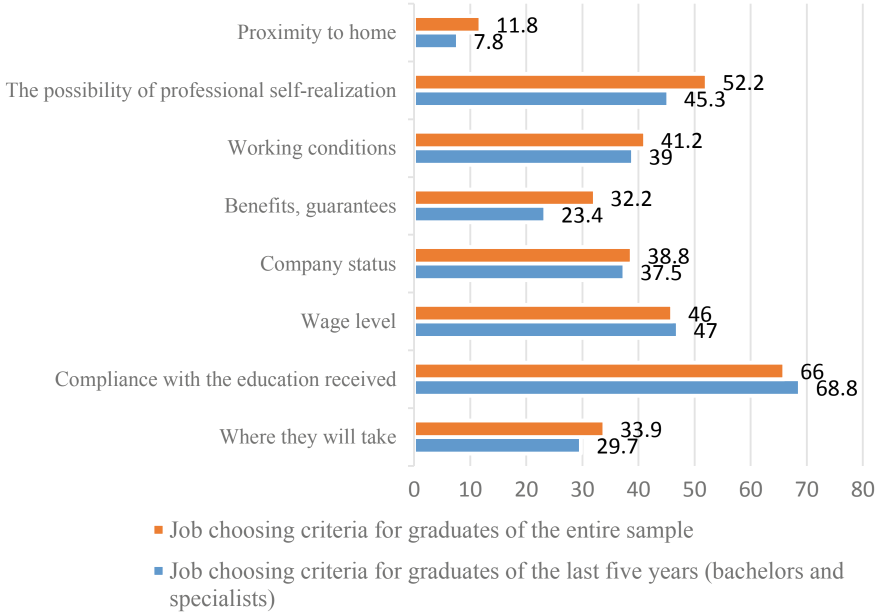


**Fig. 2** Criteria for choosing the first job of engineering graduates (%). *Source* Authors

## 5 Conclusion

The conducted research allows us to conclude that for the majority of graduates of engineering fields of training, it is important to work in the specialty they receive and the importance of professional self-realization. These are the criteria by which graduates seek employment. At the same time, one can observe high percentages of satisfaction with the possibility of professional implementation in the process of graduates' work. Most of the graduates found work during their studies or in the first three months after graduation, which indicates a high level of compliance of graduates with employers' requirements.

In order to maintain competitiveness to meet the demands of an ever-changing environment, it is necessary to solve the problems of engineering training and start with university training. The research has shown that the satisfaction of graduates, practically in the first place, is determined by the possibility of professional development. In our opinion, this task can be solved by forming necessary competencies for jobs during university training. First of all, the tasks of training competitive specialists in terms of hard skills and soft skills are solved by the basic departments. They carry out connection of universities and students with industrial partners, involvement of students in project activities, participation of employers in the development and implementation of engineering training plans in universities, participation of students in hackathons, international project contests, etc.

**Table 1** Respondents' answers to the question "Which of the listed aspects of your place of work are you satisfied with?"

| Criteria | Institute (Specialists and bachelors 2014–2018) | | | | | |
|---|---|---|---|---|---|---|
| | Humanitarian directions | Engineering directions | Legal directions | Natural science directions | Medical directions | Economic directions |
| Material security (salary) | 41.8 | 62.9 | 53.2 | 53 | 65.6 | 50 |
| Career opportunities/wage growth | 27.3 | 47.2 | 59.6 | 38.9 | 53.1 | 45 |
| Conditions for realizing their values | 35 | 27 | 25 | 23.5 | 28.1 | 21.8 |
| Opportunity for professional development | 50.4 | 65.2 | 63.8 | 53 | 53.1 | 55.6 |
| Labour intensity and workload | 32.4 | 25.8 | 21.3 | 22.3 | 40.6 | 19 |
| The attractiveness of an organization for employment | 17.9 | 31.5 | 29.8 | 25.9 | 21.9 | 30 |
| Resource intensity of job search and consolidation in the organization | 16.2 | 33.7 | 14.9 | 21.2 | 21.9 | 23.2 |
| Employment conditions | 50.4 | 51.7 | 31.9 | 48.2 | 34.3 | 45.8 |
| Other | 3.4 | | 2.1 | | | |

*Source* Authors

The current situation—the situation of digital transformation and economy of innovations—indicates that it is necessary to introduce new approaches and improve the process of shaping competencies of engineering students that are important for achieving competitiveness in the labor market. Our earlier publications present the results of our successful experience in SurSU: introduction of soft skills subjects into the curriculum of engineering and technical training areas. The disciplines "Team Building", "Effective Interaction in Project Teams", "Foundations of Image Communication" (development of public speaking skills, emotional competence, effective negotiation process, etc.) were included in the bachelor's curriculum of engineering training. Competencies formed in the process of studying these disciplines contribute to comprehensive engineering, interdisciplinary research and design activities in the field of creating new competitive automation, control and monitoring systems; contribute to collective (team) activities in the professional field, develop students' motivation for self-education and improvement in the professional sphere.

At present, the tasks of effective training of engineering personnel in SurSU are solved by involving students in project activities and forming, inter alia, competencies of project activities.

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# Digital Transformation of Business Education

**A. Kh. Malikova, A. M. Dinorshoev, and S. M. Salokhidinova**

**Abstract** The relevance of the study is due to the importance of accessible, quality education that meets modern challenges and leads to scientific and technological progress of the economy, civilized society. The aim of the study: the article aims to comprehend the importance of legal registration of digital and distance education, investing in this sphere as factors of economic and technological progress acceleration, renewal of production capacities in general. Methods of research: general scientific, as well as general, private scientific, private legal methods, which allowed a comprehensive substantiation of the thesis that the digitalization of the educational process is forced in the conditions of COVID-19 and that at the same time it is a progressive, inevitable step into the future. Results of the study: the digitalization of the educational sphere is analyzed; the necessity of accepting the Education Code in the Russian Federation is justified, which could absorb the entire legal and regulatory framework in the field of education and science, as well as contribute to the transformation of educational law in the digital economy. Practical Importance: Materials of the article are of practical value for lawmakers, politicians, researchers in the field of development of digital formats of the educational process.

**Keywords** Education · Science · Digital economy · Information technology

## 1 Introduction

In recent years, Russia, according to the Human Development Report 2019, has taken only 49th place among the 189 countries represented in the world ranking [1]. The Russian education system can regain its rightful place on the world market of educational services by modernizing them, while at the same time preserving the best traditions of Soviet education.

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Back in the XIX century Lorenz von Stein—German philosopher, economist, lawyer, author of the concept of social state, repeatedly in his works stressed that the first major step that must be made by the state in the destruction of poverty, homelessness is the introduction of compulsory, free "at least elementary mental education" [2]. At the present stage, intangible resources, such as knowledge, qualifications, labor skills, are also crucial for the development of the economy. The examples of which are the economies of Europe, Japan and other developed countries. With the low level of provision of natural resources, the cost of human development, the basis of which is education, in these countries remains high.

The great scientist categorically noted that there is no doubt that education is the highest value to every man; it is both the condition and the consequence of all success; its size and depth are the measure and value of every individual [2]. It is now recognized that education is not a guarantee of success in life, but has significant impact on its probability and, having both symbolic and practical importance, to a large extent determines the increase in opportunities, the increase in the status of the citizen. A person's education allows expanding opportunities to improve their own status, the position of their family and the state as a whole.

Current scientific research indicates that the level of education affects a person's health more than their standard of living or position in society. Education benefits a person in terms of health and longevity more than a good high-paying job, because educated people generally tend to make better decisions about their behavior and lifestyle. Von Stein also pointed out that a nation needs to be highly educated in order to recognize the importance of the health system and to realize its demands [2]. By increasing spending on education, ensuring that it is universally accessible and of good quality, the state protects and ensures the health of its citizens.

The importance of education in public life and the human right to education are reflected in the attention given to it by the entire world community. Thus, the United Nations has proclaimed the third millennium of the era of education. And this is understandable, because, according to UNDP estimates, 64% of the world's wealth is human capital [1]. Human potential of any country is the most important resource, one of the foundations of industrial development, renewal of social and scientific life. Undoubtedly, the more the state spends on research and development, the higher the level of its economic growth and standard of living.

## 2 Methodology

In the course of work on the article the following methods were applied:

- general-scientific methods are techniques used in all or most sciences, and which do not cover all scientific cognition, but are applied only at its individual stages, in contrast to the universal methods. The analysis, synthesis, induction, deduction, systematic approach, functional approach, analogy, abstraction, historical method can be referred to the general scientific methods used in this work. This group of methods allowed to comprehensively justify the thesis that the digitalization of the educational process is forced in the conditions of COVID-19 proliferation and at the same time it is a progressive, inevitable step into the future.

- private-scientific (or special, or specific-scientific) methods are techniques that have been developed on the basis of special non-legal knowledge: technical, natural, and human sciences. Of particular scientific methods in the work were used: statistical, cybernetic, psychological methods;
- private legal methods are techniques, means, principles, which are purely legal. For example, such as formal-legal and comparative-legal methods, the method of legal forecasting, etc.

The above groups of methods were used to know the current level of digitalization of the educational process, as well as to develop recommendations for the effective formation of digital transformation of business education.

## 3 Results

The goals set by the President of Russia in his annual addresses to the Federal Assembly and the Government of the Russian Federation, such as the formation of a common digital network uniting the provision of services in the main areas of life, prompt adoption of laws prioritized to create a new legal environment, digital economy, electronic services, tuned to the technological reality, etc. The digitalization of the social sphere and the improvement of its measures are unequivocally conducive. Thus, in 2019, President Vladimir Putin initiated the national project "Digital Economy," which aims to train personnel for the digital economy and create a comfortable digital environment, deals with information security and other issues. One of the areas of the national project "Digital Economy" is the service "Admission to University Online", launched in 2020 on the Unified Portal of State Services. The service "Admission to university online" makes it possible to apply remotely to several selected universities at once or to different fields of study at one university. To do this, the applicant only needs to fill out an application on the "State Service" portal. Last year, this service was used by more than 20 thousand applicants who could apply for 54 universities and colleges. The experiment, launched in the midst of the pandemic and dictated largely by restrictive measures, has justified itself. In 2021, the list of universities was significantly expanded: this summer, it is already possible to apply online to 134 Russian universities.

The priorities of modern state policy in the field of education should be aimed at digitizing the relevant social services, which will lead to obvious results: efficiency, accessibility, cheapening, increasing the speed of educational services, transparency of implementation and receiving socio-economic benefits in general [3].

In particular, digitalization modernizes, improves the educational sphere by:

(1) creating an appropriate legal and regulatory framework, the ability to monitor the implementation of legal acts and, if necessary, promptly make adjustments

by teachers, educators, employees of scientific and educational associations, representatives of civil society;
(2) transparency in information and legal space of incomes and expenses of each participant of business-education for the purpose of accessibility of education, leading to mitigation of social inequality, providing everyone with decent living conditions, free development, equal access to education;
(3) systematization of all measures of social support for quality education; etc.

The question today is not whether digitization of educational services is necessary or not, and not whether the use of digital formats in business education brings more benefit or harm. The main problem of our time is to expand measures for the effective use of information technologies while ensuring the preservation and creative use of the scientific and educational achievements of scientists and educators of the pre-revolutionary and Soviet periods.

The modern challenges and trends of the digital era require not only the use of distance learning, but also the transition to e-commerce, distance banking, and the digitization of society as a whole. The process of digitalization is undoubtedly aimed at positivizing social relations, at providing freer, more comfortable conditions for concluding and exercising social and economic rights and obligations. Digitalization can and should be viewed as one of the measures to improve the efficiency of socio-economic, cultural and political life. The digital age, which is coupled with the pandemic, forces lawmakers to become more active in streamlining and regulating Internet relationships without violating and restricting the constitutional, internationally declared natural rights of citizens.

## 4 Discussion

The growth of the level of education in society contributes to the development of socio-economic state. Therefore, we agree with the position of scientists who consider human capital as one of the main resources of any country, the main source of national wealth, determining its market stability, efficiency of functioning, prospects for strategic development. Taking into account the low level of natural resources provision, the high level of national wealth in European countries is due, first of all, to the adequate development of human capital. Modern competition is won by "skill, not number". Spending on social development, especially on improving digital formats in education and science, is now considered a highly effective investment in human capital. With the formation of a society based on global knowledge, national intellectual capital becomes the basis of economic well-being, a factor of political power of the country. In this regard, the optimal solution of strategic tasks of statehood, including the development of human capital, is possible only through the use of all the challenges and opportunities of digitalization of business education, the potential of digital transformation of the economy.

Educational services are not exclusively the domain of state and government structures. It can be provided by private individuals and non-governmental corporations. However, the digitalization of education, the introduction of digital formats and new requirements in business education should primarily be subject to state paternalism and regulated by the relevant generally binding instructions.

Education should be accessible to all, since it is one of the main social values—the intellectual potential of society. A social state must create the conditions for education for as many of its citizens as possible. Digital, distance education can help learn anywhere, anything and from anyone [4, 5]. Providing individual access through digital technologies to quality education regardless of social and property status, territorial or other differences will help not only to resolve possible future social conflicts, but also to solve issues of national security, state stability, ensuring decent life and free development of everyone.

It is unacceptable to economize in this area. Investments in human capital today undoubtedly include spending on basic research and development. The importance of electronic platforms, intelligent communications, and digital technologies is paramount for the state function of implementing the results of scientific research. Digitalization of business education will increase the exchange of data in the scientific and educational sphere [6]. Digital transformation of the economy will give the country an opportunity to actively create modern high-performance mechanisms, develop technology and infrastructure. If we are talking about the results of scientific research in the field of law, the digital platform is the guarantor of rapid and effective improvement of the country's legislation, which is a priority in the formation of a strong, economically developed, civilized state.

## 5 Conclusion

In today's pandemic environment, the role of information technology in the world is increasing day by day. As a consequence of the scientific and technological progress of society, the whole social and cultural side of an infinitely evolving civilization is changing in principle. This has particularly affected the field of education. The legalization of digital, distance education and investment in this area can be considered as drivers for accelerating economic and technological progress and upgrading production facilities in general. Digitalization of the educational process, like any other new and inevitable phenomenon, has positive and negative aspects. Among the positives are the following: thanks to information technologies in the field of education there is an opportunity to make training materially and physically more accessible; the emergence and active development of online schools, online courses, online training contributes to the development of new business education in the country; digital formats have allowed to learn some new specialties, work remotely, switch to a mixed training format or mixed work mode, without losing, and sometimes increasing people's earnings; rapid exchange of information, the ability to quickly notify each other of changes or events in the educational environment; improvement of the educational process through the development and use of various technical training tools, such as interactive whiteboards, projectors, educational platforms, digital and virtual laboratories, multimedia studios and robotics, through which you can more clearly and productively present the necessary material.

There are also disadvantages of the introduction of information technologies in education, in particular: technical failures; lack of quality connection to the Internet network; inaccessibility of information technology due to limited material resources; distance learning technologies, as well as the lack of live communication can have a negative impact on the physiological and mental state of participants in the process.

Nevertheless, the distance education process is a forced phenomenon in COVID-19 conditions and at the same time a progressive, inevitable step into the future. In order to make the educational process more flexible, accessible, qualitative, this sphere needs both investment and legal regulation.

The actual reality of highly developed states convinces that the educational, socio-cultural policy, acting within the framework of appropriate legal systems, aimed at equal access to education and free development, has a favorable impact on the further economic development of these countries. As a result of irresponsible, short-sighted attitude of the government to realization of social and cultural rights of its citizens, the level of poverty, distrust and protest moods in the society grows, the population grows old faster and dies, morality and culture fall, civil society is destroyed, social interrelations separate, inequality grows and grounds for extremism appear, the legitimacy of the state itself loses. The sustainable development of a socio-economic state always implies limiting opportunities for the growth of bureaucratization tendencies in this state. Non-compliance with the requirements of social justice subsequently manifests itself in the social, economic, cultural and political spheres. The conclusion is that new opportunities of the digital economy, supported by the practical achievements of modern developed countries should be actively introduced for the formation of a developed socio-economic state. Without the use of digital formats in the field of business education, the state today cannot rank itself as highly developed and civilized.

Based on the above, it is necessary to adopt a Code of Education of the Russian Federation, which would absorb the entire array of legal documents in the field of education and science. This law should enshrine obligatory state standards of education, including the possibility of implementing every person's right to a modern digital education, since accessible, high-quality education is a basic condition for raising the living standards of citizens. Transformation of educational law in the digital economy leads to scientific and technological development, economic progress, civilization of society. Materials of the article are of practical value for lawmakers, politicians, researchers in the field of development of digital formats of the educational process.

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# Conditions of Functioning and Development of Engineering Education in Russia

**D. V. Aleshkova, S. I. Ashmarina, and V. V. Mantulenko**

**Abstract** This contribution discusses the issues of functioning and development of engineering education in Russia. The importance of studying these issues is interpreted by the active development of society and the requirements for graduates of engineering fields. The development of society in the innovative direction is due to global trends. Innovative development is impossible without the modernization of engineering education as one of the main components of innovation processes. All this has a significant effect on the economic component of the country's development and its position on the world market. In this regard, the purpose of this work is to study the conditions for the functioning of engineering re-growth in Russia. The analysis of studies in the field of engineering education shows the relevance of a comprehensive study of the development of engineering education. The issues of the functioning of engineering education are significant in the entire world community, which is confirmed by research in many countries. Speaking about the development of engineering education in Russia, the following areas of development were highlighted: using the knowledge and experience of the old personnel fund to update educational programs, expanding the area of interests of engineering education in the country, focusing on retaining scientific and practical personnel in the country and, as a result, forming a personnel reserve, expanding exchange programs for students and using existing laboratories and centers to exchange experience and use it in practical tasks to improve the quality of the educational process.

**Keywords** Engineering education · Economic effect · Innovative development · Operating conditions

## 1 Introduction

Modern trends in the development of society necessitate its rapid modernization in all directions. Innovative development is the most progressive way to achieve this

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goal. The foundations of any modernization are laid at the stages of the idea and development of prototypes, which in the future will serve as a basis for actions. Engineering directions play a huge role in any direction of innovative development. They are the technical component of any idea, which consists in the transition from theoretical foundations to practice. Engineering sciences correctly implement into reality things that were initially only a plan.

The strategy of scientific and technological development of the Russian Federation poses the lack of qualified personnel in all training programs involved in innovative processes as one of the urgent problems [1]. Engineering sciences are the main of these areas. Hence, the relevance of studies on the topic of engineering education in Russia comes out and the question arises about the quality and possible prospects for its development. In accordance with this, the purpose of this work is to study the conditions for the functioning of engineering re-growth in Russia.

The issue of the development of engineering education has not only technological, but also political and socio-economic components. The technological component is the transfer of ideas and theoretical developments into real life. The political component allows to bring the country to a new level in the eyes of other friendly states, to increase the status and position of the country in the world community. The socio-economic component is responsible for improving the quality of life of the country's population through the modernization of society, the development of new products, the organization of additional jobs, and the professional development of employees. From an economic point of view, such metamorphoses can be extremely cost-effective, since engineering sciences have an impact on innovative development, which significantly increases the profitability of the economic entities involved in it. This makes the manufactured products the most competitive on world markets and contributes to the growth of the country's GDP. All this correlates with the key objectives of not only the strategy of the NTR of the Russian Federation, but also the strategy of the Russian Federation as a whole [2].

## 2 Methodology

As mentioned earlier, engineering education is one of the bases of innovative development of society. The purpose of the study allows to answer key questions about the current state and possible prospects for the development of the analyzed educational profile. In this regard, the authors set the following key research tasks:

1. To study the views of researchers on the importance of engineering education for modern society.
2. To show the current state of engineering education in Russia
3. To consider the main opportunities for its development and potential threats.

To solve these problems, the main general theoretical research methods were used: analysis, structuring and synthesis of information, deduction. The authors also used specific methods for studying the internal and external environment of the object under study. These methods were PEST and SWOT analysis of engineering education in Russia. PEST analysis allows to comprehensively study the environmental factors that affect the object of research. Moreover, the influence of these factors is purely one-sided. SWOT analysis consists in identifying the strengths and weaknesses of the research object, as well as external opportunities and threats to its development. In relation to external factors, the basis for SWOT analysis is directly PEST analysis. When constructing the matrix, the key points are identified that should be addressed when developing a strategy for the development of the object of study.

The information bases of the study are the works of domestic and foreign researchers on the functioning and development of engineering education, key normative legal acts in the field of scientific and technological, socio-economic and innovative development of territories. The work is of a research nature, its results can be used as a basis for further research and developments in the field of engineering education development in Russia.

## 3 Results

The main conclusions of this study are based on the results of the PEST and SWOT analysis conducted by the authors. The current trends in the field of education at the state level were analyzed. The identified factors are both general for all areas, and specific directly to engineering education. The results of the PEST analysis are presented in Table 1.

The factors listed in Table 1 are specific to Russian education. They are external, and therefore educational institutions cannot influence them and are only forced to adapt to them. Regarding political factors, we can say that there is now a general trend towards the consolidation and autonomization of educational institutions, which

**Table 1** PEST-analysis of engineering education in Russia

| | |
|---|---|
| **Political:**<br>– Establishment of priority training programs among engineering specialties at the state level;<br>– Change of educational standards at the world level;<br>– Mass association of higher and secondary specialized educational institutions | **Economic:**<br>– Reduction of the number of budget places;<br>– Reduction of science funding;<br>– Increase in the cost of training;<br>– Maintaining the level of funding for engineering education as a priority one |
| **Social:**<br>– Outflow of human capital from the country;<br>– Public distrust to the education system;<br>– Reduction of the credibility of higher education;<br>– The choice of training programs by the population that have a larger number of budget places | **Technological:**<br>– Insufficient/absent access to foreign technologies;<br>– Slow updating of the used domestic technologies |

significantly affects the issues of their management. Due to the expansion, consolidation and complication of the structure, it may be difficult to coordinate the joint work of each of the components, which will undoubtedly affect the quality of educational services. The reorientation of state interests towards engineering education and the use of world educational standards encourages an increase in state support for these areas, which acts as a positive effect from the action of external factors. This is also reflected in the economic component. Against the background of a general reduction in the number of budget places and funding of science, support for priority engineering areas from the state remains. At the same time, the increase in the cost of educating is a general trend. Social factors consist in the formation of a general distrust of the population towards the existing education system and higher education in general. More and more often, applicants choose training programs based on the cost of studying, the availability of state-funded places and only to get a wallpaper degree. In this regard, the occupancy rate of engineering educational programs is kept at a high level. However, in the future, highly qualified graduates of educational programs are increasingly immigrating abroad, believing that there are more prospects for their further development there. In this regard, the existing state support does not bring the expected effect from it. At the same time, technological factors are also limiting, consisting in the low speed of updating domestic technologies and the lack of access to foreign ones, which is especially important for engineering specialties and can affect the quality of the educational process.

From the factors identified during the PEST analysis, the most significant and promising ones were selected for further analysis. The next stage was a SWOT analysis of engineering education in Russia. The matrix is presented in Table 2.

**Table 2** SWOT analysis of engineering education in Russia

| | |
|---|---|
| **Strengths:**<br>– Availability of its own laboratories and research centers on the basis of educational institutions;<br>– Strong staff from the old school;<br>– Organization of international exchange programs for students | **Weaknesses:**<br>– Outdated equipment in educational institutions;<br>– Insufficient amount of personnel reserve;<br>– Low speed of updating of educational programs;<br>– Emphasis on a narrow specialization for engineering education (mainly the space and defense industries) |
| **Opportunities:**<br>– Establishment of priority training programs among engineering specialties at the state level;<br>– Change in educational standards at the global level;<br>– Maintaining the level of funding for engineering education as a priority:<br>– The choice of training programs by the population that have a larger number of budget places | **Threats:**<br>– Mass association of higher and secondary specialized educational institutions;<br>– Outflow of human capital from the country;<br>– Public distrust to the education system;<br>– Insufficient/absent access to foreign technologies;<br>– Slow updating of the used domestic technologies |

Considering the internal and external factors of the functioning of engineering education in Russia, it can be concluded that despite the fact that access to foreign technologies is limited, educational institutions still have the opportunity to organize their own laboratories and research centers. There is an opportunity to carry out the necessary research and develop engineering areas at the expense of available resources. This can neutralize the threat related to the slow updating of domestic technologies. The establishment of priority areas of training and the maintenance of their funding will help to attract students and the subsequent formation of a personnel reserve. However, it makes sense to pay attention not only to the moments of specialists training, but also to the issues of retaining these personnel in the country. The existing highly qualified personnel are able to adapt educational programs to international requirements, and the organization of student exchange programs will not only speed up this process, but also stimulate the exchange of experience and technologies.

## 4 Discussion

For a more complete assessment of the research topic, the materials of domestic and foreign researchers on engineering education were analyzed. Thus, Saprykin [3] writes that at present the importance of innovations in the economy has a significant impact on engineering education, there is a transition to the universality of engineers training and assigning them various roles. Tymoshenko writes about the need to separate branch engineering educational institutions in order to maintain the necessary level of training [4]. This creates a dissonance with the current situation of consolidation and unification of higher educational institutions and gives reason to regard this trend as negative for the development of engineering education. Galikhanov et al. [5] speak about the inclusion of engineering education in the global processes of society development. This is due to the active introduction of innovative technologies in all spheres of society. Mexican researchers consider engineering education as a basis for implementing the concept of Education 4.0 at different levels of education in order to update and improve the quality of the educational process [6]. Haque and Sharif [7] discuss the need to introduce additional directives in the field of engineering education to develop the best curricula and practices of engineering education. Cico et al. [8] analyze trends in the field of software for engineering education, the range and available startups in this industry. The importance of international cooperation for the development of engineering education is considered in the work of Lecorchick et al. [9] in which the development of these training programs is shown on the practical example of North America and China. A number of Indian authors consider a complex scenario of engineering education with the use of practical training as a mandatory component [10]. All this shows the relevance of a comprehensive study of the development of engineering education. The issues of the functioning of engineering education are significant in the entire world community, which is confirmed by research in many countries.

## 5 Conclusion

Summing up the results of the study, we can conclude that the issues of the functioning and development of engineering education have been relevant for a long time in various countries of the world. This is confirmed by the analysis of the works of various authors on a given topic. For Russia, the relevance is determined from the point of view of the scientific and technological development of the country, which is noted in the current regulatory legal acts. The main factors influencing the functioning of engineering education in Russia are the state policy in the field of priority areas of development, financing of education, the outflow of young highly qualified personnel from the country and insufficient access to foreign technologies. At the same time, there is a fairly strong regular personnel of the old school, the presence of its own laboratories and research and development centers at universities, as well as the organization of students exchange at the international level. In this regard, we can say that it is necessary to modernize the state policy in the field of engineering education. The main directions will be the use of the knowledge and experience of the old personnel fund for updating educational programs, expanding the area of interests of engineering education in the country, focusing on retaining scientific and practical personnel in the country and, as a result, forming a personnel reserve, expanding student exchange programs and using existing laboratories and centers to exchange experience and use it in practical tasks to improve the quality of the educational process.

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# Neural Networks for a Priori Estimates of the Student's Outcomes in Mirera

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**Abstract** The article investigates problems of a priori estimating of the student's outcomes and by using the automated assessment in digital learning platform Mirera. Special attention is paid to reviewing different architectures of the neural networks and selecting the features used for training and validation of the models. The student's outcome estimating is based on the intermediate assessments. The prior estimating could prevent drop-out of the students and apply an adaptive learning approach to adjust the learning path. Additionally, the teacher uses automated estimating results to identify students who need assistance. The authors focus on implementing adaptive learning in the digital learning platform Mirera using neural networks technology.

**Keywords** Adaptive learning · Digital learning platform · Drop-out prediction · Mirera · Neural networks · Outcomes estimates

## 1 Introduction

COVID-19 limitations in social institutions mainly caused massive remote education in academic organizations in 2020–2021. The teacher cannot work with students in a former offline mode in classrooms, and even video chats cannot replace the classroom experience. In the class, the teacher works with the students directly and can see their level of keeping focus and understanding of the material. The experienced

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teacher can efficiently triage the students to identify who needs direct assistance or who can accommodate the learning material without additional assistance. In remote education, there is also a need to develop new methods to identify lagging students in the early stages to assist them directly to prevent drop-out and poor course outcomes.

The problem of predicting the student's drop-out is well known and researched in massive online open courses and learning platforms [1, 2]. The main difference between the approach described and a traditional drop-out estimate is the following: we are estimating the student's outcome and not the probability of the drop-out.

One of the approaches to gathering additional information required to estimate the course outcomes for the individual student is by switching the homework and intermediate checks from the classroom to the online learning platforms. The approach is focused on estimating outcome for a single course based on intermediate assessments results in comparison with estimating based on specific characteristics of the student [3]. The platform provides meta-information about the assessments, for example, such as the number of tries and time of access to the system. Additionally, the platform can also use the estimates to adjust the assignments to implement adaptive learning. In the paper, we focus on researching the neural network technologies used for prior estimations of the outcomes.

## 2 Methodology

This research's prior focus is to examine the ways of predicting students' drop-out probability during their study of the course. In other words, we aim to predict the probability of the student belonging to one of three classes:

1. Badly underperforming students. This class comprises students whose result at the end of the course is considered insufficient. The sufficient teacher's effort required to bring the student back to the regular learning track.
2. Passably performing students. This class consists of students who move through the course at their own pace. They will most likely acquire sufficient results in case the teacher pays enough attention to them. Hence this class should be the prior focus of the teacher.
3. Beat-the-target students. Students in this class usually overperform others in pace and quality on their study track. They will most likely get the highest results at the end of the course, even in the absence of any teacher's attention.

During our research, we were investigating the following hierarchical course structure (Fig. 1).

Normally, the course itself consists of many contests, each, in turn, consists of several tasks. Each contest has its own weight W, which reflects its contribution to the course. Each task, in turn, also has its own weight, which reflects its contribution to the contest. To obtain the unified result, we normed task weights in the way it is written in the above picture. Normed task weights sum up to 1 and reflect the importance of the task with respect to the course.

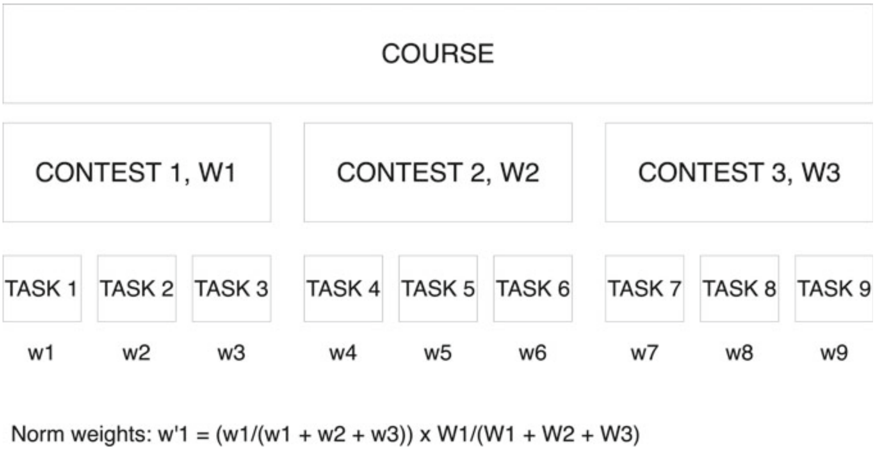


**Fig. 1** The hierarchical structure of the course assessments. *Source* Authors

While studying, the student consecutively makes attempts to pass a task in some contest. When the course expires, all the normed weights for all the passed tasks are summed up and exposed to the teacher. The teacher, in turn, decides on the grade of the student, and his decision is mainly based on the abovementioned sum of the weights, i.e. the final score of the student. Thus, in order to decide on the class of the student, we mainly have to know their final score, which is the sum of the weights of all their successfully passed tasks. To do so, we propose to use two hand-tuned thresholds, which will separate classes one from another.

As for the data available, every attempt student takes contains the following information:

1. Timestamp of the attempt.
2. State of the attempt (passed, not passed, error, plagiary detected, etc.).
3. Type of the task (regular, easy, hard, etc.).

Every time the student attempts to submit a task, we can sum up the weights they gained up to that moment. In addition, we can also compute some statistics to help us in predicting the student's final score.

Let us illustrate the above reasoning with the picture (Fig. 2).

As shown in the above scheme, we use certain statistics to directly predict the total weight the student will gain by the end of the course. Then, by comparing the obtained value with our thresholds, we can decide on the class of the student. This is, however, not the only way to do this; neither does it optimize the target metric. As a matter of fact, one can first apply the thresholds to the historical data, splitting all of the students into three classes. And then train a statistical model to directly predict the class, therefore, bypassing the auxiliary score predicting procedure. In our investigation, we verified both of the aforementioned schemes and compared their performance on the validation dataset.

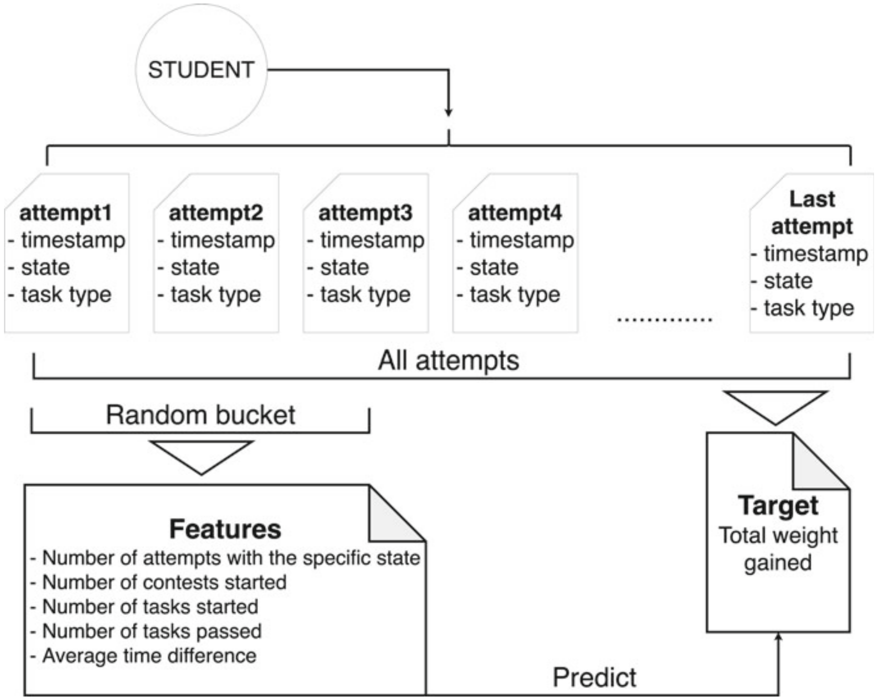


**Fig. 2** The structure of the student's data. *Source* Authors

## 3 Results

In our experiments, we investigated the scheme described in the previous section (Fig. 2). Our historical data consisted of 3206 student-course pairs. Each such pair were represented by the sequence of the student's attempts to submit a task in the course. The histogram of logarithm lengths of such sequences is shown in the picture (Fig. 3).

As one can see, most students completed a course within 20–150 attempts. However, quite a significant portion, namely, 7.8% of our students, had to undertake from 200 to even 2200 attempts to submit a course. In order to obtain a robust solution, we endeavor only to use features that are agnostic to the total amount of attempts a student takes. Following the path that we stated in the methodology section, we illustrate the distribution of the total score gained by a student by the end of a course (Fig. 4).

The thresholds for the classes shown above were advised by 3 experienced practicing teachers. The proportions of the classes generated by these thresholds can be observed in the following graph (Fig. 5).

As for the features, each student's attempt data contained the following information:

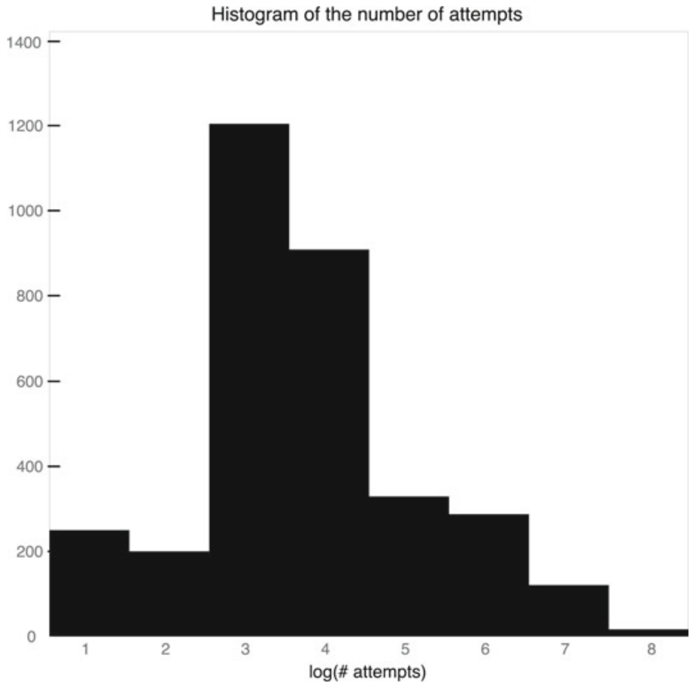


**Fig. 3** The histrogram of logarithm length of sequences of the student's attempts. *Source* Authors

1. Timestamp of the attempt.
2. State of the attempt, which takes one of three values: passed, not_passed, error.
3. Type of the task, which takes one of three values: regular, optional, exam.
4. Normed weight of the task.

Using the above data, we generated the training and validation samples as follows. We first randomly chose a starting bucket of student's attempts sequence. Then we calculated the following statistics:

1. The number of attempts with the specific state for each type of task.
2. The number of the contests started.
3. The number of the tasks started.
4. The number of the tasks successfully passed.
5. Average difference in time, i.e., student's study pace, for consecutive attempts for each task for each type of the task.
6. Score gained up to this point.

Statistics (1) were then normed by the total length of the sequence, statistics (2), (3) and (4) were also normed accordingly. Statistics (5) were matched with a uniform histogram of 30 bins from 0 to 150,000 s. All of the calculated statistics were then concatenated into a single vector, forming the total amount of 106 features.

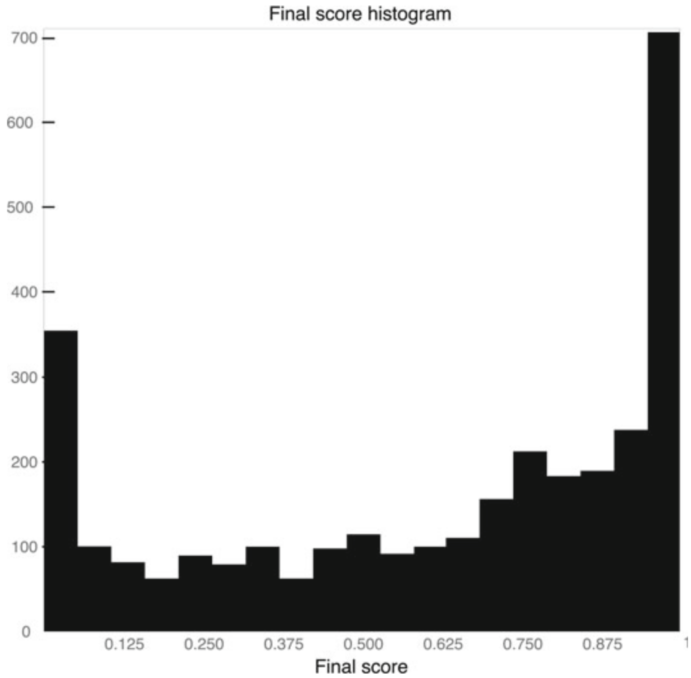


**Fig. 4** The distribution of the total score gained by a student by the end of a course. *Source* Authors

As the title of our paper states, we chose a neural network model to accomplish the task of predicting the student's drop-out probability. Our backbone architecture is illustrated in the picture (Fig. 6).

The dotted frame is repeated a specific number of times sequentially to constitute the depth structure of the network. As one can see, we use the batch normalization technique [4] along with the residual connection [5] in each hidden layer to enhance the gradient propagation and increase training speed. We examined two main approaches to the problem. In the first approach, we predict a single value which to be the final score of the student. Hence, we add a linear layer to the dimension of 1 to the above illustrated backbone, which is followed by the sigmoid activation. We then use standard MSE loss to train the neural network. To validate the results, beforehand, we put aside randomly chosen 30% of all the students.

In the second approach, we predict three probabilities for each class of students. Therefore, we add a linear layer to the dimension of 3, which is followed by the softmax layer. We then use negative log-likelihood on the logarithm of the outputs to train the whole neural network. The validation dataset stays the same as in the first approach.

For each of the two stated approaches, we also conducted several experiments with different depths to determine the optimal network complexity. The stop condition

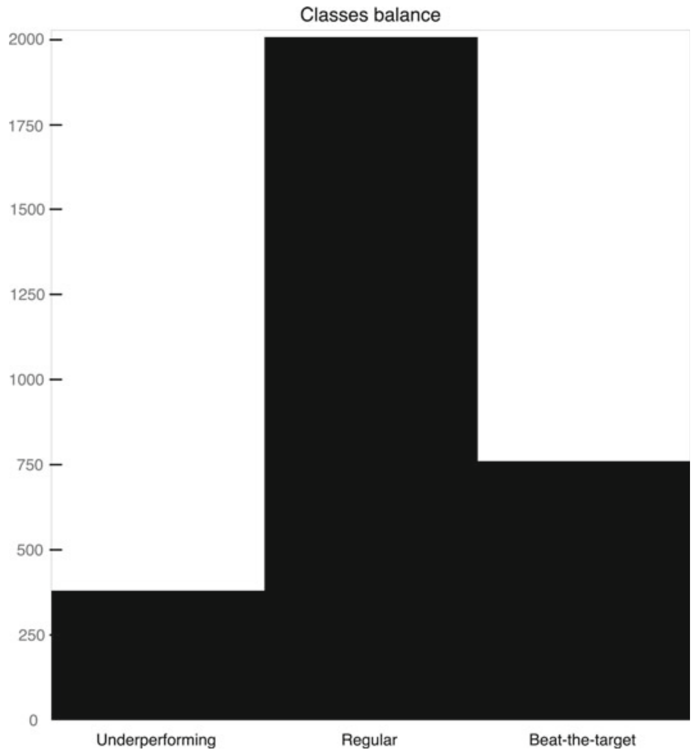


**Fig. 5** The proportions of the classes generated by thresholds gathered from distribution. *Source* Authors

for the training process is the plato overfit detector, namely, 5 epochs of a zero improvement. The results of experiments are shown in the Table 1.

Additionally, for our best model, which is the classification model with 2 layers, we draw average error rates evaluated on the validation set (Fig. 7).

Vivid lines in the above graph are chosen for the "dangerous" errors, i.e. total error rate, win-to-lose, mid-to-win, and lose-to-win error rates. However, the win-to-lose error rate is not present in the above picture due to the absence of such cases. As one can see, when the student is into his first 20% of the course, our solution already has a total error rate of 0.26. The probability of wrongly deciding that an average student is a beat-the-target student never goes higher than 0.21. However, at some point, our solution can wrongly decide that a losing student is a beat-the-target student with a pretty high probability of 0.37.

As for dim lines, they represent "safe" errors. We can see the satisfyingly fast dropping mid-to-lose error rate. We can also see quite a slow slope of the win-to-mid error rate, which shows that almost half of the beat-the-target students will be categorized as average. We see almost constant loss-to-mid error rate as well, which

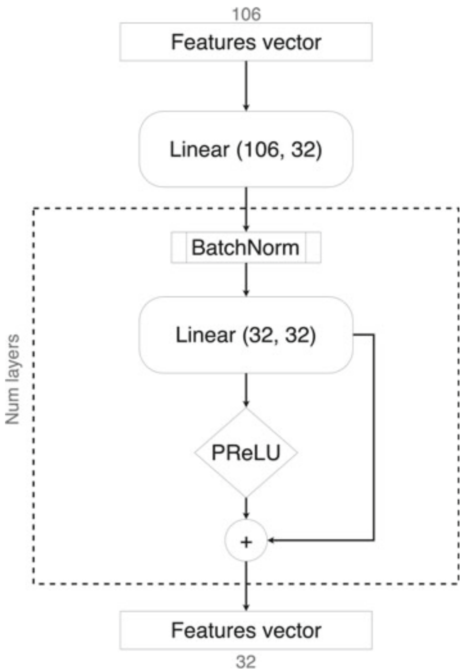


**Fig. 6** The backbone architecture of the neural network. *Source* Authors

**Table 1** Results of experiments for different approaches and depth

| Depth | Overfit epoch | Validation loss | Weighted precision | Weighted recall | Weighted F1 score |
|---|---|---|---|---|---|
| *First approach, predicting total score* | | | | | |
| 1 | 26 | 0.0462 | 0.7187 | 0.7149 | 0.6636 |
| 2 | 13 | 0.0500 | 0.7141 | 0.6853 | 0.6047 |
| 3 | 20 | **0.0447** | 0.7603 | 0.6589 | 0.5450 |
| *Second approach, predicting class probabilities* | | | | | |
| 1 | 42 | 0.5599 | 0.7617 | 0.7554 | 0.7362 |
| 2 | 36 | **0.5030** | **0.7702** | **0.7674** | **0.7467** |
| 3 | 25 | 0.5495 | 0.7466 | 0.7438 | 0.7436 |

*Source* Authors

shows that at every point, around 80% of all underperforming students would be classified as average.

There are several ways to improve obtained results. First of all, we can make a great use of a temporal structure of the data by leveraging LSTM models or Transformer based architectures [6] which showed a significant improvement in sequence analysis. Second of all, additional data such as students' communication logs with

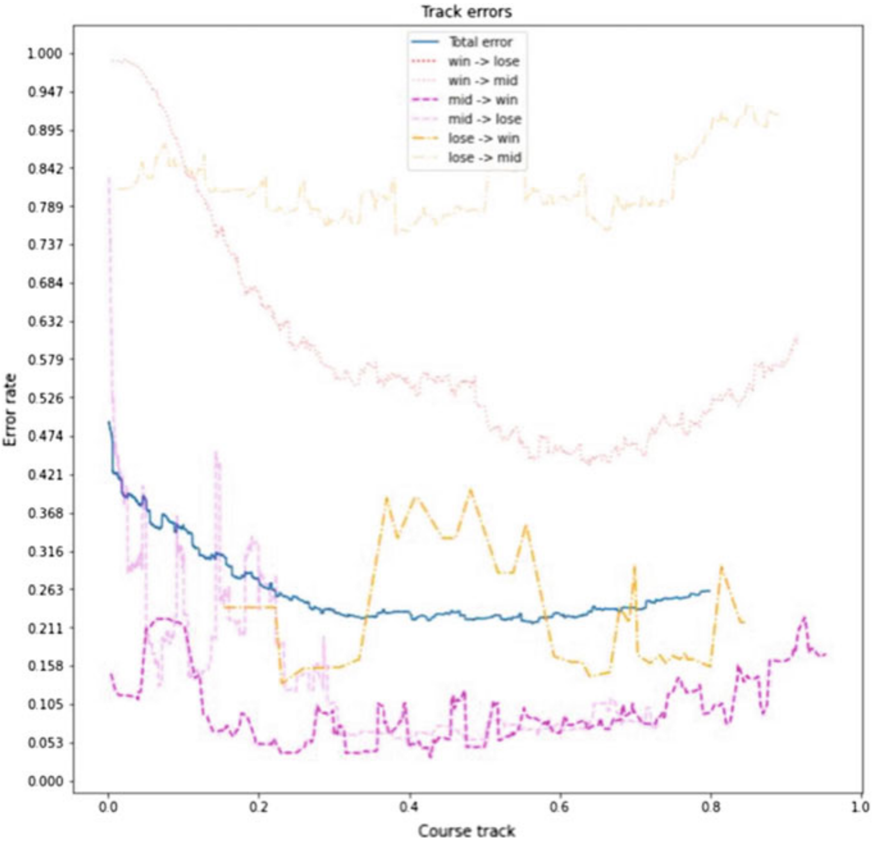


**Fig. 7** The average error rates evaluated on the validation set. *Source* Authors

system's chat bot or other behavioral data could be very useful in predicting drop-out probability.

