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Spatial Development of the Industrial Complex in the Context of the Digital Transformation of the Economy

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***Abstract*—The article outlines the key vectors of the spatial development of manufacturing enterprises in the context of the digital transformation of the economy. The purpose of the article is to identify the main factors of innovative and digital development of the industrial complex and their contribution to the formation of the volume of products, goods and services. The method of correlation and regression analysis was used as economic and mathematical methods. As a result of the analysis, the dependence of the volume of shipped goods of own production by the type of economic activity "manufacturing" on such factors as investment in research and development, specific all organizations that carried out environmental, organizational and technical innovations was determined. Based on the results of economic and mathematical modeling, a business model "spatial development of an industrial complex in the context of digital transformation of the economy" is proposed, which is recommended for use in the development of management decisions aimed at increasing the efficiency of development of the country's industrial complex. The business model proposed in the work involves infrastructural support for the digital transformation of the economy, achieving compliance with user requirements, creating new competitive digital systems and integrating them with existing information bases.**

Keywords—innovation, spatial development, industrial complex, investment, manufacturing industries, digitalization, correlation-regression analysis.

I. INTRODUCTION

The strategy of spatial development of the Russian Federation until 2025 was approved by the order of the Government of the Russian Federation of February 13, 2019 No. 207-r [1]. The strategy defines the following directions for the development of the industrial complex: providing conditions for the development of industries in the branches of promising economic specializations of the constituent entities of the Russian Federation; ensuring the expansion of geography and acceleration of economic growth, scientific, technological and innovative development of the Russian Federation; formation and development of mineral resource centers; ensuring the improvement of the environment, preserving and restoring the biological diversity of the Russian Federation, cultural landscapes and reducing the negative consequences of climate change. The development of industrial digitalization implies the development of a network of storage and processing centers for large data arrays (data centers) in territories with a significant electric power surplus, the availability of the necessary information and telecommunications infrastructure, special natural and climatic conditions (low average annual temperatures) and facilitating the export of processing and data storage. The strategy is a defining trend in the integrated development of the Russian Federation, including industrial enterprises.

This study consists of two parts: the theoretical foundations of the study and the methodology for assessing the spatial development of the industrial complex in the context of the digital transformation of the economy

A significant number of works are devoted to the development of the industrial complex of the Russian Federation.

Misbakhova et al. [2] proposes an innovative production organization strategy for industrial enterprises, which is called "resource sharing". This strategy implies the cooperation of enterprises to jointly solve various problems in the field of digitalization of organizational and production processes, increase environmental efficiency, increase the competitiveness of products through the introduction of innovations, etc. The advantage of the strategy lies in the proportional division of costs for launching projects and, accordingly, profit based on results implementation of projects.

Melnik et al. [3] examines the development of an industrial complex through the prism of the concept of sustainable development. An important component of the spatial development of an industrial complex is to increase their energy efficiency. Malysheva et al. [4] explores the possibilities of increasing the energy efficiency of enterprises

at the sectoral level. The creation of digital ecosystems is being addressed by Shkarupeta et al. [five]. It is assumed that they will be based on the model of open innovation, as part of the development of global cooperation.

Optimization of the organization of production processes with a resource-saving focus is in the area of scientific interests of Shinkevich et al. [6,7].

In addition, the development of industry within the framework of the Industry 4.0 concept, which is presented in a wide number of works by scientists from different countries, is of particular interest [8-13].

Thus, a large number of studies have been devoted to the problems of the spatial development of the industrial complex, but insufficient attention is paid to modeling the development of the industrial complex in the context of the digital transformation of the economy, which determines the choice of this topic.

II. METHODS

As a research method, correlation analysis was used, which made it possible to identify the dependence of the resulting variable characterizing the level of development of the industrial complex of the Russian Federation and independent factors of a digital and innovative nature. Regression analysis was used to identify the degree of influence of the obtained independent factors and to build a medium-term forecast. In addition, the work proposes a business model "spatial development of an industrial complex in the context of digital transformation of the economy".