## 4 Discussion

The experiments' results indicate that the approach can be used for prior estimates of the student's outcomes based on the preliminary assessments' results. But the quality of estimation needs to be improved. The experiment conducted confirms our hypothesis of the possibility of splitting the students into three categories. Based on the analysis of the students in the categories, the rationale behind the students' categories selected is caused by the possible action that could be applied to the students to bring the student back to the main learning track.

The first category of the underperformed student is required extra effort from the teacher to explain the course materials. The student of the category cannot achieve the acceptable results themselves. The possible reason is the students do not possess the competence of self-learning. In this particular case, to return the student to the main learning track, that is not enough to explain the course material; the teacher needs to evolve the student's self-learning competence.

The second category of the students can achieve acceptable results just by taking all the regular assignments in the course. Some extra attention could be required from the teacher's side to provide more unique assignments to train the students. The assignments help to evolve the competence in the subject area that confirms understanding of basic concepts.

The third category of the students can achieve good results without any additional assistance. Based on our practical observations, these students need to have advanced assignments that allow them not only to confirm the concepts' understanding but also to evolve the competence in using the concepts in close-to-real problem-solving tasks. These students can learn themselves.

The digital learning platform Mirera is selected to conduct the experiments because the platform supports remote learning processes and provides extended students' behavioral information during the remote lessons and assessment process. The platform is designed to provide all the types of data needed for the creation and validation of sophisticated estimation models based on machine learning and also neural network technologies. Because of the platform's extendable architecture, the developed estimations model could be easily integrated to provide new functionality for the teachers—users of the platform.

The physical limitation of the approach described is that the teacher needs to assess a huge amount of the specific assignment for every student. The assignments include training, regular homework, and exam exercises. To make it feasible, the Mirera platform provides an automated way of the assessment by using classical automation of the programming assessment. Additionally, the platform supports several intellectual methods for the assessments, for example, for the graphical types of exercises [7].

Another problem of estimating is the need to take into account the potential plagiarism when several students are using similar results of the assignments—the estimates for the particular students will be far from reality. The problem can be addressed from two sides: by generating unique tasks for every student and by denying the results being potential plagiarism. The problem of plagiarism can be resolved on the Mirera platform level for a wide range of the tasks' types [7].

There is also one more data source that will potentially improve the quality of the estimation process. The Mirera platform provides an intellectual chatbot [8] that does not only help the teacher to support the learning process but can also automatically answer the typical questions from the second-category students. The chatbot collects information about the requests from the particular students—also a part of the behavioral information—and the information could also be used to improve the quality of estimation. But this source of information did not use in the research conducted.

## 5 Conclusion

The connection between category and possible teacher's action described above is the first step for automation of the learning process. Because knowing the categories of the students, we can estimate the feasibility of the automation. The actions for the first category of the students are challenging to automate. These actions require a wide range of human-specific competencies needed to identify and address the student's problems. For example, to help them evolve self-learning skills. The third category's actions are not required and can be covered by simple heuristics when the platform opens advanced tasks for the excellent-performers students. The second category is the only one we are targeted at by automation. The categories of students need to be assisted by a teacher-human or by a virtual teacher. The adaptive learning technology is a kind of "virtual teacher" who can work with every student in person, taking into account all the student's specifics. The adaptive learning path is built step-by-step based on the results of the assessments, which can initiate such actions as repeating any misunderstood or forgotten concept, repeating any exercises to confirm that concept is clear, etc. [9, 10].

Finally, we are sure that our results will find applications in eye-to-eye teaching process. In this case, the learning process will be augmented by the data gathered during the automated assignments' assessment on the platform.

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# Sustainable Development in the Context of Innovations: Economic, Environmental and Information Aspects

# Sustainable Innovations in Circumstances of Pandemic Influencing Global Economies and Environment

**J. D. Ermakova**

**Abstract** Circular economy and sustainability have become a burgeoning consciousness in the recent years. It will be better appreciated and embraced by every individual when it becomes a part of our education curriculum across the globe. This should drive inter-disciplinary innovations to foster sustainability. Rapid industrialization in the twentieth century provided a major impetus for global urbanization. This led to the development of cities around industrial areas contributing largely to the socio-economic progress around the world. Cities turned into centers of education and employment for a significant portion of the growing population. To date, people are continuously migrating from rural to urban areas in pursuit of opportunities and a better lifestyle. However, this economic growth came at a huge cost of undesirable effects on the environment as well as human health. The COVID-19 pandemic has accelerated the development of key technology trends, including digital payments, telemedicine, and robotics. These technologies can help reduce the spread of the coronavirus while helping businesses stay open. Technology can help make societies more resilient in the face of pandemics and other threats. During the COVID-19 pandemic, technology plays a crucial role in keeping our society functioning in isolation and quarantine. And these technologies may have a long-term impact beyond COVID-19.

**Keywords** Circular economy · Digital industrial technology · Environmental management · Environmental protection · Sustainable economy

## 1 Introduction

Humans exist only on this planet earth and heavily dependent on the natural resources and ecosystems but industrialization accelerated the pace of humans controlling nature for their lifestyle. It also catalyzed the linear economy in which take-make-use-dispose culture is accentuated. In the last hundred years, the rapidly growing as

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well as urbanizing human population is excessively consuming the planet's limited resources and polluting the ecosystems. This is also contributing to the extreme weather conditions and rise in sea levels. This calls for a transition from our current unsustainable linear economy to a more sustainable circular economy. This change is appreciated only when it comes with a promise of positive outcomes for all stakeholders. It is explained how a circular economy is beneficial to humankind for a sustainable future in the long run. The transition also requires investments in infrastructure facilitating circularity of materials, production of clean energy, and innovations to redesign the processes and services. To standardize the concepts, the International Standards Organization (ISO) formed a new circular economy technical committee. According to the ISO, a circular economy is one where it is restorative or regenerative [1]. Also reuse/reutilization should lead to reducing waste by careful evaluation of resources.

The ISO also defines sustainability as a state of the global system, which includes environmental, social and economic subsystems, in which the needs of the present are met without compromising the ability of future generations to meet their own needs. It's evident from ISO's vision that circular economy and sustainability are intricately connected and will feed on each other. Circular economy is defined as a way of living in harmony with our ecological systems and restoring them [1].

## 2 Methodology

The circular economy metrics for cities encompass both, metrics for environmental impacts and economic growth/stability which contribute towards sustainability. However, there is no established set of circular economy (CE) indicators for measuring the sustainability of cities and in many cases data to analyze the indicators is not available. In a way, the rate of successful achievement of sustainable development goals (SDGs) mentioned in the previous section can be considered as circularity metrics. However, there is a need for a set of measurable and comparable indicators of circularity. This set should include the measurement of material flows from input to output with wastage in different economic sectors, sources of energy and consumption statistics, domestic waste generated and recycling rates, total greenhouse gas emissions of the city, the environmental pollution estimates and also the gross domestic product (GDP) with economic stability parameters.

The Economist Intelligence in cooperation with Siemens has developed the Green City Index for comprehensively evaluating the major areas of urban environmental sustainability of cities across the world. This index measures cities with a set of 30 indicators across eight categories. These categories include $CO_2$ emissions, energy, buildings, land use, transport, water and sanitation, waste management, air quality, and environmental governance. The 16 quantitative indicators that use data from official public sources, and other 14 are qualitative assessments such as the city's environmental policies. Although the Green City Index provides standard metrics to compare the environmental sustainability of different cities, their dependency on publicly available data may have compromised the accuracy of such comparisons.

Schematic illustration of the Green City Index and the Global Cities index and Outlook as outlined by Kearney [2]. The Green City Index provides a comprehensive set of factors for evaluating the urban environmental sustainability of cities across the world reproduced from the Green City Index report. The Global Cities Index and Outlook provides guidelines for measuring the economic progress of cities. The Green City Index and the Global Cities Index and Outlook together can serve as circular economy metrics for the design and development of sustainable cities. The A.T. Kearney Global Cities Index and Outlook provides a set of indicators to measure the economic progress of cities which takes into consideration the current conditions and factors contributing to future economic progress [2]. The indicators measuring economic progress include business activities, human capital, information exchange, capital investments and GDP, innovations and patents, economic policies and governance. These indicators encompass both static and dynamic dimensions of urban economic development. The information used to calculate these indices is obtained from publicly available sources. The environmental indicators of the Green City Index together with the economic indicators of the A.T. Kearney Global Cities Index and Outlook put together can be a comprehensive set of circular economy metrics for sustainable cities. These indices have been used to define and indicate the performance of 'smart cities' as well.

Also there is a Life cycle assessment (LCA) that is an analysis technique to assess environmental impacts associated with all the stages of a product's (or service's) life, from raw material extraction through materials processing, manufacturing, distribution, and use to disposal or recycling. LCA is a useful tool to evaluate true sustainability or the circularity of products. Otherwise, what may seem like a better replacement for the existing product/service is shifting or creating a new unintended problem to the ecosystem. The intention behind the LCA is to determine the full range of environmental effects assignable to products and services by quantifying all inputs and outputs of material flows and assessing how these materials flow affect the environment.

Let us consider a couple of examples to understand how LCA can help us identify the products/services that have minimal impact on the environment. LCA study for breaking even environmentally a fossil fuel-based single-use plastic bag suggests that a polypropylene bag should be used for 37 times, a paper bag should be used for 43 times and a cotton bag should be used for 7100 times [2]. An innovative alternative to the single-use plastic bags can be nature biomass-sourced biodegradable polymer bags. Also, 60% of the energy used in transporting food items to Singapore is used for fresh air-flown meats and fish which accounts for 3.7% of the food consumed. Perhaps importing food from neighboring countries or produced domestically will lower the carbon footprint. It has also been suggested that plant protein-based cultured meat or vegan meat has a lower carbon footprint than the animal-sourced meat [3, 4].

The world today is witnessing the beginning of the fourth Industrial Revolution or Industry 4.0. This revolution, unlike the past three revolutions, is driven by two primary factors—automation and data. The unique but often overlooked fact is that unlike the previous industrial revolutions which generated waste, the present industrial revolution seeks to minimize or eliminate waste and greenhouse gas emissions through redesigning the production processes and enabling industrial symbiosis (waste from one industry can serve as a raw material for another). This fact links this objective of Industry 4.0 with the principles of a circular economy.

The rise of a new digital industrial technology, known as Industry 4.0, is a transformation that makes it possible to gather and analyze large amounts of data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs. This manufacturing revolution will increase productivity, shift economics, and foster industrial growth. Advanced digital technologies empowering Industry 4.0 such as advanced robotics, machine learning, internet of things, cloud services, big data, smart sensing, and smart tagging for manufacturing, will transform production [2, 5]. It will lead to greater efficiencies and change traditional production relationships among suppliers, producers, and consumers as well as between humans and machines.

## 3 Results

The key discussion points emphasizing the subtle relationships among circular economy (CE) and sustainability concepts, influence of digital technologies via Industry 4.0, nanotechnology, life cycle assessment, bottom-up and top-down approaches, indispensable role of circular economy education, and new business opportunities. Urban areas being densely populated and packed with industries consume more than two-thirds of the total energy consumed (mostly derived from fossil fuels) and accounts for over 75–80% of global greenhouse gas emissions. The industrialization has also resulted in the exploitation of natural resources for manufacturing on a large scale to feed the ever-increasing consumer appetite. In the past 40 years, the global use of material resources has almost tripled, from 26.7 billion tonnes in 1970 to 84.4 billion tonnes in 2015, and is expected to double again to between 170 and 184 billion tonnes by 2050 [6]. This practice of over-consuming limited natural resources without replenishing them leads to unsustainable growth. In addition to this, the current linear economy model where we procure resources from nature for manufacturing desired products and dispose of them into the environment at their end-of-life is polluting our ecosystems and affecting human health. Growing research evidence points out that man-made chemical is causing major threat to the sustainability of human life. The low dose adverse effects include disruption of the endocrine system which in turn contributes to the sterility in humans. The only way to adequately protect the human population from these effects is to move from the current materials systems and linear economy to non-toxic materials and circular economy [7, 8].

If we're not careful, technology can exacerbate inequalities, too. Responsible technology governance is needed to protect against discriminatory algorithms, unethical use of data and job displacement—especially in the midst of a global pandemic, when we're relying on technology more than ever to work, learn, buy food and necessities, even see the doctor. And with this increased dependency on the internet, cyberattacks are up—so cybersecurity is more important than ever, especially for companies handling private data.

COVID-19 could widen the digital gap. As a recent World Economic Forum report explained, COVID-19 has sped up digitization—and "exposed even more clearly the gaps that still exist in digital access." While we're building new technological capabilities, it's equally important to build technological skills and access—or we risk widening the gaps further.

Technology—and specifically, ensuring technology is inclusive—is covered by three SDGs: SDG 8: Decent Work and Economic Growth. Achieving this goal requires boosting economic productivity through diversification, technological upgrades and innovation. Tech can help achieve other targets, too, like supporting job creation, entrepreneurship and the growth of micro, small and medium-sized enterprises and expanding access to banking and financial services.

SDG 9: Industry, Innovation and Infrastructure. Targets include upgrading the technological capabilities of industrial sectors in all countries, supporting domestic technology R&D and innovation in developing countries and increasing access to information and communications technology, specifically universal and affordable internet access in LDCs by 2020.

SDG 12: Responsible Consumption and Production. Targets include reducing waste, making procurement more sustainable and strengthening scientific and technological capacities in developing countries to move towards more sustainable consumption and production. Tech can also play a role in helping companies adopt sustainable practices and report that information.

We've seen substantial growth in investment in R&D—up to $2.2 trillion in 2017, from $1.4 trillion in 2010 and $741 billion 2000—and we have new innovations every day to show for it. However, we still have work to do in order to ensure everyone can access and benefit from them. Internet access is one indicator of progress. In 2019, 97% of the global population lived "within reach of a mobile cellular signal" and 93% "of a mobile-broadband signal," according to the UN SDG Progress Report 2020. This growth includes LDCs, where access to mobile-broadband signals has increased rapidly in recent years, from 51% in 2015 to 79% in 2019. There's work to do to reach the goal of universal and affordable internet access in LDCs: 19% of people in LDCs actually use the internet, compared to 87% of people in developed countries, the progress report continues. This affects our ability to meet other goals, too, as COVID-19 has required us to move many economic, educational and social activities online. Those with quality and secure internet access are able to continue daily life, and even thrive—while those without it risk falling further behind [9].

## 4 Discussion

A circular economy is a restorative and regenerative system of closed loops in which raw materials and products circulate eternally eliminating wastage as if mimicking the circularity of elements in a natural ecosystem such as forest. It also depends on renewable energy sources such as sunlight and wind instead of fossil fuels. Such a system is the key to achieve sustainability. Nature inspires the concept of circular economy where resources are valued the most [10]. Every element of nature is continuously in use by turning waste into resources repeatedly, using principles such as reduction, reuse and recycle (3Rs). Products and services are also evaluated for their environmental impact at all stages of life-cycle. Such an assessment is important to reduce their harmful effects on nature. This calls for innovation of new composite materials that are biodegradable and can be recycled with little or no impact on the environment. Circular economy and sustainability should inspire innovations which are necessary solutions to improve the current waste recycling rates, mine resources from the waste consuming fewer resources in the process, which consequently minimizes the damage to the environment and human health.

In the natural ecosystems, using the biological nutrients, the plants produce food which is consumed by animals for survival. The biological waste generated is decomposed into nutrients, and other resources in nature such as water are restored into the system through natural cycles. To mimic nature through the circular economy approach, products and services are designed and produced with minimum resources for judicious consumption and completely recycled for maintaining the circularity of materials thereby eliminating their adverse effects on nature.

The circular economy is not just limited to the reuse and recycling of material resources. It also emphasizes the use of renewable energy resources such as biogas, wind and solar energy. This again is inspired by nature where plants use the nutrients in the decomposing biomass, water and the sun's energy to produce food. To emulate the natural producers, circular economy promotes production and consumption of sustainable and greener energy instead of burning non-renewable fossil fuels.

The circular economy is not just limited to the reuse and recycling of material resources. It also emphasizes the use of renewable energy resources such as biogas, wind and solar energy. The circular economy can be leveraged to achieve multiple Sustainable Development Goals (SDGs). It holds particular promise for achieving SDGs, including goals 6 on clean water, 7 on clean energy, 8 on economic growth, 11 on sustainable cities, 12 on sustainable consumption and production, 13 on climate change, 14 on oceans, and 15 on life on land [11]. Schematic illustration of the United Nations Sustainable Development Goals (UN SDGs) that can be achieved by adopting Circular Economy principles. The circular economy vision has influenced multiple UN SDGs, particularly goals on clean water, on clean energy, on economic growth, on sustainable cities, on sustainable consumption and production, on climate change, on oceans, and on life on land.

The exploitation of freshwater resources and mismanagement of wastewater has resulted in the scarcity of drinking water on a global scale. If this trend continues, it is projected that by 2050, a quarter of the world's population will suffer severe water shortages. It's applying the principles of the circular economy such as reducing the usage of water and recycling the wastewater instead of allowing it to pollute our waterways. As discussed in the previous section, using clean energy is a core idea of a circular economy. Decoupling energy derived from fossil fuels reduces carbon emissions by 60% which is the main contributor to climate change. Also, renewable energy sources are sustainable in the long run to cater to the needs of the growing population. A complete transition to cleaner energy sources such as solar, wind and thermal power is vital by 2030.

In the current economic system, economic growth has gradually slowed down in the past few decades leading to widening inequalities in wealth and unsustainable production. The transition to an alternative sustainable circular economic system is difficult initially but will stabilize the economic growth for generations to come. It will also provide new business and job opportunities that can lead to enhanced productivity. In the earlier discussion on cities and linear economy, it was very clear that our cities have become unsustainable as a repercussion of the linear economic system and improper urban planning and management. It's adopting a circular economy, re-designing the cities to promote circularity and changing the way we live to imitate natural ecosystems.

Sustainable production and consumption is the core idea behind the circular economy. It's creating circular material flows, minimizing the usage of natural resources and the elimination of toxic chemicals to reduce our ecological footprint which forms the basis of a circular economy.

Climate change is an aftereffect of human impact on the ecological systems. The exploitation of natural resources at a rate that nature cannot replenish it fast enough and emission of greenhouse gases creating an imbalance in the natural systems are causing long-lasting irreversible changes to the climate. This has resulted in geophysical disasters and economic losses. Also, it's reducing the human impact on the ecological systems through a circular economy will contribute to the climate action goal.

Oceans play a vital role in maintaining the health of our planet. Oceans act as a buffer to the impacts of global warming as they absorb approximately 30% of carbon dioxide produced by humans' activities and produce approximately 70% of the total atmospheric oxygen. It is a major source of protein for humans and 3 billion people around the world depend on marine and coastal biodiversity for their livelihood. Anthropogenic debris majorly constituting plastics and industrial wastes have polluted the oceans to alarming levels, converting them into a toxic soup endangering hundreds of species of marine biota. A circular economy stemming from the zero-waste scenario can save the oceans and the dependent biodiversity (including the humans). Also, human marine activities such as fishing, aquaculture have to become more sustainable by limiting the consumption of ocean-based resources.

Unsustainable agricultural and industrial activities, deforestation, degradation of dry lands and freshwater resources, illegal trades of animals and plant products have created an imbalance in our ecological systems. A multitude of consequences of this imbalance such as loss of natural habitats and biodiversity, climate change, global food and water security, and conflicts, need immediate action [4, 12]. Implementing circularity of materials and sustainable consumption can reduce the stress on natural resources which in turn allows natural systems to replenish the resources. Reducing carbon emissions by using cleaner energy can contribute to maintaining the ecological balance.

## 5 Conclusion

With the emergence of industrial internet-of-things and artificial intelligence, industries are getting remodeled with cyber-physical systems for manufacturing and supply chains. These systems are smart, communicate within the local network and across networks, self-diagnose problems, procure resources at the appropriate time and can interface with humans to optimize the processes. This results in utilization of less raw materials, energy and consequently reduction in waste. Thus, Industry 4.0 facilitates circular economy principles. Schematic illustration of Industry 4.0 is enabling Circular Economy smart manufacturing, smart supply chain and a smart workforce facilitate the reduction in resource and energy consumption, and waste generation by optimizing the industrial processes. For instance, Intel, a leader in microelectronics manufacturing, has implemented sustainability innovations across its expansive ecosystem of manufacturing, technology development, and global supply chain. They have improved the wet process packaging industry in Asia by reducing the usage of harmful chemical consumables and water with greener alternatives and a dry process respectively. Intel is also providing edge computing and AI technologies to empower leading manufacturers to realize the transformation to Industry 4.0. It is estimated that the annual size of the Digital Universe—the data we create and copy—will reach 180 zettabytes by 2025 as a result of the massive flow of every-day data. This gives rise to the need for energy-efficient computing and memory, with a lower resource footprint. Ground-breaking innovations in this domain are essential for the future of our Digital universe, and Intel is currently leading in this area [5, 11].

In recent years, advanced nanomaterial and nanotechnology have enabled sustainable designs for a circular economy. The continuous pursuit of high-performance materials in terms of weight, strength, flexibility, having special properties such as self-repair ability and performing multiple functions to replace the materials in use/for new applications, have changed the landscape of desirable materials. The advancements in material science and technology have offered designers a wide range of greener materials for a multitude of applications. The new and green nanomaterial and nanotechnology are being employed in industrial solid waste treatment processes to enhance the materials extraction rate, wastewater treatment, greener building designs, agriculture, clean energy production and storage secondary raw material extraction, and other applications to replace conventional materials with a higher ecological footprint, facilitating circular economy. Schematic illustration of how nanomaterial and nanotechnology are enabling the circular economy. Nanotechnology applications in environmental sensing and detection of pollution, waste treatment and materials recycling, energy-saving and greener energy production, and new nano materials with lower ecological footprint than conventional materials play an important role in driving a circular economy.

The applications of nanotechnology in environmental management and resource conservation are more advantageous than the conventional techniques. Nanotechnology is used for monitoring and sensing environmental components such as air and water, remediation and treatment of water contaminated with heavy metals, pesticides, organic compounds air filtration treatment, and soil treatment. Nano materials have extensive applications in energy saving in several respects such as superinsulating materials for temperature control, lighter and stronger materials for automobiles, efficient lighting devices and fuel cells and also have promising potential for renewable energy production with nanostructured materials based photovoltaic. Nanotechnology can propel circularity by providing better air and water quality and in maintaining the water resources in a closed loop along with energy conservation and production of renewable energy.

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# Sustainable Development of Russian Budget System Under the Influence of Covid-19 Pandemic

**K. A. Sharonova**

**Abstract** This article analyzes the economic consequences of the spread of coronavirus infection in Russia. In order to eliminate the negative consequences of the pandemic and social support of the population, some changes were made to the country's budget legislation. This has led to various changes and uncertainties in the budget sphere. The article suggests measures to further stabilize the economic situation in the country and improve budget relations in the Russian Federation. The purpose of this study is to suggest new measures for the sustainable development of the country's budget system, to eliminate the negative consequences of the pandemic and to provide social support to the population. To achieve this goal, the article analyzes the changes that occurred in the Russian economy and budget system in 2020, determines the impact of the measures taken on the current situation, and suggests new options for improving budget relations in the country. Despite a significant number of studies in this area, the topic is relevant due to the large number of changes that occurred in 2020. As a result of the COVID-19 pandemic, many problems emerged in the economy (in particular in the public sector) and in the social sphere, which will have to be solved in the coming years.

**Keywords** Budget · Budget legislation · Budget system · Inter-budget relations

## 1 Introduction

There were major changes in the Russian economy in 2020, in particular in the country's budget system. In the current situation, a number of economic and social problems appeared, so the allocating and spending of budget funds to stabilize the economic situation became relevant. Many scientific works are devoted to this topic. Pechenskaya and Uskova [1], Kolomak and Sumskaya [2], Dementev [3], Streltsova et al. [4], Yakovenko et al. [5], Karaulova [6], Zenkina et al. [7] study the allocating and spending of budget funds. Soldatova and Pivkina [8], Kovaleva and Mulendeeva

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[9] identified the main problems that arose in the Russian economy in 2020. The Government of the Russian Federation took a number of measures, and changes were made to the budget legislation. Boyko [10], Ermakova and Girskaya [11], Ermakova [12] wrote works on the analysis of taken measures. Klimanov and Kazakova [13] consider the trends of further development of the Russian economy in their works. The purpose of this article is to identify suggestions for the sustainable development of the budget system of the Russian Federation in the context of the consequences of the coronavirus pandemic. To do this, it is necessary to analyze the changes that have occurred in the Russian economy and budget system, to determine the impact of the measures taken on the current situation, and suggest options for improving budget relations in the country. The object of this study is budget relations in the Russian Federation.

## 2 Methodology

To conduct this study, first of all, the necessary information was searched. Changes in the legislation, news portals, and scientific research were studied. The main method in this study is analysis. To achieve this goal, the article uses an in-depth analysis of all the changes in the budget system and the country's economy that occurred during the COVID-19 pandemic. The measures taken by the government and changes in the budget legislation are also analyzed. At the same time, different views on the changes, reflected in scientific studies, are given. On the basis of the analysis, various views are synthesized and the most significant details are highlighted. Using a generalized and systematic approach, we can suggest measures for the sustainable development of the budget system of the Russian Federation in the context of the consequences of the coronavirus pandemic. With the help of these methods, all the tasks are solved. It suggests that this methodology leads to the achievement of the goal set in the study.

## 3 Results

The Russian economy in 2020 faced a number of difficulties: an epidemic of coronavirus infection, a sharp drop in oil and energy prices, and a decline in exports. This had an impact on both the domestic economic situation and the state of the country's budget system, which manifested itself in a significant reduction of the revenue base of budgets with a subsequent increase in their expenditures, as well as expenditures of state extra-budgetary funds, which are aimed at eliminating the consequences of the spread of coronavirus infection and preventing a decrease in the pace of economic development. When drawing up the federal budget draft for 2020, the state authorities could not foresee a significant increase in the costs of eliminating of unexpected problems related to the financial support of measures to mitigate the negative impact of the pandemic on the country's economy, as well as to prevent and eliminate the consequences of coronavirus infection. Today, there is still an urgent need to find additional sources of budget revenues, as well as to develop a mechanism for spending budget funds to finance the intended goals of state policy.

The pandemic period caused a number of problems in the Russian economy:

- violation of foreign economic relations with other states;
- lack of financial resources as a result of falling oil prices on the world market;
- increased outflow of capital from the country, primarily foreign capital;
- decrease in entrepreneurial and investment activity as a result of prolonged restrictive measures against business;
- falling of population purchasing power, etc. [8].

In the context of the pandemic, the Government of the Russian Federation has taken a number of measures aimed at supporting of various categories of citizens, as well as enterprises and industries mostly affected by the virus consequences. It made serious amendments to the state's budget policy in terms of financing expenditures and forming budget revenues. At the same time, the current situation in the world and Russian economy, which is characterized by a rapidly transforming economic and financial situation under the influence of the epidemic, has an impact on the stability of the budget system.

In April 2020, the Russian Federation amended the legislation, according to which in 2020 the amount of public debt of the subject of the Russian Federation and municipal debt may be higher than the limits defined by the Budget Code (BC) of the Russian Federation [13], on the amount of budget allocations. These allocations are focused on financing measures aimed at eliminating the impact of the complicated economic situation in the country, on the development of the economy of the territories, with the prevention of negative results of the pandemic.

In the Russian Federation, starting from April 1, 2020, the procedure for reallocating budget allocations for measures to eliminate the consequences of coronavirus infection is changing. Now, an additional basis is provided for the introduction of amendments to the consolidated budget list of all budgets of the state budget system in 2020, without making changes to the current law on the federal budget. The amendments is the reallocation of budget allocations in order to provide financial support for measures aimed at preventing and eliminating the consequences of the spread of coronavirus infection. The source of additional resources is the reserve fund. Thus, the highest executive bodies of state power of the country and the subjects of the Russian Federation can now redistribute budget allocations between public legal entities.

The adopted law means a change in the procedure of paying off the regions' debts to the Russian Federation. The government of the country now has the right to change the repayment period of the restructured obligations of the territories: the deadline for granting treasury loans to replenish the financial resources of the budgets of the constituent entities of the Russian Federation is increased from 90 to 180 days, and restrictions on attracting debt obligations are eased.

The governments of the constituent entities of the Russian Federation now have the right to introduce changes in the expenditure items of the budgets of the constituent entities of the Russian Federation and the sources of financing the budget deficit. These measures will help to respond quickly to changes in socio-economic conditions. The subjects of the Russian Federation were advised not to reduce the planned budget expenditures. The Russian President said in his message that it is necessary to fully implement all programs and contracts. These funds are now extremely necessary for the economy. They should work to maintain the level of employment and income of the population, to ensure the sustainability of enterprises.

In addition, the Russian Federation has also taken measures to support the least self-funded local budgets: loans from the regional budget to local budgets can now be provided for up to 5 years. Before the changes were made, this period was limited to 3 years. This increasing was influenced by the current economic situation in connection with the pandemic. This change, as well as the establishment of schedules for the phased repayment of budget loans, make it possible to reduce the increase in municipal debt, reduce the volumes of bank borrowings and the costs of their maintenance.

At the same time, the attraction of financial resources is associated with increased financial risks, which requires the introduction of strict criteria and procedures for managing municipal debt. Therefore, even in the context of a pandemic, the importance of maintaining financial discipline in servicing municipal debt remains [10]. In case of violation of the terms of repayment of their debt obligations in the execution of the local budget and the inability to ensure the servicing of municipal debt by local self-government bodies, the budget legislation provides for measures to recover funds. For this reason, since the beginning of 2021, the Ministry of Finance of the Russian Federation has changed the general procedure for collecting funds for unpaid loans from the budgets of administrative-territorial units. Since the beginning of the pandemic, the state authorities of the Russian Federation have set themselves the goal of preserving the employment and well-being of citizens, as well as preventing the mass closure and termination of the activities of enterprises and organizations, which is directly reflected in the following programs of population support:

1. Increase in benefits.
2. Reducing the tax burden of enterprises, the oil and gas industry and other spheres of public life.
3. Deferral of loans and rental payments.
4. Preferential lending.
5. Increase in child benefit payments [11].

As a result of the application of such measures, significant changes were also made in the federal budget draft. Thus, the Government had to increase budget expenditures on social policy, health care, national security and other expenditure items. This was followed by the emergence of a budget deficit.

In the current socio-economic conditions, the role of inter-budgetary relations is increasing [9]. Faced with the consequences of the pandemic, the subjects of the Russian Federation are experiencing an urgent need for additional funds to ensure a high-quality standard of living for the population. For this purpose, at the end of May, 56 Russian regions received 100 billion rubles from the Ministry of Finance of the

Russian Federation, which will compensate for the loss of budget revenues at the sub-federal level. In particular, the Samara region received a grant of 514.4 million rubles from the federal center. These funds are used to minimize the negative consequences of COVID-19 and to stabilize the socio-economic situation in the region.

In the context of the economic crisis and the coronavirus pandemic, Russia is pursuing a countercyclical budget policy: all expenditures planned for 2020, and especially social ones, are fully funded, despite the drop in revenues [14]. The Ministry of Finance of the Russian Federation, together with other state authorities, has been thoroughly developing the country's development strategy all year. In the past year, in order to stabilize the economic and social situation in the country, it was necessary to introduce many changes in the current financial and further state of both the federal and territorial budgets. In March 2020, the necessary changes were made to the already approved budget for 2020 and the planning period of 2021–2022. The specification of the parameters of the federal budget was made on the basis of the socio-economic forecast of the country's development, as well as on the basis of expectations of its implementation in this year.

Based on the information provided on the website by the Ministry of Finance of the Russian Federation, it can be said that the main focus in overcoming the federal budget deficit will be placed on domestic financing through such measures as privatization, borrowing budget loans, issuing and selling government securities. The maximum amount of funds will fall on 2020, and in the next 3 years, the use of the NWFs (National Wealth Fund) will significantly decrease, which indicates a positive trend in reducing the federal budget deficit. The borrowing plan will help to implement and to make the significant level of savings funds on the budget account more flexible. To keep the level of the debt burden at a stable level, it will be possible to create parameters already from 2022, taking into account the "budget rules".

Fiscal policy and monetary policy are the main tools for limitation of the consequences of the pandemic in the Russian economy. At the same time, experts say that budget and tax measures have a greater impact on the Russian economy [15]. However, there are some limitations, such as the liquid part of the National Welfare Fund and the level of interest rates on the financial market. The choice between tax measures and direct payments from the budget should depend on the possible degree of their impact on economic entities. In the case of applying tax instruments, it is necessary to take into account the already developed model of the tax system in the country when allocating powers and obligations between the federal center and the territories, in order to create conditions for making up for budget losses to a greater extent at the expense of the federal budget. It is also worth noting the positive effect of the already implemented tax support measures. These include such measures as granting deferrals for the payment of taxes, postponing or canceling tax control measures, extending the deadline for submitting tax returns, accounting statements, additional grounds for granting installments for the payment of taxes, and providing additional benefits for certain taxes.

In the sphere of inter-budgetary relations, it is also necessary to implement rational support to the regions in the form of transfers from the federal budget. In each state, there is a question of interregional cooperation for the sustainable development of the country's economy. Horizontal inter-budget transfers and budget loans can be important tools for developing interregional cooperation and supporting regions. Horizontal inter-budget transfers have been used in Russia since 2019 in order to co-finance the expenditure obligations of one region from the budget of another. However, horizontal budget loans were fixed in the BC of the Russian Federation only in the spring of 2020. Now the regions have the right to provide budget loans to other subjects of the Russian Federation for up to 3 years. This change makes it possible to consolidate the efforts of the subjects of the Russian Federation and budget resources in order to prevent the negative consequences of the spread of coronavirus infection [12].

In the sphere of budget expenditures, the most important role should be played by the financing of state programs and national projects. At the same time, the rapid increase in health care costs, which is also provided for by the state program "Development of Health Care" [16], should not have a negative impact on the financing of other program activities. You can put forward the following suggestions to improve the efficiency of budget spending:

- providing financial assistance to the affected sectors of the economy, using such measures as subsidizing rates on bank loans and providing guarantees for loans, expanding public procurement programs for public sector organizations;
- developing an anti-crisis program to support entrepreneurship with the help of direct budget grants;
- modification of the budget rule.

In the current situation in the world economy, under the influence of the pandemic and the fall in oil and energy prices, in Russia and a number of other countries in which the budget revenue is heavily dependent on oil and gas revenues, there is an urgent need to change the budget rule in order to ensure its stability and flexibility in the long term.

Today, in a situation of serious economic instability, it is important to resolve the issues of ensuring fiscal sustainability in the long term, especially in terms of assessing the consequences and possible losses for the budget sector and the country's economy. After overcoming the acute phase of the crisis, it is advisable to undertake the following measures aimed at stabilizing the budget system and the economy:

- strengthening the regulation of the economy and the social sphere by the state to preserve financial stability. To do this, it is necessary to develop a new model of continuous economic development in the long term, as well as to modify the fiscal and monetary policy to increase investment in the economy;
- modification of the budget rule to ensure its flexibility and to strengthen its connection with the most important goals of socio-economic development. It is due to the change in the budget rule that it will be possible to implement expenditures that exceed the limits set in its original structure. This will create conditions for transparency in setting a limit of the financial resources that can be spent on providing anti-crisis measures;
- financing of only specific working state programs and national projects;

- improving the policy in the field of digitalization to ensure transparency and absolute disclosure of information about possible fiscal risks in the process of tracking them;
- global cooperation in limitation of the negative effects of the pandemic.

The settlement of issues of fiscal sustainability and balance should be based on the use of completely new theoretical and methodological approaches, taking into account the existing principles of the model of fiscal federalism in Russia and in the conditions of global economic instability.

In order to solve the main issues of budget sustainability in the long term period, as well as to strengthen the financial and debt independence of public legal entities, it is necessary to solve a number of theoretical and practical problems that are associated with the increase in the effectiveness of financial relations between administrative-territorial units within certain institutional conditions. To increase the independence and responsibility of the authorities of administrative and legal entities, absolutely new approaches are needed to solve the economic and legal development issues of the Russian model of fiscal federalism and the use of effective tools to prevent possible macroeconomic and budgetary risks.

Thus, in the context of a pandemic, the main problems of budget performance at various levels are a sharp decline in the revenue base, a significant increase in unforeseen expenses, and increased dependence of regional and local budgets on inter-budget transfers from higher budgets. Conclusions about the state of the budget system of the Russian Federation can be made only after the cancelling of all restrictions for the population and business and the recovery of the economy of the country and the world.

## 4 Discussion

This article analyzes the changes that have occurred in the Russian economy and budget system, determines the impact of the measures taken on the current situation, and suggests options for improving budget relations in the country. Thus, the goal was achieved—to identify suggestions for the sustainable development of the budget system of the Russian Federation in the context of the effects of the coronavirus pandemic. The study generated various views and suggestions on improving the budget system of the Russian Federation and eliminating the negative consequences of the coronavirus pandemic, suggested by other researchers of this topic. The article highlights the most correct, in our opinion, suggestions of other authors who study these issues. At the same time, there were no serious discrepancies between our views and views of other researchers of the indicated problem.

## 5 Conclusion

Based on the analysis of all the measures taken by the state to eliminate the negative consequences of the coronavirus pandemic, we concluded their effectiveness. We also analyzed the effectiveness of such instruments as fiscal and monetary policy. Based on the analysis done and evaluating the positive effect, we suggested the most appropriate measures for the Russian model of fiscal federalism to further stabilize the budget system and the country's economy. The identified problems and inaccuracies in dealing with the consequences of the pandemic may become topics for further research on this issue.

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# Global Experience of Import Substitution and Innovations Within Russia's Sustainable Development Prospects

**V. A. Noskov**

**Abstract** The purpose of the publication is to assess the world experience of import substitution and reindustrialization policies, and innovations in the economies of different in the development level countries. The importance of applying this experience in the process of import substitution and the unfolding reindustrialization in Russia is indicated. The author analyzes the prerequisites and causes of import substitution and reindustrialization in the world economy. The analysis of the world experience of import substitution and reindustrialization of the economy, its macro-regional features is carried out in the context of maintaining and developing Russia's economic security, accelerating its progress towards sustainable development based on innovation. The author's understanding of the problems and prospects of development processes of the import substitution, investments, and, consequently, reindustrialization in the world is offered. The positive and negative aspects of the policy pursued by a number of countries are noted. It is proposed to build recommendations for improving the import substitution policy. This, in the author's opinion, will accelerate Russia's movement towards sustainable development.

**Keywords** Economic security of Russia · Economy reindustrialization · Import substitution policy · Innovations · Sustainable development of Russia

## 1 Introduction

According to Sukharev, the important characteristic features of the deindustrialization of the economic system are a decrease in the complexity of operations, the quality of equipment and technologies, in other words, the loss of a properly organized production base [1]. As a natural consequence (and not just a deindustrialization), a country that is in the process of deindustrialization does not have its own manufacturing base for the main components of domestically produced machines. Constant

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import of high-tech products is required. In the 90s, the Russian economy experienced all the “charms” of deindustrialization, and in its most negative form. When working national industries, and sometimes the most perfect ones, were destroyed for the sake of the selfish interests of the “effective new owners” of these industries, and not even because of ideas of their optimization or overall efficiency.

In connection with the recently greatly changed guidelines of Russia’s foreign economic activity, which were influenced by certain global factors (in particular, the decline in oil prices, which reduced the ruble exchange rate and, consequently, led to an increase in the cost of import for Russia; international sanctions against Russia, which partially closed access to financial markets and controlled the import of so-called “dual-use products” to Russia, which affected the MIC (military-industrial complex) and other manufacturing industries. The Russian economy has sharply aggravated the need to choose a course for import substitution, which can ensure and significantly strengthen Russia’s economic security, facilitate the transition of its economy to the sustainable type of development [2].

## 2 Methods

The authors’ argument is based on the methodological principles of the duality of the economic nature of economic entities. Methods of comparative, system and institutional analysis, economic and statistical method are used. Sustainable economic development is not an independent problem, but a dependent part of the modern model of economic formation. On this basis, the analysis of the current state of the world experience of the policy of import substitution and reindustrialization of the economy, and their macro-regional features, is carried out. The analysis is carried out in the context of maintaining and developing Russia’s economic security.

## 3 Results

The Russian economy is still characterized by a fairly high import dependence. The highest volumes of import are present in mechanical engineering, agriculture, metalworking, chemical industry, oil and gas processing [3]. Consequently, these industries need import substitution more than others. At the same time, the specified list includes industries whose products are used by large state-owned corporations in the aerospace, mechanical engineering, chemical and other fields. A country needs import substitution when an ever-increasing share of import poses a threat to its economic security. Russia’s dependence on import has been repeatedly used by our Western “partners” for their political purposes.

Currently, it is recognized at the state level that the vector of import substitution in industrial sectors is of key importance for the development of the Russian economy in order to ensure the long-term economic and political sovereignty of the country. In turn, effective import substitution is impossible without an active policy of reindustrialization of the Russian economy on the basis of investments on a new technological basis, and on the basis of widespread use of qualitatively new human capital [4–7]. The issue of state participation in industrial import substitution was considered by many scientists. In foreign practice, this strategy has been repeatedly implemented in practice and has been called “Import Substitution Industrialization” (ISI). The most striking precedent of the ISI, the experience of which can be useful for Russia, both for its positive and negative experience, is the Latin American one, which was held in the countries of Latin America (LA) until the 1970s.

In the LA countries, the following ISI measures were applied: increased duties on the import of finished equipment, incentives and subsidies for both domestic and foreign enterprises that supply the means of production for “young immature” industries, a favorable exchange rate for the import of industrial raw materials, fuel and intermediate goods, cheap loans from government development banks for priority industries, direct government participation in certain industries, especially heavy industry, for example, steel, in which neither domestic nor foreign investors invested. State-owned enterprises acquired controlling stocks of shares in the electric power industry and other important raw materials industries, as well as in industrial production. The expansion of import of equipment and raw materials required maintaining of the overvaluation of national currencies, but it undermined the productivity of export and the degree of competitiveness of LA products, paradoxically limiting the ability to increase the import of equipment. Another shortcoming of the policy was that the priority of individual industries was unjustified, i.e. there was no attempt to focus on industries that could potentially have greater prospects. In some LA countries, the ISI operated for a considerable time only in the consumer sector, in industries with relatively primitive technologies and minimal capital expenditures per worker and unit of production. This was especially true for Argentina, Venezuela and Chile. Most of the industrial products produced in the region had such a high price that it was not possible to export it [8, 9].

Similar problems occurred in other industries. A study of heavy electric machine engineering in Argentina found that high product prices were due to excessive diversification, unused capacity, large-scale inventory of imported products for control purposes, and the difficulty of obtaining external financial assistance. Thus, protectionism and import substitution in these countries created a seller’s market and negatively affected the quality of products. The policy of autarchy—an increasing internal vertical industrial integration (stimulating domestic production of not only final products, but also intermediate goods and means of production) also hindered the growth, since production resources were not used in those industries where they could bring the maximum possible return. If the LA countries specialized in certain types of products with the greatest potential, and exported the excesses of such products, and the rest of the goods were imported, the total output would be much higher. The ISI strategy was implemented not only in the LA countries. For example, a significant part of the export of industrial products from India today is based on manufacturing industries that were previously developed as import-substituting.

Having traced the features of the world experience of import-substituting industrialization on the example of Latin American countries, we see that it certainly has an initial positive effect, but in the future, especially without adjusting the import substitution course, its negative results appear. At the same time, one of the most important problems is the narrowness of the markets. However, this characteristic of the market is not applicable to the Russian Federation. Russia has a fairly large domestic market for consumers of industrial goods and has always been an important partner for foreign countries exporting equipment and spare parts, which means that it also has the potential to implement import substitution. Let's consider the feasibility of such a policy in the Russian Federation.

The industrial base, which has been at the stage of deindustrialization for more than two decades, is not able to quickly provide import-substituting production that is competitive in price and quality. In addition, the introduction of protectionist measures at this stage will lead to the monopolization of the market and an even greater technological lag of the country, hindering the development of competitive industries-the locomotives of non-commodity exports. Protectionism can be introduced slowly rather than immediately as a result of measures to restore and develop the industry of tested product samples and its readiness to serial launching—with the expectation that we will develop similar equipment over time. Then the production at the enterprises of industries that use imports that fall under protectionist measures will stop. Thus, it is more practical for Russia not to focus on protectionism as an import substitution strategy at this stage.

Let's consider the import dynamics of machinery and equipment for 2017–2019 (Table 1). Analysis of these data suggests that the share of equipment in the structure of Russian import has not changed fundamentally in recent years, but there has been a sharp reduction in its value, which is not due to the results of import substitution, but to the fact that in the conditions of devaluation and uncertainty, Russian enterprises freeze projects that involve the purchase of imported equipment. In fact, the primary reason for the lack of competitiveness of Russian industrial products is the weak production base, as well as the high raw material orientation of the economy and the devaluation of the national currency [3].

Russia cannot afford to export more raw materials, especially oil and gas, to pay for increased import of finished engineering products. Therefore, the policy of effective import substitution in Russia, in our opinion, should begin with a strategy of reindustrialization. The technical and economic content of the reindustrialization process is industrial reformation, taking into account the fact that artificial intelligence and environmentally friendly technologies became new drivers for the growth of the manufacturing industry. Reindustrialization in recent years, especially under

**Table 1** Dynamics of import of machinery and equipment for 2017–2019

| Year | Share of import (%) | Cost volume, growth rate |
|---|---|---|
| 2017 | 50.5 | – |
| 2018 | 48.0 | −39.4% by 2017 |
| 2019 | 50.2 | +5.4% by 2018 |

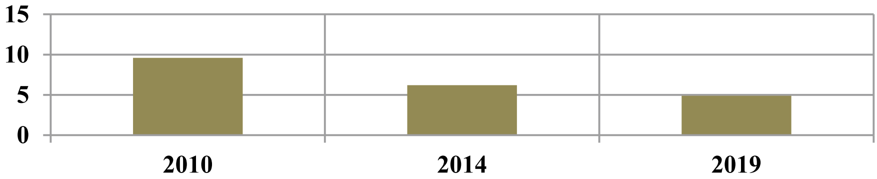


**Fig. 1** US unemployment rate, according to the ILO (% of the working-age population)

the presidency of Trump, is also being carried out in the United States of America. The initial stage of this process was the stimulating of deoffshorization (the transfer of manufacturing enterprises from East and Southeast Asian countries back to the country), and the expansion of access to affordable energy sources. In this regard, the United States began to spread the special term "reshor" (from the English word "reshore")—in contrast to the previously existing offshore process. The country has a specialized non-profit organization, the Reshoring Initiative, which encourages offshore companies to organize the transfer of jobs back to the United States.

A characteristic feature of the reindustrialization of the United States is the focus on "intelligent production" [10]. As an example of intelligent production in action, we call the Albany Nano Tech Complex, which is estimated at $14 billion. The complex receives annual financial support from the state of New York in the amount of $ 1 billion, and employs 3 thousand scientific and technical employees. The complex is known for the fact that on its basis, the world-famous IBM, Intel, in cooperation with Samsung and Toshiba, organized a new production of semiconducting products.

The US government supports special innovation and research engineering centers (technology hubs) established at major technological universities. There are currently fifteen such additive manufacturing centers in the United States. From 2014 to 2019, the implementation of the policy of reindustrialization and reshorization, the output of manufacturing industry products in the US GDP, according to the World Bank, increased by 124% from 2.8 to 3.5 trillion dollars. In addition, the unemployment rate has significantly decreased since 2010 (Fig. 1), but the trade balance is still increasing its negative values [11].

## 4 Discussion

Speaking about the complexity and revolutionary nature of the beginning reindustrialization of the Russian economy, it is worth referring, for example, to the experience of the USSR, which managed to reorient civilian production to defense during the war, to establish production as soon as possible after the evacuation of factories, as well as to completely restore industry and increase production in the post-war years. The examples of Japan and Germany in the 1950s, China in the 1980s and 1990s, as well as the experience of the so-called "new industrial countries" (NIC), which largely followed the Japanese path of development, are also demonstrative. The most important factor contributing to the accelerated modernization of the NIC of Asia was the active state participation and national cultural traditions that support the state authority—obedience to authority, respect for hierarchy, hard work, commitment to sustainable social norms, and the desire to smooth out conflicts.

The catch-up modernization of the EA/SA countries is associated in the economic literature with the “flying geese” model, as is the path of the new industrialization of Japan [12]. Each country raised its production, starting with more primitive and labor-intensive industries, such as light industry and agriculture, and then moving on to the development of knowledge-intensive and capital-intensive technological industries with increasingly high added value. Meanwhile, as industries developed new technological structures, "obsolete" production was transferred first from Japan to the NIC, and then from the NIC to other Asian countries, forming a kind of “goose wedge”, in which there are technological “leaders”, and there are leaded countries.

The main characteristics of the development of East Asian/Southeast Asian NIC was mainly export orientation, in contrast to the LA countries. Import substitution was carried out only in one or two countries in the first decade after the beginning of industrialization, after which it was curtailed and gave way to export promotion. In addition, both China and the EA/SA countries, in contrast to Latin American countries, relied on agrarian reforms and improving the standard of living in the villages. The main engine of the industrial and economic development of the Asian NIC was industrial policy. Less attention was paid to foreign trade policy, tariff barriers, currency regulation, etc. While in the LA countries, exports during import substitution steadily declined, in the NIC, its steady growth was observed. The most positive dynamics of export growth in the years of new industrialization in the countries of East Asia/Southeast Asia was noted in Hong Kong, South Korea and Singapore, but they are not yet able to beat the indicators of China.

In South Korea, as in the LA countries, import-substituting industrialization was carried out, but only until the early 1960s. Then, the country began to implement the export orientation of its industrial policy, while maintaining currency control. The South Korean government was developing five-year economic development plans. A similar practice existed in some developed countries (Japan, Italy, France, etc.). Pricing control, research and development (R&D), and mechanisms for promoting manufactured goods to international markets were developed [13]. The first goods produced for export were standard light industry goods, then machine tool construction and mechanical engineering, as well as the chemical industry (1970s) became priority industries [14].

The industrialization of the Southeast Asian and East Asian countries was based on increasing capital accumulation, as in Japan, whose example served as a guide for these countries (Table 2), and in the 1990s they exceeded similar indicators in Western countries. It should be noted that the main sources of capital investments in Asian NIC were mainly domestic savings of the population, sometimes forced, as for entrepreneurs and workers in Singapore (from 5 to 15% of income), as well as profits from the export of raw materials and agricultural products [15].

**Table 2** The share of capital investment in GDP in Southeast Asia and East Asia countries %

| Country | 1950–1970 | 1990–2000 |
|---|---|---|
| South Korea | 10 | 37.1 |
| Malaysia | 15.3 | 36.1 |
| Singapore | 14.5 | 36.3 |

With regard to the development and application of human capital in these countries, the increase in R&D spendings and the number of students in technical specialties alone was not enough. Thus, the share of these expenditures in the GDP of Japan and South Korea was about 3%, i.e. more than that of developed Western countries. However, the effective use of these investments requires that studies and research and production activities were organized in a certain way. In particular, this organization means a more free, creative, changeable nature of work, the possibility of try-and-error, while these countries are characterized by clear regulations and a rigid hierarchy of work activities. In addition, a significant role was played by the historical factor: the lack of traditions of scientific schools and experience in the implementation of scientific research and development.

## 5 Conclusion

Having considered the main features of reindustrialization and import substitution in foreign countries, both developed and developing, we consider it appropriate to summarize their experience, to determine the positive and negative aspects of their policies (Table 3). And on this basis, we suggest to continue building the improvement of the policy of import substitution and reindustrialization, innovative development of the Russian economy, based on the following fundamental provisions:

1. In developed European countries, as in the United States, there was a “positive” deindustrialization, as production was transferred to third countries while maintaining the management, control and development of high-tech services related to production. In Russia, deindustrialization had a “negative character”, as a result of which there was actually the destruction or degradation of most industries, with the loss of scientific, technical and stock potential, the growth of the share of services was not associated with industrial production. In fact, there was not postindustrialization, but “servicization" of the domestic economy.
2. Due to the high import dependence of the Russian economy on such an important commodity segment as machinery and equipment, which is used in many industries that are important for the country’s economic security, as well as in connection with the recent political and foreign economic situation, the country needs a policy of import substitution in the field of industrial production. However, the choice of an import substitution strategy becomes more important. Due to the weakness of the Russian production base, the low competitiveness of the Russian machine-building industry, and the raw materials orientation of the

**Table 3** The world experience of reindustrialization, import substitution and innovations in the economy and its significance for the sustainable development of Russia

| Countries | Positive experience | Negative experience |
|---|---|---|
| Latin American countries (Brazil, Argentina, Mexico, Chile, Peru, etc.) | Stable exchange rate of the national currency (to attract domestic and foreign investors, increase sales on the domestic market and for export), cheap loans, subsidies to foreign investors in the amount of 89% of investments—Brazil, 50–60%—Mexico (which contributed to the arrival of foreign MNCs in the automotive industry) state support for unattractive industries for investment (heavy engineering) | The overall state participation without control, for example, by representatives of industry associations or competing enterprises, led to the misuse of funds ("import substitution is not for industry, but for a certain number of industrialists") |
| USA | The close connection between science and production, the prestige of engineering and working professions, low energy tariffs, reschorization with the creation of new jobs | Negative balance of payments due to steadily increasing import, including equipment and technologies |
| East and Southeast Asian countries | A large share of investments in R&D, an increase of human resources in industry, a gradual focus on priority industries, a gradual transition to more high-tech (we started with light industry, then developed machine tool construction, mechanical engineering, chemical industry) | Lack of experience in scientific developments and scientific schools |

economy, import substitution in Russia should begin with a reindustrialization strategy, using the positive experience of the United States, Latin America, and the NIC of Asia.

3. Reindustrialization as a strategy for effective import substitution should be aimed at both the growth of the Russian economy and the diversification of its foreign trade relations. With regard to the latter direction, we distinguish two main guidelines:

   - a focus on the development of high-tech export, measures to support which have been repeatedly considered in the domestic economic literature. High-tech engineering products have much higher added value and higher income elasticity than raw materials export;

- focus on the diversification of import deliveries (intermediate goods, raw materials and technologies instead of finished equipment), as well as the diversification of suppliers in order to avoid the vulnerability of the economy.

4. For the reindustrialization of the Russian economy, the reindustrialization of the machine tool construction is of priority importance, since its technical condition largely determines both the level of machine-building and the level of technological independence of the country. The paradox of the current trend of Russian import substitution in mechanical engineering is that the "import-substituting" products of machine-building enterprises undergo the so-called finishing on imported machines, most often from Germany, Japan, and South Korea.
5. The government should create conditions for active cooperation between business and science, the largest universities in Russia, and increase of the share of investments in R&D by introducing appropriate tax incentives. It is necessary to really strengthen the connection between science and production, to increase the prestige of engineering and highly qualified working professions.

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# Innovations for Home Within the Global Sustainable Development Concept: Key Landmarks

**N. I. Ivanova**

**Abstract** Sustainable development has already become the priority of the global community with special attention paid to climate changes, energy efficient technologies and energy transition via decarbonization. Smart home technologies contribute to each of the listed items making buildings ecological, sustainable and efficient. These technologies surely bring benefits for economic actors—households, companies (primarily these that produce hi-end products) and government—as well as certain risks. In the paper the smart home market segments get examined. The most active smart home end users are revealed. The available data on the market segmentation by region is analyzed. North America is predictably the leading market for smart home systems. Special attention is paid to the Russian smart home market that faces a number of challenges. Lack of the smart home concept awareness among potential consumers, absence of a uniform data transmission technology, security problems and high cost of technology installation are considered to be the most serious deterrents. The instruments that may boost the smart home market in Russia are sketched. The companies that lead on the global and Russian markets are listed. Russian companies are very few on the list so far. However smart products continue to develop, digitalization keeps advancing and prices for smart home systems tend to fall. This will additionally accelerate the market in Russia in the long run.

**Keywords** Information technologies · Internet of things · Sustainable development · Smart appliances · Smart grids

## 1 Introduction

The modern mass production techniques have caused environmental problems. These determine the need to change the way of economic life. New ways of the global development are being searched. It is surely vital to focus on sustainable long-term human development that can keep ecosystems and biodiversity safe. Thus renewable

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energy and energy efficiency are in the spotlight. The green economy concept has become a strategic priority for many governments over the past decade. Advanced technologies constitute the main tools that help to implement the concept at the local level [1]. Today the city is undergoing a global transformation. This requires the infrastructure based on smart grids. So the elements of smart home are being introduced around the world to make home more comfortable, safe and efficient. A rational approach to the arrangement of living space gets formed.

## 2 Methodology

The major goal of the paper is to examine the global market for smart home devices and services that keeps actively developing within the sustainable development concept. The tasks are as follows:

- to reveal the key traits, segments and actors of the market;
- to summarize the challenges the market has to face;
- to highlight the features of the Russian market for smart home systems that is on the stage of infancy at the moment and is getting shaped.

The goal and the tasks have determined the methods used in the paper. So the methodological base is made up of comparison, analysis, synthesis, classification, generalization and descriptive statistics. The key traits, segments and actors of the smart home market have been revealed through analysis and synthesis. The challenges threatening the market have been summarized via comparison, classification and generalization. The specific features of the Russian market for smart home systems have been highlighted basically with the help of generalization and descriptive statistics. The statistical indicators that characterize the size and dynamics of the smart home market and its saturation have been selected. Special attention has been paid to the average income on the market segments and the key consumer groups—both on the global and Russian levels.

## 3 Results

Advances in the internet of things (IoT) technology and the growing demand for energy-efficient solutions have led to the emergence of the global market for smart home systems. This market is for network devices and related services that make home automated for private end users. These devices are either directly or indirectly connected to the Internet. Their main objectives are to control, maintain and regulate the functions of a private household [2]. Remote control and monitoring of devices and their direct communication with each other through IoT technologies comprise the key component of home automation that makes a home smart. The services required for the domestic network maintenance and management are surely to be considered. These include fees for apps or external monitoring services. Experts expect the global smart home market to grow by an average of 18.4% up to 2026. The market is likely to be influenced by macroeconomic and other factors.

Urbanization and infrastructure projects stimulate growth on the global smart home market. Rapid urbanization has led to a variety of challenges such as high living cost, environmental pollution, rising crime rates, massive investments in infrastructure and unprecedented growth of data volumes. These problems have increased the demand on the smart home market. The implementation of smart city projects and the need to create a smart infrastructure also expand the smart home market. Infrastructure development makes the market grow in emerging economies. Thus urbanization and infrastructural projects form the basis for the global smart home market. The latter is comprised of the following segments:

- energy management;
- comfort and lighting;
- home entertainment;
- control and connectivity;
- smart home security;
- smart appliances.

The energy management segment covers products and services that control and reduce energy consumption (e.g. automated heating control and timers) as well as sensors (temperature, sunlight and rainfall sensors) [3]. Devices that improve the living atmosphere are within the comfort and lighting segment. These are sensors and actuators (door and window sensors, blinds) plus connected and remotely controlled light sources (smart lamps) or garage door controls.

The home entertainment segment includes multi-room entertainment products and services such as sound systems as well as connected remotes and streaming devices (Amazon Fire TV stick, Google Chromecast).

Control and connectivity implies the necessary equipment and services that are part of the smart home network. The segment covers smart speakers (Amazon Echo, Google Home, etc.), central control and communication units, control buttons and smart plugs for controlling non-smart devices.

The smart home security segment covers the devices and services for network access control and management of buildings and premises. These are surveillance devices (security cameras plus related data storage and transmission services, motion detectors, programmable and remote door locks) and risk monitoring equipment (connected smoke and moisture detectors). The smart appliances segment includes all types of household appliances that are connected to the Internet. The total revenue on the smart home market is about 91 billion USD in 2020. The compound annual growth rate (CAGR) is calculated to average 15% within 2020–2024. Thus the market will grow up to 159 billion USD by 2024.

Security and control systems have recently been among the most popular smart devices. Smart home technology can integrate burglar alarms into a complex system, which as well performs other actions such as blocking exits or providing access to video surveillance records via the Internet. The global home security segment is projected to grow up to 23 billion USD by 2021.

The comfort and lighting segment will demonstrate the highest annual growth rate. The 2020–2024 CAGR is expected to be 20.5% resulting in the market size of 19.5 billion USD by 2024. The smart appliances category ranks second in terms of expected annual growth rate. Revenue is projected to grow at a rate of 16.5% in 2020–2024 reaching 39.6 billion USD by 2024.

The average income per a smart home was above 1000 USD in 2017. The most highly demanded were smart appliances and security control devices. The average income is expected to decrease by 33% by 2024. This is caused by increasing competition on the smart home market which pressures the prices down.

Households demonstrate a growing demand. Their share was 9.3% in 2020 and is expected to average 19.3% in 2024. The most active users of smart home systems in 2019 (33%) were the 25–34-aged.

The global smart home market faces a number of challenges such as lack of awareness, absence of uniform standards and devices compatibility, high prices, threat of cyberattacks and privacy concerns. The high cost of implementing smart home solutions is the major constraint on the market. Making a home smart implies the installation of expensive devices and high-end equipment. This creates a connected environment. Hence the associated costs are too high for the average consumer.

In short smart systems and all the related services that provide home automation for private end users constitute the smart home market. The market size amounted to 74 billion USD in 2019, 91 in 2020 and is expected to reach 159 by 2024. The most popular market segments are smart appliances and security control. They contribute the most to the income from sales of smart home systems. The most active smart home end users are aged 25–34.

North America is the leading market for smart home systems. Its share was above 41% of the world market in 2017 (the latest available data on the regional market segmentation). The North American smart home market demonstrated strong growth throughout 2018. The installed smart home systems increased by slightly below 50% and reached 135.4 million USD by the end of the year: 13.3 of multi-functional or complex smart home systems plus 122.1 of point solutions designed for a single function. The installed base embraced 33.8 million homes. Some of these had several smart systems in use. This corresponds to 23.9% of households making North America the most advanced smart home market in the world. The number of households using smart home systems is projected to grow by 12.3% annually in 2018–2023 reaching 60.3 million smart homes by the end of the period [4].

## 4 Discussion

The industry is at the very beginning of development. The share of households with installed smart systems amounted to about 0.6% at the end of 2017 [5]. The trends boosting the smart city and smart home markets have become evident recently. The state that regulates and initiates the digitalization of economy including infrastructure and the key market actors primarily telecommunications operators, IT companies and digital equipment manufacturers are among those who make the market grow.

The market is witnessing an active expansion of the smart home systems in individual apartments and apartment houses. The latter get equipped with automation systems with heating, ventilation, air conditioning, power supply, lighting and security being deeply integrated. The demand for smart homes remains dependent on the IoT which helps devices be connected with each other and exchange data.

Russia accounts for 11.3% of smart home equipment sales in Europe. The market size for smart home systems in Russia was 344 million USD in 2017. It grew in 2018 and reached 437 million USD. 1.2 million of smart home devices were purchased in 2018. That is 30% more than the year earlier. CAGR 2020–2024 is expected to be 18.9% and the market size will exceed 1.5 billion USD by 2024.

The Central Federal District with a 52% share leaded in the regional structure of the Russian market for smart home systems in 2018. Moscow and the Moscow Region accounted for 44%. The Northwestern Federal District ranked second (13%) and the Volga Federal District third (10%).

The three main segments on the Russian market for smart home systems are smart appliances, security and entertainment with smart appliances leading on the market (194.8 million USD in 2019 or a 33% market share). This segment was a permanent sales leader 2017 through 2019. Security devices ranked second with a 25% market share. This segment shrank by 3% compared to 2017. The entertainment segment ranked third with a market share of 17%. Home automation management kept actively developing: 8 and 12% on the market in 2017 and 2019 respectively.

The average income per a smart home in Russia was 407.75 USD in 2019. As forecasted, this indicator will be smoothly declining to 334.8 USD in 2024 [5]. The most active smart home systems users in Russia are the 25–34-aged. They constitute the 35.2% share of consumers on the market.

The Russian smart home market faces a number of challenges. Lack of the smart home concept awareness among potential consumers, absence of a uniform data transmission technology, security problems and high cost of technology installation are among the most serious deterrents.

Further digitalization, government initiatives and affordable prices for smart home systems will help consumers appreciate the opportunities to save resources and ensure the safety of family members and property via smart home products, devices and solutions. The market will get boosted.

## 5 Conclusion

The size and trends of the smart home market have been revealed and discussed. The market size was estimated at 74 billion USD in 2019 and is expected to expand up to 159 billion by 2024. The most actively growing market segments are smart appliances and security. These are the largest contributors to smart home sales revenue worldwide. The global leaders implementing smart home systems have been identified. The North American region is leading in the smart home technology introduction. Market revenue reached 22.3 billion USD in 2018 and had increased by 24.8% since the previous year. The USA is the key market for smart homes in North America. The latter is followed by Europe with 15.2 billion USD of revenue. However, Asia–Pacific countries, India, Japan and China in particular, are expected to demonstrate the fastest annual growth on the market in 2018–2026.

iTSCOM, Comcast, Xiaomi, Panasonic and Korea Telecom are among the key actors on the smart home market as well as Deutsche Telekom and Centrica Connected Homes. Bosch is still a leading global technology and service provider. The company pays great attention to innovations in ecology and adheres to sustainable development. The Bosch Group offers both complete and point solutions on the smart home market. Europe remains the major market for the company.

The Russian market for smart home systems is currently at the stage of formation. The market size was 599 million USD in 2019 and the average income per a smart home was 407.75 USD. The most active segments are similar to those that are active globally: smart appliances, security and entertainment. The Central Federal District with a 52% market share leads in the regional structure.

The key actors on the Russian smart home market can be identified as follows: half of the Russian smart home market is occupied by suppliers from the USA, China, Germany and Austria. Solutions from Amazon, Google and Xiaomi are popular. The Russian manufacturers—Rubetek, Yandex, Wellink Technologies, Wiren, House-Clever—play a minor role on the market so far. The systems are sold mainly through large retailers and telecom operators. The problems and prospects for the Russian smart home market have been outlined. The market faces a number of deterrents. Lack of awareness among consumers, absence of a uniform data transmission mode, security concern and high cost of initial installation are among the most significant ones. However smart products continue to develop, digitalization keeps advancing and prices for smart home systems tend to fall. Thus consumers will surely appreciate the opportunities to save resources and ensure the safety of family members and property via smart home products, devices and solutions. This will additionally accelerate the market in the long run.

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# Cybercrimes as a Threat for Sustainable Development in the Digital Era

**N. Yu. Guryanov, E. R. Khafiyatullina, and Yu. A. Urgalkin**

**Abstract** The study deals with the growth of cybercrime activity spreading rapidly throughout the modern world. Today cybercrime is one of the most serious threats for national security and sustainable development. The aim of the research is to make a complex analysis of the cybercrimes taking into account information and technic innovations, economic and legal factors, behavioral and psychological aspects of this problem. The latest statistics in this area is given in the study. Modern diverse types of cybercrimes are identified and characterized. Social engineering is analyzed as an effective method of human psyche and behavior manipulation. Specific legal regulation of cybercrimes in western and eastern countries is considered, as well as the countering cybercrime practice in modern Russia. It's concluded that the modern measures of countering cybercrimes are mainly based on the legal experience of the Western countries. But it's not enough. More legal regulation instruments must be introduced in this specific area. Special attention must be paid to the further development and improvement of the legal acts on cybercrimes.

**Keywords** Cybercrime · Cybersecurity · Law · Legal regulation · Social engineering · Sustainable development

## 1 Introduction

The main phenomenon influencing the life of the society in the XXI century is an active development of information and telecommunication technologies. It's often noted that a new digital period in the human history has already started. The system of social interactions in the digital era is based on the active Internet using. The last one makes all sorts of communications more accessible, stimulates the development of various productive spheres of human activity [1]. According to the data of the

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Digital 2020: Global Digital Overview, 4.5 billion people have used resources of the Network in the beginning of the 2020; it's about 60% of the whole humanity [2]. But the wide spread of the network technologies has led not only to the progressive development of the society, but also to the expansion of the new types of social threats. One of them is a new type of criminal actions called «cybercrimes». The sphere of cybercrimes is rapidly increasing in the first two decades of the XXI century. Today it's one of the most serious problems for the modern countries and governments.

Cybercrimes are committed through the hacking of websites and e-mails, distribution of malicious programs and illegal information of different content. Cybercriminals carry out their illegal actions in the virtual space with a help of technical devices and innovative technologies. The last ones are the most important instruments for the criminals of this area. Their main aim is to steal and sell the personal or confidential information, to damage or destroy computer systems by inserting malicious sites and computer viruses. It's obvious that this type of the crime actions poses a serious threat to the information security and sustainable development.

Today cybercrimes aren't only a problem of the personal Internet users; they've got a wide social and international resonance. The growth of cybercrimes affects the whole states and countries all over the world. Sberbank has calculated, in 2020 the losses of the Russian economy from cybercrimes were over 3.5 trillion rubles; to the end of 2021 this number can increase twice, that'll make up the total 7 trillion rubles. According to Sberbank data, at the present moment the number of the world cybercriminals is about 1.5 million people; to the end of 2021, this number may increase by 30% [3]. In Russia the number of cybercrimes has increased by 20 times over the last 7 years, and by 25 times over the last 5 years [4]. This negative tendency has especially intensified in the first half of the 2020 by the cause of coronavirus pandemic [5]. It's connected to the moving of the greater part of processes and operations to an online format. From that very time the number of cybercrimes has increased by 92% in comparison with the same period of the previous year. In 2020, the experts fixed 85% increasing of cybercrimes [6]. Meanwhile, only 25% of cybercrimes are successfully solving [4].

## 2 Methodology

The method of classification is used to characterize and make a typology of modern cybercrimes. The last ones are divided into two related groups—technically oriented and based on the methods of social engineering connecting with an impact on the human psyche. The dialectic method provides the authors an opportunity to show a short history (just over 20 years) of the cybercrimes evolution in its development and dynamics. The comparative method is used to find out the differences between the number and character of cybercrimes in the beginning of the twenty first century and nowadays. It's also used to show the differences between the legal regulation of cybercrimes in western and eastern countries, and in modern Russia. The method of analysis helps the authors to make conclusions about the character and difficulties of countering cybercrimes in the digital era. Prognostic method is used to give recommendations about the present state and difficulties in countering cybercrimes. It also helps to outline the ways of its optimization and overcoming in the nearest future.

## 3 Results

### *3.1 Modern Types of Cybercrimes: Variety and Technical Orientation*

It was the 23 of November 2001 when the famous «Convention on Cybercrime» [7] was signed in Budapest by the members of the Council of Europe. It was one of the first serious steps to handle cybercrimes. It was also the first official document establishing the need for the legal pursue of cybercriminals. Five main types of offences against the confidentiality, integrity and availability of computer data and systems were mentioned in this Convention [7]. Among them there were illegal access; illegal interception; data interference; system interference; misuse of devices [7]. Almost two decades have passed since that very time, and the sphere of cybercrimes has changed much and expanded greatly. There are many new types of cybercrimes widely representing in the digital era. They are phishing, farming, cyber-drug trafficking, cyberterrorism, social hacking (piracy) and some others. Let's take a closer look at the most notable of them. Modern cybercrimes are financially oriented. All of them are the socially dangerous actions that affect the sphere of financial and economic relations, such as the plastic cards fraud, the left of funds during the banking actions, etc.

One of the most widespread types of cybercrime is phishing. It's based on the stealing of the personal data to access the bank accounts. Without saying, this procedure is carried out fraudulently. The cybercriminals often send the users a file or link containing malicious ciphers. If you click on such a link, your data is read, your bank account is hacked and your finance is stolen.

A type of cybercrime related to the distant computer hacking is called «farming». In the case of farming the cybercriminal gets a full access to the computer system: he can edit documents, monitor the computer user's behavior with a help of audio and video surveillance resources, enter various malicious programs, collect information about the user, etc. The main threat of farming is that the user doesn't even understand that he's an object of the criminal manipulations.

There's also another type of cybercrime activity such as cyber-extortion. In the case of cyber-extortion malicious code is entered to the computer system of the personal user or the company. Then all his files are encrypted. And finally he receives an offer to restore them in exchange for a monetary reward (usually in the form of bitcoins or other cryptocurrency).

Cyber-traffic in drugs and weapons is also a widespread type of cybercrimes. It's carried out with a help of information technologies: the encrypted coordinates of the «product's» location are brought to the client, and the payment for it is also made in a virtual form. It's also necessary to mention the phenomenon of cyberterrorism [8]. In its case the terrorist acts take place with a help of information technologies. They include the calls for terrorist actions and sending information about the terrorist attacks planning in future.

### 3.2 Social Engineering as an Effective Method of Human Psyche and Behavior Manipulation

Social engineering is related to the manipulations with the human psyche and behavior in order to hack the security systems and steal important information. Social hackers (or social pirates) use various techniques to get illegal access to information they are interested in. Most of them are basing on the mental impact on the human psychology in order to get the personal data [9]. This can be either a computer or a phone attack. The fact is influencing the human psychology is much more simple than the technical actions of hacking computer systems. The most popular method of social engineering is «phishing», we have mentioned above. Its aim is to «fish» the personal data from the technically uneducated Internet users.

Social hackers are really good experts in the field of human psychology and they use their skills successfully. They can pretend being someone else and thus mislead the naive person; they can also blackmail or abuse the trust of their potential victims. When the hacker fraudulently gets an important data, his following task is to install a malicious program to control the victim's device. Further efforts are concentrated on making this program undetected for such a long time period as it's possible.

In the digital era young people are becoming victims of cybercrime activity more and more often. The most terrible and irreversible process of influencing children and youth is their mass involvement in various suicidal groups, where the theme of death is presented as romantic, and leaving life is popularized. There are several methods of influencing young people. It can be not only direct interactions in social networks, but the offer of watching videos, discussing soap operas, and helping to make homework. Certain recommendations for reading online literature or listening to music can also be dangerous. That's why more active efforts should be taken to prevent this type of cybercrimes, to protect children and young people from it.

### 3.3 The Legal Regulation of Cybercrimes in Western and Eastern Countries

An absolute leader in the sphere of the Internet legal regulating is the modern Germany. Here the changes to the «Network Enforcement Act» of 2017 [10] were adopted on the 1 of January 2018. According to them all the leading network platforms such as Twitter and Facebook must rapidly delete any illegal content from their field. And the level of such an «illegality» is set in accordance to the 22 chapters of the German Criminal Code [11]. If it isn't done operatively the fine for violation can be really huge—up to 50 million euros [12].

As for the UK, there are several laws restricting the rights of the single Internet users in the interests of the whole state. One of them is the «Data Protection Act» of 2018 [13]. This Act regulates the processing of personal data relating to individuals, to Parliament and to the Crown. It also makes provision about the enforcement of the data protection legislation. In general, the UK has at least six laws (one of them—joint with France) on the regulation of the Internet activity.

In 2016 the members of the European Union created the «Code of Conduct on countering illegal hate speech online» [14]. It was coordinated with the four main platforms—Facebook, Microsoft, Twitter and YouTube. In addition to it «The Directive on Copyright in the Digital Single Market» [15] was adopted in 2019. Its aim is to make Google, Facebook and other platforms pay compensations to publishers and painters. In Italy there are the similar legal acts concerning copyrighting and providing pre-trial blocking of sites.

The US also take care of their cybersecurity. Here the Internet is regulated by at least eight profile laws. Already in July of 2007 the «Protect America Act» [16] was adopted by President Bush. It permitted special services to wiretap any foreign phone calls. This Act was valid for a period of 180 days, and then the Congress refused to renew it. But its main provisions were included in the «FISA Amendments Act» [17] of 2008. It's used as a legal basis for the mass surveillance programs widely practiced in the modern America.

One of the most famous laws touching the Internet was adopted in China in 2017 [18]. Its aim is to protect the national «cyberspace sovereignty» and to regulate an activity of the network providers, their products and services helping to collect, store and process the users' data. This law is also a guarantee of information security in the strategically important industries of the country. For violators, the fine is up to 1 million yuans,—it depends on the certain level of the committed cybercrime.

There are the laws restricting the Internet activity in modern India. One of them is called «Information Technology Act» [19]. It provides for criminal liability for sending messages of an offensive character. There's also a chapter giving the authorities of the country a right to intercept, monitor, or decrypt information through any computer resource. A very strict law «On Regulation of Publications on the Internet and Combating Crimes Committed by Means of such Publication» or «The Internet Law» [20] was adopted in modern Turkey. It gives the authorities a right to pre-trial blocking sites containing illegal information and especially an insult to the state principles.

As we can see, there are the laws regulating the Internet activity in most countries of the modern world, both Western and Eastern.

### 3.4 Countering Cybercrime Measures in Modern Russia

It's significant, The Criminal Code of the Russian Federation [21] doesn't contain the concept of «cybercrime». It's still absent. And Chap. 28 of the Code—«Crimes in the Sphere of Computer Information»—is one of the smallest chapters of this important legal document. There are only 4 articles in this Chapter providing for liability for crimes committed with the using of computer technics and innovative technologies.

Article 272—«Illegal Accessing of Computer Information»—provides for liability in the cases of the destruction, blocking, modification or copying of computer information. Article 273—«Creation, Use, and Dissemination of Harmful Computer Viruses»—prescribes criminal liability for all these actions. Article 274—«Violation of Rules for the Operation of Computers, Computer Systems, or Their Networks»—assumes the presence of major damage (more than 1 million rubles) [21]. If the damage is at least 1 ruble less, there's no crime. As a result, there's no criminal liability. In 2017 one more addition was made to the Russian Criminal Code. Article 274.1 provides for liability for unlawful influence on the critical information infrastructure of the Russian Federation.

It's obvious that these four articles aren't clearly enough to counter cybercrimes in an effective way, to ensure the information security of the country and implement the model of its sustainable development. Therefore, Russian President Vladimir Putin, speaking on the 20th of November at the Asia–Pacific Economic Cooperation (APEC) summit, described the situation with the growth of cybercrimes with the words «We're far behind» [4]. In his speech, he accented the fact that the rapid development of technologies causes the growth of number of cybercrime operations.

The Russian leader noted that the development of e-commerce and the provision of various online services are our future. Technologies are updating and changing rapidly. But the field for various types of scammers is also increasing [4]. In such a situation, according to the Russian president, it's important to inform people in a timely manner about the ways to protect themselves against cybercrimes, to establish an effective interaction between the law enforcement agencies and the banking community, the Internet service providers and the mobile operators. It's also necessary to develop international coordination in the field of the personal information protection and the countering cybercrimes.

## 4 Discussion

Today, a number of experts consider cybercrimes as a most serious threat for national security and sustainable development of different countries all over the world. The studies in this area show a complex system of criminal factors that has already been created in the global network. Over time, they are getting more diverse and widespread. Modern scientists pay special attention to an impact of technological advances on social processes, human factor in cybercrimes [22], problems of cybersecurity, privacy and freedom protection in the modern world [23]. The cyberchanges in the essence of the modern crimes and the format of the new laws corresponding to this area are also subjects of discussion. But it's clearly not enough.

The legal framework and regulations of cyberspace and cybercriminal activities still remain poorly developed. In fact, evolution of computer technologies and emergence of the new group of criminals—hackers and cybercriminals—go far ahead of the legal system formed in this area. This makes impossible to create laws regulating relations in the cyberspace operatively; increases the chances for the cybercriminals to go unpunished in more and more cases.

There are also great difficulties with solving cybercrimes. Their victims often don't want to contact police to report a computer crime because of the disbelief in the real results of such a procedure. One more reason for such a civil inactivity is the legal illiteracy of a most number of people facing cybercrimes.

Besides, it's much more difficult for the policemen to identify a cyber-fraudster than an ordinary criminal. Most cybercriminals are well-educated and highly skilled programmers. They don't leave «traces» of their presence at the place of the crime. Very often their victims don't even think about the crime that has taken place against them. So, it takes a long time to find it out. By this time all possible «virtual traces» are usually disappear in full measure.

Facing cybercrimes, police officers need a help of the highly qualified specialists in the field of programming. But their number among the police officers isn't still enough. There is no general judicial and investigative practice in the case of this category. The united cybercrimes' prevention and solving program is also absent.

## 5 Conclusion

The sphere of cybercrimes is spreading fast in the modern world,—their number is increasing exponentially. As a result, the global network is unable to resist different kinds of illegal cybercriminal actions that have already got an international character. Today more and more new types of cybercrimes are forming in the virtual space. And it's necessary to find an effective method of countering for each of them. This causes a number of difficulties, as it was mentioned above.

Today, an increasing number of the Internet users suffer from the destructive actions of the cybercriminals. But the level of their computer skills and the awareness scale in this area don't raise or even change towards quality improvement. The number of online communications and activities of various Internet communities, including extremist and terrorist groups, is also growing fast. The anonymity of their participants is increasing. There are many cases of manipulations of human consciousness and behavior on the Internet through the virtual reality.

The measures of countering cybercrimes are being taken all over the modern world, especially in the highly developed technical countries. They are mainly based on the legal experience of the Western Europe. With the help of these measures the awareness of the Internet users about cybercriminal activities is gradually increasing; the legal regulation instruments are introducing in this specific area. Special attention must be also paid to the further development of the legal acts on cybercrimes. It's a necessary condition for effective legal regulation of the cybercrimes, ensuring cybersecurity and achieving sustainable development in the modern digital era.

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# Statistical Analysis of Foreign Trade Turnover Sustainable Performance in the Russian Federation

**E. I. Sukhanova and S. Y. Shirnaeva**

**Abstract** Currently the foreign economic activity of the Russian Federation is carried out within serious contradictions in foreign policy with the United States and the European countries. In the current conditions, the assessment of the sustainable development of foreign economic activity is an urgent task. In this light there is a need to assess the sustainable development of foreign economic activity. Constant monitoring of foreign trade turnover indicators and assessment of their sustainable performance contribute to the timely identification of challenges and threats at their initial stage. The study is aimed at a statistical analysis of the sustainable performance of foreign trade turnover indicators. Indicators of the sustainable performance of the time series trend and the levels were calculated. Based on these calculations, it is determined that the time series of the indicators under study are relatively stable. The Spearman rank correlation coefficient plotted in the paper characterizes the time series of indicators under study as the series with an average sustainable performance. The statistical methodology used for the analysis of economic indicators sustainable performance that was applied in this study allowed a more reasonable approach to the selection of variables for modeling. It could be also applied for constructing adequate models and using them for analysis and forecasting. Sustainable performance indicators of foreign trade turnover can be seen as the indicators of foreign economic activity sustainable development in general.

**Keywords** Foreign trade turnover · Sustainable development · Sustainable performance indicators · Time series

## 1 Introduction

Currently, the reduction of natural resources share in the export and the increase of high-tech products and advanced technologies in the Russian Federation (RF) foreign economic activity are seen as the priority. To complete this task, it is necessary to

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ensure effective interaction between the foreign economic complex and the country's innovation system [1, 2]. The foreign economic activity in the RF is carried out under serious foreign policy contradictions with the United States and European countries. Therefore, a shift in the structure of foreign trade turnover in the RF is observed [3, 4]. There has been a shrink in exports and imports with Ukraine and other countries. Exports to China, India, and Brazil have increased. The oil crisis of 2020 and the pandemic also have promoted the shift in the structure and impetus of Russian foreign trade turnover [5]. Given the situation, an urgent task is to assess the sustainable development of foreign economic activity [6, 7]. Constant monitoring of indicators of foreign trade turnover, assessment of their sustainable performance contributes to the timely identification of challenges and threats at their initial stage.

In this paper the term "foreign trade turnover sustainability" is defined as a certain level of development, steady dynamics, timely and relatively stable fulfillment of all obligations backed by sufficient profit [8]. The statistical study and analysis of the sustainable performance of foreign trade turnover indicators in the RF is seen as the primary objective of this work. Dynamic stability will be inspected in this study. In statistics, dynamic stability is defined, firstly, as the category opposite to variability, and secondly, as the steadiness of the transformation direction, i.e., the consistency of the trend [9]. To consider the question of sustainable performance of the RF foreign trade turnover indicators, the stability of the time series of indicators that characterize it will be investigated.

## 2 Methodology

The main requirements for the time series stability include the minimization of fluctuations in the time series levels and the presence of a certain trend of change critical for society [9]. Taking this into account, for indicators that characterize the foreign trade turnover of the Russian Federation, stability or, in other words sustainable performance is understood as the behavior of a time series in which the regularity in the change in the levels of the series prevails over randomness with a constant progressive development of the phenomenon [9].

In this paper, two approaches were applied to the statistical study of the sustainable performance of foreign trade turnover indicators in the RF. At the first stage, indicators were inspected in relation with the stability of the time series trend. The second step included the study on stability of the time series levels. In vein with the aim of the study, statistical methods of time series were used. To check if a certain trend is present in time series changes that is necessary for society, a combination of several methods were used, namely graphical method, the Foster-Stewart method, and a method of comparing the average levels of the series. The sustainable performance index of the levels and the sustainable performance coefficient were calculated. It was performed to assess the stability of the time series levels. The Spearman rank correlation coefficient was calculated. It was done to assess the stability of the trend.

## 3 Results

The paper considers the following foreign trade turnover indicators of the Russian Federation (billion US dollars):

$Y_1$—export of goods—total;
$Y_2$—export to non-CIS countries;
$Y_3$—export to the CIS countries;
$Y_4$—import of goods—total;
$Y_5$—import of goods from non-CIS countries;
$Y_6$—import from the CIS countries.

The information array of the study includes statistical data in monthly dynamics for the listed indicators for the period from January 1999 to November 2020 (263 observations) [10]. Initially, it was checked whether there was a society-needed trend of changes in the time series of all the indicators under consideration. The test was carried out with the assumption that the absence of the trend is more preferable than the trend of the wrong direction. The graphical method was first used for verification. The time series graphs of indicators $Y_1$, …, $Y_6$ are presented in Fig. 1.

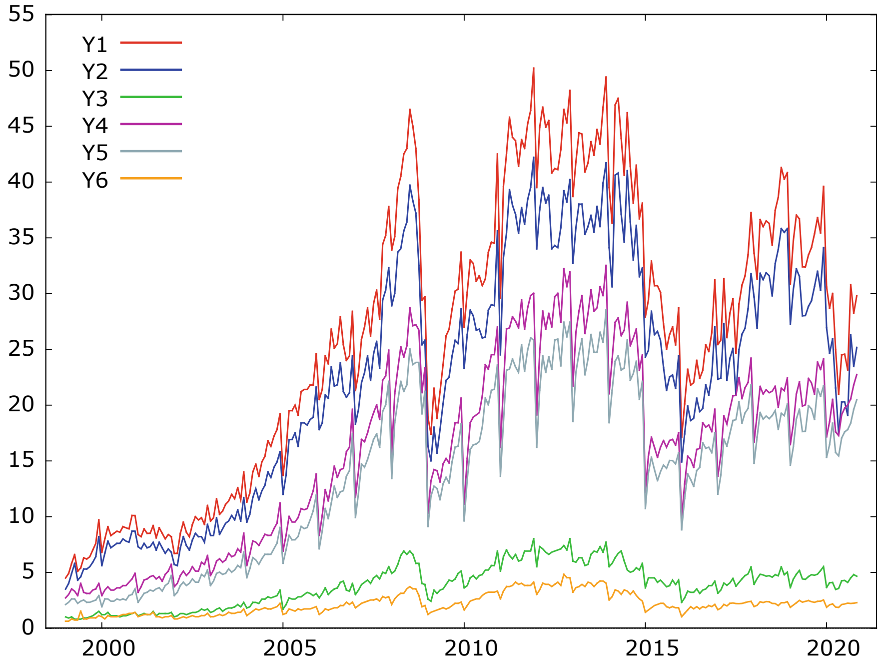


**Fig. 1** Dynamics of foreign trade turnover indicators of the RF goods (January 1999 to November 2020)

**Table 1** Trends presence testing for time series of foreign trade turnover indicators in the Russian Federation

| | $Y_1$ | $Y_2$ | $Y_3$ | $Y_4$ | $Y_5$ | $Y_6$ |
|---|---|---|---|---|---|---|
| Foster-Stewart method (observed value) | 17.9 | 14.6 | 9.4 | 13.2 | 13.7 | 6.1 |
| Comparison method of mean levels (observed value) | −15.3 | −15.4 | −14.1 | −15.9 | −16.3 | −11.7 |
| Trend | Growth | Growth | Growth | Growth | Growth | Growth |

Following the time series graphs, the instability of the growth trend and the presence of seasonal fluctuations of non-constant amplitude for the last 22 years can be observed. Since the graphical method is an approximate and exploratory one, next, more accurate statistical methods to check for trends were used: Foster-Stewart method and the method based on comparing the average levels of a series. The outputs of calculations for each method are presented in Table 1.

According to the results of the Foster-Stewart method, the hypothesis of the absence of a trend is rejected at the 5% significance level for all the time series (the critical value was 1.96). Following the results of the comparison method of series mean levels, it was found that the hypothesis of means equality is rejected at the 5% level of significance (the critical value was 1.65). That is, the discrepancy between the means is significant for all the time series under study. The application of these methods showed that all the time series of foreign trade turnover indicators meet the requirement of a society-needed trend of change (growth trend). To investigate the stability of the indicators time series under study, the following indices were considered.

1. Sustainability of levels index:

$$i_{\overline{y}} = \frac{\overline{y}_1}{\overline{y}_2}, \tag{1}$$

where $\overline{y}_1$—average value for the level that is above-trend line, $\overline{y}_2$—average value for the levels is down-trend line. It is used within the growth trend.

The stability of the time series levels will be higher dependent on the proximity of the value of sustainability performance index to one [11].

2. Sustainability of levels coefficient:

$$K_y = (100 - V_y), \tag{2}$$

where $V_y = \frac{1}{\overline{y}} \cdot \sqrt{\frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{n-p}}$—variability coefficient, $y_i$—actual time series level; $\hat{y}_i$—time series level calculated with a trend equation; $\overline{y}$—rank mean level; $n$—observation number; $p$—number of trend parameters число; $i$—observation item.

**Table 2** Calculation results for sustainable performance indicators of foreign trade turnover in the RF

| | $Y_1$ | $Y_2$ | $Y_3$ | $Y_4$ | $Y_5$ | $Y_6$ |
|---|---|---|---|---|---|---|
| $i_{\overline{y}}$ | 1.86 | 1.86 | 1.93 | 2.00 | 2.00 | 1.93 |
| $K_y$ (%) | 66.18 | 66.40 | 63.42 | 64.06 | 64.08 | 62.03 |
| $r_{yt}$ | 0.69 | 0.69 | 0.67 | 0.71 | 0.72 | 0.61 |

The closer the value $K_y$ is to 100%, the higher the time series levels stability of the indicator under analysis is.

3. Spearman's rank correlation coefficient to assess the stability of a series trend:

$$r_{yt} = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2 - 1)}, \tag{3}$$

where $d_i$—the ranks difference between this series levels and the numbers of observations, $n$—observation number, $i$—observation item.

The closer the value of Spearman's coefficient $r_{yt}$ to 1 is, the higher growth sustainability of the indicator is, the closer the value $r_{yt}$ to (–1) is, the more stable the indicator downturn is. The calculation results for the coefficients from Eqs. (1)–(3) are shown in Table 2.

Following the results of calculations of the level sustainable performance indicator $i_{\overline{y}}$, it is determined that the time series of the considered indicators are relatively stable. The value of the sustainable performance coefficient $K_y$ also indicates the relative stability of the time series levels under study. This can be justified by the random and seasonal components in the evidence structure of time series. If there is a task to forecast for such time series, it is crucial to reckon the seasonal index. The Spearman rank correlation coefficient characterizes the time series of foreign trade turnover indicators as series with average stability. The findings about the degree of stability correspond to the classification given in [11].

## 4 Discussion

Traditionally, the Dickey-Fuller stationary test, autocorrelation tests, and various econometric models are used when studying time series of economic indicators [12, 13]. The issues of sustainability of foreign economic activity processes, in particular, foreign trade turnover, have not been sufficiently studied. The issues of foreign economic activity sustainability, in particular, foreign trade turnover, have not been sufficiently studied up to now. Shashlo suggested assessing the sustainability of foreign economic activity using mathematical models and an integral sustainability indicator [14]. The method of finding preventive boundaries by Shewhart is used by

Polozhentseva for the study of the sustainability of foreign trade turnover indicators [15]. To estimate the degree of the system stability of foreign trade turnover, the concepts of "corridor" or "zone of stability" are defined, which allow analyzing the system at any given time. The research abovementioned does not reflect the prospect to study time series in terms of the levels stability and the trend stability. The approach presented in this study allows for a more detailed analysis of the sustainable performance indicators of foreign trade turnover. The results of the study can be applied to modeling and forecasting different indicators of foreign trade turnover. It is evident that the instability of the considered indicators can negatively affect the forecasting properties of the model.

## 5 Conclusion

The study of the foreign trade turnover sustainable performance indicators of the RF in the time span from 1999 to 2020 was explored in this paper. Indicators of the stability of the trend and levels were calculated. Following the calculations of levels stability index $i_{\overline{y}}$ and stability coefficient $K_y$ it was determined that the time series of the indicators under study are relatively stable. The Spearman rank correlation coefficient characterizes the time series of indicators of foreign trade turnover as series with average stability. The method of statistical study of the sustainable performance of economic indicators suggested in this paper allows a more reasonable approach to the selection of variables for modeling. It also allows constructing adequate models and using them for analysis and forecasting. Stable indicators of foreign trade turnover represent themselves as indicators of the sustainable development in the domain of foreign economic activity in general.