To build an economic and mathematical model of the impact of digitalization and innovation on the level of development of industrial production in the Russian Federation, we use correlation and regression analysis. As a resultant variable characterizing the level of industrial production, let us take the indicator Volume of goods shipped of own production, works and services performed on our own (trillion rubles) by type of economic activity "manufacturing". Based on a preliminary correlation analysis, a list of factors characterizing digital and innovative development by the type of economic activity "manufacturing" was determined - internal costs for research and development, million rubles; share of organizations implementing environmental innovations,%; the proportion of organizations that have carried out organizational innovations,%; share of organizations implementing technological innovations,%; share of organizations with a website,%. The dynamics of indicators characterizing the development of the industrial complex in the context of digital transformation of the economy is presented in Figure 1,2. Calculations were carried out according to Rosstat data [14].

In order to model the management of the development of an industrial complex in the context of the digital transformation of the economy, it is necessary to assess the key factors.

We will diagnose the state of the industrial complex in the context of digital transformation and determine the development prospects.

The indicator "the volume of shipped goods of own production, works and services performed on their own (trillion rubles)" is a resulting variable characterizing the level of development of the industrial complex of the Russian Federation. In 2010-2019. there is a positive dynamics of the indicator, despite the unstable economic and political situation in the world and in the Russian Federation during these years. So, in 2019 compared to 2010, production volumes increased 2.3 times and amounted to 43856.7 trillion. rubles.

Consider the explanatory variables of the economic and mathematical model that characterize the digital and innovative development of enterprises of the type of economic activity "manufacturing". Such development is impossible without spending on research and development, which is obvious for the industrial enterprises themselves. Thus, research costs increased 5.5 times in the period under review and in 2019 amounted to 117.3 billion rubles (Fig. 1).

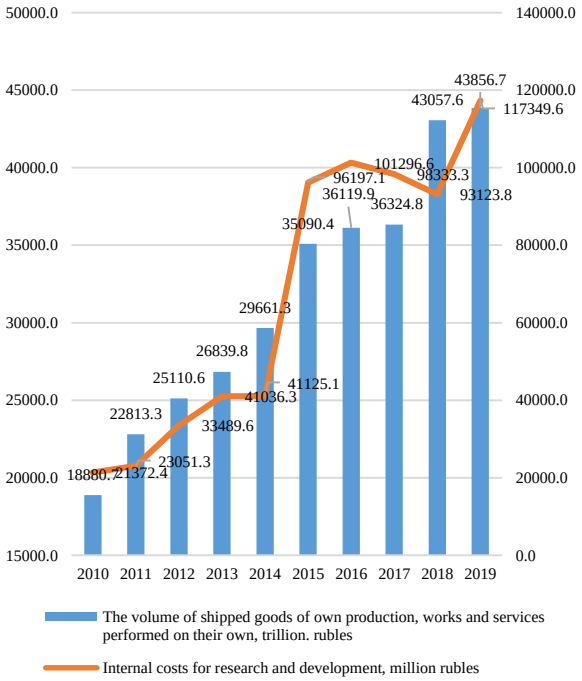

Fig. 1. Dynamics of indicators "volume of shipped goods of own production, works and services performed on their own (trillion rubles)" and "internal costs of research and development, million rubles" in 2010-2019 [14]

Moreover, spatial development implies a balance of environmental, organizational and technological innovation. The share of organizations engaged in technological innovations increased from 11.3% in 2010 to 18% in 2019.However, in the period under review, the share of enterprises engaged in organizational innovations decreased (in 2019, the indicator was 3.3%, which is 0.7% below the 2010 level) and environmental innovation (1.7% in 2019, 4% below the 2010 figure).

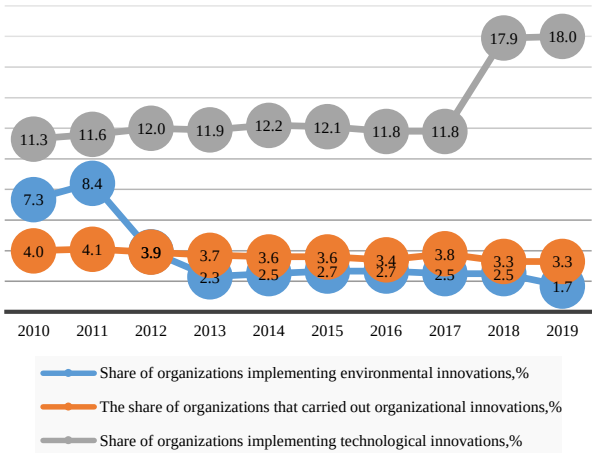

Fig. 2. Dynamics of indicators of the share of organizations that carried out environmental, organizational and technological innovations in 2010-2019.