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# Creative Industries Development in Russia: A Way to Transform the Urban Environment

**O. V. Kuznetsova**

**Abstract** The article is devoted to the development of creative industries in the Russian Federation and their impact on the urban space. Urban creative spaces create an additional effect for the city. The place of creative industries in the economy is determined and the differences between "tvorchestvo" (creative mental work) and "creativity" are considered in this research. To understand the essence of creative industries, in addition to ordering the relevant terminology, a list of creative industries is provided. It is noted, that currently, there is no legally defined definition of creative industries. The paper describes the mechanism of creating a creative space, highlights some essential characteristics of a creative space. The main focus in creating places of attraction for creative entrepreneurs and citizens is on the local team. The article outlines the main advantages for the city that may be obtained from the creation of creative spaces and some problems in the development of creative industries in the Russian cities.

**Keywords** Brownfield · Creative economy · Creative industries · Intellectual property · Revitalization · Urban space

## 1 Introduction

The economic growth of the state is determined by investments in intangible assets at the present development stage. In most sectors of the economy, the surplus value of products is provided by intellectual and creative activities. The creative economy, also known as the "orange economy", promotes the sustainable development goals, in particular, it stimulates production activities, creates new jobs, encourages innovations, supports small and medium-sized businesses, and promotes social inclusion. Emphasizing the importance of developing this sector, the UN has declared 2021 the International Year of Creative Economy for Sustainable Development [1]. The development of a creative economy will promote more balanced and affordable trade

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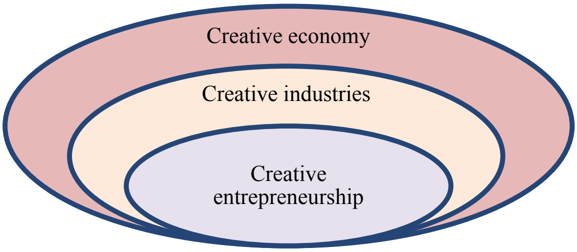


**Fig. 1** The place of creative industries in the economy

in new dynamic economic sectors [2]. The concept of "creative economy" is defined as a unity of individuals and businesses that create cultural, artistic and innovative products and services [3]. The creative economy is a type of economy that is based on the capitalization of the intellectual property. It is characterized by a significant role of new technologies and discoveries in various fields of human activity, a high degree of uncertainty, a large amount of existing information and an urgent need to generate new knowledge. The creative economy is based on a set of creative industries, in which the added value is produced at the expense of the creative potential of a human. Building a creative economy is based on synchronization between the economy and the culture. Creative industries are the core of the creative economy. The creative industries themselves are based on creative entrepreneurship (Fig. 1).

In recent years, the term "creative industries" can be found quite often. But, this term does not have a single interpretation. The Ministry of Culture of the Russian Federation has developed a draft concept for the development of creative industries and mechanisms for implementing their state support in large and largest urban agglomerations until 2030, which attempts to streamline the existing knowledge about creative industries and ways of their development [4].

In the Russian legislation, there are only two documents that mention the creative industries: in addition to the above-mentioned concept (project), there is also the Decree of the Government of the Russian Federation of April 15, 2014 No. 317 on approval of the state program of the Russian Federation "Development of Culture" [5]. This resolution establishes state assistance in the development of creative industries as one of the priorities for the culture development in Russia. That is, creative industries appear as a part of the cultural industry (together with art and crafts). The concepts of creative and cultural industries do not differ in different sources. But, in the Russian language "tvorchestvo" is an creative idea, and "creativity" is a realized idea that brings profit (Fig. 2). Culture is the realization of universal human spiritual values. The creative industry is closely related to the concept of the knowledge economy. Culture, creativity and knowledge are essential elements of the contemporary entrepreneurship.

Cultural and creative industries are those industries that combine the creation, production, and commercialization of creative content and that are intangible and cultural. These materials are usually copyrighted and may take the form of a product or service. Creative industries are areas of the economic activity in which the added

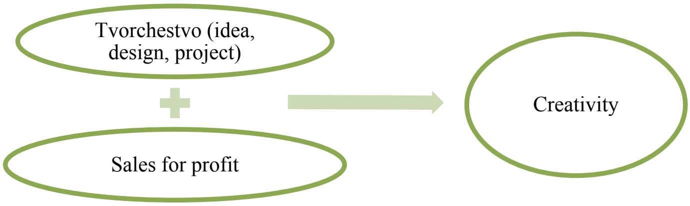


**Fig. 2** Differences between "tvorchestvo" and "creativity"

value is determined mainly by the creative potential of a person, and most of the subjects of which belong to the category of the creative entrepreneurship.

Creative industries are those in which the value structure consists of more than 50% of intellectual property rights (intellectual property). The task is to turn the intellectual property into a product or service and then implement it. The creative industries include advertising, architecture and urbanism, fine arts, crafts, decorative and applied arts, folk art projects, design (all directions), fashion, production of film and video products (our suggestion is to highlight the animation), music and sound design, performing arts, theater, publishing and journalism, R&D, software, including interactive entertainment programs, toys and games, television and radio, Internet broadcasting, video games.

We will also highlight the industries related to creative industries. These include:

- historical and cultural heritage (museums, libraries, archives, cultural landscapes, natural objects, historical places, etc.);
- art and antique market (fairs, salons, exhibitions);
- sports, fitness, healthy lifestyle;
- tourism: hotels, service;
- consulting services;
- park complexes;
- recreational activities (performances, festivals, fairs);
- gastronomic industry.

A creative cluster contains interconnected organizations and enterprises located on the territory of compactly located real estate. Creative clusters are managed by a company under a single brand and unite residents (tenants) from the sectors of creative industries, subjects of creative entrepreneurship in general. These clusters have the necessary infrastructure for creative and (or) entrepreneurial activities, are a center for creators and consumers of creative products and have a positive impact on the territory of their presence. Some researchers suggest considering a creative cluster as a technopark in the field of creative industries that converts creative energy into a working business and increases the contribution of such industries to the gross product of a city/region. This point of view is justified because at present, due to gaps in the legislation, it is impossible to obtain preferences for participants in the creative industries on a general basis.

Entrepreneurs, craftsmen working on the same territory in the same creative cluster, work together, for each other, they are interconnected providing services to each other and to external consumers. They are a center for both creators and consumers of a creative product. Their activities lead to a positive impact on the development of the whole territory. Industrial spaces, which have lost their industrial function, are often used to organize a creative cluster. After reorganization (revitalization and redevelopment) they become a center of attraction. A creative art incubator is a type of a business incubator that specializes in supporting and developing creative industries and creative entrepreneurship in general. The tasks of the creative incubator are to promote and provide services that are necessary for the formation of a sustainable business, to refine and update a creative idea for a relevant type of business activity. A creative space is a public area designed for free self-expression, creative activity, and human interaction. These can be former industrial or administrative spaces, subsequently revitalized, which have received new functions while preserving the architectural appearance. The places are used for the organization of multifunctional cultural centers with exhibition halls, cafes, restaurants, co-working spaces, offices, theater and concert venues, the mandatory presence of residents—creative business enterprises (art workshops, production, office, shop, etc.). An art residence is a specially equipped space for the creative self-realization of representatives of the creative industries, usually designed for a temporary, rather than stationary stay in it, which is presented to people of creative professions, usually on a competitive basis, from other regions/countries, for the exchange of experience, intercultural dialogue and the implementation of joint art projects. The grant period corresponds to the project implementation period, usually from 3 months to 3 years (maximum).

## 2 Methodology

The following research methods were applied in this study: synthesis, classification, induction, analogy. The research stages include the study of ways to create a comfortable urban environment, the formulation of a hypothesis about the impact of the development of creative industries on the formation of a comfortable urban environment, the analysis of the problem of the development of creative industries in Russia, the formulation of possible results for the city from the creation of creative industries. The research objectives are to define the concept of "creative economy", to identify the place of creative industries in the economy, to determine the list of industries related to the creative type, to define the term a "creative cluster", to propose a mechanism for forming a creative space, to identify the role of the creative industries development in the formation of a high-quality urban environment, to identify the main problems in the development of creative industries in the Russian cities. The research is based on the concept of Florida's creative class [6].

## 3 Results

Mapping of creative industries includes research, monitoring, preparation of analytical materials in the field of creative industries, creative economy and cultural policy of the region through the formation of a map of the creative resources of the territory to assess the potential of the abilities. The transformation of the urban environment is currently supervised by the federal project "Creating a comfortable urban environment" of the national project "Housing and Urban Environment" [7]. In order to consolidate the efforts of the state, the population and private business and to improve the comfort of living of citizens, it is necessary to move away from the subsidized model of financing the transformation of the urban space. The development of creative industries transforms the city through the use of illiquid residential and non-residential stock (abandoned and unfinished buildings, objects that could not be used in modern market conditions, buildings of former factories and plants). For more information, the mechanism for creating a creative space is shown in Fig. 3.

It is more expedient to attract creative entrepreneurs to grounds like brownfield. This will provide businesses with a quick entry with a minimum of investment compared to other types of objects, and for the city it will be a solution to the problem of abandoned or unused buildings that spoil the appearance of the city.

Revitalization is the creation of an active urban environment on the site of abandoned and non-functioning real estate. This is what the team of a future creative space is doing. The place is created for a specific request, both from entrepreneurs and from the population (in priority, these requests must match each other). Over time, it becomes a center of attraction for the city's population. If you make this place meaningful and give it a purpose, it becomes interesting for the population, attractive for entrepreneurs both in the profile of the creative space and in related industries. Indeed, the development of creative industries is becoming an incentive for the transformation of urban spaces. Different industries combine on one platform, complementing each other. First, the team transforms the space, promotes the place,

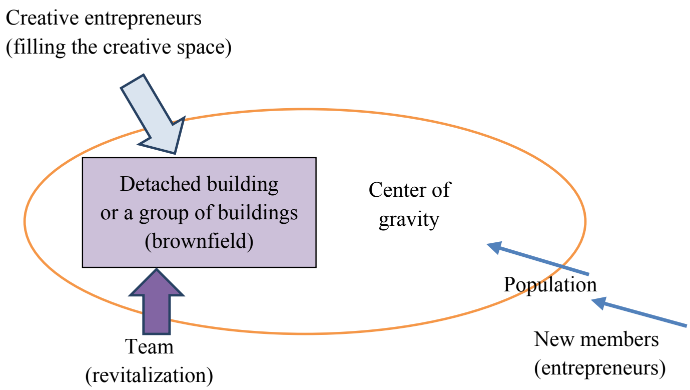


**Fig. 3** The mechanism for creating a creative space

and fills it with participants. It becomes a center of attraction for people. But, the place will be relevant if there are those who can be attracted, potential residents or a request from the population.

Creating an environment is a complex process, so you need to create an incremental plan, break the project into several stages. A specific feature of the redevelopment of recent years in Russia is the shift of assets from square footage to a quality environment. That is, the participants are ready to give up large spaces in favor of high-quality sites. This may be a smaller object, but if there is a workshop on the first floors, there are services related to the creative industries, then the rental price may be much more expensive and the place will be more in demand. And such a space will work for the development of the place where it appears.

When developing a project for creating a creative space, you should pay attention to such characteristics as: project cost, sources of funding, availability of the project development concept, location in relation to the city center, transport accessibility, the existing attractiveness of the object for citizens, the presence of creative industries in the city, type of ownership of the revitalization object, availability of free sites near the object (possibility of placing residential objects), development stage (planned terms of implementation).

Only with the involvement and initiative of the local team is it possible to create a really interesting project. You need to start with a request for something, there really should be a need, and there is no point create a space because you just need to use an abandoned object in one or another way. The following conditions are important for the success of the project team:

- the focus on the local product and regional human resources;
- the availability of a project idea and a business plan;
- the support from the local authorities;
- the attention to the urban content and real requests;
- the involvement of citizens.

It should be noted that there are industries that can generate profit, for example, the IT industry or new media, and there are industries that can only pay for themselves, and only if there are favorable conditions and support from the authorities. However, even industries from the second category can become quite interesting for creating creative spaces, due to the fact that they will become a center of attraction for people, and the payback of the ground, the generation of profits will be got from neighboring industries. It is possible that one part of the building will be given over to a hotel, apartments and housing, and another—to a museum. There must be a compromise between creativity and entrepreneurship.

Creative industries are a key tool for the development of the urban environment. The development of this sector contributes to the regeneration of the image of the city and its semantic content, making the areas of concentration of creative spaces and the life there more comfortable. We can talk about a direct relationship between the quality of the urban environment and the development of creative industries.

The development of creative industries contributes to the economic development of cities, including the overall improvement of the economic condition and the creation of new jobs by supporting the development of business in cities. Another effect of the development of creative industries will be the improvement of the socio-cultural situation—the development of the socio-cultural sphere of cities, including public spaces and recreational facilities.

Additional advantages for the city in creating creative industries will be:

- involving urban communities in the urban development,
- complex effect of projects in the urban economy;
- support for local creative initiatives on the city development;
- creating new socio-cultural formats and new places of attraction in the cities;
- association of cultural institutions to improve the life of the city.

Creative industries are an economy with a social impact. Creative industries have a greater social impact on the city than any other industries, and they have a quick effect. People's feelings about the city change when there are places of attraction, there is a favorable urban environment. The attractiveness of the environment, including for investment, depends on the availability of a creative environment. People want to stay in this city and the creative industries contribute to this. We should also highlight the synergistic effect in the development of creative industries as a result of the concentration of creative professionals in one place. The investment and tourist attractiveness of the city depends on the saturation of the space with creative industries.

## 4 Discussion

The development of creative industries is gaining popularity in large and small cities of Russia. However, there are still many questions related to the development models of such spaces. We will highlight the main problems in the development of creative industries in the cities of the Russian Federation:

1. Creative industries are not part of the urban economy. There is no complete synchronization between improvement programs, implementation of infrastructure projects, and cultural initiatives. Despite the fact that almost all cities have improvement programs, these facilities do not facilitate the city development. The fullness of urban facilities gives a complex effect for the city, but those objects that are currently represented in city improvement programs do not meet this criterion.
2. The lack of effective interaction of city departments, businesses and cultural institutions in the creation and implementation of creative (creative) products.
3. Lack of programs to involve and support small and medium-sized businesses in the implementation of creative industries projects. City businesses perceive this as a public burden from the authorities.
4. There is lack of new places of attraction in the city and filling them with new positive meanings and cultural traditions. There is often no base for the development of creative industries.

The existing experience in implementing creative spaces shows that there is no single rule according to which a creative cluster should be formed. It can be:

- a space in a dense urban environment, on the outskirts or in the countryside;
- a commercially successful project with a quick payback period or a funded project that does not assume a payback at all;
- a cluster, where similar or complementary industries are concentrated (a wide-profile cluster or a monocluster);
- a cluster represented by one or a hundred residents;
- a single building (from 100 to several tens of thousands square meters), a group of buildings located nearby or scattered throughout the city, etc.

And whatever approach the creators of creative spaces choose, each of them has a chance of success with a well-built strategy and an implementation plan.

## 5 Conclusion

Today the developed postindustrial countries see the source of the maturity and stability of the society in the transition to the creative economy [8]. Creative industries are one of the most promising development areas of the Russian economy due to the huge potential and ability to transform the raw materials sector of the country's economy. The volume of the creative sector is constantly growing, which means that there is a need to legislate the concept of creative industries. Creative industries can change the mood of the city, the city's development strategy, and the target audience in the city. Investors come to cities where there are creative people. The social responsibility of business in cities with creative industries is increasing. In conclusion, we highlight the main results for the city from the creation of creative industries:

- incentives to stay in the city (reduction of the youth migration);
- the higher quality of life of the population;
- attraction of investments;
- the urban environment development, including on the outskirts;
- capitalization of real estate;
- systematic development of creative industries—as soon as three or four points of attraction of creative industries appear, they generate the emergence of new participants.

A lot of Russian cities already have creative spaces, most of which are based on abandoned and unused areas. The revitalization of such spaces allows not only to create a comfortable space for creative industries, but also to help the city to solve the problems of these territories, to form points of attraction for citizens, to increase the migration, investment and tourist attractiveness.

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# Analysis of Innovative Development of the International Community Countries and Russia

**E. A. Konopatskaya**

**Abstract** This is a study of innovative development in the international community countries and Russian Federation regions based on accumulation models of human capital. Topic research choice increased interest is due in the development and high-tech products implementations in various spheres of economic activity of states, providing them additional competitive advantage. International organizations are actively exploring the issues of innovative development. The Russian Federation provides support for the creation and use of high-tech products through an innovative development strategy program. However, the efforts made are not enough. Many Russians Federations organizations working in the innovation field are having trouble in financing science-intensive industries and products, as well as needing highly qualified personnel. In addition, in the context of globalization, the knowledge exchange and experience in this area is important. In our opinion, in the Russians Federations regions the innovative development is similar to the patterns of the formation in the international community countries. During the study, the following solved tasks: (1) assessment of human capital as the basis for innovative development in the international community countries and the Russian Federation for 2018; (2) general patterns identification and individual characteristics of innovative development in the international community countries and the Russian Federation, in general in aggregates and in the regional aspect. The study was conducted using indicators provided by the World Bank and the State Statistics Service of the Russian Federation for 2018.

**Keywords** Innovative development · Human capital models · Model verification

## 1 Introduction

The development of modeling, from the standpoint human capitals influence on the economic growth, is consider within the framework of three approaches. Proponents of the first approach believe that economic development is influenced the rate of

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human capital accumulation in a particular country, and is determine by the productivity of skilled workers. Their ideas are described in the works by: Becker [1], Mincer and Higuchi [2], Chiswick [3], Ogundari and Awokuse [4], Diebolt and Hippe [5], Kuzmin et al. [6] etc.

In another approach, scientists believe that the human capital stocks determine the ability of economy innovate or borrow technology from more developed countries, which affects the rate of the country economic growth. Thus, human capital is a source of new ideas, as well as a factor that facilitates the perception and diffusion of innovations. Many scientists are engaged in the development of this direction: Benhabib and Spiegel [7], Badinger and Tondl [8], Kazmi et al. [9] and others.

Proponents of the third approach believe that human capital is investigate in the relationship between accumulation and influence on economic growth. In addition, on the human capital influence are also by indirect factors, for example, human health, a stable political situation in the country, regulatory support, etc. The convergence of these factors enhances both the process of human capital formation and its impact on economic growth. The ideas of this approach are described by Ali et al. [10], Li and Wang [11], De Abreu Pereira Uhr et al. [12] and others.

Generalization of human capital models revealed that researchers proposed to measure human capital using different indicators. For example, using the number of people employed in the economy with higher education and the number of patents filed per worker, the level of coverage (primary, secondary, technical, higher) education [9], etc. We studied the innovative development of the international community countries and the Russian Federation according to the model of Benhabib and Spiegel [7]. In our opinion, this model is of scientific and practical interest because of the use ease and ease of interpretation of its coefficients at the degrees of the corresponding variables. In addition, the model allows for the exchange of knowledge and experience between different countries:

$$Y = A\, K^{\alpha}\, L^{\beta}\, H^{\gamma}, \tag{1}$$

where A—technological interception coefficient; H—average number of years of study.

Benhabib and Spiegel [7] suggested that the technology hijacking effect (A) appears in the process of knowledge exchange when a country borrows better technologies from more highly developed countries. Let us write Eq. (1) in linear form:

$$Ln\left(\frac{Y}{L}\right) = Ln\,(A) + \alpha\, Ln\left(\frac{K}{L}\right) + \gamma\, Ln\left(\frac{H}{L}\right) \tag{2}$$

where A—technological factor.

The formation of indicators system for assessing human capital was carried-out using indicators provided by the World Bank [13] and the Federal State Statistic Service of the Russian Federation [14] for 2018. To the model verification of Benhabib and Spiegel for 110 countries of the international community, we used the

**Table 1** Indicators used as a function of human capital H

| Notation | International community countries | Russian Federation |
|---|---|---|
| *H—measures human capital expenditures* | | |
| H2 | Researchers in R&D, per million people | The personnel engaged number in scientific research, development, people |
| H8 | Expenditure of the research and development, % of GDP | Expenditures covering internal research and development (all sources), billion rubles |
| *H—measures the human capital achievements (incomes)* | | |
| H3 | | Innovation products volume (goods, works, services), mln. rubles |
| H4 | Patent applications, residents | |
| H7 | Charges for the payments and intellectual property use (current US$, BoP) | |
| H9 | Export of high-tech goods, current US$ | Proceeds from the export of technologies and services of a technical nature per year, (thousand USD) |
| H10 | | Payments for the import of technologies and technical nature services per year (thousand USD) |

following indicators: Y—GDP, current US $; L—Labor force, total; K—Gross fixed capital formation, current US $. In the Russian Federation, the Benhabib and Spiegel models adequacy was carried-out according to the following indicators: Yr—GRP in basis prices, million rubles; Lr—the number of employed persons 15–72 years, thousand people; Kr—fixed assets availability, mil. rub. We will evaluate human capital (function H) in the model Benhabib and Spiegel from two positions: expenses and income using the indicators presented in Table 1. The considered models formed a theoretical basis for assessing human capital as a source of innovation in the international community countries and Russian Federation regions.

## 2 Methodology

Improving the innovative development strategy program of the Russian Federation [15] should be based the results' use of quantitative assessments of human capital as a source of innovation. The need to conduct a study in the regional aspect, based on the analysis of a large amount of data, determined the priority of studying and generalizing its modern methods by statistical methods. Based on the analysis results and generalization of human capital models, it will be possible to developing the indicators systems of innovative development for the international community countries and the Russian Federation regions. Verification of human capital models as a source of innovation for the international community countries and Russian Federation regions requires the homogeneity condition fulfillment for the sets included in the model. In this regard, it becomes necessary to conduct an exploratory data analysis, including the calculation of descriptive statistics, the study for homogeneity, and the determination of "outliers" by the Zaks's method, the sets correspondence to the normal distribution law. The degree of homogeneity of the sets aggregate and the territories with abnormally large deviations of values is reveal by based on the exploratory data analysis results. The coefficient of variation was use as a measure of uniformity. Getting groups that are more homogeneous was determined using statistical grouping.

The identification of general patterns of innovative development for international community countries and individual characteristics inherent Russian Federation is basis on the verification of econometric models of human capital. We will conduct a study both as a completely taken together, and within the formed typological groups' framework for the international community countries and Russian Federation regions.

## 3 Human Capital Models Verification in the International Community Countries and the Russian Regions

As an exploratory data analysis result, we concluded that there is a high degree of differentiation both in the international community countries and in the Russian Federation regions. Using the method of statistical grouping by the level of income per employee (Y/L in the international community countries, Yr/Lr in the Russian Federation regions), the studied datasets were divided into four homogeneous groups: regions with a high level of GDP per employee (group 1), with above average (group 2), below average (group 3) and with a low level of GDP per employee (group 4). Of the 110 countries of the international community, the first group with a high level of economic development included 27 states, the second—42 countries, the third—35 countries, the fourth—6 countries. The small number of the fourth group with a low level of GDP per employee, led to the need to combine it with the third group, which is also characterize by a low level of development. Further research was carry out with three groups: with high level of GDP per person employed, medium and low levels of GDP per person employed. In the Russian Federation, as a applying result the method of statistical grouping by 75 regions, 5 territories form group 1, 29—group 2, 35—group 3 and 6 territories—group 4. The small number of groups 1 and 4 led to the need to combine them with group 2 and group 3 respectively. Therefore, the study of human capital models in the Russian Federation was carried out by us the aggregate and within two groups: with high and low levels of GRP per employee.

The process of identifying general patterns of innovative development for the countries of the international community and individual characteristics inherent in the Russian Federation regions base on the Benhabib and Spiegel model verification.

**Table 2** Models of human capital for the international community countries and the Russian Federation in total for 2018

| | International community countries | | | Russian Federation | | | |
|---|---|---|---|---|---|---|---|
| Model | a | b | c | d | e | f | g |
| | Ln (H7/L) | Ln (H8) | Ln (H9/L) | Ln (H2r/Lr) | Ln (H3r/Lr) | Ln (H8r/Lr) | Ln (H10r/Lr) |
| **Const. A** | **700816** | **153277** | **5324.1** | **21.05** | **24.29** | **10.07** | **24.78** |
| *P* value | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.007 | 0.003 |
| **Coef.**$\alpha$ | **0.84** | **0.89** | **0.91** | **0.75** | **0.51** | **0.75** | **0.71** |
| *P* value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Const.**$\gamma$ | **0.065** | **0.075** | **0.024** | **0.076** | **0.23** | **0.04** | **0.024** |
| St. er | 0.000 | 0.038 | 0.0325 | 0.006 | 0.000 | 0.007 | 0.043 |
| $\mathbf{R^2}$ | **0.96** | **0.96** | **0.96** | **0.73** | **0.85** | **0.73** | **0.69** |
| Crit. F | 1488.3 | 678.05 | 1417.2 | 102.225 | 210.074 | 101.92 | 58.703 |
| *P* value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| N | 110 | 64 | 110 | 77 | 77 | 77 | 56 |

Bold indicates the calculated coefficients of the equations of the Benhabib and Spiegel model (2) are highlighted
Bold indicates the coefficients of determination R^2 are highlighted

The study carried out over the entire set of territories and within the formed groups. Table 1 shows the indicators presented to assess the human capital function H. They used to build the models presented in Table 2. For 110 countries of the international community, five models of human capital, compiled according to "Eq. (2)". As a result, three models turned out to be statistically significant (see Table 2, models (a), (b) and (c)).

The coefficients of determination were 0.96 in all three models. All the coefficients of the equations are statistically significant at the 95% level of reliability, therefore, so we concluded that the models of human capital for the countries of the international community are adequate for the entire set.

During the verification of the Benhabib and Spiegel model within the three formed groups, the relationship between the country's economic growth and its research and development costs (H8) was not reveal. Table 3 shows the results of the identified dependencies between the economic growth of countries and human capital, represented by: fees and charges for the use of intellectual property (H7), the export of high-tech goods (H9), within typological groups.

Thus, for the countries of the international community, according to three typological groups, four adequate models of innovative development were building. In the equations compiled, the coefficients of determination vary from 0.72 to 0.91 and indicate the presence of strong dependencies between the resultant and factor signs. The equations coefficients are statistically significant according to their verification results by the Student's t-test at the 95% reliability level.

**Table 3** Models of human capital by countries of the international community within the formed groups for 2018

| $p < 0.05$ | **A** | Coef.$\alpha$ | Const.$\gamma$ |
|---|---|---|---|
| *Group 1—level of GDP per person employed* | | | |
| **Model 1** | | Ln (K/L) | Ln (H7/L) |
| $R^2 = 0.82$, Crit. F = 55.966, N 27 | **38.29** | **0.74** | **0.063** |
| **Model 2** | | Ln (K/L) | Ln (H9/L) |
| $R^2 = 0.82$, Crit. F = 50.30, N 27 | **34.68** | **0.76** | **0.039** |
| *Group 2—medium level of GDP per person employed* | | | |
| **Model 3** | | Ln (K/L) | Ln (H9/L) |
| $R^2 = 0.72$, Crit. F = 55.966, N 41 | **62.62** | **0.67** | **0.04** |
| *Group 3—low level of GDP per person employed* | | | |
| **Model 4** | | Ln (K/L) | Ln (H7/L) |
| $R^2 = 0.91$, Crit. F = 218.12, N 48 | **36.91** | **0.68** | **0.07** |

Bold indicates the calculated coefficients of the equations of the Benhabib and Spiegel model (2) are highlighted
Bold indicates the coefficients of determination R^2 are highlighted

Verification of models of human capital, as a source of innovation, for 77 Russian Federation regions in 2018 in accordance with Table 1, revealed four strong relationships between economic development and human capital, both in terms of costs and income. Table 2, models (d), (e), (f) and (g) presents the results of the study.

The largest share of the explained variance, 85%, is observe the model (e) (Table 2) and indicates a strong statistically significant relationship. It uses the indicator "Innovation products volume (goods, works, services), mln. rubles" (H3r). Model (g) (Table 2) is the smallest share of the explained variance at 69%, were human capital is the payments for the import of technologies and technical nature services per year (H10r). In the assessing process of the Russian Federation human capital from the perspective of expenditures, two adequate models were also built, with determination coefficients equal to 0.73 (Table 2, models (d) and (f)). All obtained coefficients models (d), (e), (f) and (g) were checked for compliance with the Student's t-criterion at the level of $p < 0.05$. Table 4 presents the models taking into account the typological differences of the Russian Federation regions.

The incentive for the development of regions with a high economic level is the receipt of results from innovative activities. The model (5) (Table 4) constructed for group 1 of regions, in which the innovation products volume is used as the function H3r, is statistically significant. The proportion of variance explained is 65%. This is a moderately relationship between the resultant and factor characteristics. In regions with a low level of GRP per employee, forming group 2, there is a relationships increase for this indicator (Table 4, model (7)). The determination coefficient increased by 9% and took a value equal to 0.74.

In the other three models of human capital with a low level of development (group 2), an average degree of interconnection was revealed with a coefficient

**Table 4** Models of human capital by Russian Federation regions within the formed groups for 2018

| $p < 0.05$ | A | Coef.$\alpha$ | Const.$\gamma$ |
|---|---|---|---|
| *Group 1—high level of GRP per employee* | | | |
| **Model 5** | | Ln (Kr/Lr) | Ln (H3r/Lr) |
| $R^2 = 0.65$, Crit. F = 28.974, N 33 | **98.6** | **0.43** | **0.21** |
| *Group 2—low level of GRP per employee* | | | |
| **Model 6** | | Ln (Kr/Lr) | Ln (H2r/Lr) |
| $R^2 = 0.51$, Crit. F = 21.05, N 41 | **1303.304** | **0.47** | **0.105** |
| **Model 7** | | Ln (Kr/Lr) | Ln (H3r/Lr) |
| $R^2 = 0.74$, Crit. F = 55.95, N 43 | **810.89** | **0.29** | **0.13** |
| **Model 8** | | Ln (Kr/Lr) | Ln (H8r/Lr) |
| $R^2 = 0.46$, Crit. F = 16.79, N 43 | **428.84** | **0.48** | **0.04** |
| **Model 9** | | Ln (Kr/Lr) | Ln (H10r/Lr) |
| $R^2 = 0.46$, Crit. F = 10.25, N 26 | **502.35** | **0.49** | **0.06** |

Bold indicates the calculated coefficients of the equations of the Benhabib and Spiegel model (2) are highlighted
Bold indicates the coefficients of determination R^2 are highlighted

of determination from 0.46 to 0.51 (Table 4, model (9), (8) and (6)). Checking the coefficients of the variables, the constructed equations for compliance with the Student's t-criterion, determined them as statistically significant at the $p < 0.05$ level.

## 4 Discussion

The human capital has a positive effect on the economic development of 110 international community countries (Table 2, models (a), (b) and (c)). Evaluating it from the point of view of income and expenses, we got similar results. In model (b), the human capital coefficient of elasticity of the function, represented by research and development expenditure (H8), is 0.075. In model (a) it takes the value 0.065. The least influence on the state development is exerted by the export of high-tech goods (H9). The coefficient of elasticity for this indicator is 0.024. In our opinion, such a small contribution can be explained by the small number of exported high-tech goods in the total number of countries. The coefficient A in the Benhabib & Spiegel model characterizes the rate of technology interception in the knowledge exchange process. In the countries of the international community, the fastest exchange of experience and technologies (A = 700,816) occurs when the indicator "Charges for the payments and intellectual property use (current US$, BoP)" (H7) is used as function H. This is 4.5 times more than the similar coefficient obtained in model (b) and 131.6—in model (c) (Table 2).

During the human capital assessment for 77 Russian Federation regions in 2018, it was revealed that the largest contribution to the country's economy—23%—is due to an increase in sales of innovation products volume (H3r) (Table 2, model (e)). The elasticity coefficient in the model for the human capital function, characterized by the number of personnel employed in research and development (H2r), takes the value of 0.076. This is three times lower when using the H3r function. Note that in the international community countries, the relationship between Researchers in R&D (H2) and economic growth has not been identified, that is, the development of the leading countries is conditioned not by the number of personnel in this area, but by the quality of the work performed.

Use of the indicator "Expenditures covering internal research and development (all sources), billion rubles" (Table 2, model (f)) as a function of H in the model of Benhabib and Spiegel made it possible to determine its contribution to the development of the countries at the level of 4%. Thus, the results of assessing the effectiveness of human capital in the Russian Federation from the standpoint of expenditures (H2r, H8r) and income (H3r) differ significantly. This is an individual feature of the state. In the international community countries, similar calculations (Table 2, models (d), (f) and (e)) practically coincide and amount to about 7%.

In contrast to countries in the international community, no relationship has been identify between economic growth and high-tech (H9r) exports. However, the Russian Federation development is positively influence by the import of technologies and services of a technical nature (H10r). During the analysis and results generalization obtained, we concluded that the exchange of experience and knowledge for all states is important, but it happens in different ways. In this case, the countries of the international community act as suppliers of innovations through the export of high-tech technologies (Table 2, model (c)). The Russian Federation through imports (H10r) acquires new knowledge and assimilates it at the fastest rate, since the technological coefficient A for this model (Table 2, model (g)) takes the highest value equal to 24.78. The elasticity coefficients for these functions H9 and H10r coincide and are equal to 0.024. Thus, the positive influence of human capital on the international community countries and the Russian Federation regions has been reveal.

## 5 Conclusion

In the process of analyzing innovative models of human capital for the countries of the international community within the framework of three formed groups (Table 3), it was established:

1. Receiving funds from fees and charges for the use of intellectual property (Table 3, models (1) and (4)) has a positive effect on the economic development of countries with both high (group 1) and low income (group 3). The elasticity coefficients for the human capital function are 0.063 in model1 and 0.07 in model (4). The assimilation of new knowledge occurs at approximately the same

speed. The technological coefficient A in model1 is 38.29, and in model (2) its value is 36.91.

2. Note that the coefficient of elasticity obtained during the verification of the model using the indicator "Charges for the payments and intellectual property use" (Table 2, model (a)) as a function of human capital for the entire aggregate of 110 countries of the international community is also is equal to 0.065, but with a huge speed of assimilation of new knowledge.
3. Thus, we can conclude about the formation of a strong, stable relationship between economic growth, physical capital and income from innovation, characterized by the function H7 at all levels of differentiation.
4. The economic development of countries from group 2, characterized by an average level of GDP, is positively influence only by the export of high-tech goods (H9), which is use as a function of human capital in the Table 3, model (3). The calculated coefficient of elasticity for this function is 0.04. It is twice as large as the similar coefficient obtained in the process of model verification for the entire set of 110 countries (Table 2, model (c)). Thus, that for this category of countries, only the ability to exchange innovations and the speed of their assimilation are of paramount importance.
5. The countries with a high level of GDP (group 1), the impact of exports on economic growth (Table 3, model (2)) also almost doubled. The coefficient of elasticity is 0.039. However, the value of the technological coefficient A of model (2) is two times less in comparison with the same value calculated in model (3). They are 34.68 and 62.62, respectively (see Table 3).

According to the statistical grouping results, the Russian Federation is included in the second group of countries with a medium GDP level of per employee, whose economic growth is due to an increase in the export of high-tech goods (H9), borrowing innovations from the countries of the leaders of the international community and the speed of their assimilation (Table 3, model (3)). However, in the course of the human capital innovative models analysis for the Russian Federation within the framework of two formed groups (Table 4), individual characteristics of development were also identified:

1. For regions with a high level of GRP (group 1), in 65% of cases, their economic development is positively affected by an increase in the innovation products volume (H3r). In model (5), the elasticity coefficients for the function of physical and human capital were 0.43 and 0.21, respectively. Thus, the regions development—the Russians Federations leaders is similar to the leading international community countries development and in 21% of cases is due to innovations introduction. The speed of assimilation of new knowledge (A) is more than 2.5 times higher than the analogous technological coefficients in models (1) and (2) of group 1 (Table 3) and 1.5 times higher than the countries of group 2 of the international community (Table 3, model (3)).
2. For the regions group 2, was reveal one strong relationship between the indicators of the model (7) with a coefficient of determination of 0.74 (Table 4). Human capital provides a 13% contribution to economic growth. It is consider

from the perspective of income and is represent by the innovation products volume (H3r). The coefficient of elasticity for the function of physical capital is 0.29—this is the smallest value.

3. In the other three built innovative models, average dependencies revealed, with the coefficients of determination equal to 0.46 and 0.51.
4. From the point of view of expenditures in group 2, the largest contribution to the development of regions, 10.5%, is provided by the personnel engaged number in scientific research, development (H2r) in model (6).
5. In the Russian Federation, for regions group 2, the effect of technology borrowing is very important. In model (6), parameter A is 1.6 times higher than that of model (7). That is, the speed of assimilation of new knowledge is faster where the personnel engaged number in scientific research, development (H2r) is use as human capital.
6. Investments in expenditures covering internal research and development (H8r) contribute to the development of the whole country and in the group 2 Russian Federation regions on the level of 4%. (Table 2, model (f) and Table 4, model (8)). However, the strength of the relationship between the effective and factor characteristics of model 8 is 1.5 times lower than for the country as a whole, and its coefficient of determination is 0.46.
7. The import of high-tech goods (H10r) in model (9), used to estimate the human capital of group 2, contributes to economic growth by 6% (see Table 4). This value is 2.5 times higher than the analogous value of the elasticity coefficient for the function H10r (Table 2, model (g)), calculated for the country as a whole. Note that such an increase observing against the background of a decreasing strength of the relationship, since the coefficient of determination of model 9 is 0.46. Thus, by importing high-tech goods, regions with low economic development master new technologies and reduce the gap with the leaders. Thus, the Russian Federation innovative development constitutes its competitive advantage in the international community. The development of our own high-tech goods and services provides the greatest contribution to the country's economic growth. The obtained study results can be used the federal and regional Russian Federation services innovative strategy development.

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# Marketing Process in Information Security Context: Comparison Between Czech Republic and Belgium

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**Abstract** Due to increased numbers of cyber-attacks, cyberbullying and data breaches incidents influence the Digital Marketing Process that refers to the processes involved in delivering products and services to the customer (process of paying for influencing practically in the same way as the value users received). The unreliability and extreme information vulnerability of Digital marketing processes, as well as implemented collaboration platforms that complete with different document sharing, online meeting modules, etc., which are part of a company's operational marketing infrastructure processes and marketing mix tools, afterwards leads to a loss of the company's reputation and, as a result, to financial losses. The attitude to the issue of information security and personal data protection is different from country to country and from business to business thus represent different ways. This paper proves that there is a relationship between the use of information security strategy as part of the digital marketing process and the company's positive reputation among consumers in countries such Belgium and the Czech Republic, as well as the willingness of businesses in these two countries to invest resources in information security to reinforce the marketing process. The study provides evidence that there is a difference in the perceptions of information security among businesses and consumers in Belgium and the Czech Republic, and differences in the perception of information security threats and data privacy before the Coronavirus and current attitude of future strategies in relation of information security as good reputation guaranty of the reliable marketing mix process.

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## 1 Introduction

Today's global economy cannot function without the Internet, the "cloud," email, networked computer automation, and other components of "cyberspace," including the global consumer credit card payment networks [1]. Companies are increasingly focusing on the "Process" phase of marketing planning when developing a 7P marketing strategy, as it often influences the decision to make a purchase and forms the emotional attachment of customers [2, 3]. Process is the moment when a customer contacts or pays for a company and a product or service [4]. In cyberspace, such a process is often subject to cyber-attacks and does not go beyond the responsibility of the marketer, although methodologically it is one of the tools for creating a brand and routing a company or product [5]. The impact of earlier access to related and extensive information on business decision making is demanding, especially when it evaluates and measures this impact on business results as a consequence [5].

Ensuring availability of the service is ensured against the simultaneous production and consumption of the service, together with process management. Product, process and physical evidence are the most affected marketing-mix factors by considering Industry 4.0. Managerial implications which were also presented based on the numerical results [6]. Loss prevention in this area is far more complex than it is with the traditional theft of chattels, or indeed, even with various kinds of trade secrets. The simple point here is that the process of entrustment with information is not what it is for chattels. Being in the conditions of technological dependence on the reliability of their own marketing working "field tools" (e.g. communication platforms, terminals and payments for online payments, cloud systems for processing and storing data), marketers learn to work in a new cyber infrastructure where the reputation of the brand depends not only on marketing specialists [7, 8]. Cyber infrastructure became to play a significant role in the context of cyber autonomy and could potentially increase the degree of information and data protection as well as fill in the current gaps of the cyber and information security industry as well as support Cyber Autonomy which also includes reputation defense [9, 10]. All this will potentially strengthen the phase of the Process, which is important for the formation of customer loyalty, affects the likelihood of purchasing goods and makes the purchase comfortable for the customer [11]. According to research by the Association of Small and Medium-Sized Enterprises and Self-Employed Persons of the Czech Republic (Asociace malých a středních podniků a živnostníků České republiky)—entrepreneurs take digitization very seriously [12]. Cyber security is important for 4 out of 5 respondents, and the digitization process taking seriously for 3 out of 5 entities. Czech entrepreneurs are generally more sensitive to the topic of security. With evolving digital tools and their higher use in business a higher level of security goes hand in hand. Most businesses are aware of the increased levels of cyber risk. What is interesting is the fact that some companies protect the data itself more than, for example, security operations of their businesses (AMSP ČR). Year 2019 became the year of digitalization for most of Czech entrepreneurs' business and brought to Czech SMEs knowledge of the tools provided by this rapid digital transformation. Base on Scientific and Technical Research Reports that as published by the Publications Office of the European Union in Brussels in the beginning of 2021—cyberspace provides a new delivery mechanism that can increase the speed, diffusion, and power of an attack, and ensure anonymity and undetectability. Infrastructures, essential services and supply chains can be attractive targets in order to intimidate and apply pressure. Diverse and complex relationships stem by and large from the activities of firms that may be controlled or influenced [13]. Cybersecurity should be a top concern among digital marketers. Since security is paramount to their success, digital marketing firms need to take extra precautionary measures [14].

Several authors have observed a relationship between information security concerns and modern marketing to security of the data in the subject of security of process [15–17]. As well as security in the payment system process that is used in marketing when security capabilities have to offer and provide good levels of security. Because e-payment systems require trust on the part of the merchant's and merchant's customers, a transparency of services is required, and a pristine reputation is critical [18]. However, knowledge about security still reminds me of an issue. According to previous studies 76% correctly answered questions about everyday security risks and where popular online services store customer data, while about 84% of respondents correctly answered a question that asked about the definition of encryption. Voluntariness is a major issue in the consent process for cloud service providers. Voluntariness could potentially be improved if service providers adopted a different business model that gave users more options for controlling their own privacy settings [16]. The adoption of certain "enabling technologies" (e.g. information systems and improved Big Data analytics techniques) is necessary to accomplish this digital transformation. However, the implementation of digital supply chains and more advanced marketing techniques is hindered by the high investments and important challenges related to the digitization process [19]. Service marketing mixes differ predominantly from the 4 Ps of traditional marketing and entail an additional three Ps (i.e. people, process, and physical evidence). Process is related to the systems and procedures that act as vehicles that deliver value to customers [20]. Building information security for supporting such a marketing mix element as "Process" that compline with data privacy and at the same time ensure the whole chain of the "digital process activities: could require an additional affordable lot. In contrast the mistakes could cause for example negative publicity or compliance issues due to security compromises. Furthermore, there is a risk to commercial reputation and potential costs associated with leaks of high-value information [17]. That is why it could be important for enterprises to pay more attention to reputation defenses as protection or support of capital and assets in order to protect an organization's character, performance, and what the organization stands for, whether in digital or non-digital format. In addition, studies also highlight that security artifacts often have a weak or insignificant influence on trust and behavioral intentions when compared to important antecedents of trust, such as brand reputation [18]. As big threat organizations face when a breach occurs is damage to its reputation. Given the financial, legal, and reputational harm, no organization benefits from a cyber-attack [21]. The potential for damage to company reputation and credibility raise the concern about reputation defense and need to establish the right strategies and rules for protecting it. With data breaches becoming more commonplace, it is time that marketers were invited to participate and engage in the protection of consumer information.

Marketers were invited to participate and engage in the protection of consumer information [22–24]. Lack of Information security strategy within the digital marketing process decreases in brand confidence. According to PwC, the level of consumer confidence in companies is declining every year. At the same time, 85% of respondents will not use the services of an enterprise if they doubt its cybersecurity policy to build cybersecurity into business products and processes. For digital businesses—and almost every company we know of aspires to be a digital business—cybersecurity is an important driver of product value proposition, customer experience and supply chain configuration [25]. Digital businesses need, for example, design security into IoT products, build secure and convenient customer interaction processes and create digital value chains that protect customer data [26]. Security of the marketing process guarantees institutional and procedural dimensions, helping with critical appraisal of all the key aspects of the internal market [15, 27, 28]. Information security and cyber risk are one of operational risks. Those refer to the potential for business losses of all kinds of financial, reputational, operational, productivity related, and regulatory-related—in the digital domain [26]. Because smaller businesses (SMBs) may have less cyber security infrastructure in place than a large corporation, cyber criminals and hackers have been targeting them with increasing frequency. As the result about 71% of all data breaches affected companies with fewer than 100 people on the payroll [29]. SMBs benefit from using new team collaboration tools (chat, video conferencing, screen sharing etc.) for internal and external communication. However, it also causes a different type of risk beginning from risk of not protecting data privacy and non-human traffic to risk associated to social media, Personal and Payment Details as well as risk of process and cause loss of asset and Loss of Function/operational ability [1]. That is why Companies need extra protection because their networks can become sources of botnet-based attack. In order to pay for advertising, you'll have to provide a method of payment. Unfortunately, there will be hackers looking to capture your account and password information [30]. Most types of digital marketing require businesses to collect and process massive amounts of data about their customers. In case of a breach, all this information can be used for malicious purposes, directly harming the clients and striking a terrifying blow to the company's reputation. It means that cybersecurity should be a primary concern of any digital marketer [31].

## 2 Methodology

The article uses scientific approaches, in particular observation, analysis, synthesis, induction, deduction, and methods of comparison and logic. As a methodological basis for the analysis, the article also uses the analysis of concepts and survey data. Data were collected through anonymous questionnaires distributed in selected social media, related professional groups and through emails. Respondents were informed about the survey and asked for further collaboration. Respondents received assurance that all responses were anonymous and confidential. The respondents were divided into two groups according to countries. Survey data were collected in January and February 2021 in Czech Republic and Belgium. Respondents ranged in age from 18 to 65. All results were therefore weighted according to the population proportions. The sample in each country are 2 groups Individuals and SMBs. The survey instrument consisted of items measuring the following variables. The respondent was asked to express their agreement with each of ten statements (method of "Likert Scale") reflecting the attitude of a six-membered scale that includes values from "bad" to "positive". This method of interviewing respondents was chosen on the basis of judgments about the use of the opinions of qualified specialists, experts regarding the composition of the sample who have experience in this area. Placement of an online version of a survey on servers conducting functionality tests and its verification, distribution of the survey between respondents, analysis and discussion of results. Collection of survey data using a questionnaire hosted on the online survey platform Google Forms. The questionnaire comprised a number of scales, represented online using individual or matrix style layouts with responses entered via radio buttons, drop-down menus, or free text entry as appropriate. Drawing conclusions from the obtained results. For identifying the differences, the research base on similar countries reveal. The country comparison bae on the basic economic macroeconomic data, indicators and ratings presented in Table 1.

It is believed that information security is not a part of digital marketing 7P communication mix activities for most businesses and there is no difference between business attitude in the different European Union countries and also information security has not connected to company reputation and companies do not need to have an information security strategy for such processes as payment systems and distribution procedures to securely process. This general opinion became the hypothesis of pilot

**Table 1** Country comparison Czech Republic and Belgium. Numbers for 2019 and 2020

| Indicator | Czech Republic | Belgium |
|---|---|---|
| Population | 10,693,939 | 11,522,440 |
| GDP per capita | 22,813 | 44,565 |
| Doing business | 35 | 45 |
| Unemployment Rate | 3.2% | 5.6% |
| Fitch Rating | AA- | AA- |
| Moody's Rating | Aa3 | Aa3 |

research carried out by the authors of this paper in 2021 in the Czech Republic and Belgium. The results of this pilot survey showed that it is in fact a lack of information security strategy and cyber attacks on the marketing process can negatively affect the company's reputation, loss of profits.

Hypothesis 1: Existing difference in the perceptions of information security and security of digital marketing process among SMBs and individuals in Belgium and the Czech Republic. Hypothesis 2: Information security strategy is essential as part of the digital marketing process for SMBs in Czech Republic and Belgium. Hypothesis 3: The presence of information security processes affects and reinforce company reputation. Hypothesis 4: Security in the digital marketing process in Czech Republic and Belgium can influence the willingness of users to purchase.

## 3 Results and Discussion

The attitude to information security and data protection in different countries is differ. Table 2 proves data and relationship between security of digital marketing process among respondents in Belgium and the Czech Republic, as well as the willingness of businesses in these two countries to invest in ensuring information security of the digital marketing process.

This study reflects a survey of users depending on the availability of a safe purchase process, as well as customer confidence. Technology, while empowering consumers, can also have a negative impact at the same time. Their customers are also concerned about the safety and preservation of confidential data when paying for goods and services (Table 3).

From the one side we analyze answers of small and medium-sized businesses (SMBs) from Czech Republic and Belgium and existing differences in the perceptions of information security, security of digital marketing process and impact on company reputation among SMBs from those counties. From the other side we also analyze the existing difference in the perceptions of information security, security digital marketing process, impact on reputation and willingness to purchase within individuals Czech Republic and Belgium. The analysis demonstrates that there exist differences in the attitude to information security, security of digital marketing process and role of reputation within and between SMBs and individuals in Czech Republic and Belgium.

Despite that 66% of Belgium SMBs respondents "Agree" that information security is connected to company reputation and almost the same number of SMBs (70%) from Czech Republic also agree with these segments, however 20% of the responders from Czech Republic answered "I do not know" on the same questions compering to just 6% SMBs from Belgium. Furthermore, the difference in the perception we can see on answers regarding planning to increase information security budget, thus 40% SMBs from Belgium "Agree" with it compared to 82% in Czech Republic. Possible explanation of that big difference we can see in another answer form the same groups "Did you already invest into information security tools" when we can

**Table 2** Notes (%) of the total number of respondents in the whole sample

| | Business—Belgium (%) | | | | | Business—Czech Republic (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Has Coronavirus increased your use of digital technology? | 2 | 6 | 50 | 44 | 2 | 0 | 16 | 44 | 20 | 4 |
| Did you already invest in communication technology tools? | 0 | 36 | 56 | 10 | 2 | 0 | 20 | 38 | 10 | 32 |
| Are you planning to invest into communication technology tools? (collaboration platform complete with document sharing, online meetings, etc.) | 0 | 2 | 46 | 46 | 10 | 0 | 2 | 76 | 14 | 4 |
| Did you already invest in communication technology tools? | 0 | 40 | 46 | 14 | 4 | 0 | 10 | 54 | 8 | 28 |
| Did you already invest into information security tools? | 0 | 40 | 46 | 14 | 4 | 0 | 34 | 28 | 8 | 30 |
| Are you planning to increase your information security budget? | 0 | 6 | 40 | 38 | 20 | 0 | 2 | 82 | 16 | 0 |
| Do you think information security is connected to company reputation? | 0 | 8 | 66 | 24 | 6 | 0 | 8 | 70 | 2 | 20 |
| Does a poor information security process have an impact on the inability to execute marketing processes threatens normal marketing processes? | 0 | 6 | 59 | 32 | 8 | 0 | 2 | 36 | 14 | 28 |
| Is information security of the company one of the tools to reinforce company reputation? | 0 | 14 | 54 | 32 | 4 | 0 | 2 | 70 | 12 | 16 |
| Do you think that marketing processes such as payment systems and distribution procedures can be compromised as a result of a cyber-attack? | 0 | 8 | 46 | 30 | 16 | 0 | 4 | 54 | 10 | 32 |

*Note* 1-strongly disagree, 2-disagree, 3-agree, 4-strongly agree, 5-I don't know

**Table 3** Notes (%) of the total number of respondents in the whole sample

| | Individuals—Belgium (in %) | | | | | Individuals—Czech Republic (in %) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Has Coronavirus increased your use of digital technology? | 0 | 4 | 46 | 48 | 2 | 4 | 4 | 42 | 50 | 0 |
| How do you assess the danger of cyber attacks, since the outbreak of the Coronavirus? | 4 | 4 | 52 | 26 | 14 | 4 | 6 | 61 | 16 | 12 |
| Does the company's information security strategy influence buying decisions? | 2 | 10 | 56 | 24 | 8 | 2 | 6 | 50 | 20 | 22 |
| Is information security connected to company reputation? | 0 | 4 | 50 | 28 | 18 | 2 | 2 | 72 | 10 | 17 |
| Do you think that every company should have an information security strategy for such processes as payment systems and distribution procedures to securely process payments and assure product delivery? | 2 | 2 | 44 | 40 | 12 | 2 | 0 | 58 | 13 | 7 |
| Will you reconsider buying a product or service from a company that had a cyber attack which resulted in the leakage or theft of the company's customers' personal data? | 20 | 24 | 28 | 20 | 8 | 6 | 10 | 58 | 10 | 16 |
| Does the presence of information security processes affect your assessment of the company's reputation? | 4 | 0 | 48 | 32 | 16 | 0 | 10 | 58 | 10 | 16 |

*Note* 1-strongly disagree, 2-disagree, 3-agree, 4-strongly agree, 5-I don't know see that 46% Belgium "Agreed" v.s. to 28% Czech Republic which could mean that most probably Belgium respondents already invested in security tools. Differences in the perceived importance and knowledge of the security in digital marketing process can be seen on the "Does a poor information security process have an impact on the inability to execute marketing processes threatens normal marketing processes" as 28% of Czech SMBs answered "I do not know" compering to only 8% of SMBs respondents from Belgium. Nevertheless, both groups "Agree" or "Strongly agree" that marketing processes such as payment systems and distribution procedures can be compromised as a result of a cyber-attack. For this reason, another added value of the research that shows "black spots" about the importance of the security of marketing processes and the possible need for a deeper study of this topic or required future research. It shows higher values or the critical value as well as areas that should be investigated in the future.

Most of the Individual respondents in both countries have mutual opinion and "Agree" or "Strongly Agree" that the company's information security strategy influences their buying decisions (e.g., based on the survey "Agree" has 50% from Czech Republic and 56% in Belgium). As well as the majority of respondents from both groups and both countries were of the opinion that every company should have an information security strategy for such processes as payment systems and distribution procedures to securely process payments and assure product delivery—with these statements "Agree" 44% respondents from Belgium 58% respondents from Czech Republic. As our survey is based on respondent views in a (partially) security strategy as essential as part of the digital marketing process for SMBs i.e. we could say that such Information security strategy that could be in place may play important role for overall company reputation. Hence, our survey gives respondents the opportunity to reason and form their own opinion about company strategy, thereby providing the best possible directions for SMBs on the consumers' true views.

## 4 Conclusion

There are cross-country differences in opinion regarding information security processes that could affect assessment of the company's reputation among individuals in Czech Republic and Belgium: 58% of Czech individuals "Agree" with that competing to 48% from Belgium. However, Belgian respondents are more unequivocally convinced of this need which is 32% of the total mass of respondents and is three times higher than the data for the same response of respondents in the Czech Republic. Given the intensity of public concern about information security, reputational issues could not be short term, hoc and defensive but should have strategic view and long term planning to defend reputation. Companies should have insight into the root causes of or the facts behind their reputational problems. The most important advantage of such a conjoint setup between marketing, reputation defence and IT or ICT teams is that it could build long-term redistribution of the risks that related to information security, good reputation and prevention of the financial losses [32].

There are definitely challenges in preparing to meet serious financial losses threats that are based on the willingness of users to purchase based on the implemented or not implemented security in the digital marketing process within a company. However, the research shows that respondents from Czech Republic (58% choose "Agree") are willing to reconsider buying a product or service from a company that had a cyber-attack which resulted in the leakage or theft of the company's customers' personal data. While the answers of the respondents from Belgium were almost equally distributed between the answers 20% "Strongly disagree" 24% "Disagree" 28% "Agree", 20% "Strongly agree" and 8% "I do not know". It could be that respondents see the cyber attack as just a temperate incident or do not see it's a fault of a company. Even if a company could behave not responsible in this area of information security while behaving ethically in another area. We argue that lack of the abilities of the companies to demonstrate verifiable secure marketing processes they take to secure their marketing activities. Nevertheless, we argue that because of lack of the abilities of the companies to demonstrate verifiable secure marketing processes they take to secure their marketing activities in the long term could lead to influence the willingness of users to purchase. Companies should focus on the information security of digital marketing processes that matter most to customers and business partners, something that may call transparency in information security strategy, reputation defence actions or operation changes in the marketing mix setup process.

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# Features of Organization's Sustainable Development in the Innovation Activity Context: Russian Practice

**O. N. Potasheva**

**Abstract** The aim of this research is to form an opinion on the specific features of the sustainable development of Russian companies in the framework of their innovative activities. Based on the generalization of statistical data, the trends of deterioration of the results of innovation activity in the Russian Federation for 2015–2019 are established. The analysis of statistics materials and the results of the own research conducted on the base of 5 enterprises in the Samara region showed that among the main factors influencing the implemented innovations, there are the financial component, the availability of the necessary personnel, the available technical base, the ability to provide information support and perform predictive analytical calculations, the payback period of investments. The application of the sustainable development policy is mainly prioritized by joint-stock companies, which consider financial, technical and human resources to be the most significant factors of innovations. The surveyed organizations expressed their opinion about the high complexity of making innovative decisions and the existing need to form a system of management accounting for innovations, control of specific risks of innovation and sustainable development, as well as the use of specialized analysis methods.

**Keywords** Environmental innovations · Innovations · Information support of innovations · Sustainable development · Technological innovations

## 1 Introduction

The implementation of a sustainable development strategy is becoming an important condition for doing business in the face of significant external uncertainty associated with the pandemic and high competition. Interpretations of the sustainable development state of the organization are diverse, but most of them point to such characteristic features as:

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- achieving the goals of ensuring the competitiveness of the organization and its financial stability;
- successful implementation of technological, product and information innovations;
- staff satisfaction with the income received and the social guarantees provided;
- conservation of natural resources and minimization of negative environmental impacts.

In other words, the sustainable development of an organization is a process that is balanced, taking into account the needs of all interested groups, both in the current moment and in the future. Such a broad coverage of strategic tasks is associated not only with significant costs for business entities to solve them, but also with a significant impact of risks and uncertainties, which indicates the increased complexity of information and analytical support for this process.

Management decision-making for achieving the sustainable development goals in the context of innovation includes diverse sources of information: economic, technical, legal, social, political, environmental, and many others. For successful implementation of innovations, it is important that business entities understand how to build an information and analytical system, since it is used to carry out all stages of consideration of innovative solutions: their planning, justification, introduction, implementation control, and evaluation of results. At the same time, organizations do not always have the necessary human, financial and material resources, and the existing infrastructure does not meet the requirements in all situations.

## 2 Methodology

In the course of the study, public data of state statistics on innovation activity in the Russian Federation were used. To process these data, a vertical and horizontal analysis was carried out, and methods of coefficient calculations were applied. In order to interpret the indicators obtained from the analysis of statistical data, 5 enterprises were interviewed. The interviewees were asked the following questions.

1. How actively does your company develop innovations in the business process? What factors have the greatest impact on this?
2. In what area of innovation does your company have the most experience (production technologies, organizational activities, new types of products/services, environmental innovations)?
3. Has your organization developed a sustainable development strategy? By whom and with what frequency is its implementation monitored?
4. How is information support for innovation activity and sustainable development implemented?
5. Does your organization conduct an analysis of the effectiveness of innovation activities?
6. What analytical indicators are used by your organization to assess the results of sustainable development?

## 3 Results

The interview participants in our research were top managers of 5 companies operating in the Samara region. The interview results are summarized in Table 1. The analysis of statistical data on the innovative activities of Russian companies showed that in value terms, the volume of innovative goods, services and works performed by organizations increased from 3843.4 billion rubles in 2015 to 4863.4 billion rubles in 2019. If we focus on the ratio of innovative goods, works, and services in the total volume of sales revenue, we can note its decline from 8.4% in 2015 to 5.3% in 2019. This indicator is heterogeneous in different regions of the Russian Federation (Table 2): the Volga Federal District is often the leader (the indicators annually exceed the average level in the Russian Federation by at least 1.5 times), and the Far Eastern Federal District showed the lowest values for the largest number of periods, which is quite well explained by differences in the economic and geographical position and infrastructure plan [1].

In absolute terms, the cost of innovation activities of Russian organizations increased from 1200.4 billion rubles in 2015 to 1954.1 billion rubles in 2019. But at the same time, the ratio of costs for technological innovations in the total volume of goods shipped, works performed, and services decreased from 2.6% in 2015 to

**Table 1** Brief description of the interviewed organizations in the Samara region (Volga Federal District)

| No. | Type of economic activity | Income characteristics | Characteristics of the employees number | Applied type of innovations | Period of work on the market (years) |
|---|---|---|---|---|---|
| 1 | Construction of engineering communications for water supply and water removal, gas supply | More than 800 million rubles | More than 500 people | Technological, environmental | 13 |
| 2 | Rental and management of real estate | More than 800 million rubles | 71–100 people | Technological | 17 |
| 3 | Repair of machinery and equipment | 100–150 million rubles | 51–70 people | Technological | 8 |
| 4 | Wholesale trade of electrical equipment | 500–800 million rubles | 30–50 people | Organizational | 8 |
| 5 | Activities of health resort organizations | 100–150 million rubles | 71–100 people | Technological | 8 |

**Table 2** The ratio of innovative goods, works, and services of organizations in the total revenue from the sale of goods of their own production, services, and works in the federal districts of the Russian Federation in 2015–2019 (%)

| Federal district | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|
| Central federal district | 12.79 | 11.60 | 6.94 | 6.22 | 5.00 |
| North-Western federal district | 6.25 | 5.10 | 6.30 | 5.77 | 5.59 |
| Southern federal district | 5.85 | 8.36 | 9.03 | 5.60 | 2.71 |
| North Caucasus federal district | 8.90 | 6.40 | 5.84 | 4.43 | 5.28 |
| Volga federal district | 12.96 | 14.11 | 13.35 | 13.30 | 11.26 |
| Ural federal district | 2.72 | 4.35 | 5.17 | 4.34 | 3.26 |
| Siberian federal district | 4.06 | 3.47 | 2.99 | 2.20 | 2.55 |
| Far Eastern federal district | 6.76 | 3.30 | 3.32 | 3.44 | 2.95 |
| The Russian Federation as a whole | 8.44 | 8.50 | 7.23 | 6.55 | 5.27 |

2.1% in 2019. Next, we will evaluate the statistical indicators of innovation activity by types. In the process of statistical observation by the state statistics bodies of the Russian Federation, technological and environmental innovations are singled out separately. The ratio of organizations that implemented technological innovations in the total number of surveyed organizations is 21.6% according to 2019 data (in 2017—20.8%, in 2018—19.8%). From the point of view of the criterion of carried out economic activities, the leaders in technological innovations in the Russian Federation for 2019 are:

- enterprises producing computers, electronic and optical products—61.9%;
- technological innovations, electric equipment manufacturing companies—51.8%;
- for the production of other machinery and equipment—51.4%;
- manufacturers of medicines and materials used for medical purposes—45.5%;
- manufacturers of motor vehicles, trailers and semi-trailers—43.7%.

The ratio of organizations that implemented environmental innovations in the total number of organizations surveyed is extremely insignificant and is experiencing a downward trend: from 1.6% in 2015 to 0.6% in 2019. The interviewees noted that an important motive for developing innovations is the desire to gain competitive advantages in business by maintaining a high quality of conducting specialized activities. Also, all participants claim that when making innovative decisions, the owners and leadership are aimed at obtaining the effect of improving the efficiency of the transformed product or service, which implies performing accompanying calculations of forecast indicators. In other words, it is important that innovations bring economic benefits in the medium term.

Among the main factors influencing the implemented innovations, the interviewees named: the financial component, the availability of the necessary personnel, the available technical base, the ability to provide information support and perform predictive analytical calculations, the payback period of the required investments.

The surveyed companies expressed confidence that they have more experience in terms of technological innovations, marking them as more traditional and familiar. In terms of environmental innovations, the interviewees noted that it is important, first of all, to comply with the requirements of environmental legislation, but they are not ready to proactively increase the amount of commitments made by the company, publicly stating this. It is quite natural that out of all 5 surveyed enterprises, the construction company, whose impact on the environment in comparison with the others has more expressed character, is engaged in environmental innovations.

4 out of 5 companies stated that they have a sustainable development strategy, it is noteworthy that they also have the form of joint-stock companies. The interviewees noted that the goals and objectives of sustainable development are considered, as a rule, at the shareholders' meeting. Monitoring of goals is tracked by key financial indicators, at least quarterly, while the other parameters (innovations, personnel) are evaluated mainly annually.

Many interviewees assessed the information support of innovation activity as insufficient. The financial accounting system does not meet the needs for the data required for innovative solutions, and from the point of view of the formation and management of innovation accounting, there are significant problems with the technical component and the lack of personnel with the necessary qualifications, or the high cost of consulting solutions in this area. Companies have also expressed the need to take into account and control the risks of innovation and sustainable development, signaling a lack of information resources in this regard.

The analysis of the effectiveness of innovation activities is also carried out by traditional methods of evaluating the results, and investment analysis approaches are also used. The interviewees noted that the emergence of specialized methods for analyzing innovations might allow leadership to make innovative decisions based on an expanded system of indicators, and think more prospectively.

## 4 Discussion

Abbas and Sagsan [2] based on a survey of managers of companies in Pakistan operating in various fields of economic activity, by modeling the responses obtained using structural equations, established the relationship between the applied technologies of knowledge transfer and the speed of dissemination of environmental innovations. In addition, they concluded that the process of innovation activity is equally important for enterprises of any business scale, regardless of the field of activity.

Baumgartner and Rauterb [3] are convinced that sustainable development as a process integrates economic, environmental and social development, focusing on meeting not only existing needs, but also potential significant needs in the future. In this regard, the researchers note that the motives of sustainable development encourage enterprises to act strategically, which for the effective implementation of plans requires careful planning of the implementation process of this strategy, its content and context. This strategic approach ensures the effectiveness of corporate sustainability management and contributes to the increasing value of the business.

Chams and Garcia-Blandon [4] believe that innovative methods of managing the organization's human capital are a significant factor in increasing the effectiveness of the organization's sustainable development.

Hamalainen and Inkinen [5] distinguish a special category of innovations, defining them as disruptive. Such innovations can be applied in different areas of activity, they are always distinguished by a non-standard approach, which allows to radically change technological solutions and restructure the business processes of the organization, contributing to sustainable development.

Hamdoun et al. [6] conducted a study of possible factors that contribute to improving the results of innovative activity of the enterprise. Based on the assessment of the experience of 136 industrial companies from Tunisia, they concluded that the application of quality management and a targeted process of knowledge transfer can significantly increase the results of innovations in production and business.

Prange and Pinho [7] after conducting a survey of 120 exporting companies from Portugal, concluded that organizational innovations have a significant impact on establishing a link between drivers and the performance of an organization.

Rosati and Faria [8] based on an information base of 2413 reports on the sustainable development of companies representing 90 different countries, concluded that the processes of sustainable development are more effective in countries with developed social responsibility, high education costs and a low level of market regulation. The researchers recommended that public authorities in various countries take into account the impact of the identified factors to help business entities achieve the sustainable development goals.

Silvestre and Tirca [9] when assessing sustainable development, give this process a very broad interpretation, giving it a macroeconomic character and noting that such a state can only be achieved through joint purposeful efforts of industrial enterprises and the public with the assistance of authorized state authorities.

Song et al. [10] in the course of the study, established the positive impact of applied environmental innovations on the achievement of the company's sustainable development goals, implemented through the use of technologies for collecting, systematizing, and interpreting big data.

Wu [11] during the research, came to the conclusion that there is a special category of innovations focused on sustainability. These innovations are characterized by increased complexity of their development and implementation, since they are complex, covering both economic, environmental and social aspects of activity. The researcher identified the positive impact of the supply chains management process, aimed at interacting with socially responsible suppliers, on the introduction of innovations focused on sustainability.

## 5 Conclusion

In the course of the study, it was found that Russian organizations experience certain difficulties in implementing innovative activities. This is confirmed by the decrease in the ratio indicators of innovative products in total sales in 2015–2019, as well as a decrease in the share of innovation activity costs in relation to revenue. It is revealed that the implementation of innovations by Russian organizations is heterogeneous on the territory of the country, but at the same time, it is most actively implemented in terms of technological innovations in the presence of clear leaders engaged in industrial production. At the same time, the share of environmental innovations is insignificant. In the implementation of the sustainable development policy, the priorities are given mainly to joint-stock companies, which consider the financial, technical and human resources to be the most important factors of innovations. The surveyed organizations expressed their opinion about the high complexity of making innovative decisions and the existing need to form a system of management accounting for innovations, control of specific risks of innovation and sustainable development, as well as the use of specialized analysis methods.

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# Green Retail: Multi-aspects of Environmental Innovations

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**Abstract** The global economic space is characterized by high dynamism. The changes affect all areas of business, the consumer environment and all categories of the public. This article examines the concept of green retail as a concrete form of implementation of the global idea of sustainable development in a green economy. The analysis of approaches to the determining of green retail allowed to identify several aspects of the consideration of this innovative concept and its role in enhancing the environmental efforts of all participants in the supply chains. The phrase "the retailer's environmental initiative" does not mean that the retailer is solely responsible for the well-being of the current and future generations. Consumers, suppliers, government, and public organizations are rightly identified as stakeholders, since the effective achievement of environmental sustainability goals is ensured by joint efforts. The presented model of retail compliance with eco-trends does not currently involve a separate consideration of the benefits for the organization's staff, which is more in line with the actual state of affairs in Russian retail. However, presenting the benefits of the retailer, we consider the staff as its integral component, its key resource, for the development of which favorable conditions should also be created.

**Keywords** Circular economy · Environmental sustainability · Green retail · Innovation · Logistics economy · Trade marketing

## 1 Introduction

Along with the widely discussed issues of innovations caused by the digitalization of various sectors of the economy, the solution of environmental problems of the community remains a priority. Technological innovations are increasingly being considered both in the organizational and economic aspect, and in the context of environmental repercussion, the contribution to maintaining a favorable environment.

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Changing consumer behavior, strengthening the trend of environmental responsibility required almost radical adjustments to such elements as product, package and promotion. According to the Nielsen global study, 73% of respondents support the idea of sustainable development and understand the importance of maintaining a favorable environment. 62% of Russians admit their willingness to change their consumer behavior if it leads to a reduction in the negative impact on the environment. 57% of respondents in Russia, when choosing a seller, emphasize the high importance of their participation in environmental protection programs [1]. The relevance of the topic of this study is determined by the need for strategic development of retail, the adaptation of trade marketing to the trends of modern society.

## 2 Methodology

The process model of this study is classical. The concepts of sustainable and circular economy developed in the context of the ecological paradigm, the accumulated knowledge and practical experience in the field of green retail development are used as an input stream. The concept of sustainable development is applied to retail, meaning the company's long-term behavior in the complex activation of economic, environmental and social resources with concern for the current and future generation [2]. The concept of circular economy, born at the intersection of the sciences of economics and ecology, adjusts the distribution system, the priorities of which are secondary resources [3]. Accordingly, it is necessary to determine the functions of green retail in the "closure" of the natural system, within which the produced resources are fully used or processed. Retail, as the most important sector of the economy, follows its modern guidelines. The method of deduction allowed us to analyze the principles of the green economy in its concrete embodiment—green retail, whose entire activity, including interaction with other participants in the supply chain, is reduced to the reasonable use, preservation and multiplication of natural capital through innovative initiatives. To achieve the objectives of this study, we analyzed new scientific information presented by publications of foreign scientists mainly, since in Russia the interest of the academic community in the development of green retail emerged relatively recently. For the same reason, an analysis of a limited number of industrial electronic resources was presented. Over the past 10 years, the author held meetings in the form of conversation with representatives of various business areas, including retail. This period of time allowed us to track changes in the thinking of entrepreneurs, employees of trade enterprises. Using the opportunities of teaching practice in higher education, the author regularly held round tables and discussions on the subject of perception and evaluation of the modern society trends by young people. The main theme of such events was the contribution of companies and consumers to maintaining the environmental sustainability. A systematic approach was applied to the data synthesized in the course of desk and field studies, which made it possible to clearly show the multi-aspect concept of green retail and its key trends.

## 3 Results

For a long time, social and ethical marketing was not recognized in Russia as the highest stage of the company's market development. The main strategic guidelines have traditionally been the provision of high quality products and maximum customer satisfaction. Recently, the need to do something socially significant was controversial. Numerous meetings of the author of this article with retailers stated their complete confidence that the image of the merchant as a public figure is not important to customers. In their opinion, it was quite sufficient to offer a quality product at a reasonable price. These assumptions were also confirmed by the results of communication with representatives of the consumer community. In this regard, first of all, the mental barrier associated with the implementation of social projects of Russian retail was overcome, postponing the awareness of the importance of environmental sustainability for a later time. However, globalization and digitalization of information processes contributed to the rapid spread of common environmental values. Despite this, Russian buyers have recently become aware of the importance of their contribution to maintaining the environmental stability of society.

The solution to the problem of ensuring sustainable development is relevant for business in any sector of the economy, especially such a significant one as retail. The special position of retail in the supply chain is determined by the scale of the impact of its initiatives on the activities of all participants in the product movement. The organization of sales of high-quality goods that meet the demand of consumers as much as possible is already considered as inferior. Modern companies determine their prospects on the consumer market taking into account their contribution to environmental sustainability, concerns for people and nature. The idea of developing green retail in addition to environmental goals covers many positive changes in the trade business. The content of the green store concept can be considered in the following aspects (Fig. 1).

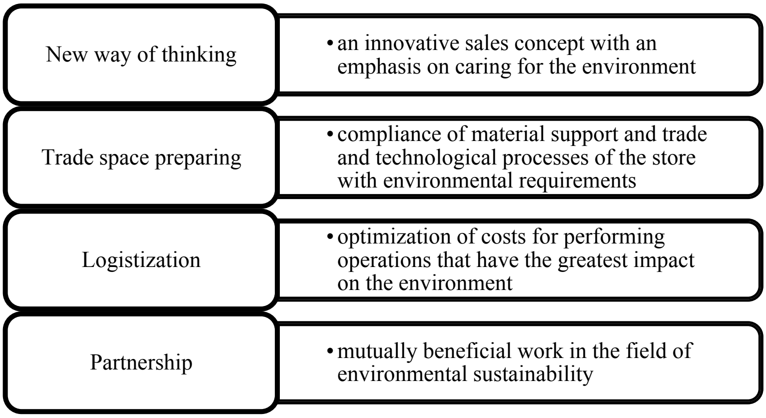


**Fig. 1** The multi-aspect nature of the green store concept

When "greening" a trading company, it is important not just to change the existing mentality of retailers, which is traditionally aimed at making a profit. However, marketing orientation is also not enough nowadays. Achieving maximum customer satisfaction involves reaching the current and future generations, who, in addition to high-quality, environmentally friendly goods, need to be aware of their social role, good feelings of its fulfilment. We are talking about the strategic vision of the retailer's stable position on the market. This is the collective thinking, attitude and behavior in unison of the company, its employees, partners and consumers.

In 2019, the largest Russian retailers officially recognized the social responsibility of their business and started implementing a strategy in the field of sustainable development. However, for small local stores, these guidelines are at the stage of consideration and understanding.

The organization of retail space in accordance with environmental principles involves saving resources consumed, for example, electricity at points of sale, materials (including recycled), from which trade furniture is made. Participation in the global environmental project obliges each retailer to more efficiently operate heating and air conditioning systems, high-end energy efficiency equipment. Experts recommend using POS-displays as a data medium of information about the store's green policy.

Logistics of trade and technological processes involves optimizing the retailer's costs. By implementing the principles of Retail Reverse Logistics, companies become a full-fledged part of the circular economy. With the transfer of most of the purchase and sale transactions to the online environment, the activity of Retail Reverse Logistics can be supported and strengthened by a greater selection of various acceptance points of defective, used goods and packaging.

The policy of reducing the costs associated with the transportation and storage of goods is aimed not only at obtaining economic benefits. The maximum use of the cargo volume of vehicles, reducing to a minimum the empty running contributes to less pollution of the environment.

The artificial environment generates about 40% of annual global greenhouse gas emissions, and retail is among the top ten most carbon-intensive sectors of the economy. Therefore, the issues of reducing retail and warehouse spaces are becoming particularly relevant from the point of view of the well-being of an individual nation and the world as a whole. The operation of green retail within the framework of the sustainable development program involves the implementation of a decarbonization strategy. Environmentally adequate trade and technological operations, well-designed buildings allow the retailer to benefit economically from the use of low-carbon technologies [4]. A systematic approach to the analysis of the development of global and Russian retail allowed to identify 4 main sectors, within which many environmental incentives of an innovative nature can be proposed (Table 1).

The population's concern about their own health, due to the deteriorating environmental situation, gave impetus to the development of an entire industry of healthy food products. The trend for a healthy lifestyle encourages consumers to prefer

**Table 1** Ecotrends in retail

| Eco-trends | Member of the green retail system | | |
|---|---|---|---|
| | Consumer | Retailer, company staff | Society, planet |
| Product | Health benefits | High margin | Consumer culture, national health |
| Packaging | Reducing the retail price by paying only for the product, reducing the costs of purchasing new packaging<br>Positive self-assessment of an environmentally conscious consumer | A favorable image as a factor of the company's competitiveness, increasing the loyalty of customers, partners and the internal public, attracting investors with high environmental requirements | Installation of fandomats, acceptance of goods for processing reduces the volume of harmful household waste<br>Popularizing the principles of circular economy |
| Trading service | Switching to online provides convenience regardless of the time and place of purchase | Cost savings for the maintenance of premises Career development of sales and operational personnel | The level of environmental pollution in the process of offline trading reduces |
| Logistics | Reduced retail price due to the trading costs associated with transportation and warehousing | Reducing of empty vehicle running<br>Reducing the costs of maintaining warehouses | The level of environmental pollution during transportation reduces<br>The vacant warehouse spaces can be used for social and cultural purposes |

products that show themselves as natural, "bio", "vegan", without genetically modified organisms, gluten-free [5]. As the healthy food market becomes saturated and consumer demand increases, manufacturers and retailers are increasingly finding it difficult to maintain a high level of competitiveness of their companies. Under these conditions, the focus shifts from the product to its packaging. Packaging is becoming one of the drivers of green retail growth, serving as a key carrier of advertising and promotional information and being the subject of a reverse flow in Retail Reverse Logistics. Green retail is an active participant and influencer of the closed-loop economy. Along with the direct supply chain, the reverse material flow is established. Stores not only organize the collection and recycling of packaging and old goods, but also financially stimulate the participation of the buyer by giving them a discount when buying a new product.

The digitalization of retail not only simplifies the sale of goods in any time and geographical space, but also supports the idea of reducing retail and warehouse spaces, contributing to the decarbonation of the company's activities. Maintaining a favorable environmental is a responsibility of not only a retailer. All the sustainable development goals can only be achieved together with conscious buyers and interested partners. Despite the fact that the environmental initiative comes from the retailer, its implementation is possible only with the support of all stakeholders. Thus, by developing environmental initiatives in any sector of retail activity, all stakeholders receive a set of benefits: from obvious economic to high-quality living conditions in the future. The ecological transformation of the retail space is real, although it requires costs, but in the long term, the retailer gains an undeniable competitive advantage and, as a result, a high profit [6].

## 4 Discussion

Within the framework of the given topic, most of the studies of the world scientific community are devoted to such aspects of green retail as the quality of goods and informing consumers about the activities carried out within the framework of the company's environmental policy. Information about the retailer's participation in the social project and the positive changes received should be widely and necessarily broadcast. Given the varying degrees of influence of information sources on consumers, companies should recognize the absolute leadership (after television) of social networks. Lu and Miller presented the results of a unique study of the long-term economic efficiency of green retail, comparing the scale and result of the impact of SMM and CRM. Scientists came to the conclusion that it is advisable to combine both information channels. Attention should be paid to the fact that consumers respond more to messages about health benefits than to information about price and environmental achievements [7]. The features of the collaboration sale of healthier food provision, combining the efforts of retailers, practitioners and other interested participants, are described by Boelsen-Robinson et al. [8]. Expert support for the sale of eco-friendly products increases the impact of the retailer's communications.

Dhir, Sadiq, Talwar, Sakashita, and Kaur emphasize the importance of high-quality consumer awareness of environmentally friendly production. Scientists are the first in the academic community to note the existence of discrepancies between people's attitudes to "environmentally correct" products and actual purchases. They are also the first to study the role of labeling in the formation of green trust [9].

At the same time, it should be noted that the potential impact of retail trade on the environmental behavior of participants in the entire supply chain was not sufficiently studied. Retailers' initiatives, given their unique position in the supply chain, are able to attract customers interested in the processes of reuse and recycling of packaging materials as widely as possible. However, the real effect of the environmental policy of retail is achieved if it is scaled up. Vadakkepatt et al. discuss actions that will allow world-famous trading companies to make significant progress in this area. By organizing the collection of used packaging and goods (reverse supply chain), retail can assist the manufacturer in achieving the sustainable development goals [10].

## 5 Conclusion

The concept of green retail is a relatively new trend for Russia, but there is a positive trend towards its adoption by major market players. Environmental responsibility is now considered not just as an element of marketing communications, it creates a competitive advantage and a key criterion for choosing a retailer for environmentally conscious customers, whose number is growing year by year. Understanding and supporting the new thinking of consumers creates a special emotional connection with the retailer, maximizing loyalty to its brand.

Price competition is a thing of the past. The joint work of suppliers, retailers and consumers for the benefit of present and future generations comes to the fore. Green retail goes beyond economic achievements, complementing them with social and environmental development. Environmental stability allows retail chains to increase corporate competitiveness, strengthen the loyalty of environmentally conscious customers, and maintain a favorable image for different categories of the public. Meeting the requirements of the external micro-and macro-marketing environment, a trading company receives financial bonuses from increasing the added value of such an intangible asset as corporate reputation [11].

The difficulties of rapid and large-scale dissemination of the concept of green retail is largely due to the apparent additional costs that innovative environmental projects will lead to, the budget of which, moreover, is quite difficult to determine accurately. Oral methods of interviewing representatives of trade companies and consumers, conducted regularly over the past decade, have made it possible to separate the installations of large international or federal retailers and small non-chain stores. Consumers of any generation have always shown interest to the environmental initiatives of any organizations. However, due to the territorial accessibility of retail, proximity to places of consumers concentration, it becomes easier to implement the ideas of careful attitude of nature to the environment. Due to the principles of green retail, it became possible for the population to participate in the development of the circular economy. A systematic approach to the analysis of the functioning of green retail.

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# Impact Factors of the Digital Economy on Economic Growth

**P. E. Zhukov**

**Abstract** At the twenty-first century digital economy based on digital, information services become a driver of the development for the entire economy. The ability to adapt to the requirements of digital economy may have a decisive impact on the development of companies in some traditional sectors (e.g. car production), the public services sector and, in particular, to the competitiveness in the financial sector. In terms of growth factors, the modern digital economy is the economy of ideas, because it is the new ideas associated with scientific and technological progress that become factors of value creation, cash flow generation and growth. Two main factors can be identified in the development of the digital economy and its revolutionary impact. The first is reducing transaction costs for marketing and advertising of goods. The second is the creation of new digital services for consumers, businesses and public sector. The impact of the first factor to China's economy is estimated on the example of Alibaba as 1.1% of the additional GDP growth at least. In Russia, it is possible to assess the potential (not realized) effect for the growth of agricultural production by about 50%. However, the resources for development at the expense of the first factor are limited. Development through the second factor, new digital services, may be much longer, but it depends on the emergence of new technologies in the field of information processing and transmission.

**Keywords** Digital economy · Economic growth · E-trade · Factors of growth · Transaction costs

## 1 Introduction

The aim of the research is to explain the sharp rise of value of digital companies and the implied impact of digital sector on economic growth in the early twenty-first century. The challenge is to identify the major factors in the impact and to assess the scale of the impact. To do this, model for GDP dependence on e-commerce was

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built, as well as the model of dependence on lowering transaction costs. For the first model, the best approximation for stationary parameters was found by minimizing deviations with OLS.

## 2 Why Do Digital Companies Lead the Stock Markets?

In the development of digital technologies, there was a period from about 1994–2000, when psychological factors prevailed and the increase in value was not always confirmed by cash flows. All companies with "dot" or "com" tags in their name began to grow rapidly in price, despite their real results. In the end, in 2000, investors came to the conclusion that the fascination with Internet companies is a bubble, that is, the growth of their value is based not on the cash flows they create, but solely on expectations of price growth. At 2000, the Internet bubble collapsed, which get the name "dot.com bubble."

Capitalization of digital companies has been growing significantly faster than the profitability of the broad market for more than 10 years. Undoubtedly, along with fundamental factors, psychological factors make a significant contribution to this rally—investors' assessment of the growth prospects of companies. This is especially evident in the example of Elon Musk's Tesla. So far, this belief has not been questioned. In addition, since 2010, the growth in the value of companies in the digital economy is fully confirmed by fundamental indicators (operating cash flows are growing at a rate of 12–15%) [1]. The reputation of digital companies has been restored, then they have steadily taken the first places ranking on capitalization, displacing other companies. Today, there are at least seven leading IT giants whose business is based largely on digital services—Microsoft, Google, Amazon, Apple, Facebook, Tencent, Ali-Baba which occupy the first seven positions in capitalization as of March 1, 2021. This list is far from complete and is compiled only by the one criterion—capitalization (key for the financial theory). If you evaluate IT companies, for example, on the profit from software sales, the list of leaders will look very different. In any case, the list of leading IT companies can include at least 18–20 companies that closely follow the leaders by capitalization—for example, TSMC, Intel, Nvidia, Samsung, LinkedIn, Reddit, Twitter, YouTube, Disney, Verizon, Comcas, Adobe Inc., AT&T, Salesforce.com, Cisco Systems, Oracle Corporation, IBM, and others.

The new IT sector is currently in fact a driver of economic growth, and digital giants are ahead not only of traditional industries (oil, gas, engineering, automobiles, trade) but even financial companies such as banks and insurance companies in terms of capitalization, profit and cash flows. It can be assumed that the time of rapid growth of the digital industry (10–15% per year) is limited as it cannot last indefinitely. But from the experience of periods of rapid growth in other industries (oil, electronics, automotive, etc.) we can assume that this period may last for at least 10 years or more.

In addition, digital technology is revolutionizing the whole economy. Companies in car manufacturing (as an example) can generally stay competitive only by introducing IT systems into business process management and into end products. Thus, it is possible to conclude that at the beginning of the 21-st century has happened the event that changed the economic landscape, namely, the emergence of a fundamentally new sector of the economy, the digital economy based on digital services, and the willingness to provide these services is beginning to have a decisive impact on the development of companies in some traditional sectors of the economy, public services and especially the competitiveness of the financial sector.

The digital economy has features that make it difficult to use classical economic theory developed in the nineteenth century to describe traditional sectors. In particular, it is controversial to use the traditional factors of production on which modern economic theory is based starting with the ideas of Say and Ricardo [2]—labor (taking into account qualifications), land (natural resources) and capital (money and investments in material and intangible assets). The influence of scientific and technological progress in the classical theory of the twentieth century is usually considered within the Solow model [3] as an increase in the productivity of capital factors. In order to take into account the realities of the twentieth century to the capital, intangible assets were added—brands, software, patents, intellectual property rights, etc. In a modern interpretation, they are often supplemented by abilities (usually entrepreneurial), human capital, innovations and etc.

If we take a break from the features of the designations, it is obvious that all new factors are connected with new productive technologies and ideas, which become an independent factor of production in the modern economy of the twenty-first century. Thus, to describe the effects of digital technology on the modern economy, a new factor is needed which is associated with new technologies and ideas. It can be assumed that the modern digital economy is an economy of ideas, as new productive ideas related to scientific and technological progress become factors of value creation, cash flow generation and drivers of economic growth.

Three main issues are considered there: how the digital economy creates new value, what are the main factors in its apparent and rapid growth, and what are the possible limits of that growth. It is intended to distinguish between two effects (development factors) of the digital economy—the promotion of goods or services created in the traditional economy and the creation of new (digital) goods or services. While both ways of creating value can be interconnected and even difficult to discern, they are still fundamentally different in their economic nature. The main hypothesis is that the digital economy at the present stage of its development realizes, basically, the first effect, so it contributes mainly to marketing. From an economic theory, this means lowering transaction costs to find buyers, make transactions and share information. However, a growth resource based only on reducing transaction costs is limited and probably may not last longer than 10–15 years.

The second driver of the digital economy's growth, which could theoretically have unlimited duration, is new digital services based on new features—new technology (associated with new processors, memory and data transmission) and new ideas for their use. In the case of the digital economy, new factors that are associated with new ideas play a major role. They can be described as intangible assets, human capital, etc., but as shown above such a description will always not be adequate.

## 3 Limits on the Rapid Growth of Intermediary Services for Digital Companies

Consider the first hypothesis (the first development factor)—a typical digital company at the current stage of its development is not so much creating new products or services, as contributes to their marketing, performing a mediation function. In this case, the digital company's revenues will be generated by mediation between manufacturers and consumers of goods or services (e.g. like Uber). First of all, it takes in account contextual advertising in search engines and social networks (e.g. like Google and Facebook), which use Big Data in order to offer the product to the consumer. This represents a significant portion of the cash flow of search engines and social networks, including Google, Facebook, Tencent, etc. In other cases (such as taxi-ordering services Uber), digital services are provided to consumers by service providers, while receiving significant commissions (in the case of ordering a taxi is about 30% of the check).

Another example of this mediation function is the operations of electronic trading platforms. Note that this activity brings the main income at least to the two IT giants—US Amazon and its Chinese rival Alibaba. Electronic trading platforms (ETPs) such as those created by Amazon and Alibaba are divided into three main types—B2B, connecting companies and businesses, B2C connecting companies and consumers (e-commerce) and C2C connecting individuals and allowing them to trade with each other. The impact of e-commerce on world trade is analyzed in the WTO report [4]. Examples of Amazon and Alibaba show that B2B ETPs may provide faster economic growth. From the economic theory, the following factors of influence of ETP may be identified: (1) reducing transaction costs incurred by mediators and advertisement, (2) decrease prices (due to the elimination of mediator's commissions) and therefore increase profits that the manufacturer receives through sales growth. As a result, the economy is growing.

Consider this effect on the example of the Chinese company Alibaba. According to fundamentals, Alibaba Group grew by 20–30% per year in 2013–2020. Note, that Alibaba's annual revenues from the commission are growing, but their share in the income is constantly declining—it is amounted to 18% of all income by 31.03.2019, while the commission's revenues grew by 30%, and the company's revenues by 39% (excluding consolidated income from acquisitions). But what impact has this had on the development of China's economy? The influence of Alibaba group on the development of the Chinese economy is considered in the work [5], where it is assessed as at least 1.1% of China's additional GDP growth in 2008–2020—see Table 1 for GMV (gross merchandise volume) of Alibaba and GDP of China from 2014 to 2020.

**Table 1** GMV of Aliababa and China GDP in bln. $

| | GMV | Growth (%) | GDP | Growth (%) | GMV/GDP (%) |
|---|---|---|---|---|---|
| 2014 | – | – | 10,439 | 7.3 | 2.6 |
| 2015 | 394 | 46 | 11,016 | 6.9 | 3.6 |
| 2016 | 485 | 27 | 11,138 | 6.7 | 4.4 |
| 2017 | 547 | 22 | 12,144 | 6.5 | 4.5 |
| 2018 | 768 | 28% | 13,608 | 6.6 | 5.6 |
| 2019 | 853 | 19 | 14,200 | 6.5 | 6 |
| 2020 | 1023.6 | 20 | 15,500 | 6.5 | 6.6 |

## 4 Model to Assess the Contribution of E-Commerce to the Economy

Consider the following model which is designed to assess the impact of the first factor (reducing transaction costs) for e-trade (e.g. Alibaba and Amazon):

$$\mathrm{GDP(t)} = (1 + \mathrm{g(t)})(\mathrm{GDP(t-1)} - \mathrm{GMV(t-1)}) + \mathrm{GMV(t)} \tag{1}$$

$$\mathrm{GMV(t)} = \alpha(\mathrm{t})\mathrm{GMV(t-1)} + \beta(\mathrm{t})\mathrm{GDP(t)} \tag{2}$$

Here g is the GDP growth without taking into account the effect of e-trading, α—the share of the old business in GMV, β—the share of the new business in GDP, created by the e-commerce in the year t (g, α and β are less than 1). From Eqs. (1) and (2) may be find averages g, α, and β that are not dependent on t, which minimize the error of GDP and GMV (e.g., with OLS or the method of generalized moments GMM).

Substitute Eqs. (1) in (2): GMV(t) = α GMV t − 1 + β ((1 + g) (GDP(t − 1) − GMV(t − 1) + GMV(t)) and get: GMV(t) (1 − β) = (α − β(1 + g)) GMV(t − 1) + β (1 + g) GDP(t − 1).

Divide both parts into GDP(t − 1):

$$\begin{aligned}&\mathrm{GMV(t)/GDP(t-1)}\\&\quad = (\alpha - \beta(1+\mathrm{g}))/(1-\beta)\mathrm{GMV(t-1)/GDP(t-1)} + \beta(1+\mathrm{g})/(1-\beta)\end{aligned}$$

This way is derived the equation to determine the optimal parameters with the OLS, Eq. (3):

$$\mathrm{GMV(t)/GDP(t-1)} = \mathrm{a\ GMV(t-1)/GDP(t-1)} + \mathrm{b} \tag{3}$$

$$\mathrm{a} = (\alpha - \beta(1+\mathrm{g}))/(1-\beta)$$

$$b = \beta(1 + g)/(1-\beta)$$

By minimizing the data from the Table 1, the result for "a" is 0.97, with the standard error 0.18 (the regression value is about 0.006, and the R2 is 0.87). Approximating results:

$$a = (\alpha - \beta(1 + g))/(1-\beta) = 1$$

$$b = \beta(1 + g)/(1-\beta) = 0.011$$

There "b" is the average contribution of Alibaba Group to the overall growth of China's economy—plus 1.1% of GDP annually.

## 5 Development of E-Commerce in Russia

An analysis of the development of e-commerce in Russia can be found in the RAEX (Expert-RA) report "Electronic Trading Platforms in Russia: In Search of a Future" [6]. According to experts, the volume of trade for the top 12 Russian ETPs in 2017 amounted to 9.5 trillion rubles (approximately $146 billion). However, the market in 2017 almost did not grow, which means that the potential for extensive growth of e-commerce in the public sphere (according to the experts of RAEX) is exhausted in the medium term. However, there are sectors of the Russian economy which suffer from the dictates of intermediaries, such as agriculture, food production and sales. To qualitative assess the possible impact of e-commerce, here a simplified model is offered. This model is based on Eqs. (4), (5) which take into account the increase in output by reducing transaction costs. In Eq. (4) it is assumed that sales growth (S) is proportional to the price change (P) multiplied by the elasticity of the price (λ). Equation (5) defines price reduction as a function from that part of the σ transaction costs (trans) to the search for new buyers, at the expense of which the price is reduced (the remainder equals the additional margin of the seller's profit):

$$(S(t + 1) - S(t))/S(t) = \lambda \times \Delta P(t)/P(t) \tag{4}$$

$$\Delta P(t) = \sigma \times trans(t) \tag{5}$$

In particular, for the production of agricultural products, it is possible to estimate the σ and λ approximately as equal to 1, and the percentage of price change for the final buyer as 50% (the assessed margin of profit of intermediaries).

## 6 Conclusion

In terms of growth factors, the modern digital economy of the twenty-first century has not only created a new sector of the economy, but has also made revolutionary changes in other sectors of the economy. The new economy of the twenty-first century is largely the economics of ideas, as it is the new ideas associated with scientific and technological progress that become factors of value creation, cash flow generation and growth. There are two main factors evaluated for the IT economy and its apparent revolutionary impact on the growth of the economy in the beginning of twenty-first century. The first is to reduce transaction costs for marketing, advertising and marketing of goods, accelerating the development of the entire economy. The second is the creation of new digital services for consumers, businesses and the public sector. On the example of Alibaba, it is possible to assess the impact of the first factor in China—only the direct effect was at least 1.1% of additional GDP growth. Development effects due to the second factor—new digital services may be much longer, but it depends on the emergence of new technologies. If there are new revolutionary solutions—e.g. in artificial intelligence, or in the field of technology development (new quality of communication), it is possible to predict the emergence and rapid development of new digital services, which can spread forward the time limits of rapid growth in the digital industry and the whole economy.

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# Innovative Activities in Russian Regions and the Impact of the Pandemic COVID-19

**E. A. Malysheva, R. H. Mutalapov, and Yu. S. Lisachkina**

**Abstract** The article discusses the innovative business of the business in the regions including, taking into account the influence of the Pandemic Cowid-19. The purpose of the article was to study the degree of innovative business development, taking into account the impact of the pandemic. The tasks were solved: it was proved that innovative development is an important factor contributing to the growth of the country's competitiveness in the world arena; the conditions for the formation of the competencies of an "innovative person" were considered, as well as modern and relevant types of innovations, among which incremental, disruptive, sustainable and radical innovations are presented. The works of researcher on the innovative developments issues were studied. The position of Russia is shown in Global Innovation Index over the past few years. It is shown that the pandemic has accelerated the process of robotization in health care in the regions. The authors consider an example of smart devices that actively help doctors in this period and another one of a Russian startup "Connectome.ai" which is the invention to control biosafety at DIREKTIVA: CEO enterprises.

**Keywords** Artificial intelligence · Digitalization · Immersive technologies · Innovation · Innovative activities · Innovative management

## 1 Introduction

In recent years, the innovative development of Russia was one of the key areas of state development. However, having numerous strategies and implementing various support measures, significant results were obtained. Innovative development is an important factor contributing to the growth of the country's competitiveness on the world arena [1]. With the understanding of this fact, in the long term of development, Russia puts global objectives: ensuring a high level of well-being of the population,

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consolidating the leadership position on the world stage. To achieve them, it is necessary to rethink the current economy model and gradually carry out the transition to innovative socially-oriented. This implies an existence of an essential share in the markets of intellectual and high-tech services, an increase in innovative products in the industrial sector and innovative companies [2]. Innovation has long been the basis of economic development. Without innovation, in principle, the financial well-being of individual sectors of society, and even countries are impossible.

## 2 Methodology

An important task is to create competitive innovative systems, in the process of which highly qualified personnel are involved. To do this, it is necessary to create conditions for the formation of the competencies of the "innovative person". This implies that each person must adapt to constant changes, play its role in the general innovative community [3]. Such competencies include:

- ability to continuous education, the desire to obtain new knowledge;
- ability to critical thinking;
- creativity, the ability to work, both in the team and independently, willingness to work in a highly competitive environment;
- possession of foreign languages [4].

To increase these competencies, the formation of such an "atmosphere" in society, which provides freedom of creativity, is encouraged and awarded possession of such competences [5]. There are the following types of innovation:

- incremental (they are convenient because they are often easy to sell, because you do not need to explain the key principles of your product or service—people are already familiar with how they work; they do not create new markets and often do not use radical new technologies, they can attract higher paying customers because they satisfy customer needs);
- subversive (this is where traditional business methods fail and require new opportunities; this is an innovative dilemma, since new market participants provide an alternative solution that requires new opportunities that traditional companies do not necessarily have in their products);
- sustainable (traditional business management methods and sustainable innovations are often sufficient because they are the most profitable, and the risks are lower; they exist in the current market, and instead of creating new value networks, they improve and expand existing);
- radical innovation (technological innovation, such as a personal computer and the Internet, are examples of radical innovations that changed the way of functioning and communicating around the world. These destructive innovations provide our society platform for growth, which leads to a very accelerated economic growth).

The pandemic showed that some areas of business were frozen in the introduction of innovation, but at the same time there was a sharp surge of human ingenuity in other areas, primarily in health care. The rapid and worldwide proliferation of coronavirus requires extraordinary approaches that allow us to win the overall victory in the fight against the global threat [2].

## 3 Results

The position of Russia in Global Innovation Index over the past few years is held in the middle of the ranking. In 2020, Russia ranked 47th, in the previous year on 1 position was higher. Position on Subindex "Innovation Resources" is higher than on Subindex "Innovation Results", which indicates that it is not enough to increase the scope of resources to achieve serious results in the field of innovation [6]. In the ranking of the subjects of Russia for the greatest value of the regional innovation index in 2020, the following subjects are listed:

1. Moscow.
2. St. Petersburg.
3. Nizhny Novgorod Region.
4. Republic of Bashkortostan.
5. Kaluga region.
6. Chuvash Republic.
7. Republic of Mordovia.

This rating is an assessment of the educational, economic, and information potential of a region or a separate city, showing opportunities for creating, adapting and implementing various innovation. At the highest position, Moscow, as the Center for Innovation Activities in Russia, is further located in descending order: St. Petersburg, Nizhny Novgorod region. The rethinking role of innovation, both in the economy and in society, contributed to the Pandemic COVID-19. The main priority should be improved environment for innovation, promoting competition, the involvement of a wide range of companies in innovative activities. Skolkovo's innovation center—a modern scientific and technological complex for the development and commercialization of innovative technologies, operating in Moscow, and resident companies provided a significant assistance to society during quarantine and pandemic, the following projects were created and implemented during the Pandemic period COVID-19:

1. Uchi.ru: This is a platform that makes it possible to conduct lessons in online format. This platform was developed by the Skolkovo resident company. The purpose of creating an online platform is the ability to study various school items in a pace convenient for a child. On the platform you can do it yourself, as well as hold school classes. The tasks themselves are proposed in the format of an interactive game. When a quarantine for schoolchildren was declared, a "Virtual

Class" service was launched for lessons remotely. In the lesson, students who have passed registration may be present. The teacher sees a list of those present, and the student can raise his hand. Also, on the service you can download files, show presentations and typing [7].

2. DRD Biotech: This is a biomedical company that reoriented at the time of the pandemic, and put the goal to create an express test for antibodies to the COVID-19 virus. The company has created a test that is able to give a response 10 min after delivery. Tests for the presence of a virus in the body in Russia were detected by a polymerase chain reaction with reverse transcription, which determines the presence of a virus at an early stage, when the infection has already happened, but there are no manifestations. In turn, the test for antibodies should be done when symptoms appear, the test results allow you to determine how long the body's response has been strong, at what stage is the disease. The pandemic accelerated the process of robotization in health care. Smart devices actively help doctors in this difficult period. At the end of April 2020, in the European Medical Center, Sberbank launched a robot-disinfector in the test mode, designed to combat viruses in both the air and on various surfaces. The device conducts planned and emergency room processing. Powerful UV lamps are able to destroy up to 99.99% of pathogens, including coronavirus [7].
3. "Stakhanovets": This is an online program that shows what employees are engaged in the entire working day. So, the program collects data on how many hours the staff workers worked on which sites and so on. Thus, the manager produces an objective assessment of the performance of subordinates. This program makes it possible to manage accounting and control, and employees helps in dismissing priorities and proper time management, because all employees have access to reports that are sent to the head. Thus, labor collectives are maintained and the productive and efficient activity of the company is maintained. Thanks to the support of resident companies of the Innovation Center Skolkovo, many successful technologies have been created, which not only stimulate the country's economy, but also solve socio-economic issues. At the end of March, the Russian startup Connectome.Ai presented an invention to control biosafety at Direktiva: Chanitaria enterprises. The system is a smart wage: it tracks the quality of the WHO hand washing quality, and also checks the presence of personal protective equipment, recognizing persons and actions of employees. Everyone who neglects the rules of sanitary processing and security, the production entrance is automatically blocked. The principle of operation of the system is based on video analytics and artificial intelligence, so it will not be able to deceive it. The device is actively implemented at the food industry enterprises: a smart wicker monitors the biosafety of the meat processing plant "Myasnitsky row" [7].

Increasing the innovative activity of the Russian economy will be facilitated by the implementation of the innovative policy of subjects of Russia. For which the successful experience of actors engaged in active innovation activities, for example, Moscow, St. Petersburg, Nizhny Novgorod region, and Mordovia, will be valid and appropriate. The implementation of the innovative strategy of the subjects of Russia should be directed to the formation of the competencies of the “innovative person” among citizens, the creation of an innovative infrastructure, the development of innovative entrepreneurship.

## 4 Discussion

As for the whole environment for the development of innovative entrepreneurship in Russia and in the regions, it must be said that in recent years it has improved significantly: new development institutions have emerged, which together provide support at all levels of technology readiness—clusters appeared from fundamental studies before launching industries Technoparks and business incubators. A large range of measures to accelerate technological development and enormous money for this is provided for in the National Projects “Digital Economics”, “Improving labor productivity and employment support”, “Science”, “Culture” and a number of sectoral state programs. According to the results of the National Project “Science” at least 250 large companies should be involved in the creation of technologies, products and services, and with the participation of organizations—participants in scientific and educational centers and centers of the competence of the national technological initiative—at least 1.5 thousand patent applications must be submitted. All this makes it possible to expect that Russia will reach 50% of innovative active companies by 2024 [6].

The pandemic also made his contribution and became a powerful trigger of innovation. So, many business owners were in front of the choice: either in a few days invent, how to rebuild—to introduce new trade formats, refill employees, for example, from the restaurant’s waiters in food delivery, and so on, or in a month they will not have a salary to people and We’ll have to close. The pandemic became a powerful catalyst for the introduction of innovations not only in medicine, which is obvious, but also in all other areas of the economy—from education to transport.

If earlier business planned the development of a slow pace, then over the past year everything turned over. For example, Sberbank has developed a school digital platform. From the fall of 2019 and until mid-March 2020, schoolchildren were trained on it 15 pilot Russian schools. Business saw how the situation was developing in the country with a coronavirus pandemic, and was adjusted on time. When it became obvious that schools would close on quarantine, “Business—Innovation” sharply accelerated the work on the finalization of the platform and its scaling in the regions. In two weeks since the beginning of self-insulation, the platform was introduced in more than 2 thousand schools in 23 regions of Russia. The guys across the country did not just quickly returned to training, and they gained access to the best content from the best teachers [8].

Compare the rate of introduction of innovation is difficult, and most importantly—meaningless. The introduction of innovations is the guarantee of the competitiveness of any business, and state, and private, and in the conditions of a pandemic, this is also a pledge of survival. Business should always put in front of him the task to help the state and at the height of the epidemic to participate in a variety of joint projects with the state, introduce innovation for the state. As for the cost of innovation, the peculiarity of our country is that the state spends significantly more than a private business on them, and in the most technologically developed countries—on the contrary. Sources on R&D relative to GDP (1.1%) with us even higher than in Japan, Canada and Switzerland. But in general, investments in research and development below, because there is a private business in innovation three times more than the state—about 3% of GDP, and in Russia—only 0.3% of GDP [6].

## 5 Conclusion

Coronavirus pandemic helped Russian companies to begin restructuring business organization towards digitalization [9]. Such processes will have long-term consequences and will not stop after the end of the COVID-19 pandemic. Companies working with end-consumers also strive to ensure that even during a pandemic, all processes have been debugged or reconfigured if there is such a need. After all, it is the ability to adapt the channels of interaction with end users and customers is necessary to maintain the current income of buyers, the driver to attract new customers, and, accordingly, the guarantor of the stability of the corporation. The ability to quickly adapt to these changes is particularly critical today. This requires the revision of barriers and opportunities through the prism of innovation models. During the COVID-19 period, the main driver of innovation is the possibility of reducing the costs and the introduction of technologies aimed at rapid adaptation of production processes. Innovative activities in the regions of Russia during the pandemic period only increased in order to provide business competitive advantages in the market. The crisis pushed the management of companies to adopt complex solutions to optimize existing business models, search for cost reduction paths, as well as to the development of new business directions. Thus, the COVID-19 pandemic allowed the companies to lay a foundation for future development and the development of new markets after the end of the epidemic.

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# Green Innovations Development in Russia as Factor of Sustainable Development Goals Achieving

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**Abstract** This study analyzes the development of green innovations in the Russian Federation as one of the main factors in achieving the sustainable development goals. Sustainable development is the most important tool for the effective country development and enables to increase its competitiveness in the world. Unfortunately, the current trends in the country do not allow for a quick transition to this concept. The world is now experiencing an sharpening of environmental problems. We have almost reached the extreme point. Therefore, the formation of effective tools for greening is urgent, including the introduction of green innovations. Green innovations allow to solve most of the country's environmental problems either small or huge ones. But at the same time, society is not sufficiently interested in their development and application. Nowadays, the policy of the state is focused on solving economic and social problems and in some cases to the detriment of the environment. This already indicates a failure to comply with the basic principle of sustainable development. At the same time, in Russia, there are slight positive trends in the field of green innovations. Therefore, to speed up this process, it is necessary to form an effective mechanism for stimulating green innovations, which will speed up the process of sustainable development of the country.

**Keywords** Energy efficiency · Environmental efficiency · Green economy · Green innovations · Greening the economy · Sustainable development

## 1 Introduction

The quality of human existence in the near future is determined by the level of sustainable development achievement. Sustainable development is understood as the development of society that allows to meet the needs of a person nowadays, while preserving such potential for future generations. Sustainable development involves the harmonious development of three aspects: social, economic and environmental.

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The main goals and directions of sustainable development were determined by the UN Conferences. During which the formation of a “green economy” was identified as a priority. The UN draft resolution highlights the green economy as the main tool for ensuring the sustainable development of society [1]. By green economy, the UN understands an economy aimed at improving the well-being of society without harming the environment. Getting on the path of developing a green economy is impossible without accelerated innovations. Since the priority of the green economy is a “low-carbon economy” and improving energy efficiency, it is the development of green innovations that will be relevant as the main factor in achieving sustainable development in the country. The directions of effective implementation of green innovations are not yet fully formed in the Russian Federation. In the conditions of crisis development, economic problems are mainly solved and short-term goals are formed. The raw materials orientation of the country’s economy also does not contribute to the development of innovations aimed at improving human well-being while preserving the environment. At the same time, Russia does not fully understand the concept of sustainable development and most often reduces it only to the stability of the country’s economic system. Therefore, further development of the country is impossible without a complete rethinking of the sustainable development strategy. Innovative development should also be primarily focused on the creation of environmentally friendly technologies.

## 2 Methodology

The author used the methods of quantitative and qualitative analysis. In particular, such as comparative analysis of socio-economic and environmental processes. The main indicators of the assessment of the environment state in the Russian Federation, their comparison with other countries, as well as their dynamics were considered. The main criterion for assessing the state of the environment in the Russian Federation was the Environmental Performance Index (EPI) compiled by the Yale Center for Environmental Law and Policy. This index is based on two large groups of indicators: ecosystem viability (natural resource management) and environmental health and is calculated every two years. A structural and dynamic analysis of green innovations developed and applied in the Russian Federation was also carried out. The indicators that characterize the implementation of green innovations were determined based on the definition from the United Nations Environment Programme (UNEP). According to this definition, under the green economy we understand an economy type that ensures the social justice and the long-term improvement of human well-being. It also includes a significant reduction of environmental risks [2]. This program highlights the following areas of greening: clean water and sanitation, sustainable agricultural development and organic farming, energetics greening, processing and disposal of solid household waste, transport greening, construction of “green” buildings, conservation and restoration of life environment, forest restoration, preservation of water resources, conservation and effective management of ecosystems, etc.

Nowadays, the Russian Federation does not have detailed statistical information on the indicators of all the presented areas. Therefore, within the framework of this study, for the analysis of the implementation of green innovations, such as greening of energy and transport, sustainable development of agriculture and organic farming, processing and disposal of solid household waste, were identified.

## 3 Results

The share of the creation and use of green innovations in the Russian Federation is currently quite low compared to the indicators of Western Europe and the United States. As already mentioned, this situation is due, firstly, to the raw materials orientation of the economy, the protracted crisis state of the economy, and secondly, Russia has not formed a culture of efficient consumption of natural resources, due to their large availability. Unfortunately, most industries operate on the basis of the concept of a frontal economy. There is a quite large proportion of violations of environmental legislation due to the high level of corruption in various controlling entities. All this created a systemic problem of the formation of eco-friendly production and consumption in Russian society. At the same time, we would like to note that Russia has a high potential for the development of green innovations due to the existing natural resource potential and innovation potential. As part of this study, an analysis of the environmental situation in the Russian Federation was carried out. The Environmental Performance Level (EPI) was selected for the assessment (Table 1).

180 countries participate in the rating [3]. Against the general background, Russia's rating can be considered quite acceptable. The negative fact is that the country's environmental performance rating has decreased almost twise in four years. This was facilitated by environmental disasters on the territory of the country, a decrease in the level of environmental responsibility of enterprises due to the crisis phenomena in the economy. Therefore, it can be noted that if the environmental priorities in Russia will not change, then we can expect a deterioration in the situation. The sustainable development of a country with such a trend will be carried out at a rather slow pace. This also makes it possible to justify the need for intensive development of green innovations in the country. Next, we will present the level of use of green innovations in the Russian Federation (Table 2).

According to Table 2, it can be noted that in Russia for the period from 2017 to 2019, there was an increase in the use of environmental innovations. At the same

**Table 1** Rating of the Russian Federation on the environmental performance index

| Years | EPI rating |
|---|---|
| 2016 | 32 |
| 2018 | 52 |
| 2020 | 58 |

**Table 2** Dynamics of innovative approaches to greening in the Russian Federation in 2017–2019

| Indicators | 2017 | 2018 | 2020 |
|---|---|---|---|
| Share of energy generation from renewable sources excluding hydroelectric power stations (%) | 0.23 | 0.24 | 0.28 |
| Generation of energy from renewable sources, including hydroelectric power stations (%) | 17.0 | 17.3 | 17.6 |
| Utilization and neutralization of production and consumption waste (mln tons) | 3264.6 | 3818.4 | 3881.9 |
| Agricultural enterprises producers of organic products, units | 46 | 59 | 94 |
| Reduction in the GDP energy intensity (p.p) | −0.26 | −0.09 | −0.2 |
| Reduction of the gross consumption of fuel and energy resources due to the technological factor (p.p) | −25.94 | −7.76 | −5.41 |
| Electric vehicle park (units) | 1771 | 3600 | 6300 |

time, the presented positive trends are insignificant. There is currently no accelerated transition to sustainable development. Therefore, there is a need to create an effective mechanism to stimulate the transformation of economic activity towards green development. This mechanism should be supported by the country's sustainable development strategy, as well as the state program for financing projects for the development and use of green innovations.

In most countries, the state plays a leading role in the implementation of green innovation programs. In Russia, unfortunately, there is no clear program for the development of innovations in the field of greening the economy and society. Currently, there is only one effective tool for improving environmental sustainability—the National project "Ecology". Its goals are effective management of production and consumption waste, reduction of atmospheric air pollution in large industrial centers, improvement of drinking water quality for the population, preservation of biological diversity, ecological improvement of water bodies and preservation of unique water systems, ensuring a balance of forest disposal and reproduction [4].

In Russian practice, the following methods and tools are used to support and encourage green innovations: direct budget financing of environmental projects; subsidies for costs recovery; concessional lending of environmental projects and programs; a system of differentiated coefficients; and cost recovery for environmental measures. Despite a fairly wide range of tools, there is still a fragmentary approaches from the state to the implementation of the principles of the green economy. The formation of an integrated approach to the creation and use of green innovations in the Russian Federation requires the creation of a system for achieving sustainable development, within which a clear mechanism for stimulating green innovations should be defined. In Fig. 1 the author's approach to this mechanism is presented. Thus, a unified system should be created in the country that allows for effective implementation of environmental innovations, which will speed up the process of transition to the sustainable development. This system is primarily based on the development of a regulatory mechanism to stimulate and control this process, as well as the active

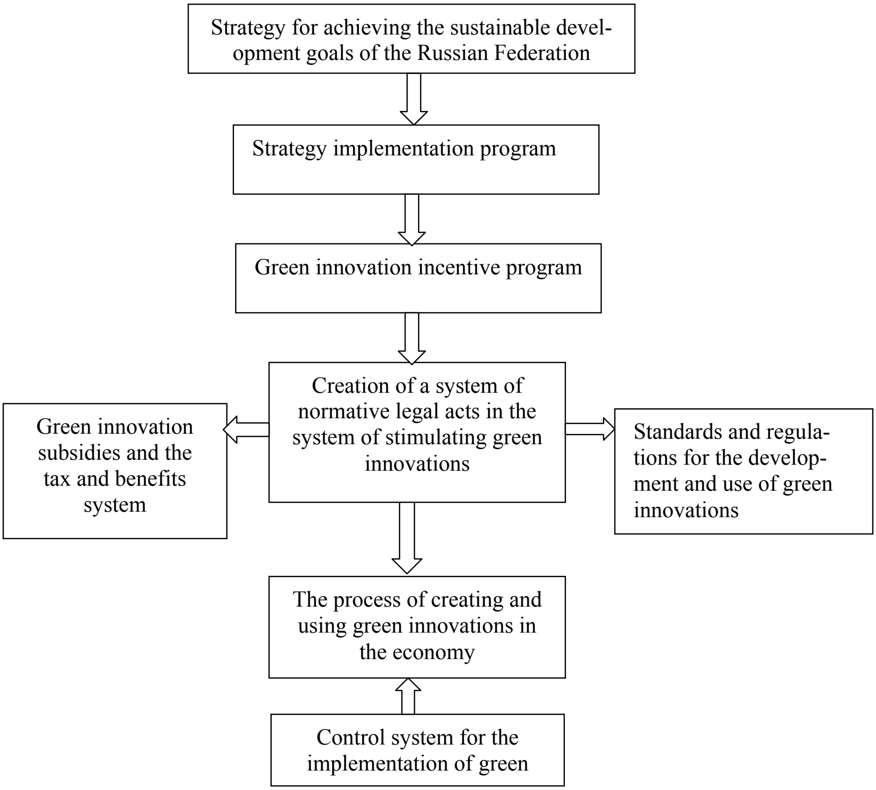


**Fig. 1** Proposed mechanism for stimulating green innovations in the Russian Federation

involvement of economic entities in the process of creating and using green innovations and ultimately minimizing the use of non-ecological methods of production and consumption.

## 4 Discussion

Many works of foreign and domestic scientists are devoted to scientific research in the field of sustainable development, the creation of a green economy and the introduction of green innovations. All studies are based on the formation of approaches to achieving the sustainable development goals. Among foreign studies, the most prominent are studies of building an effective system and mechanism for stimulating green innovations and evaluating the achievement of sustainable development goals. Thus, in the work of Ospina-Forero, Castañeda, Guerrero, it is indicated that the achievement of the sustainable development goals is possible only when using a network approach, which consists in evaluating the system of indicators in their relationship and contribution to the goals achievement [5]. Yang et al. suggest the creation of an alliance of government, universities and industry [6]. They note that given the high risk of research and development and the negative external effects of existing green technology alliances, the Chinese government is focusing on the green innovation ecosystem. As part of this, it is suggested to introduce the stricter environmental standards to compensate the shortcomings of market inefficiency. Meng, Wang, Zhang, and He, consider green innovations as the main factor determining the development of the supply chain using the mechanism of state subsidies [7].

The use of the most popular approaches to the introduction of green innovations is suggested by Calza et al. [8]. They note that big data is a growing trend in strategic management. The study presents how companies can benefit from big data to improve environmental involvement by providing a conceptual model through a comprehensive and panoramic literature that links big data sources to the adoption of various green strategies. The main conclusion of the study is that companies that want to implement a strategy of pure innovations often turn to an external partner for developing the needed architecture necessary to use the capabilities of big data.

The mechanism for stimulating green innovations is proposed by Hu et al. [9]. They study the impact of green credit policy (GCP) on green innovations at highly polluting enterprises (HPE). The study of Yi et al. [10] is devoted to the stimulation of green innovations. Their results show that a joint tax subsidy policy can lead to higher social security and higher levels of investments in green innovations than a single tax policy or subsidies policy. Moreover, practical training in green innovations can replace some of the investments in innovation, while improving the quality of the environment and social well-being, especially through joint tax subsidy policy. Among the domestic studies in the field of sustainable development, I would like to mention the approach of Bobylev et al. [11]. It notes that Russia needs to increase the well-being of the population, including the economic, social and environmental components of the life quality. And this is a different logic of development and measurement of socio-economic progress. In this regard, it is not necessary to keep up with traditional quantitative indicators, whether they are cost indicators (GDP, etc.) or physical production volumes (energy resources, etc.). The new economy should focus on qualitative rather than quantitative development.

## 5 Conclusion

Sustainable development is currently the most promising direction of Russia's socio-economic development. The formation of this concept will solve the internal contradictions between the economic, social and environmental aspects, and will also increase the country's competitiveness at the global level. Today, the development of the domestic economy takes place in most cases in an extensive way. The constant solution of problems with the emergence of crisis situations does not allow to fully pay attention to the environmental aspects of the country's development. Most development programs are aimed at stimulating economic growth in all possible ways, in order to achieve a higher level of population' income. At the same time, Russian society does not single out environmental problems as primary. It is also worth noting the low ecological culture of the population. All this in general indicates the lack of a systematic approach to the formation of sustainable development in the Russian Federation.

The most important factor influencing the formation of sustainable development is the development of green innovations. They allow to form a modern tool of influence, covering all aspects of greening. There is currently no clearly defined concept of green innovations. Most researchers believe that these are innovations related to the greening of energy and transport, the ecological development of agriculture, the restoration and conservation of forests, water resources, the greening of human habitat, as well as the effective management of ecosystems preservation.

According to the analysis conducted in the study, although there are positive trends in the creation and application of green innovations in Russia, they are very insignificant and do not correspond to world indicators. As part of the study, a mechanism was proposed to stimulate the creation and application of green innovations in Russia. It includes the development of an effective strategy for the sustainable country development, formation of programs for the realization of this strategy, the formation of a system of normative legal acts, as well as a system of state and public control over the introduction of green innovations.

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# Innovation as Basis for Sustainable Economic Development of Industrial Enterprises

**I. A. Toymentseva, V. D. Chichkina, and O. N. Denisova**

**Abstract** The article deals with the issues of an industrial enterprise strategic management, the goals and tasks the enterprise management facing. The article defines the essence and concept of the enterprise strategic management, the development stages of the enterprise sustainable innovative development, presents the enterprise organizational and economic development mechanism. The authors present a method for choosing an enterprise development rational strategy, based on the theory of odd sets and economic and mathematical modeling methods, and show the practical implementation of this method. The authors pay special attention to the priorities of industrial enterprises in the context of the strategic innovative development. Scientific works of foreign and domestic researchers on the innovation implementation in industrial enterprises activities are analyzed. The enterprise organizational and economic development mechanism formulated by the authors is of scientific interest. The management entity (decision-maker) influences the object (industrial enterprise), using certain functions, principles, methods and tools ensuring the continuous long-term sustainable enterprise development on the basis of this mechanism. The authors note in order to develop enterprise successfully it is necessary to develop and implement rational management decisions in three directions: innovative related to the introduction of modern technologies, production allowing to produce competitive products and financial ensuring the enterprise profit.

**Keywords** Concept · Efficiency · Innovative development · Modeling · Strategy · Strategic management

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## 1 Introduction

Nowadays, the main purpose of the strategic development in Russian industries is to overcome the economic crisis through the innovative technologies implementation in production processes and the competitive product production. So, it is necessary to organize new production enterprises, modernize equipment at operating enterprises, introduce technological innovations in the production process and produce competitive products that are in demand by the market. The solutions are the following:

– develop industrial enterprises' infrastructure;
– implement modern innovative technologies, including digital ones;
– improve the skills of the company's personnel;
– develop models and mechanisms for strategic management of enterprise development;
– implement economically sound projects for investing money in the company's fixed assets;
– to develop priority directions of strategic innovative development of the enterprise.

In order to develop the company successfully, it is necessary to implement rational management decisions in three directions: innovative, related to the modern technology introduction, production allowing to produce competitive products, and financial ensuring the company profit. The enterprise innovative potential management involves the formulation, the innovative development strategy and control over its implementation. The development of innovative strategies should be based on the enterprise external environment analysis, the enterprise innovative potential determination, the use of modeling methods in making strategic decisions. Despite the solution of many problems in the strategic management field, methods, models and mechanisms of an industrial enterprise strategic development taking into account the innovative component are not clearly defined, which confirms the relevance of the study.

## 2 Methodology

The purpose of the research is the theoretical justification and scientific and methodological provision elaboration for the innovative strategy formation for the industrial enterprise development based on economic and mathematical modeling methods. The industrial enterprise strategic development consists in finding management solutions capable quickly adapt to the emerging external changes in order to increase its sustainability and further development in the long term. The concept of industrial enterprise strategic development is a system of views on the developing and implementing strategic plan process taking into account the interaction and consistency of all enterprise structural divisions in making management decisions on its further innovative development. Foreign economists are very intensely discussing the topic of the fourth industrial revolution and the high-tech strategy formation and implementation. The concept of Industry 4.0 is based on the idea of connecting machines and people through the Internet of Things (IoT). This creates a single horizontal and vertical relationship between all participants in the supply chain from the supplier to the end user throughout the entire product lifecycle. For example, value creation in the entire supply chain can be made more efficient, flexible, and focused on the service quality improvement, which can strengthen the chain sustainability result in the main areas: economic, environmental, and social [1–3]. However, there are certain difficulties in implementing this concept in all supply chains [4]. The key aspects of the industrial enterprises strategic development are: the enterprise development methodology and principles, strategic development methods and models, the enterprise organizational and economic mechanism for managing the activities, the optimal strategy formation and implementation with the feasibility and economic efficiency determination of its implementation. The strategic development methods used by the authors in the study include: computational and analytical (method of calculating economic indicators); heuristic (methods of expert assessment); economic and mathematical (the theory of fuzzy sets); empirical (measurements, comparisons, analysis, modeling). The industrial enterprise strategic development process consists of three main stages (Fig. 1).

At the first stage, studies of the enterprise external and internal environment are carried out, its market competitiveness assessment is given. The second stage focuses on building the general strategy development in enterprises and determining some strategic alternatives. At the third stage, the optimal strategy was implemented and its economic efficiency was assessed. Due to the results obtained, it is possible to adjust defined goals and objectives to build a new development strategy taking into account the occurred changes. On the industrial enterprise strategic development process basis developed by the authors, the systematic approach application is justified ensuring the interconnection and coordination of all elements of enterprise management to provide the continuity and integrity of the functioning of the logistics system for the long term. The stages of the strategic development process are correlated with the development prerequisites, the strategy implementation conditions, and the change possibility under the influence of changeable conditions.

In general, the system functioning is focused on the industrial enterprise strategic development in the implementation of innovative activities. To achieve the planned results of the system implementation it is necessary to create a strategic innovative development model of an industrial enterprise which takes into account the input environmental factor influence, the strategy formation and implementation based on the innovations that contribute to improving the enterprise economic results (capital productivity, productivity, profit, profitability) at the output.

Management decisions made by business leaders in the rational development strategy are mainly based on the assessment of financial indicators. The enterprise efficiency evaluation as a whole is always associated with the indicators system defining characterizing the initial position and the desired result achievement. The

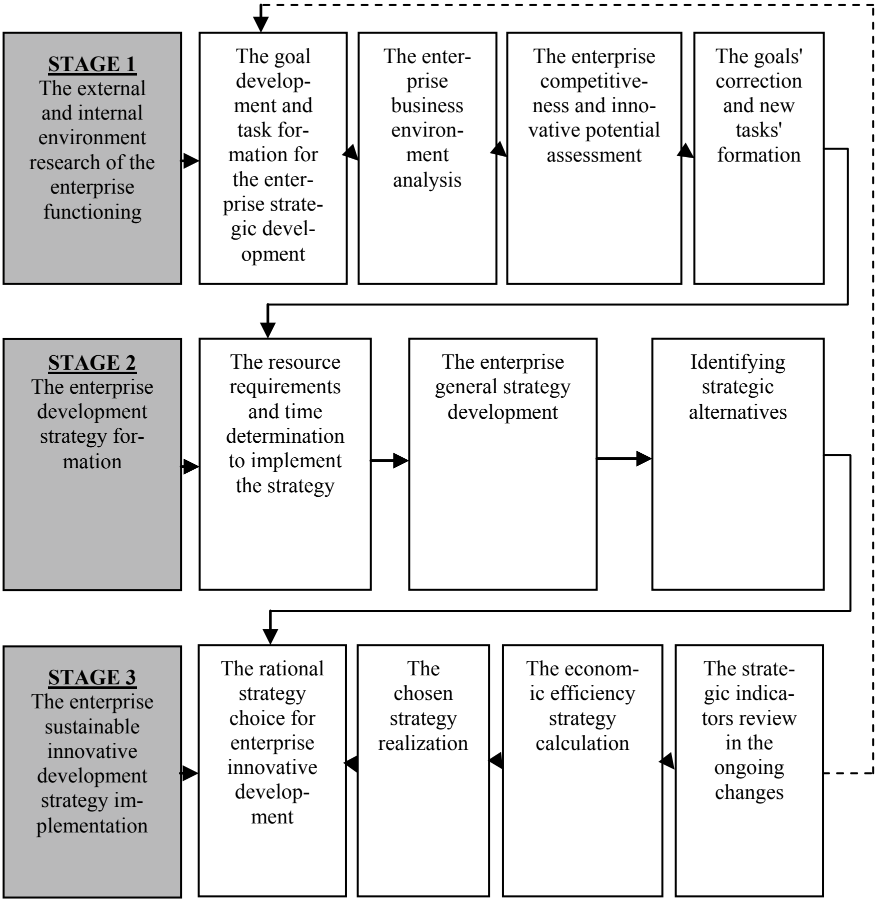


**Fig. 1** The process of strategic development of an industrial enterprise

enterprise activity results in the indicator values form are assessed using the formed criteria. On the basis of these criteria the enterprise management activity corrections are made.

The second approach is based on the strategic effectiveness criteria set identification that best corresponds to the enterprise objectives and multi-dimensional comparative evaluation of the alternative strategy options effectiveness. One of the main options for evaluation is the various criteria quantitative comparability, so their values should be expressed in relative units. The economic and mathematical modeling methods based on the theory of fuzzy sets are used for this purpose.

You should choose the strategic alternative having the minimal risk, and the maximum calculating results of the remaining criteria. The method of complex multidimensional comparative evaluation, calculated with the reference values and weight coefficients of each parameter, was used for solving this problem. This method allows

**Table 1** The initial data matrix for a rational strategy choice

| Strategy number | Indicators | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| C1 | X 11 | X 12 | X 13 | X 14 | X 15 | X 16 |
| C2 | X 21 | X 22 | X 23 | X 24 | X 25 | X 26 |
| C3 | X 31 | X 32 | X 33 | X 34 | X 35 | X 36 |
| ……. | | | | | | |
| C n | X n1 | X n2 | X n3 | X n4 | X n5 | X n6 |

to take into account not only the indicators absolute values of each alternative strategy, but also its proximity or distance degree to the reference strategy indicators. In this regard, it is necessary to express the coordinates of the compared strategies in corresponding coordinates' fractions of the reference strategy taken as a unit. The task is to minimize the final result to an ideal strategy (Table 1).

We propose the choice algorithm from alternative options of the enterprise development optimal strategy using the theory of fuzzy sets. At the first stage, the following parameters are determined:

1. A set of parameters $X_j(j = \overline{1, 6}),$ most relevant to the enterprise goals.
2. The reference value for each parameter—the maximum or minimum, depending on the indicator impact on the overall assessment:
   - if the largest value $X_{\max j}$ is selected as the reference value, then all the values of this row are divided by it, and the grid would be filled $x_{ij} = X_{ij}/X_{\max j}$.
   - if the smallest value $X_{\min j}$ is selected as the reference value, then the reference value is divided by the other values of this row and the grid would be filled $x_{ij} = X_{\min j}/X_{ij}$.
3. The each parameter rank.

The specific weight $w_j$ is calculated for each parameter $x_j(j = \overline{1, 6})$, taking into account $\sum_{j=1}^{6} w_j = 1$, $w_j \in [0; 1]$, according to the formula: $w_j = \frac{2(N-R+1)}{N(N+1)}$, $R = 1, 2, ..., 6$ where N—the number of indicators taken into account; R –(rang), j = 1, 2, …, 6.

At the second stage, alternative strategies ($C_1, C_2, \ldots. C_n$) for the enterprise performance are determined. Next, the quantitative and qualitative indicators values for each strategy variant are calculated, taking into account the each parameter rank and reference value. The theory of fuzzy sets allows to reduce the qualitative assessment of indicators to quantitative ones, while both are in the range of 0–1.

At the third stage, a complex assessment is calculated for each strategy (C) using the formula:

$$K_{1\text{int}} = X_{11} \cdot w_1 + X_{12} \cdot w_2 + X_{13} \cdot w_3 + \cdots + X_{16} \cdot w_6 = \sum_{j=1}^{6} X_{1j} \cdot w_j$$

,

$$K_{2\text{int}} = X_{21} \cdot w_1 + X_{22} \cdot w_2 + X_{23} \cdot w_3 + \cdots + X_{26} \cdot w_6 = \sum_{j=1}^{6} X_{2j} \cdot w_j$$

,

$$K_{n\text{int}} = X_{n1} \cdot w_1 + X_{n2} \cdot w_2 + X_{n3} \cdot w_3 + \cdots + X_{n6} \cdot w_6 = \sum_{j=1}^{6} X_{nj} \cdot w_j$$

Further, the maximum value option from the each strategy obtained complex assessments is found, so, this strategy will be a rational strategy for the industrial enterprise sustainable innovative development.

## 3 Results

The authors present the concept of the innovative strategic development in industrial enterprises. The strategy method to evaluate the enterprise innovative development through the theory of fuzzy sets is proposed. The authors have developed an organizational and economic mechanism for the industrial enterprise sustainable development management, which is shown in Fig. 2.

The organizational and economic mechanism for the enterprise strategic development management is a set of methods and tools affecting the ongoing economic processes and helping to adapt the enterprise to the current changes. The management entity (decision-maker) influences the object (industrial enterprise), using certain functions, principles, methods and tools capable to ensure the long term enterprise continuous sustainable development (Table 2) based on this mechanism implementation.

Based on the presented methodology, the industrial enterprise innovative economic development rational strategy was selected (Table 3).

Based on the calculations, we can conclude the third strategy $C_3$ is the rational strategy for enterprise sustainable innovative development of the three strategies presented due to its great importance. Strategy $C_3$ is the most promising of the alternative strategies considered, and therefore it can be defined as the innovative leader strategy. To increase the industrial enterprise sustainable development, it is necessary to develop priority areas and programs for their strategic innovative development. Effective forms of organizing industrial and innovative activities are at the same time techno parks, information technology centers, investment sites, business incubators creation and development with the large and medium—sized businesses support can strengthen the industrial enterprise innovative activity. The industrial sector territorial development can become effective on the scientific and educational integration basis and innovative and technological activities. This direction includes the research and

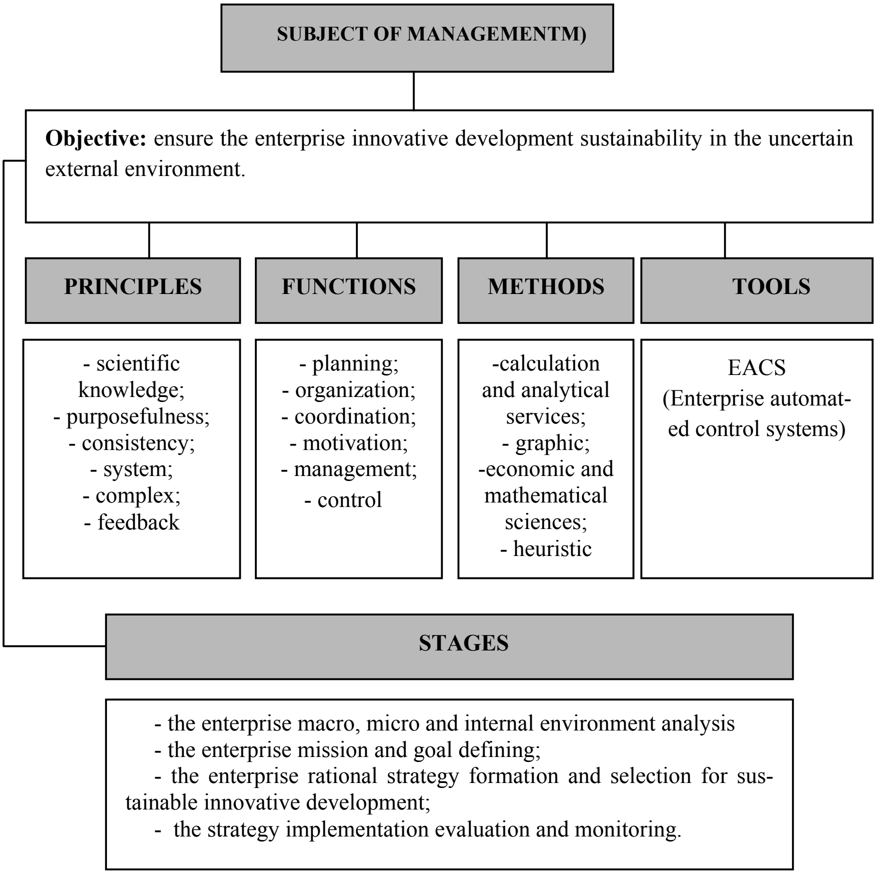


**Fig. 2** The process of strategic development of an industrial enterprise

**Table 2** The initial data matrix for the optimal strategy determination

| Strategy number | Investment volume, (thou.rub) | Payback period, (years) | Net present value, (tho.rub) | Profitability indicator (profitability index), (%) | Risk level | Innovative product volume, (thou.rub) |
|---|---|---|---|---|---|---|
| Reference | $X_{\min j}$ | $X_{\min j}$ | $X_{\max j}$ | $X_{\max j}$ | $X_{\min j}$ | $X_{\max j}$ |
| Rang | 2 | 6 | 4 | 5 | 3 | 1 |
| C1 | X 12 | X 13 | X 14 | X 15 | X 16 | X 11 |
| C2 | X 22 | X 23 | X 24 | X 25 | X 26 | X 21 |
| C3 | X 32 | X 33 | X 34 | X 35 | X 36 | X 31 |
| … | | | | | | |
| C n | X n1 | X n2 | X n3 | X n4 | X n5 | X n6 |

**Table 3** The rational innovation strategy selection from the alternatives

| Strategy number | Investment volume, (thou.rub) | Payback period, (years) | Net present value, (tho.rub) | Profitability indicator (profitability index), (%) | Risk level | Innovative product volume, (thou.rub) | The chosen strategy comprehensive assessment | Optimal innovation strategy choice |
|---|---|---|---|---|---|---|---|---|
| Reference | Min | Min | Max | Max | Min | Max | | |
| Specific gravity | 0.236 | 0.032 | 0.143 | 0.053 | 0.087 | 0.389 | | |
| C1 | 0.33 | 0.63 | 1.00 | 0.95 | 0.80 | 0.81 | 0.677 | 0.845 |
| C2 | 0.67 | 0.92 | 0.49 | 0.95 | 0.86 | 1.00 | 0.771 | |
| C3 | 1.00 | 1.00 | 0.41 | 1.00 | 1.00 | 0.97 | 0.845 | |

innovation-technological organizations, secondary and higher professional institutions development, the inter-district innovation and production complexes, innovative entrepreneurship support funds formation.

## 4 Discussion

Currently, the economy still does not have a clear definition of "innovation potential" and therefore there are no indicators to quantify it. The practical aspect of the innovation potential is revealed in Drucker's works [5], he examines the industry development as a whole and focuses on certain aspects of the enterprise innovative potential. A team of authors led by Barancheev considers innovation as a way of task implementation to achieve the enterprise innovative goals [6]. Kortov considers the enterprise innovative potential as the enterprise resource total to meet the innovation emerging needs [7]. Titova, Demidov, and Smirnova believe the innovative potential is the enterprise ability to ensure the fixed assets renewal improving the production process efficiency [8]. Foreign economists are currently discussing the concept of Industry 4.0, which was originally developed and aimed at the competitiveness strengthening of the German manufacturing industry by increasing labor productivity, flexibility and sustainability of the entire supply chain [4]. This concept provides new production facilities creation in the home country. Similar concepts have been implemented around the world, for example, US enterprises created the "Industrial Internet Consortium" project, China presented "Internet Plus" or "Made in China 2025", and South Korea launched the "Manufacturing Innovation 3.0" program [9]. The innovative potential is given special attention in the works of Müller et al. [10], Ancarani and Di Mauro [11], Dachs et al. [12] since the high-tech strategy is based on modern innovations considering the Internet of Things.

## 5 Conclusion

Currently, companies choosing the development innovative way need to implement digital platforms in their activities reducing internal production costs, improving the goods and services quality provided to consumers, strengthening competitive advantages in the market and increasing profits. So, we can consider several options for using such digital platforms.

1. Innovative platform. It is created simultaneously with the main existing company business and is intended mainly for the company growth due to new offers in the digital field, new technologies implementation and increasing market share by entering adjacent markets.

2. Digital platform. This system is aimed at the company operational efficiency improvement through innovation and the benefits of the existing ecosystem based on the digital services.
3. Combined model. It speeds up the rapid introduction of innovations in new services and allows developing several areas of activity simultaneously, increasing the entire company efficiency.

Thus, we can conclude the innovations introduction contributes to the enterprise sustainable development, strengthening market positions, competitive advantages and achieving high economic performance.

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# The Impact of Business State on the Financial Country Stability

**O. V. Borisova, M. P. Lazarev, and S. Y. Balychev**

**Abstract** The article is devoted to identifying the degree of financial results influence of Russian companies on the financial stability of the whole country. The theoretical aspects of financial stability at the macro level and the theories of financial sustainability of companies are studied. As a result, an underestimation of the role of the non-financial sector companies influence on the financial stability of the country was revealed. The authors suggest an alternative approach to assessing the country's financial stability. It allows to take into account that a crisis can arise in any industry and quickly identify it through industry models for predicting financial stability. The approach was tested on the example of mining companies. The obtained results show that there is a mutual relationship between financial indicators at the macro level and financial indicators of companies, so the authors say that the financial stability of a country depends on the financial stability of economic sectors. Therefore, the use of indicators characterizing the financial market in the traditional approach is unfortunately not exhaustive. The development of industry models will allow to quickly identify threats that destabilize the state of the country.

**Keywords** Growth · Financial stability · Financial sustainability · Profitability

## 1 Introduction

The study of financial stability issues has remained relevant for several decades. Many studies were conducted, but there is no single concept showing the essence. The first approach is represented by the fundamental works of central banks that monitor financial stability based on their own methodologies. They define a significant number of indicators. So the number of studied indicators on financial stability in Russia is more than 15, in Italy-17, in Germany-20. They describe changes in GDP, the state of the credit market, change in the debt of legal entities and individuals, the state of the equity and debt markets, and the dynamics of interest rates on financial

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instruments. The set of indicators differs significantly by countries, which indicates different methodologies for assessing financial stability by central banks of different countries.

The second approach is based on the concept of financial stability at the micro level. It appeared as a result of a series of studies on two areas of corporate financial diagnostics and anti-crisis management. The authors studied numerous factors that lead to the financial stability of companies. Studies on financial diagnostics were aimed at studying the life cycle of companies and the transformation of their financial indicators during the stage changing at which it is located. To determine the state of companies, numerous absolute and relative indicators of financial sustainability were used, the number of which differed significantly in the author's methods. Works within the framework of anti-crisis management are associated with the identification of factors of financial instability and the study of conditions that affect this process. The degree of problems in the company was determined based on aggregated indicators presented by models for assessing the probability of bankruptcy, obtained with the use of correlation and regression analysis. It should be mentioned that in the last decade, there have been studies combining the issues of financial diagnostics and anti-crisis management, and the methods of these areas are beginning to be used in a complex to obtain the most reliable results and develop further recommendations. Thus, studies in the financial stability area remain relevant. Taking into account the instable development that is caused by the coronavirus, the losses incurred by business during the pandemic, as well as the variety of existing approaches, the authors conducted a study on this issue to determine the impact degree of various business sectors on the key macroeconomic indicators that characterize the financial stability of the country.

## 2 Literature Review

The methodology of financial stability is actively developing. Initially, this term was used at the macro level. International organizations and central banks of various countries regularly monitor financial stability. International organizations include the Financial Stability Board, the International Monetary Fund, the Bank for International Settlements, the World Bank, and the European Central Bank. Semi-annual and annual surveys are made in most countries of the world, for example, in Great Britain (since 1996), Sweden (since 1997), Hungary and Norway (since 2000), Austria and Spain (since 2001), Belgium, Denmark and France (since 2002), Canada and Finland (since 2003), Australia (since 2004), etc. The European Central Bank monitors the financial stability of the Eurozone. On its website, the methodology for macroprudential indicators of the state of the European Union countries is presented, on the basis of which the index of financial stress of each of the participating countries was determined since the 70s.

Studying stability issues at the global level, Avlasenko, Avlasenko, Peshkhoev, Podkolzin, Savelyeva conduct a study of the financial stability of the banking system and determine the list of threats based on regional aspects [1]. The study is conducted using a cluster analysis based on World Bank data for 126 countries from 1998 to 2017. As a result, the researchers suggest quantitative indicators of the financial sustainability of the global banking system, criteria for a qualitative assessment. On the basis of these data, all countries could be divided into clusters according to the stability level.

In the context of instability, the development of an early warning system for systemic risks, developed in the study of Gospodarchuk and Amosova [2], is of particular interest. In this regard, the authors proposed the Attention-LSTM neural network model. Using text mining, they developed a network public opinion index that is incorporated into an early warning model to monitor the situation.

Studying the prevention of banking crises, Izumi analyzes the impact of state guarantees and state financial regulation on the financial stability of countries. The author shows the relationship between the government's tax revenues and bank investments. Policy effectiveness depends on debt acceptable level [3]. The banking crisis with a sovereign default is the result of ineffective policy. Improving financial stability can be achieved by reducing the fiscal costs on guarantees, which is associated with the regulation of banks in order to retain excess liquidity and reduce banking operations. The paper shows the negative impact of guarantees and liquidity regulation on the debt sustainability due to the increase in the expenses and the reduction in tax revenues. At the same time, the studies show that the financial stabilization results in different countries can be achieved through a combination of different measures. Regulation is more effective in countries with minimal liquidation costs, high funding costs, and low project returns than a combination of policy measures. Maintaining financial stability through a combination of guaranty and regulatory policies produces result in countries with high liquidation costs, minimal financing costs, and a high rate of return on capital.

Gupta, Kashiramka studied a sample of banks in India in the amount of 1046 cases from 2007 to 2019, and concluded that private sector banks are more stable than state-owned ones [4]. A year later, Ouyang, Yang, & Lai after analyzing 76 banks of the Persian Gulf countries, it was proved that state-owned banks are more stable than private ones, but only in the case of their small banks [5]. The financial stability of state-owned banks declines as their size increases. At the same time, Islamic banks are more likely to default than traditional banks. Conducting a study on the stability and sustainability of Al-Kharusi, Murthy state that the instability of the major players in the banking sector leads to a reduction in lending [6]. There is a credit squeeze, which leads the economy to a recession or to slow growth.

Feghali, Mora, Nassif show a U-shaped relationship between a country's financial development and company investments, and a higher degree of the financial development is linked with a stronger negative impact of financial income on investments [7]. A study of Boulanouar, Alqahtani, Hamdi shows that financial development and pollution develop independently [8]. The study covered 27 industrialized countries for the period 1991–2014. As a result, the reduction of environmental pollution above a certain threshold level was revealed due to innovations. At the same time, it was shown that high innovations negatively affect the environment, and improved financial development increases pollution. Analyzing the financial development, Safi, Chen, Wahab, Ali, Yi, Imran reveal the absence of a long-term link between carbon emissions and the financial development of countries [9]. The paper shows that an increase in economic growth of 1% leads to an increase in carbon emissions by 0.243% in the long term. The findings of the study are supported by the results of a panel analysis of data in the E7 countries (Brazil, China, Indonesia, India, Mexico, Russia and Turkey) for the period 1990–2014. In 2016, Adrian, Liang considered a relation between the emerging financial conditions in the framework of the monetary policy of a state and financial stability in various sectors of the economy [10]. They separately analyzed the nature of financial instability in the banking sector, shadow banking and the on the asset market. As a result, the authors state that financial sustainability of the country changes if there is a decrease in requirements in the underwriting standards, an overabundance of debt financing, a sharp change in effective demand, an increase in the number of sales of property to cover obligations.

Micro-level studies also develop models. In particular, Borisova, Kalugina, Kosarenko, Grinenko, Ishmuradova using the statistical set of 16,620 cases for 2013–2014 for Russian electric power companies, suggest an approach for developing industry indicators of business financial stability [11]. Ibrahim, Vo showed that an increase in the availability of payments and saving accounts does not affect the financial stability of the organization, and the availability of loans weakens it if the solvency of the borrower is not taken into account. As a result of the study, the authors conclude that the use of credit negatively affects financial stability [12]. Thus, it is shown that financial stability is more often determined at the macro level and is associated in most cases with the banking sector, since it has a significant negative impact on the state of the economy. Non significant number of studies consider financial stability at the micro level, linking it to the sustainability of the considered companies. This study suggests that in order to achieve the country's financial stability, it is advisable to manage a number of factors of the financial sustainability that differ based on the size of the business, its industry orientation and a number of other characteristics.

## 3 Results and Discussion

Financial stability at the macro level is determined by a set of indicators. The key indicator is the size of GDP, since it affects the decision of economic entities to invest free funds in the development of business and the economy as a whole. When forecasting growth and favorable market conditions, this indicator increases, and when investors refuse to invest in the economy, it decreases. Negative forecasts for GDP may badly affect the volumes of the banking sector, due to a reduction in investment by investors, an increase in the key rate, lead to an increase in the debt of companies and households due to a correction of consumer behavior on the market and a fall in the quotations of equity and debt markets. The change in the size of the companies debt will affect their financial sustainability, which should change. There are two possible situations. In the first case, the indicators of financial sustainability will change abruptly from period to period. In the second case, there will be a steady downward trend.

Reducing the volumes of investment in the economy will lead to a lack of financial resources for business development, which will have to postpone the implementation of the planned projects. Thus, the profit indicators of such a company in the current period may be stable or have a tendency to decrease. The reduction in investment will affect the volume of assets of companies, since they will not have money to update their funds. Changes in the volumes of the investment and debt markets lead to an imbalance in the banking sector, which can serve as an indicator of financial instability. This imbalance quickly begins to affect the state of economic sectors, making the situation worse.

Earlier it was shown that financial stability monitoring is carried out on the basis of data from the financial market. The indicators of the real economy sector in these monitoring reports do not determine, what, according to the authors, does not always correctly identify the problem and the sector in which it began.

The economy digitalization and the digitization of a significant number of processes at the state level allows to form a comprehensive monitoring system to observe and analyze the financial stability of the economy, which will allow to quickly track emerging problems with financial sustainability in all sectors of the economy. To solve this task, it is suggested to develop financial stability models for companies in different economic sectors at the state level. They can be based on the approach suggested by Altman [13]. It is advisable to determine the degree of financial stability of companies in the industries based on models for diagnosing the bankruptcy of companies. The development of a model for each sector of the economy should begin with testing, which allows to identify the predictive power of existing models. If you get low results, you need to develop a new model. The technology is presented in the work of Borisova et al. [11] on the example of electric power companies. When identifying a model that has a normal predictive ability, it is advisable to use it to develop a scale of financial sustainability of industry companies. For this purpose, the coefficients of the model should be converted to binary form. Further, as a result of the calculation of the logistic regression, a scale is determined by which companies will be divided into groups based on the degree of their stability.

Due to changes in the macroeconomic processes, these models will need to be retrained annually so that they give correct results and consider the latest specifics. The information base for this process is available. The data of the SPARK analytical system can be used for this purpose. Their constant quarterly update, if models are available, will allow to quickly monitor the financial stability of industries and determine the levers of influence on it. The hypothesis put forward by the authors was tested on the example of mining companies. The total number of companies in the statistical population under study is 31, which are registered in SPARK by their main type of activity. 26 companies are privately owned, 1 is mixed, 2 are owned by foreign legal entities, and 2 are jointly owned. The study was conducted for 2012–2019. The total number of observations is 248. The sample includes companies from 16 regions of the Russian Federation. SPARK estimates that 23 companies have a low level of risk, 2 companies have high level of risk, 6 companies have medium level of risk; according to the legal form, LLC—25 units, non-public joint-stock companies—6 units. The analyzed companies differ in their activities. 2 companies are engaged in the open-pit mining of anthracite, 6 in the open-pit mining of brown coal (lignite), 14 in the ores and sands of precious metals, 1 in the ores of other non-ferrous metals, 5 in the coal open—pit mining, 1 in the underground mining, 1 in the coal processing, 1 in the mining and processing of brown coal (lignite). The initial sample was adjusted based on the completeness of the information provided by the companies, as a result, 202 observations were used in the calculations. The rationale for the expediency of the approach presented by the authors consists in comparing 73 financial indicators for mining companies and 25 macroeconomic indicators. The study also compared the growth rates of companies' financial indicators and macroeconomic indicators.

The correlation analysis of the indicators shows that there is a direct correlation relationships between the indicators of an individual mining company and macroeconomic indicators. Thus, GDP has a correlation with inventories (0.63), accounts receivable (0.53), current assets (0.6), assets (0.53), authorized capital (0.6), long-term borrowed funds (0.56), long-term liabilities (0.57), accounts payable (0.57), revenue (0.52), cost value (0.51). This fact does not contradict previous studies, since the sample under study contains medium-sized companies whose performance results make a significant contribution to the size of GDP. When conducting a correlation analysis between the average industry indicators and macroeconomic indicators, the presence of a direct relationship was confirmed. It ranged from 0.62 to 0.92. Thus, financial stability of the industry indicators, GDP will grow. There is also a correlation between GDP and the average relative indicators of the share of short-term debt in the total volume (0.7), and the quick liquidity ratio (0.6). The obtained results indicate the existence of a mutual influence of the industry financial state and the financial stability of the country, since the size of GDP is indirectly taken into account by the top management of companies when making management decisions and when changing the size of short-term debts in a particular company, which affects the degree of liquidity of its short-term assets. There is also a strong inverse relationship between GDP and the amount of reserve capital of industry companies, which indicates a reduction in reserves in a situation of financial stability and their increase under the influence of negative factors. Similar dynamics with a slight correction for the strength of the correlation can be traced between the average industry indicators and the following indicators: with investments in fixed assets, the volume of loans issued to legal entities, the volume of funds of organizations in bank accounts, the volume of state internal debt, customer funds in banks, deposits of legal entities.

It is revealed that high indicators of profitability of costs, assets and capital, an increase in the turnover ratio for the industry lead to an increase in GDP, and therefore should be monitored as key factors ensuring stability. The growth of loans in the industry negatively affects the gross margin, reducing it, which causes the need for control to minimize unbalancing actions and determine the volume of crediting that stimulate the development of the industry and the country's economy as a whole. At the same time, the average index of internal growth of companies is small, which

**Table 1** The predictive power of the insolvency models of Springate, Lis, Legault for mining companies, %

| Share of companies | Model name | | |
|---|---|---|---|
| | G. Springate | R. Lis | J. Legault |
| | Z > 0.862 | Z > 0.037 | Z > 0.3 |
| Experiencing financial problems | 47 | 57 | 83 |
| Not experiencing financial problems | 53 | 43 | 16 |

makes it necessary to attract funds to the industry. Only in 4% of the considered cases, it exceeds 10%. In 30% of the considered cases, it is absent due to the presence of losses in companies, most of which will use loans to restore their activities. Further, to assess the financial stability of mining companies, the authors tested the insolvency models of Lis [13], Springate [14], Legault [15] (Table 1). The bankrupt companies did not participate in the study.

To establish the fact of financial stability for companies in the industry, two models of Springate [14] and Lis [13] were selected. Both models allow us to obtain correct results, provided that the boundary value of the Z indicator changes. The companies under study have a long life cycle. More than 60% of the considered companies have been on the market for more than 10 years. 71% of these companies have a certain internal growth. It should be noted that due to the specifics of their activities, the demand for their goods is cyclical and largely depends on stability. The selected insolvency models show problems for the sample in the case of sales losses, losses recorded on the balance sheet and when current assets exceed current liabilities. We suggest to assess the financial stability in the industry using the model of Springate based on binary indicators (Table 2).

The obtained results show the presence of right-sided asymmetry in the statistical population under consideration. As the result of the binary model of Springate decreases, companies will feel more financially sustainable.

**Table 2** Assessment of the financial stability of mining companies based on the model of Springate using binary indicators

| The result obtained from the binary model of Springate | Number of cases | Percentage of cases in the complex under consideration |
|---|---|---|
| 0.500 | 16 | 0.079208 |
| 0.269 | 78 | 0.386139 |
| 0.119 | 55 | 0.272277 |
| 0.047 | 31 | 0.153465 |
| 0.018 | 22 | 0.108911 |

## 4 Conclusion

The study conducted by the authors revealed the following results:

Financial stability as a concept is studied by many scientists. Recent studies showed a significant number of factors that affect this condition. All studies can be clearly divided into two main approaches, which study macroeconomic indicators or indicators at the company level in relation to recent financial changes.

The set of indicators of financial stability identified in the work varies depending on the approaches used by the authors. The studies show the evolution of their development, therefore, further study of these issues is necessary in order to correctly assess financial stability at the macro level and be able to maintain this state for a long time. The use of the mining industry for testing companies, which is system-forming and capital-intensive, fundamentally different from the financial sector, allows to judge the validity of the results obtained, reflecting the existing patterns of economic development.

The authors' study on the example of mining companies shown the presence of a strong degree of influence of key industry-average financial indicators on the macroeconomic indicators that characterize the country's stability. Based on the random nature of the tested sample of companies, we note that there is a similar influence in all sectors of the national economy. Consequently, monitoring the financial stability of the banking sector and the financial market should be replaced by monitoring the financial stability of all sectors of the national economy. This will allow to quickly identify emerging problems and make decisions on their prompt elimination. The algorithm suggested by the authors for assessing the financial stability of the industry showed its viability. When evaluating existing companies, it was revealed that 93% of them are financially stable, while only 7% experience significant difficulties due to losses and complications in operating activities.

Making decisions on the introduction of the system proposed by the authors will entail the need for a radical restructuring of the existing mechanism for financial monitoring of financial stability. The work of the proposed system will be possible in the case of the organization of relevant ministries and departments joint activities, on which it is advisable to assign responsibilities for the development of industry models for assessing financial stability.

Existing digital technologies and collected data will serve as the basis for the proposed approach. Financial indicators of companies from the SPARK database will allow to develop similar models for all sectors of the economy. And the rapid updating of the database will contribute to the regular retraining of existing models, taking into account the latest macroeconomic changes. As a result of the innovations proposed by the authors, financial stability will be monitored in all sectors, and operational information on its changes will be available to the governments of the country. This will lead to increased efficiency in identifying industry financial problems, the duration of the existence of companies on the market, to the development of timely measures to support individual industries in connection with changing macroeconomic conditions and the development of new mechanisms for regulating emerging problems.

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# Development Opportunities for Responsible and Sustainable Logistics

**I. V. Yakhneeva and A. N. Agafonova**

**Abstract** The problem of social responsibility and sustainable development in the logistics business does not have sufficiently broad coverage in public reports of companies, in scientific research, and market surveys. Especially it applies to business in the Russian Federation, where the market of 4PL services, fulfillment e-business is at the stage of emerging, and the market of last-mile logistics services is at the stage of active growth. Without achieving business sustainability, entrepreneurs have mostly failed to reach the conscious strategic management of their business. However, today it is exactly the logistics sphere where the issues of the feasibility of innovations, rational use of resources, and environmental protection arise sharply. The policy of corporate social responsibility in logistical subsystems has a clearly defined functional approach and is implemented mainly by transnational companies, large logistics operators. The development of the logistics sphere is tightly connected with the trends of Industry 4.0 and requires the managers to realize the strategic priority of business sustainability. The purpose of the study is to identify the nature of responsible and sustainable logistics in today's economy, search for opportunities for its growth and determine the conditions for effective implementation of CSR principles in supply chain management. The study of methodological assumptions and industry experience made it possible to formulate practical recommendations for the development of CSR programs, taking into account the interests of stakeholders and sustainable development in logistics.

**Keywords** Corporate social responsibility · Green logistics · Innovations · Supply chain management · Sustainable logistics

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## 1 Introduction

Today's logistics industry is actively developing various approaches based on the concepts of social responsibility and business sustainability. The modeling of Sustainable Design, oriented design of physical objects, artificial environment, and services in accordance with the principles of sustainable development has become widespread. A comprehensive embodiment of this approach is the Sustainable Design of supply chains under the active cooperation of participants in the logistics process [1]. Besides, the logistics concept of shared responsibility, formed by the convergence of current management theories and practices, is also a priority. It is focused on maximizing the ratio between the company's benefits and logistics costs while taking into account the social and environmental aspects of activities. The social component of logistics is mainly manifested in the possibility of solving social problems caused by increasing consumption, shortage of goods, decreasing purchasing power of population, presence of hard-to-reach and distant locations of consumers, low level of labor safety. The environmental component is aimed at solving the problems of the ecology, the low level of environmental culture, irresponsible consumption, and other factors. The approach to the implementation of logistics processes, taking into account their impact on the environment and society is associated with the concept of green logistics. In examining the characteristics of social responsibility through the lens of logistics, academics note that it extends over the entire supply chain, is present in customer relations, in the process of creating appropriate working conditions and personnel development, has an impact on the environment, and exists in the life of the local community. In this regard, it is difficult to separate CSR from all activities of a company and related supply chain.

Another important component of the concept of social responsibility in logistics is the Efficient Consumer Response (ECR) strategy. The presence of serious obstacles to business cooperation and effective interaction aimed at increasing consumer value made it necessary to optimize supply chains using ECR. It was originally initiated by retailers and their suppliers. The ECR approach focuses on the achievement of mutual interests of participants of supply chains, elimination of conflicts, customer-oriented strategy, and priority of long-term partnerships over opportunistic ones. The ecological direction of the concepts of sustainable development and social responsibility is usually associated with the commonly used term "green logistics" [2]. In this regard, logistics management is based on a rational resource and energy approach, focused on reducing the negative impact on the environment and the use of new technologies to maintain the balance in ecosystems. A common practice is the study of the problems of green and sustainable logistics (G&SL) as a whole [3]. The study analyzes logistics practices in light of the implementation of the concept of social responsibility and sustainable business development.

## 2 Methodology

The research methodology includes methods of analysis and synthesis. The analytical part aims to identify purposes and components of corporate social responsibility in logistics. The empirical basis of the study is public data provided by Russian and foreign companies. These companies are DHL [4], Coyote [5], PWC [6, 7]. The theoretical framework is a synthesis of scientific research. Based on the concept of business sustainability, theoretical provisions for logistics and supply chain management are generalized. The combination of theoretical and practical research allowed to identify conditions of effective implementation of CSR principles and factors of sustainable logistics.

## 3 Results

Today, sustainable business development is considered in close correlation with the introduction of the concept of corporate social responsibility. Consumer groups and society as a whole make pressure on businesses for revision of priorities and transmitted values. Since trends observed in consumer behavior are a major factor, these are the key factors that largely determine the content of corporate policies of enterprises. Recent research findings reflect such changes. For example, according to a PWC report, 83% of consumers claim to be environmentally conscious when making purchases, with more than 77% of Russian consumers willing to pay extra for sustainable or ethically produced goods. Also, 42% of consumers are willing to pay extra for the products of companies that implement the concept of sustainable development [7].

One of the current trends in modern logistics is the conservation of resources. This is confirmed by Logistics Trend Radar by DHL company that has been collecting and analyzing changes in the logistics industry for 5 years [4]. Many companies use DHL's Radar as a benchmark in the world of logistics innovation. According to the 2020–2021 results, one of the new trends in logistics is related to packaging, specifically the desire of industry participants to automate, reduce waste, and use reusable and cyclic models for their packaging. Looped supply chains and the transition to a circular economy are viewed in scientific papers as key factors in sustainable development [8]. The optimization of the maintenance system contributes to reducing resource waste and favorable environmental impact. Cases of non-optimal use of equipment are detected, which allows increasing the service life, and, consequently, to save materials and natural resources [6]. Another trend is the tightening of legislation. Some countries have established legal requirements for manufacturers that require companies to be responsible for products after they are sold. Separate provisions regulate the responsibility of suppliers and consumers for the recycling or disposal of waste, packaging, and product excesses. Measures of responsibility for environmental damage are also stipulated. The focus on environmental sustainability and the reduction of natural resources is forcing companies to find environmentally friendly and safe logistics solutions, use resources more efficiently, and implement recycling technologies. For example, in Germany, the packaging is returned in reverse order along the supply chain. Consumers return the packaging to the store, the retailer has to provide a return to the wholesaler, the wholesaler to the manufacturer. However, the concept of "green logistics" has a downside to its application. Reducing one type of cost inevitably leads to an increase in another cost item. "Green logistics" requires establishing an infrastructure for organizing and managing return flows. Additional costs are associated with the transportation of waste, the creation, and movement of tare, and product packaging. The increase in costs can be significant (up to 50–100%), and this change reduces the amount of savings derived from the implementation of green technology or will be reflected in prices. Besides, the more goods will be reused or restored, the less demand there will be for new goods, which will lead to a loss of income for their producers, as well as suppliers of raw materials, logistics companies, etc.

The events of the last year have had a significant impact on the formation of trends in logistics. Digitalization, automation, and the urge to provide customized services have determined the importance of certain trends. Thus, the formation of sustainable logistics as a transformation of "green logistics" became possible. Since the activities of transport and logistics companies are highly polluting and have an impact on climate change, these issues are attracting more and more public attention. PwC predicts that sustainable and green logistics solutions will be in massive demand over the next five years [6]. As for fair and responsible logistics, according to some estimates, this is the trend for the next 10 years [4]. However, despite the long-term nature of the forecasts, companies should think about the essence of responsible logistics today (Table 1). Companies of all sizes, in all industries, across all regions are starting to take sustainability seriously; 81% are more focused on it today than they were just three years ago. And supply chain is at the forefront. The global supply chain has "woken up" to the fact that sustainability is not a trend, but a priority that needs to be an integral part of any sound strategy [5].

For a socially oriented organization in the field of logistics, it is important to:

1. Set clear financial and customer goals.
2. Visualize the connections between different ideas and show how those ideas can lead to concrete results.
3. Identify the necessary organizational units (people) that will support new endeavors and changes, including any necessary changes in training and business processes.
4. Communicate corporate goals and show how they will be achieved.
5. Change internal processes to achieve a high level of social responsibility.
6. Achieve a high ethical level in business relations with stakeholders.

As the concept is closely connected to the stakeholder approach of CSR, it is necessary to identify the main stakeholder groups (Table 2). The key stakeholders are selected based on the organization's mission statement and its CSR programs.

**Table 1** Objectives and essence of responsible logistics policy

| Logistics subsystem | Objectives and essence of responsible logistics policy |
|---|---|
| Transportation logistics | – Investing in personnel, providing employees with opportunities for professional development. Evaluating the contribution and involvement in achieving strategic goals according to the principle of mutual benefit<br>– Improvement of processes and services leading to a reduction in the negative impact on the environment, while maintaining financial efficiency. Implementing technologies that reduce emissions of pollutants and waste<br>– Participation in public events related to road safety |
| Warehouse logistics | – Environmental protection<br>– Volunteerism by employees<br>– Supporting charitable projects by providing storage space<br>– Helping victims of natural disasters<br>– Integrated logistics |
| Production logistics | – Water saving in the production and distribution process<br>– Energy saving<br>– Choice of more environmentally friendly vehicles<br>– Reduction of carbon dioxide emissions through the introduction of green technologies, as well as their use in packaging manufacture and waste management |
| Return logistics | – Remanufacturing<br>– Resource recovery, restorative maintenance<br>– Support of environmental standards<br>– Product life cycle extension |

To achieve the expected effect of social responsibility programs, their content should correspond to the company's strategy. In other words, the goals and objectives of CSR should be as close as possible to the company's mission and strategy. Accordingly, CSR programs may have an internal and external orientation. For example, if the main stakeholders are the company's employees, then internal CSR is implemented, and if the company is interested in potential employees to be involved, or consumers, then external CSR is implemented.

In terms of sustainability, it is important for the logistics business to:

1. Identify factors of competitiveness of logistics businesses based on the principles of social responsibility.
2. Identify the changing needs of the market regarding the nature of logistics services.
3. Elaborate proposals for the development of marketing tools following the concept of social responsibility.

The combination of the principles of logistics, social responsibility, and business sustainability allows us to identify the factors of sustainable logistics (Table 3).

The introduction of the concept of sustainable development in logistics is mutually conditioned by the transformation of other functional areas, changes in approaches to the management of marketing, personnel, material and financial resources.

**Table 2** Expected results from the implementation of social responsibility programs by stakeholder groups

| Stakeholder group | Expected result |
|---|---|
| Executives (top management) | Growth of business worth, increase of its investment attractiveness<br>Management of reputational risk, support of corporate reputation<br>Corporate culture development<br>Shaping of employees' loyalty<br>Improvement of business competitiveness |
| Personnel | Gaining social privileges and benefits<br>Professional development and career growth, improvement of qualification level<br>Favorable working atmosphere, comfortable conditions for professional activity |
| State authorities | Development of market infrastructure<br>Development of business environment<br>Provision of workplaces to the regional population<br>Tax deductions |
| Consumers | High quality of service<br>Optimization of customer projects<br>Provision of consumer risks<br>Flexible cooperation terms<br>Reduction of transaction costs |
| Cargo carriers | Openness and transparency of relations<br>Provision of logistics risks<br>Flexible cooperation terms<br>Reliable business relations |
| Universities (major in logistics and supply chain management) | Provision of internship bases for students<br>Joint research projects<br>Exchange of knowledge and experience |

## 4 Discussion

In the business world, "sustainability" is considered and evaluated in three separate categories: environmental, social, and governance sustainability. Sustainable logistics combines these three categories in the most distinctive form. The environmental component of sustainability is related to the application of so-called "green" technologies in the process of production and packaging of products, in transportation and warehousing operations. Certain subsystems of logistics fully meet the conditions of environmental friendliness, in particular, logistics of secondary resources. The social category is determined by the transformation of business priorities, which is associated with increased attention to the interests of people and society under the influence of changes in consumer behavior. Governance sustainability includes issues of ethics, principles of formation of management bodies, shareholders' rights,

**Table 3** Sustainable logistics factors

| Sustainable logistics factors | Logistical approaches and actions |
|---|---|
| Economical | Minimization of total logistics costs in the supply chain<br>Optimization of resource use in the process of manufacturing and distributing products and services<br>Return logistics, secondary resource logistics |
| Social | Exploring the potential and actual impact of logistical processes on people, society, and culture<br>Forming partnerships following ethical principles<br>Coordinating logistics processes in supply chains under CSR principles |
| Environmental | Preventing the negative environmental impact caused by operations related to the supply of material resources and finished products at all stages of the flow processes, including recycling and reuse<br>Application of environmentally friendly and safe tools ("eco-labeling", electric vehicles) |

the interaction between partners in the supply chain. The approach to sustainability in this context covers the entire production and logistics cycle.

The results of the study indicate that there are prerequisites for the implementation of the concept of CSR in logistics, which is confirmed by practical examples of its implementation. However, companies that use sustainability principles and relevant indicators usually do it voluntarily: either based on their strategic business goals or because they are obliged to provide such information. Therefore, it is premature to claim that there is an established trend in this area. Nevertheless, industry leaders tend to be followed by other representatives of the business community. It will become necessary for them to understand sustainability scores, how they are obtained, what they represent, and how they should be used by various stakeholders. These questions are the subject of the next phase of the study.

## 5 Conclusion

The active penetration of high-tech innovations in the field of logistics with a steady trend of customization of its services has determined the particular relevance of the concept of sustainable development. The study showed a wide coverage of spheres of activity in the modern policy of responsible logistics. At the forefront is transport logistics, which has the greatest impact on pollution and climate change. The principles of responsibility and sustainable development are also formed in the production, return, warehouse logistics. Their implementation implies the development of environmental management in organizations, the use of professional codes of ethics, taking into account the interests of stakeholders. Companies need to strive for a stable situation in the market through an open exchange of achievements in social and environmental innovations. The logistic principle of rationality finds qualitatively new forms of realization in the strategies of sustainable development, uniting the functional areas of logistics and supply chain participants in the pursuit of social and economic synergy.

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# Formation of Noonomics in Engineering Economics

**O. A. Bulavko, V. V. Chekmarev, and Vl. V. Chekmarev**

**Abstract** Noonomics in the concept of the noosphere in its origin involves the formulation of theoretical and methodological prerequisites for inclusion in the structure of economic knowledge in both the engineering and digital economy. One of them can be a spatial approach based on the concept of a multidimensional and multilevel economic space. Earlier, scientists thought that in order to answer a number of questions of their science, a scientist should leave his own subject and trace the theoretical, cognitive and philosophical foundations of his method of thinking. Based on the above, the authors define the purpose of the article as the institutionalization of the conceptual representation of noonomics using the approach and the development of a methodology for noonomical research in the digital space. The novelty of the work is the revealed specificity of the hierarchical structure of the three-level economic space based on the use of reproduction-level meta-system analysis, which will allow to effectively implement business processes in the engineering economy.

**Keywords** Density of economic relations · Engineering economy · Metasystem · Multidimensional economic space · Noonomics · Noodevelopment

## 1 Introduction

Questions of the noonomics formation are increasingly attracting the attention of researchers. Earlier, scientists thought that in order to answer a number of questions of their science, a scientist should leave his own subject and trace the theoretical, cognitive and philosophical foundations of his method of thinking. This is required

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in order to justify a disrupted and non-visual way of thinking for the development of a new, different from the usual, currently paradigmatic, perception of the world [1]. One of the new ways to study social development is the spatial approach, which is the basis of the theory of multidimensional economic space. The formation of the theory of economic space is a theoretical and applied problem of understanding noonomics, the solution of which is possible using topology and a cognitive-metaphysical approach. Taking into account the position of Brodunov, which was taken out as the epigraph of the article, we note that "economic growth" is a concept that replaces the concept of "the pace of development" or the formation of an economic space in which it is possible to live below the poverty line, but it is pointless [2, 3]. But the concept of noospheric spatial development is becoming a paradigm for economic science. We emphasize that the hierarchy of levels of analysis of the economic space is based not on the technological pyramid structure of the economy, but on the dynamics of the density of economic relations. These aspects make it possible to effectively implement business processes in the engineering economy and analyze economic phenomena in the digital space.

Currently, many Russian and foreign authors write about determining the future of economic science. For example, Nusratullin fundamentally justifies the future of economic science [4]. Surnina offers a scientific and practical study of spatial economics [5]. Suspitsyn analyzes the potential and limitations of spatial transformations [6]. Yaremenko's fundamental conclusion that the research space is multi-level [7] is filled with economic content (taking into account the idea of technological heterogeneity of the economy) for the application of the spatial approach in creating models of inter-level interactions based on topology. Especially important are the processes of information interactions. The scheme of economic interactions in the information exchange between its participants is considered in detail in the works of Parinov [8]. However, it should be noted that while in physics space and time are considered fundamental structures, since most physical concepts are introduced through operational rules that use distances in space and time (this fact indicates the empirical fundamental nature of space and time), in economics the concept of "economic system" plays a significant role in creating theoretical constructions. But at the same time, there is a need for a deeper study of the reality surrounding a person at the level of the metasystem. With the consideration of the economic system and the meta-system, we will begin our reflections on the role of the spatial approach in achieving the goal set out in the abstract.

The history of the development of the definition of the "system" concept content will soon celebrate its centenary. At the same time, a paradigm system concept has not yet been created. We can see an evolution of the system concept, including the ontological, gnostic, and epistemological meaning of the concept. Without setting the task of searching for criteria for distinguishing between certain systems, we will choose for analysis only one type of system out of all their huge set—the economic system. We will define the "economic system" concept content in the sense that will allow it to be used in the future when including economic systems of different levels in the structure of a multidimensional economic space, based on the available characteristics set out in the works.

Based on the definition that the system is a form of representation of the subject of scientific knowledge, we will call the system economic in the case when the interaction of people (consumers and producers), characterized as economic ties and/or economic relations, are implemented using resources in the process of creating a product (regardless of its form). This definition of the "economic system" concept content will further allow, within the framework of the spatial approach, to set tasks of studying the patterns of spatial interaction of systems and their elemental composition, that is, to make a qualitative transition from the analysis of the system interaction and its parts to the analysis of the system and its elements interaction. It is the composition of the elements, their properties, and diversity that generally determine the type and form of the economic system. The analysis of multilevel relationships in the system of economic relations using the ideas of academician Yaremenko was the source of the formulation of the level structure of meta-economics with the justification of the seven levels of economic systems functioning [7].

## 2 Methods

In the conducted research, the methods of system and factor analysis are considered. Much attention was paid to empirical and diagnostic methods. The study also used economic and mathematical methods. The authors considered the method of scientific abstraction, which reflects the aspects of the objects under study. The method of graphic images clearly demonstrates the economic dependence of processes and phenomena. The authors paid much attention to the method of geometric interpretation. In the course of the study, the method of retrospective analysis and the method of long-term forecast were used. The authors consider the method of analysis and synthesis, which provides a systematic approach to complex objects of a study. The study also uses a modelling method that allows us to study socio-economic phenomena according to their theoretical model. And finally, it is impossible not to mention the historical and logical methods, which involve the study of socio-economic processes in a historical sequence with logical conclusions and generalizations.

## 3 Results

The allocation of levels of analysis of economic relations within the framework of meta-economics allows us to consider these relations from the perspective of the principle of multidimensionality and introduce a new economic category "*density of economic relations*". In the suggested concept, the density of economic relations is a criterion for the spatial concentration of economic processes and economic phenomena. Let's note that although each subject (including the aggregated one) has its own space, as it is shown in the works of Brodunov [2] and other researchers who agree with his approach, isolation does not exist, and, therefore, a comprehensive system-spatial approach is required. Obviously, the understanding of the hierarchical structure of the economic space should be based on the goal of developing recommendations for the regulation, or coordination, or management of economic processes (phenomena) for the harmonious coexistence of diverse functions.

The concept of "economic space" has appeared in various interpretations relatively recently. There are several poorly connected approaches. We will list them without setting the task of their disclosure in this publication. But we will specify those, that, in our opinion, are promising and are presented in the works of such scientists as Parinov [8], Shchetinina [9]. The spatial approach is considered by us as one of the theoretical and methodological foundations of noonomics. The concept of ontology as the ultimate form of thought and practice allows us to focus on such a characteristic of noonomics as spatiality/topologicity. But noonomics is no longer a "flat" economy, but a spatial-volume one. Of course, our thesis requires a detailed proof of the identification of specific characteristics of noonomics, its universal properties, and the categorical distinction between noonomics and economics. But in the works of Bekov, an attempt was made to find a concrete historical forms of economic space using such characteristics as length, structure, coexistence and interaction of elements [10, 11].

## 4 Conclusion

The results of the study confirmed that the definition of economic space (multidimensional and hierarchically multilevel) as an object and subject of economic science, its configuration and structure is significant for the formation of noonomics due to the following circumstances. Firstly, the formulation of the object and subject of economic theory, which includes economic relations, economic systems, economic phenomena and processes of production, consumption and exchange, and in general—everything that identifies the nature of the interaction of humanity with the universe, characterizes and defines in many ways the discourse of the study. Secondly, the economic space as an object that has a multidimensional (three-dimensional) configuration makes it possible to use the synthesis of various analysis methodologies. Defining the economic space as a multidimensional and hierarchically multilevel space formed by: (a) individuals and legal entities that enter into economic relations to fulfill their needs and express these needs of economic interests; (b) physical and non-physical objects that are sources of satisfaction of economic interests and economic relations. Thus, we avoid the trap of ignoring the social and psychological factors that affect the effectiveness of economic interactions. Thirdly, the definition of economic space as the *subject* of analysis involves the implementation of research not of the economic space itself, but of the phenomena and processes occurring in it. Moreover, based on our definition of an economic system, a multilevel economic space is a meta-system, since the subjects of the economic space interact not only directly, but also indirectly, exerting mutual influence through a system of effects, stocks, transactions, events, etc. Thus, all levels of the economic space are interconnected, and its structure is functional and unfolds in the flow of evolutionary time [12]. Fourthly, the uncertainty and speed of changes in the external environment mobilizes scientists to better understand the world functioning. And the process of "do an about-turn" is not suitable for this. This means that the perception of the noofuture of civilization as a noosphere (and noonomics as part of the noosphere) is a trend of ensuring the sustainable development of humanity (noodevelopment). It is this thesis that is characteristic of Brodunov's works [2, 3]. Fifthly, in the three-dimensional economic space, there are resonant wave processes (crises as forms of economic dynamics), which can be attributed to the class of objects of economic science, called states. And the prognostic of noonomics is to justify the "straightening of the energy" of economic space, when we talk about life not **on** space, but **in** space. The spatial approach to the formation of noonomics has both methodological and theoretical potential and implements an interdisciplinary understanding of the interrelationships of various functioning levels of economic relations subjects and agents of economic systems as actors of economic space and, thus, can be considered as one of the theoretical and methodological foundations. Technological challenges of the XXI century determine the main vectors of socio-economic development of states, which are associated with the transition to noonomics in the engineering economy [13].

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# Trends of Employee Layoff in Russian Post During the Pandemic Period

**V. V. Grikhno and M. V. Simonova**

**Abstract** Transfer to telecommuting, part-time salary and unpaid leave have become unavoidable occurrences during the COVID-19 pandemic. Restrictions, caused by the spread of infection, forced employers to lay off a fairly large part of their workforce, which was a consequence of the economic decline in the country as a whole, and had affected income of businesses and population both. This caused an increase in anxiety among workers and employers, leading to an upshot in turnover rates of organizations. Regardless, people would still occasionally resign of their own accord during the pandemic, something that represents scientific interest in regards to studying causes for turnover and working conditions. The main subject of this study is the response of employees to the work conditions during COVID-19, which reflects in the causes of resignations. The article analyzes changes in staff turnover during a pandemic using the Russian Post JSC of the Volga Region as an example. The causal analysis is carried out among the resigning employees, and used as foundation for conclusion on main causes of resignation. The main trends in changes of employee behavior during the period of coronavirus restrictions and their influence on staff turnover have been identified.

**Keywords** COVID-19 · Human resources · Staff · Staff adaptation · Staff training · Staff turnover

## 1 Introduction

Staff management is one of organization activities tied to its functionality, which is mainly responsible for regulating social and labor relations, which went through significant change during the pandemic. Organization's staff, one of its primary assets, was not only under threat of layoffs, but of transformation of conditions and essence of labor process as well [1]. In a variety of cases, a direct presence of employees at the workplace is required for the production process [2]. However,

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during the pandemic, the situation of emergency forced organizations to look for ways to reduce presence of staff on site. Restrictions, caused by the spread of COVID-19 have forced employers to transfer a major part of the workforce to remote work or lay them off whatsoever [3]. This was a consequence of general economic decline in the country, which had a negative effect on income of both businesses and individuals [4]. The remote work legislation was passed before long, despite the protracted nature of debates surrounding the issue. Staff turnover in conditions of spreading coronavirus is declining, but this is a forced temporary situation, which, provided stabilization of the situation, will return to the preceding or even greater values [5]. Transfer to remote work cannot be attributed to staff turnover, but we cannot ignore it as a latent consequence of the pandemic. That may affect turnover rate in the future, which determines the relevance of this study.

Staff turnover is a natural phenomenon and is innate in most organizations [6]. Staff replenishment occurs for a variety of reasons: retirement, maternity leave, military conscription, staff rotation within the company, including layoffs, etc. In order to satisfy their needs, employees search for a new workplace, with, for example, higher salary, more comfortable working conditions or other subjective or objective reasons. Objective reasons might include the general shift in the world's attitude to work, employee independence is increasing, loyalty to organization decreases, the priority shifts to personal goal achievement [7]. At the same time, the ideological component of work is declining. There is also an uptick in subjective reasons. Such reasons include ones formed directly in the work collective—antagonistic relationship with management staff, despotic leadership, lack of opportunities for training, development qualification training or further career growth. It is also possible to highlight such reasons that are disconnected from relationships in the team, but arise, for example, from inconvenience of daily commute or work schedule [8]. From the staff turnover rate, one can discern and draw conclusions about a variety of human resource processes in organization, it is especially important to analyze such data in times of crisis, such as the current period of the COVID-19 pandemic [9]. Staff movement trends and identification of staff turnover causes in a pandemic period can help in discerning key elements for establishing systems of adaptation, training and motivation, which determines the relevance of this study. During the period of coronavirus infection restrictions, were established a significant number of regulations governing behavior of staff during the pandemic, such regulations significantly differ from the generally accepted work ethic pre-COVID-19. These changes affected nearly all spheres of social and labor relations, for example, work hours, the mode of work, forms of employment, salary, all of which are likely to have an impact even after the end of the pandemic [10]. That explains why this issue is so relevant and incites heightened interest among employers.

Transfer to remote work, part-time salary and unpaid leave—became common occurrences during pandemic, but in the post-pandemic period it is crucial to look for new solutions, allowing to mitigate repercussions of the changed working conditions. Maintaining integrity of the team, which has been formed through several years, is the task of any anti-crisis manager, something that becomes even more imperative after staff had to face stressful conditions, and for increasing labor efficiency both [11].

Staff stability is one of cornerstones for efficiency of any endeavor and successful function of the organization, regardless of economic situation [2]. The pandemic provoked rapid changes in labor processes, which would take a significant amount of time to resolve in a different situation [12]. The consequences of such processes for work collectives are yet to be determined, but even now it is crucial to understand the causes for the increase in turnover rate, which in many cases keeps rising, despite the difficult unemployment situation.

## 2 Methodology

Large federal companies are of particular interest to the research, as they operate across the entire country under uniform corporate rules and federal laws, yet their staffing situation is mostly dependent on the situation in the region. Let's then consider the main causes for voluntary resignations before the pandemic and after the first wave of coronavirus using Russian Post JSC, as an example. Organization is both one of the largest employers in the country with 335 thousand employees and is included in the list of strategic organizations and provides services in all regions, however, the staff turnover of Russian Post has not decreased despite such an unstable situation, which is something of great scientific interest.

Objective side of the turnover rate for 2017–2019, statistics for which were posted in the official report by Russian Post JSC, also requires consideration. Data available for 2020 is still in the process of being analyzed and is yet to be published. To analyze subjective reasons for turnover, we will analyze the results of an anonymous study among the resigning of the Russian Post, conducted before the start of the pandemic and a month after the start of self-isolation.

Main purpose of the study is to determine the structure of causes for resignations against the background changes in working conditions caused by the pandemic using Russian Post JSC as an example. To achieve this, it is necessary to solve following tasks: analyze the professional and qualification structures of Russian Post JSC in the regions and country as a whole before the pandemic and a month after the introduction of self-isolation measures. Following methods were used in the study: the method of statistical analysis, comparative analysis, analytical analysis, analogical method, as well as questionnaires and descriptions.

## 3 Results

Through all periods, Russian Post JSC remains a responsible employer that performs both a service and a social function. The company not only refrained from layoffs, but also continued to improve working conditions of its employees during the pandemic. Near the end of 2020, a large-scale salary increase program was completed, this program was started in 2019 and affected 90% of operators, sorters, drivers and postmen. The total amount of funding received by the program amounted to more than 12 billion rubles. The salary of employees of the main production process increased by an average of 19%, which is more than three times higher than the average growth across the country. This occurred against the background of increased costs due to need to ensure compliance with antiviral measures, to which the Post allocated over 1.5 billion rubles [13]. To analyze the professional and qualification structure, let us go over the change in the number of personnel of an organization by federal districts in more detail [14]. Table 1 shows data on the actual headcount by federal districts for 2017–2019. The table shows that the number of employees is subject to insignificant changes: in 2018 compared to 2017, the actual number changed by −1.42%, in 2019 compared to 2018 by −1.46%.

**Table 1** Staff structure by federal regions, ppl

| Year | 31.12.2017 | 31.12.2018 | 31.12.2019 | | | |
|---|---|---|---|---|---|---|
| Russian post JSC | Actual number | Actual number | Ratio 2018/2017 (%) | Actual number | Ratio 2019/2018 (%) | Ratio 2019/2017 (%) |
| | 340,772 | 335,921 | −1.42 | 331,011 | −1.46 | −2.86 |
| Far Eastern Federal District | 18,038 | 17,473 | −3.13 | 21,867 | 25.15 | 21.23 |
| Volga Federal District | 75,520 | 75,224 | −0.39 | 73,248 | −2.63 | −3.01 |
| Northwestern Federal District | 33,583 | 33,905 | 0.96 | 32,779 | −3.32 | −2.39 |
| North Caucasian Federal District | 14,011 | 13,903 | −0.77 | 13,938 | 0.25 | −0.52 |
| Siberian Federal District | 47,220 | 46,551 | −1.42 | 40,630 | −12.72 | −13.96 |
| Ural Federal District | 25,211 | 24,804 | −1.61 | 24,249 | −2.24 | −3.82 |
| Central Federal District | 95,607 | 92,966 | −2.76 | 93,595 | 0.68 | −2.10 |
| Southern Federal District | 31,566 | 31,082 | −1.53 | 30,697 | −1.24 | −2.75 |
| Others | 16 | 13 | −18.75 | 8 | −38.46 | −50.00 |

**Table 2** Staff structure by job category, ppl

| Year | 31.12.2017 | 31.12.2018 | 31.12.2019 | | |
|---|---|---|---|---|---|
| Russian post JSC | Actual number | Actual number | Ratio 2018/2017 (%) | Actual number | Ratio 2019/2018 (%) |
| | 340,772 | 335,921 | −1.42 | 331,011 | −146 |
| Senior management staff | 26,326 | 60,009 | 127.95 | 60,575 | 0.94 |
| Specialists | 29,761 | 28,206 | −5.22 | 29,511 | 4.63 |
| General service employees | 1277 | 1242 | −2.74 | 1538 | 23.83 |
| Manual workers | 29,294 | 32,462 | 10.81 | 33,547 | 3.34 |
| Workers in main Professions, including those | 254,114 | 214,002 | −15.79 | 205,840 | −3.81 |
| Postmen | 122,309 | 120,928 | −1.13 | 117,475 | −2.86 |
| Sorters | 21,158 | 18,575 | −12.21 | 17,619 | −5.15 |
| Operators | 67,377 | 66,585 | −1.18 | 66,915 | 0.50 |

Performed calculations show that in 2019 there was a redistribution of staff between Far Eastern Federal District and the Siberian Federal District, which is in line with the federal policy of Far Eastern region development. The Volga Federal District shows a slight decrease in the total number of personnel, which reflects the general trend in the country. One of the reasons for the reduction in the total number of personnel is the automation and digitalization of processes taking place at the Post in recent years [14]. This has also impacted the changes to composition by job category, calculations for which are presented in Table 2.

As a result of digitalization of the work process, there is a reduction in working personnel and a subsequent increase in management personnel, which represents an increase in requirements for the qualifications and level of education of employees. Such as in 2018, since 2017 the number of senior managers increased by 128% from 26,326 people to 60,009 people. Accordingly, the number of employees in main professions decreased by 15.79% from 254 114 to 214 002 people.

In 3 years, the share of employees with higher education increased from 18.1 to 19%, subsequently, the share of employees without specialized education for the same period decreased from 51.6 to 43.9%. There was a significant increase in the number of employees with secondary vocational education from 30.3 to 37.1%. The data is presented in Table 3.

Turnover indicators, presented in Table 4, show a fairly high level of youth contingent in personnel and the lowest level of turnover only at the pre-retirement age. The large difference in turnover rates among men and women indicates the need for in-depth research on the reasons for resignations based on gender. The turnover rate

**Table 3** Distribution of employees by education, ppl

| Year | 31.12.2017 | 31.12.2018 | 31.12.2019 | | | |
|---|---|---|---|---|---|---|
| Russian Post JSC | Actual number | Share, % | Actual number | Share, % | Actual number | Share, % |
| | 340,772 | 100 | 335,921 | 100 | 331 011 | 100 |
| With higher | | | | | | |
| professional education | 61,726 | 18.1 | 61,585 | 18.3 | 62 900 | 19.0 |
| With secondary | | | | | | |
| vocational education | 103,370 | 30.3 | 103,730 | 30.9 | 122 648 | 37.1 |
| Other education | 175,676 | 51.6 | 170,606 | 50.8 | 145 463 | 43.9 |

**Table 4** Personnel turnover rate, %

| Year | 2017 | 2018 | 2019 | 3-year average |
|---|---|---|---|---|
| Actual value | 34.83 | 34.84 | 33.73 | 34.47 |
| *Turnover distribution by age* | | | | |
| Under 30 years (inclusive) | 8.54 | 8.54 | 9 | 8.69 |
| From 31 to 40 years | 8.13 | 8.14 | 8.18 | 8.15 |
| From 41 to 50 years | 7.01 | 7.01 | 6.85 | 6.96 |
| From 51 to 55 years | 3.7 | 3.7 | 3.45 | 3.61 |
| Above 55 years | 7.44 | 7.45 | 6.26 | 7.05 |
| *Turnover distribution by gender* | | | | |
| Male | 8.8 | 8.04 | 8.01 | 8.04 |
| Female | 26.75 | 26.8 | 25.72 | 26.42 |

was calculated as a cumulative total for the year. A high percentage is typical for the industry, as 43.9% of employees have no special education.

## 4 Discussion

Comparison of indicators of staff turnover before and after pandemic and establishment of main causes of resignations against the background of strained economic situation and rising unemployment, represents a certain interest. Operational quantitative data is being processed; however, sociological surveys allow us to gauge the mood of employees who made the decision to resign and the circumstances that influenced this decision. Conducting a study of causes for resignations in different branches of Russian Post JSC in Volga region during the period of self-isolation and a month after lifting some of the strictest regulations among resigning employees.

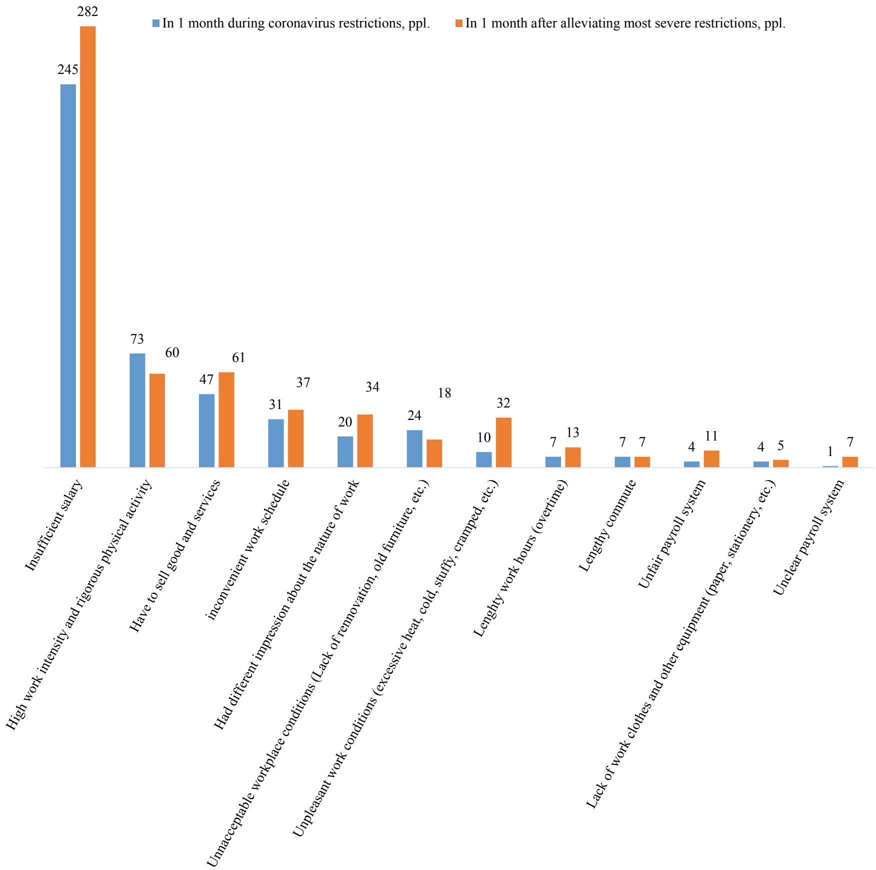


**Fig. 1** Analysis of resignation causes

Evaluation of questionnaire results (see Fig. 1) allows one to group the answers by risk zones and highlight the distinctive trends. Let's consider the results of the survey in more detail.

The most widespread reason for resignations both during the peak of the pandemic and after its decline is the insufficient salary 245 employees (38%) out of 645 respondents, after the lifting of restrictions, 282 employees (35%) out of 800 selected it, which points to the real problem, when workers would rather leave and lose their source of income even with a sharp reduction in employment. This might indicate the low competitive value of salary in Russian Post, as well as the possibility of finding more attractive work conditions even in such arduous circumstances. This alarming symptom points out the need for changes not only in salaries, but also in the system of motivation. The employees' mood did not change the large-scale wage increase program carried out by the Russian Post started in 2019. And as such, it can be assumed that by the end of 2020, the number of resignations due to dissatisfaction with the size of salary should decrease, which will make it possible to assess the effectiveness of the measures taken.

High work intensity and rigorous physical activity is not as common an answer as low salary, such answers are 3 times less common—74 employees (11.5%) during the pandemic versus 60 people (7.5%) after the lifting of most severe restrictions. Subsequently, the work conditions created by the organization are quite acceptable, nevertheless, a negative attitude towards work conditions is one of the most widespread causes for resignation, grouped together with other answers related to living conditions. For example, only 10 employees chose the answer "difficult working conditions" during the pandemic, while after the restrictions were lifted, 32 employees chose this answer. Also, very few of those who resigned chose the "long working hours", which indicates organization's compliance with the labor legislation. An alarming symptom is the growth of responses that the employee had a different idea of what he was going to do and that now he has to sell goods and services. This points to the lack of quality in both recruiting process and staff adaptation, when applicants do not quite accurately understand the content of future work before starting, and also the lack of the necessary employee training after hiring [15]. Insufficiently developed competencies and skills of staff are the most common cause of poor performance.

## 5 Conclusion

As a result of conducted study, the following conclusions can be drawn: pandemic period shows a decrease in staff turnover, since employees are less likely to decide to change jobs in an unstable situation; staff turnover against the background of coronavirus restrictions is significantly influenced by the subjective reasons for employee resignation. It is crucial to note that insufficient salary remains the most common reason for resignation, both during the peak of the pandemic and after the decline of its most acute phase. The second most common reason is "work intensity and heavy physical activity". Analyzing the main causes for resignation, it can be concluded that during the pandemic, an employee decides to resign if the reason for resignation significantly affects his working conditions. At the same time, the employee is prepared to wait for more favorable conditions for changing jobs, if the reason is insignificant enough at this stage. However, after the stabilization of the situation and the removal of temporary pandemic restrictions, we see an increase in turnover, including for various everyday reasons for resignation. In the author's opinion, the decrease in staff turnover is associated not only with fear of losing their job due an unstable pandemic situation in the country. The decision to change jobs is influenced by a variety of factors. Such as a long period of illness and rehabilitation in case of contracting the virus; anxiety for family and friends; difficulties of remote job search and online interviews, which creates difficulties for employees of the main production, older people, etc. In order to study causes of staff turnover during the period of coronavirus restrictions in more detail, it is also necessary to study the length of service in the company of resigning employees in more scrutiny and analyze the quality of staff recruitment and training.

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# Stakeholders and Their Role in the Context of Sustainable Development

**E. A. Malysheva**

**Abstract** The pursuit of sustainable development has become a necessity for all business sectors due to the high sensitivity of stakeholders to the economic, environmental and social aspects of companies' activities. The sustainable development of companies is considered in three dimensions (economic, social and environmental). The importance of CSR as a way to achieve sustainable development of companies is growing. To implement this approach, it is necessary to consider building interaction between the company and its stakeholders. In order to determine the level of interaction with interested parties, an analysis of non-financial statements of Russian companies was carried out. The paper reveals the main essence of the main groups of internal and external stakeholders in modern practice, as well as modern approaches to the choice of methods of interaction with them. Effective engagement with stakeholders has been proven to contribute to business efficiency through understanding and support from a wide range of stakeholders and to reduce non-financial risks.

**Keywords** Company · Corporate social responsibility (CSR) · Non-financial risks · Stakeholders · Sustainable development

## 1 Introduction

The number of Russian companies implementing the principles of sustainable development in their activities is constantly growing. The sustainable development of companies is considered in three dimensions (economic, social and environmental). Most companies understand that sustainability is important for their long-term success, as well as for operating and thriving in new markets, strengthening their reputation in the eyes of stakeholders, and reducing non-financial risks. The importance of CSR as a way to achieve sustainable development of companies is growing.

The discussion of "corporate social responsibility" is characterized by analytical vagueness and a lack of understanding of application practices. On the one hand,

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the company must fulfill its economic function of producing products and services necessary for society. As a result, creating jobs for the population, high profits, and dividends for shareholders, while maintaining the established rules of the game of doing business, in particular open competition, avoiding fraud and deception. On the other hand, it is believed that companies are a complex mechanism, the existence of which depends on many components of the environment [1]. In 2019, an event occurred that turned the entire capitalist world: the leaders of 181 largest companies redefined the appointment of the corporation. The new goal of business is to change the world for the better, and not just increase profits [2]. In this context, the modern definition of corporate social responsibility, this is a system of responsibility of business owners to representatives of interested parties for the results of doing business, which are expressed in the economic efficiency and creation of the strategic value of the company through three areas of activity: management of relationships with stakeholders, management of social investments, management of non-financial risks.

The problems of non-financial risks for companies play an increasing role in Russia. The most common non-financial risks are: social risks—a decrease in the company's efficiency, as a result of the decline of highly qualified personnel [3], the risk of increasing social tension in the company's territories of presence, as a result of low-popular decisions regarding employees and social infrastructure facilities; reputational risks—when a company's reputation is undermined, due to an event that was the result of a previous business risk or other incident, it risks losing revenue and reducing confidence in the company from customers, partners and investors [4]; environmental risks—a large number of companies and investors recognize that business with its increasingly complex global supply chains plays an important role in reducing risks and must work together to address their environmental impact [5]; corporate governance risks—managers may make incorrect management decisions that benefit them, but harm the shareholders of the company, one group of stakeholders may benefit unfairly at the expense of other groups of stakeholders due to the weakness of the company's control system and lack of transparency in disclosure [6].

## 2 Methodology

This study was conducted by reviewing the literature of domestic and foreign authors in the field of sustainable development and corporate social responsibility, analyzed and summarized the data presented in non-financial reports of Russian companies, as well as analytical reports. In the course of the study, the existing approaches to the concept of CSR are described, the main directions of activity in the field of CSR are determined. The most common non-financial risks of companies have been identified. The relationship between corporate social responsibility (next CSR) and the concept of stakeholders is shown. The main groups of stakeholders and the integration of their interests into the activities of companies have been studied. The existing methods of interaction with stakeholders and the need to take into account their interests in the field of socially responsible innovations are described.

## 3 Results

For investors, this category of risk is becoming more and more significant, along with commercial and economic risks. A 2020 study of institutional investor opinions by EY services practices found that most of the study participants (98%) indicated a shift to a more rigorous and rigorous approach in assessing non-financial performance of companies [7]. When implementing the processes of any modern company in the direction of corporate social responsibility, it is necessary to take into account the interests of those who are focused on all this. In the face of difficult and serious economic, social and environmental challenges, companies are increasingly turning to responsible innovation, meaning they are committed to creating value for multiple stakeholders by developing new products or services that do no harm and improve the living conditions of people and the planet. Interaction with stakeholders allows you to minimize and manage non-financial risks [8], as well as positively influence the company's implementation of the CSR policy [9].

In 1984, Freeman first detailed the theory of stakeholders, which turns to morality and values in the management of the company [10]. Stakeholder theory emphasizes the interrelated relationship between business and its consumers, suppliers, employees, investors, communities, and others interested in the company. The theory states that a company should create value for all stakeholders, not just shareholders. According to this theory, the ecosystem of stakeholders includes everyone who invests in, participates in, or influenced by the company.

In accordance with ISO 26000 "Guidance on Social Responsibility," identifying and interacting with stakeholders is a basic element of the company's social responsibility [11]. The need to involve stakeholders in the reporting process is first mentioned in the international standard AA1000SES, this standard determines the importance of meeting non-financial reporting expectations and requirements of stakeholders. Interaction with stakeholders develops their trust in the company and their understanding of its contribution to sustainable development, which contributes to the company obtaining its "social license to operate" [12].

There is no common stakeholder list for all companies or even for one company, it will change over time [13]. There are two main stakeholder groups—internal stake-holders and external stakeholders. Internal stakeholders provide services to the organization and are highly dependent on the company's achievements, decisions and performance Table 1. Internal stakeholders consist of all those who work in the company: employees, individuals or groups who own the company, all those who participate in the management of the company. All of them are directly related to the activities of the organization and are crucial for the development of the company.

The integration of business into society leads to a wide range of interactions with a number of different external stakeholder groups Table 2. A number of external

**Table 1** Internal stakeholders

| Group | Interests of stakeholders |
|---|---|
| Shareholders | – Economic efficiency<br>– Business sustainability<br>– Transparency of business processes |
| Managers | – Level of responsibility<br>– Social status<br>– Amount of remuneration |
| Staff | – Professional and career development<br>– Safe working conditions<br>– Decent conditions of remuneration<br>– Availability of benefits and discounts |

**Table 2** External stakeholders

| Group | Interests of stakeholders |
|---|---|
| Clients | – Improving the quality of goods and services<br>– High service standards |
| Suppliers | – Fair competition and responsible market behavior<br>– Transparency, including procurement transparency |
| Local community | – Support the development of regions of presence<br>– Provision of products and services<br>– Job creation |
| State | – Development of regions of presence<br>– Contribution to economic growth<br>– Payment of taxes<br>– Improvement of the company's regulatory support |
| Non-profit organizations | – Support for local social activities<br>– Holding socially significant actions |
| Educational institutions | – Targeted training<br>– Development of industry science |

stake-holders need to be taken into account in the company's decision-making and operations. External stakeholders do not participate in the day-to-day activities of the company, and organizational activities have an impact on them [14, 15]. They are not aware of the company's internal problems and solve them from the outside.

## 4 Discussion

To analyze the current experience in the implementation of measures by Russian companies to interact with stakeholders, companies that are leaders of the indices of the Russian Union of Industrialists and Entrepreneurs (RUIE) on sustainable development were considered [16]. The companies under analysis include representatives of the chemical, metallurgical, extractive, financial and telecommunications sectors. Based on the findings, conclusions were drawn about the current state of Russian companies in the field of relations with interested parties. 85% of the reviewed companies (32 out of 38) interact with stakeholders and reflect its results in their public sources. Each company chooses its own way of presenting information, not limited to one approach, for example: by stakeholder groups, by substantive topics, by region, by responsible departments, etc.

When analyzing the results of the study, it was revealed that in 58% of cases, companies disclose their stakeholders in official sources. A total of 38 companies were surveyed in this survey. These companies not only disclose information, but also display interaction with stakeholders in non-financial reports. In addition, they publish internal rules, codes and standards of their activities in official sources. Accordingly, we see that modern companies operating in our country strive to implement social responsibility in the course of their activities, they strive to implement a policy of interaction with stakeholders using various methods in their practice.

Stakeholder engagement includes methods used by market researchers and academia. When choosing methods, companies are guided by a qualitative or quantitative approach. A qualitative approach uses open styles of discussion and debate. Forums, conferences, focus groups, individual in-depth interviews and observation are most often used. The quantitative approach covers more people and uses more standardized measurement tools such as surveys, short street interviews, online surveys, etc. These methods will reach a wider audience, but are limited mainly to closed questions and rating scales. Stakeholder engagement and engagement should be ongoing and systematic.

## 5 Conclusion

Companies tend to recognize certain value associated with stakeholder engagement. The practice of interaction with interested parties, implemented by Russian companies, became an integral part of their activities, as a result, companies managed to obtain: social license to work, expand and introduce innovations, improve the relationship between the company and its stakeholders, create a positive public image and improve reputation, avoid costs associated with litigation or boycotts, identify emerging trends, take a proactive approach to them and move ahead of their competitors. The 2030 Agenda for Sustainable Development recognizes the need for inclusive participation and effective stakeholder engagement for the successful implementation of the Sustainable Development Goals (SDGs). Based on the results of its activities, the companies have formed a favorable environment around them, which contributes to improving the efficiency of its business, through mutual understanding and support from a wide range of stakeholders. Better stakeholder relationships help companies develop assets such as customer loyalty, reduced employee turnover, and improved reputation. These assets all provide competitive advantage and corporate value. An approach based on CSR of the business and sustainable development helped companies to consider and prevent non-financial risks.

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# The Use of Artificial Intelligence Technologies and Big Data in Law Enforcement

**M. A. Yavorsky and S. V. Mikheeva**

**Abstract** The modern world is changing rapidly. The society is already at the stage of its development when information has become an important strategic and managerial resource. Socio-economic transformations and advances in digital science and technology inevitably require radical changes in the organization and management processes of public authorities. The work is dedicated to a topic that is currently relevant, has not been sufficiently studied and requires further research-the use of artificial intelligence (AI) and Big Data technologies in the activities of law enforcement agencies. The article presents some of the main areas of application of automated intelligent processes in investigative, operational and investigative activities, in the field of public order protection and public safety, and in penitentiary institutions. Possible ways to improve the use of AI and Big Data technologies in law enforcement agencies are presented, and tasks aimed at solving "problem areas" of their application are formulated. The work is interdisciplinary in nature, combining the methods and results of previously conducted research in a number of sciences and scientific disciplines.

**Keywords** AI technologies · Big data · Law enforcement

## 1 Introduction

AI and Big Data technologies have been one of the fastest growing areas [1, 2]. They are widely used in the public and private sectors: in various sectors of the economy and industry, in transport, in medicine, in the information sphere and other areas of modern society. Modern data analysis tools allow you to solve the problems of finding hidden patterns in the available information; analyze the interests and preferences of people, get data on their health and movements; make a psychological portrait of a

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person, determine the traits that unite groups of people; identify “behavioral anomalies” and “hot spots”; establish the financial capabilities of a person, his expenses, transaction data, etc. The list of possibilities of methods for analyzing and systematically extracting large amounts of data is constantly expanding. Among the main areas of application of automated intelligent processes are: information collection, storage and processing of information; analytical and predictive models; implementation of digital investigations; provision of communications and interaction. In the vast majority of countries, law enforcement agencies also use Big Data technologies. These sets of information are also used to uncover and even assess the likelihood of committing crimes, which contributes to their prevention [3, 4]. Using the analysis of information arrays, the social reaction to the committed crimes is determined and predicted, potentially dangerous groups in social networks are identified, etc. [5].

## 2 Methodology

This research was carried out using both general scientific methods, such as analysis, synthesis, deduction, induction, and specific scientific methods: comparative legal, systemic, and structural. In addition, we effectively used the possibilities of field observation methods and sociological knowledge to obtain the necessary information. The primary sources of the study were scientific publications and reports devoted to the field under study. Along with this, we used the results of a survey of law enforcement officers, students, graduate students and teachers of the legal cycle disciplines of the Institute of Law of the Samara State University of Economics and the Samara Law Institute of the Federal Penitentiary Service of Russia. Information was collected in direct communication with the employees of the investigation and inquiry bodies. The materials obtained are quite representative. This allowed us to consider several important issues related to the use of AI technologies and Big Data in the activities of law enforcement agencies, as well as to formulate proposals and recommendations designed to eliminate “problem areas”.

## 3 Results and Discussion

In recent years, representatives of various sciences have been paying more and more attention to information technologies: technical, economic, sociological, pedagogical, etc. The analysis of the scientific literature of specialists in the field of economics, technical sciences, sociology, and information security shows a significant interest in the use of digital technologies in various spheres of society. The public is increasingly turning towards understanding the importance of the digital economy, digital transformation and digital development of the state and public spheres. However, the study of the possibilities of using AI and Big Data technologies in legal science and practice, including in the field of law enforcement and public safety, is only gaining momentum. The problematic issues of their application remain insufficiently covered in the literature. Based on the analysis of scientific literature, regulations, law enforcement practice and other sources, the authors analyze the use of automated intelligent processes in investigative, operational and investigative activities, in the field of public order protection and public safety. The tasks and ways of improving the practice of using these technologies were formulated. Digital law enforcement, according to the authors, should become an element of a single model of the social system of the future. To ensure the competitiveness of our society, it is necessary to develop a law enforcement system with advanced management technologies in this area. In the context of information and technological progress, these technologies should become a key factor in optimizing the activities of law enforcement agencies.

The analytical tools and complexes based on AI technology that are being implemented today for law enforcement agencies and special services are capable of:

1. Quickly get (online) access to information, evaluate its qualitative and quantitative parameters. Currently, specialized software systems have been developed and are being used to search for and, most importantly, systematize a huge amount of data from Internet sources in the conditions of "information noise" and information "congestion" (spam, contextual advertising, repeated messages, etc.), which make it difficult to perceive the information you are looking for.
2. Analyze information about committed offenses, including archived data on crime. Thus, existing information systems, analyzing data on offenses, are able to predict the likely time and place of their commission, which contributes to the reduction of crime. The analysis of digital data allows to carry out a controlled criminological experiment, to make decisions aimed at changing the criminogenic situation. Automated analysis of large amounts of data makes it easier to test hypotheses about the causes and conditions of offenses and about the best measures to prevent them in order to develop effective forms and methods of crime prevention.
3. Detect hidden connections between objects and processes (people, cars, mobile phones, places, etc.). Information awareness of law enforcement agencies, generalization and interpretation of data contributes to the establishment of criminal social connections. Software systems are able to identify the active participants of a particular group and the forms of their interaction. Thus, it is possible to identify the opinion of users of social networks on any discussed issue, topic, event, etc. The neural network allows detecting similar offenses, or, for example, serial crimes (multi-episode criminal acts) committed in different regions of the country, to identify patterns and suggest that the investigator combine these cases.
4. To search for and detain criminals. The technology of machine facial recognition in the video stream by full or partial image allows you to identify a person wanted by law enforcement agencies, even in places of mass presence of people (train stations, airports, stadiums, etc.) [6]. Similar technologies were successfully used in Russia at the 2014 Winter Olympics, as well as during the

2018 World Cup [7]. Existing software systems for voice recognition based on comparative analysis with samples that are available to law enforcement agencies, in real time, allow you to identify a person, determine the location of the caller, automatically put the phone on wiretap and record all conversations.

5. Artificial intelligence technologies help to model tactical actions for the detention of offenders, investigative situations of the initial stage of the investigation, contribute to the process of putting forward versions, determining the directions of the investigation of crimes.
6. A separate sector of the development of the use of digital technologies, including AI and Big Data is the penitentiary authorities, which are part of the system of law enforcement agencies in Russia, have their own analytical, technical and operational units. Based on the results of the use of AI, data is collected and processed and decisions are made in various areas of prison activity. AI technology can be used to monitor convicts, ensure security (including using video analytics and predicting the behavior of convicts and prison staff), monitor persons who have been subjected to preventive measures that are not related to detention, and monitor the behavior of released persons. It plans to use automated systems to control the need to create, expand or reduce penitentiary institutions in the regions, depending on the number of persons serving sentences there, and to eliminate the human error factor as much as possible when predicting the behavior of persons in custody or serving sentences (including possible conflict situations). AI technologies can also be successfully applied in the activities of prison psychologists, personnel of logistics, legal and personnel services.

Thus, AI technologies can be applied in many areas of activity of security and law enforcement agencies, penitentiary institutions: investigative, operational-search, organizational and managerial activities, etc. It is difficult to imagine a solution to the problems of ensuring public safety and public order, detection, investigation and prevention of crimes without information technologies. Data sets of operational-search, operational-reference and expert purposes are processed by automated information-reference systems; automated information-search systems; automated expert systems that provide forensic examinations; automated systems for creating portraits; automated fingerprint information systems, etc. In the practice of law enforcement agencies, the possibilities of the Internet for detecting crimes, the scientific organization of their investigation, and the coordination of police activities in general are being introduced. AI technologies and Big Data help optimize traffic for the purpose of safety and fixing traffic violations. They are used to quickly identify criminal events and persons, and to ensure the security of protected objects and information systems of government bodies, institutions and organizations of various forms of ownership. In Russia, the “Safe City” hardware and software complex has been implemented in municipal districts and urban districts, which includes automation systems for the activities of the unified duty and dispatch service, municipal services of various directions, systems for receiving and processing messages, systems for calling emergency and other services of various activities, systems for monitoring, forecasting, alerting and managing all types of risks and threats inherent in this municipality. The "Safe City" complex is a set of functional and technical requirements for hardware and software, regulatory legal acts and regulations of interdepartmental interaction aimed at countering threats to public safety, law and order and the safety of the environment, forming, together with the existing federal security systems, an intelligent multi-level security management system for the subject of the Russian Federation in general and the municipality in particular, through forecasting, response, monitoring and warning of possible threats, as well as monitoring the elimination of the consequences of emergency situations. In the field of law enforcement and crime prevention on the territory of the municipality, the law enforcement unit of the "Safe City" complex allows you to:

– carry out video surveillance and video recording, including the removal, processing and transmission of video streams from video surveillance cameras about offenses and emergency situations, including damage to communications, infrastructure and property;
– analyze video and audio streams, including: automatic event registration based on the video stream analysis system; video event analysis; real-time video stream analysis; face identification and recognition;
– receive and display information about the location of people and moving objects;
– ensure the functions of public control over the activities of representatives of local executive authorities responsible for measures to ensure public order and security.

From a technological point of view, the "Safe City" system is hybrid and has an integrated modular architecture. Within the framework of the complex, various subsystems are operating and being tested: security and fire, engineering (emergency) alarm systems, a system for monitoring access to technical premises, a system for dispatching elevator facilities, a system for turning on and off engineering equipment, a house-wide and individual integrated resource counting system, an emergency dispatcher (voice) communication, a geo-information (topographic) system, and a system for monitoring traffic flows. Thus, the "Safe City" complex is a multi-level intelligent security management system (AI) that can predict, respond, monitor and prevent possible threats, and control the process of eliminating consequences. However, unfortunately, despite the obvious economic and social effects, it is currently not possible to provide all (even large) cities with such complexes in any country in the world, but it is obvious that over time the territorial coverage of such systems will only grow both in Russia and abroad. As some authors rightly point out, the use of AI is the preferred tool in the fight against drug trafficking, illegal migration, cybercrime, illicit trafficking in weapons and radioactive materials, piracy and terrorism [8]. The analysis of investigative and judicial practice and the conducted survey of law enforcement officers shows that information technologies are used in the disclosure and investigation of more than 80% of offenses.

## 4 Conclusion

The use of digital technologies in the Russian law enforcement system faces a number of problems that significantly reduce the effectiveness of law enforcement agencies. Among the areas of improving the use of AI and Big Data technologies in law enforcement agencies are:

- combining information from disparate sources into a single repository;
- development of software that allows you to identify the necessary information;
- use of software and hardware solutions that accelerate the processing of huge amounts of structured and unstructured information;
- automated documentation of the facts of criminal encroachments on protected (controlled) objects.

The implementation of the possibilities of using AI and Big Data technologies in the activities of law enforcement agencies requires solving a number of tasks:

- the legal regulation of the use of AI technologies and Big Data requires significant changes (especially criminal procedure legislation);
- it is necessary to increase the level of digital competencies of law enforcement officers in the use of AI and Big Data technologies»;
- it is necessary to intensify the development of methodological recommendations on the use of AI and Big Data technologies, to provide them to investigative bodies, inquests, expert units, etc.;
- it is necessary to speed up the equipping of law enforcement agencies with specialized information systems, advanced software and hardware;
- it is necessary to increase the storage time of information transmitted via the internet;
- further development of digital documentation of the facts of criminal encroachments on protected (controlled) objects is necessary;
- it is necessary to continue the deployment of software and hardware satellite navigation devices purchased for the needs of law enforcement agencies;
- it is necessary to develop new methods and secure devices for storing, processing large amounts of data and speeding up information transfer processes.

These "problem areas" and fundamental vulnerabilities in the use of AI and Big Data technologies stand in the way of improving the security system as a whole. Their elimination will allow to integrate the existing records (operational reference, search, forensic, preventive and registration, persons released from places of deprivation of liberty, etc.), will ensure the adoption of adequate management decisions, will significantly increase the level of security and the effectiveness of the disclosure, investigation and prevention of crimes. We believe that the creation of unified centralized operational centers for ensuring public safety will also contribute to the solution of these tasks. In the near future, digital technologies will increasingly penetrate the law enforcement sphere and thus find new applications. The formation of digital competence of law enforcement officers, along with legal, psychological and special training, will become one of the main requirements for police education. AI and Big Data technologies open up huge prospects for fighting crime and improving law enforcement.

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# Comparison of Training Effectiveness of Neural Networks in Whole and in Blocks

**E. A. Gubareva, S. I. Khashin, and E. Shemyakova**

**Abstract** Despite the fact that artificial neural networks are used as a research and forecasting tool in various fields of knowledge, the choice of the most important properties of neural networks remains mainly empirical. Based on the study of sufficiently informative examples, the paper compares the effectiveness of two training methods, when one step of training of an artificial neural network is performed for the entire training set as a whole, and when for one step of training this set is divided into separate blocks. As a result of the conducted numerical experiments, recommendations were obtained for the initial choice of parameters such as the size of blocks and the learning rate, as well as for changing these parameters during the training of a neural network.

**Keywords** Block · Neural networks · ANN training · Regression · Epoch · Efficiency

## 1 Introduction

Nowadays, artificial neural networks (ANNs) are becoming an increasingly important research tool in various fields of knowledge [1–3]. A significant part of the new results in computer graphics, pattern recognition, and time series analysis were obtained using ANN [4–11]. Despite this, the choice of the most important properties of a neural network: its architecture, the size of blocks (batches), the learning Rate (LR), remains mainly empirical. The authors of many works in this field either simply report on the parameters they choose, or say that after a number of experiments they

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settled on some architecture and on some other ANN parameters [5–7, 9, 10]. In this paper, considering the fixed architecture of the ANN, we will try to justify the methods of selecting the block size and the value of the learning rate.

## 2 Methodology

Neural networks are most often used to solve two types of problems: classification and regression. In our work, we decided to focus on the regression problem, since it is precisely this problem that occupies a central place in the prediction of time series [6]. We will assume that the training set consists of vectors of a fixed size, that is, convolutional neural networks will not be considered. Thus, the training set (*dataset*) is a matrix of real numbers. Let's mark the first element *of the i*th row as $y_i$, the others as $(x_{i1}, ..., x_{in})$.

A neural network is a function of two vector arguments:

$f(X, W)$f(X, W), here $X \in \mathbb{R}^n$ are the input parameters, and $W \in \mathbb{R}^m$- are the internal ones.

The task of training a neural network is to select a vector of internal parameters $W$ so that the condition is met for all the row vectors of the training matrix $X_i$

$$y_i \approx f(X_i, W)$$

more precisely, so that the function

$$S(W) = \sum_i (f(X_i, W) - y_i)^2$$

took the smallest possible value.

To minimize the function $S(W)$, there are a lot of methods implemented in various application software packages, one of which is the TensorFlow package [12]. Standard methods, such as tf. train. GradientDescentOptimizer, tf.train. AdagradOptimizer, tf.train. Adam Optimizer and others presented in this package are varieties or modifications of the gradient method. In our work, we used only the basic gradient descent optimizer. One step with a given learning rate (LR) means the transition from the vector of internal parameters $W_0$ to $W_1$:

$$W_0 \to W_1 = W_0 - LR\frac{\nabla S}{|\nabla S|}$$

where $\nabla S$ is the gradient vector of the function $S(W)$.

If we have a function of $m$ variables.

$$S(W) = S(w_0, w_1, ..., w_{m-1}),$$

then its partial derivatives can be found approximately:

$$\frac{\partial S}{\partial w_i} \approx \frac{S(w_0, ..., w_{i-1}, w_i + \varepsilon, w_{i+1}, ...w_{m-1}) - S(w_0, ..., w_i, ...w_{m-1})}{\varepsilon}$$

it is required to $m + 1$ calculate the value of the function.

In neural networks, the method of backpropagation is usually used to calculate the gradient. In fact, this is just a rule of differentiation of a complex function, adapted to our case. This is more efficient than the numerical method. The measurements carried out on a large number of examples show that the time of finding the gradient by the method of backpropagation of the error is 0.25–0.35 m times longer (for large $m$ ones) than the time of calculating the function $S$. That is, it is 25–35% of the time required to numerically find the derivative.

Based on the fact that the time of a single calculation of the function $S$ for large $m$ is negligible compared to the time of finding the gradient, and the analytical method of finding the gradient is 3–4 times more efficient than the numerical one, an analytical method is used to train the ANN.

The most important indicator is the convergence rate of the method. If the learning rate (the LR parameter) is not too large, then the error value (the objective function $S$) will decrease more or less uniformly at each step of the method. We will measure how much the objective function will decrease on average in one step. More precisely, let $S_0$ be the value of the objective function at the beginning of the step, $S_1$—at the end. The value will be called the efficiency of the step.

$$q = 1 - \frac{S_1}{S_0}.$$

The effectiveness may also be negative. This means that the objective function at this step was increased.

Usually, in real tasks, to obtain a well-trained ANN, the number of training vectors must be large: hundreds of thousands, millions. Therefore, it is almost impossible to fully calculate the function $S(W)$ and, moreover, to find its gradient. To solve such problems, the training set is divided into *batches* of some fixed length. We perform one step of gradient training in two ways:

– performing one step of gradient descent over the entire training set;
– performing one step of the same length for each block. In the theory of neural networks, this is called the learning epoch.

Since the learning epoch means passing through all the blocks, the amount of calculations in both cases is almost the same. Our task is to compare the effectiveness of both methods, depending on the block size and the training era.

## 3 Results

As a result of measurements for a large number of examples, it turned out that the obtained qualitative picture of neural network training remains the same in all cases. In this paper, we will consider the effectiveness of training neural networks by the example of solving several typical problems, for which the theory of neural networks is used.

***Example 1*** Let's take any image, for example, a standard lena.bmp size $512 \times 512$, we reduce it to a gray palette and consider it as a tabular function on a unit square with values in the segment [0,1].

Then the training matrix, after mixing the rows, will have the form:

$$\begin{array}{ccc} Y & x[1] & x[2] \\ 0.635294, & 0.000000, & 0.000000 \\ 0.537255, & 0.986301, & 0.009785 \\ 0.517647, & 0.344423, & 0.011742 \\ & \ldots & \\ 0.458824, & 0.299413, & 0.344423 \\ 0.760784, & 0.612524, & 0.606654 \end{array}$$

We will approximate the function $S(W)$ using a three-layer neural network, which has two input values (the coordinates of the point $(x_1, \ \ x_2)$, we assume that $0 \le x_1 \le 1, \ \ 0 \le x_2 \le 1$). In the first layer, we take 8 neurons with an activation function—a hyperbolic tangent. In the second layer, we also take 8 neurons with the same activation function, and in the third layer—one neuron again with the same activation function. The total number of internal network parameters is 105, i.e. $W \in \mathbb{R}^{105}$.

***Example 2*** We take any image and we will predict the brightness of the next point through the brightness of several previous ones, the location of the indices of which (from 0 to 17) is set by Table 1.

The brightness of the point varies from 0 to 255. Dividing by 255, we assume that all values lie in the range from 0 to 1. Since the work did not consider the brightness, but the deviation of the brightness of the next point from the brightness

**Table 1** The location of the indexes (from 0 to 17) selected for the previous points, the current point is marked *X*

| | −3 | −2 | −1 | 0 | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|
| −3: | | | 15 | 13 | 16 | | |
| −2: | | 10 | 7 | 6 | 8 | 11 | |
| −1: | 14 | 6 | 2 | 1 | 3 | 9 | 17 |
| 0: | 12 | 4 | 0 | X | | | |

*Source* Authors

of the previous one, the values lie in the range from −1 to 1. Thus, for a color image of the size 512 × 512, we get 765,075 training elements together for all three RGB channels, with 18 input values in each.

$Y,\ \ x[1],\ \ x[2], \ldots, x[18]$

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.058824 | −0.039216 | −0.011765 | 0.003922 | ⋯ | 0.019608 | 0.007843 |
| −0.105882 | −0.062745 | 0.011765 | −0.168627 | ⋯ | −0.070588 | −0.431373 |
| −0.003922 | −0.015686 | 0.039216 | 0.000000 | … | 0.039216 | 0.192157 |
| 0.003922 | 0.035294 | 0.019608 | 0.007843 | … | 0.011765 | 0.074510 |
| | | | .................. | | | |
| 0.035294 | 0.035294 | 0.015686 | 0.058824 | … | 0.050980 | 0.019608 |
| −0.011765 | 0.000000 | 0.023529 | −0.011765 | … | −0.019608 | 0.058824 |
| 0.003922 | 0.043137 | 0.031373 | 0.035294 | … | −0.043137 | 0.007843 |
| 0.105882 | 0.062745 | 0.011765 | 0.149020 | … | 0.215686 | 0.262745 |

For approximation, we again use a three-layer neural network, similar to the previous case, not with two input values, but with 18. The total number of internal network parameters is 233.

Let's consider how both the learning efficiency changes, starting from the initial, random value of the vector $W_0$ and as the training progresses, when approaching the local minimum (Table 2).

The top row (Ep.) of Table 2 shows the training epoch under consideration: 0 (the very beginning), 10, 30, 100. For each epoch and for each selected learning rate (1; 0.3; …; 1–5), two numbers are given: the average efficiency of a normal step (q1) and the average efficiency of one learning epoch by blocks (qb), both numbers are in percentages. For example, the number 1.36 means that the target function will decrease by 1.36% in one step

**Table 2** Comparison of the effectiveness of ANN training

| Ep | 0 | | 10 | | 30 | | 100 | |
|---|---|---|---|---|---|---|---|---|
| LR | q1 | qb | q1 | qb | q1 | qb | q1 | qb |
| 1 | 25.48 | 23.71 | −2.44 | −0.97 | −2.00 | −1.45 | −1.88 | −0.97 |
| 0.3 | 1.36 | 25.09 | 0.81 | −0.14 | 1.28 | −0.07 | 0.78 | −0.16 |
| 0.1 | 0.25 | 25.20 | 0.25 | −0.02 | 0.24 | 0.05 | 0.25 | 0.00 |
| 0.03 | 0.13 | 25.24 | 0.14 | −0.02 | 0.14 | 0.02 | 0.12 | 0.00 |
| 0.01 | 0.05 | 25.15 | 0.05 | −0.01 | 0.06 | −0.01 | 0.05 | −0.02 |
| 3–3 | 0.02 | 24.83 | 0.02 | −0.01 | 0.02 | −0.01 | 0.02 | −0.02 |
| 1–3 | 0.0387 | 24.620 | 0.0049 | 0.0053 | 0.0076 | −0.0002 | 0.0069 | −0.0212 |
| 3–4 | 0.0061 | 24.103 | 0.0015 | 0.0185 | 0.0020 | 0.0087 | 0.0021 | −0.0174 |
| 1–4 | 0.0003 | 24.028 | 0.0005 | 0.0272 | 0.0007 | 0.0232 | 0.0007 | −0.0077 |
| 3–5 | 0.0001 | 20.2245 | 0.0002 | 0.0292 | 0.0002 | 0.0323 | 0.0002 | 0.0039 |
| 1–5 | 0.0018 | 8.5857 | 0.0001 | 0.0071 | 0.0001 | 0.0095 | 0.0001 | −0.0050 |

*Source* Authors

$$S_1 \approx (1 - 0.0136) \cdot S_0 = 0.9864 \cdot S_0.$$

Negative numbers mean that at a given learning rate, the objective function does not decrease, but increases.

Table 2 shows that at the very beginning of training (Ep. = 0), with the correct choice of speed (LR), the training efficiency in both cases can be almost the same (≈24%). But if with the first method of training, the suboptimal speed sharply reduces the efficiency (25.48; 1.36; 0.25; …), then, when training in blocks, the efficiency is maintained at the same level enough for a wide range of changes in the learning rate (LR = 1, …, 3e − 5).

After 10.0.30 epochs (Ep. = 10, 30) the learning speed for a normal step should be reduced by about one or two orders, and in the case of block learning, the speed should be reduced even more.

At 100 epochs (Ep. = 100), block learning becomes chaotic, the objective function can either decrease or grow. If we are not satisfied with the accuracy achieved at this stage, we need to increase the block size.

Similar results were obtained during the experiment of training the ANN, which was planned to be used for predicting time series.

***Example 3*** For this purpose, data on weekly and daily prices on Brent and WTI crude oil from the EIA U.S. (Energy Information Administration) from 1987-05-20 to 2020-08-24 were taken from the source [13]. The analysis of the history of the time series showed that the daily data fluctuates too much, since they depend on many random factors, and are not given for all days in a row (for example, there is no data for weekends and holidays). Therefore, prices averaged by weeks were used for the analysis (as a result, we received data for 1737 weeks).

The forecast of the oil price for the next week is based on data on the price value for several previous weeks. The immersion depth of the time series was selected in the range from 5 to 15 weeks. Thus, we get a training matrix of 1730 rows (approximately) and 6–16 columns.

For approximation, we use a three-layer neural network with 5–15 input values (depending on the depth of immersion) and with an activation function $f(x) = \frac{1}{1+e^{-x}}$ (sigmoid) in the first two layers and a trivial function $f(x) = x$ in the output layer.

## 4 Discussion

In most works devoted to the training of neural networks [1, 9] it is proposed to set a small block size (usually several tens). Direct checks show that at the initial training epochs, this gives a much better network than when using large blocks on the same number of initial epochs. In [14], the effect of a decrease in the learning rate and an increase in the block size is compared. It is concluded that under certain conditions it is better to maintain the learning rate, but increase the block size.

According to the authors of the study [15], based on numerical experiments, it is concluded that for a certain class of neural networks, increasing the block size from several tens to several thousands or even tens of thousands significantly speeds up calculations, and the accuracy does not deteriorate.

In our work, we show that it is better not to fix the block size in advance, but to dynamically increase it, starting from a few dozen and up to the block size equal to the entire available training sample. However, at present, the training samples may be so large that they will not fit into random access memory. In this case, the maximum sample size should be determined only by the available amount of memory.

## 5 Conclusion

At the beginning of training a neural network, with a random choice of the initial approximation, it can be recommended to choose a block of the minimum size. Since the calculations in each block are accompanied by certain overhead costs, too small block size will also be inefficient. The optimal initial block size should be from several tens to hundreds. The initial learning rate should be as high as possible. If we assume that all the data on which the training takes place has the order of one, then it is best to take LR of the order of 0.1 m, where m is the dimension of the space, the number of trained parameters.

During the training process, it is recommended to increase the block size, and at the same time reduce the learning speed. If the target function has not decreased during several (three or-four) training steps, then the learning rate should be reduced, optimally—reduced by half.

To control the block size, it is needed to calculate the angle between the current offset direction and the previous one at each step. If for the last few (4–8) training steps this angle is on average more than 60° that is, the average value of the cosine of the angle is less than 0.5) then the block size should be increased, optimally twice. Of course, each step after that will take more time, but it is better to move slowly in the right direction than quickly and randomly in the wrong or just random direction.

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