In 2010-2019. the proportion of organizations with a website increased by 1.8 times and in 2019 amounted to 51.9%. This indicates the development of digitalization in the field of marketing and sales of industrial products.

III. Main Part

Evaluation of the dynamics of the indicators of the economic and mathematical model made it possible to identify negative trends in the decline of indicators important for the industry, such as the proportion of organizations that carried out environmental and organizational innovations. We use these factors to build an economic and mathematical model of industrial development, on the basis of which the business model "Spatial development of an industrial complex in the context of digital transformation of the economy".

Economic and mathematical modeling is an integral part of industrial enterprise management. The positive developments in mathematical analysis, operational research and analysis, probability theory and mathematical statistics have influenced the development of various economic models.

TABLE I. Results of correlation analysis (compiled by the author based on data [14])

	Y	**X1**	**X2**	**X3**	**X4**	**X5**
Y	1					
X1	0,94	1				
X2	-0,75	-0,70	1			
X3	-0,89	-0,80	0,80	1		
X4	0,76	0,57	-0,42	-0,73	1	
X5	0,95	0,87	-0,72	-0,79	0,78	1

In order to model the management of the development of an industrial complex in the context of the digital transformation of the economy, it is necessary to assess the key factors.

Consequently, the obtained correlation model can be used to predict the dependent variable - the volume of shipped goods of own production, work and services performed on their own, trillion. rubles. It should be noted about the identification of some contradictory patterns. So, the following independent variables have a positive effect on the growth of the resulting indicator - internal costs for research and development, million rubles (rx1 = 0.94); the share of organizations implementing technological innovations, % (rx4 = 0.76); the proportion of organizations that had a website,% (rx5 = 0.95), which is quite logical and reflects the modern economic policy of the state. Thus, the given development vectors should be supported.

$$Y = 27214{,}4+0{,}1*X1-147{,}2*X2-5157{,}8*X3+473{,}2*X4+289{,}7*X5,$$

where Y is the volume of shipped goods of own production, works and services performed on their own, trillion. rubles;

X1 – internal expenses for research and development, million rubles;

X2 – proportion of organizations that have carried out environmental innovations,%;

X3 – proportion of organizations that have carried out organizational innovations,%;

X4 – share of organizations that have carried out technological innovations,%;

X5 – proportion of organizations with a website,%.

At the same time, a negative impact on the dependent variable of the following indicators was noted - the share of organizations that carried out environmental innovations,% (rx2 = -0.75); the share of organizations that have carried out organizational innovations,% (rx3 = -0.89). The negative impact of these indicators is explained by their negative dynamics in the period under review, which indicates that it is necessary to revise the economic policy aimed at developing the greening of the industry, taking into account the optimization of organizational structures.

As a result, we received a protocol for performing regression analysis, which reflects the main results of the calculations. The protocol is shown in Figure 3. Let's consider its content.

Regression statistics					
Multiple R		0,989			
R-square		0,978			
Normalized R-square		0,950			
Standard error		1891,096			
Observations	10				
ANOVA					
	df	*SS*	*MS*	*F*	*Signifi-cance F*
Regression	5	629343054	12586861	35,19	*0,002113*
The remainder	4	1430498 3,3	3576245,8		
Total	9	643648037			

Fig. 3. Results of checking the adequacy of the resulting model (compiled by the author based on data [14])

Let's check the adequacy of the proposed economic and mathematical model.

1) The coefficient of determination was 98%, which suggests that a 98% change in the volume of shipped goods of own production, works and services performed on their own, million rubles for the type of activity "manufacturing" is

explained by the independent variables included in the model - internal costs for research and development, million rubles; share of organizations implementing environmental innovations,%; the proportion of organizations that have carried out organizational innovations,%; share of organizations implementing technological innovations,%; share of organizations with a website,%.

2) P-value less than 0.05 indicates the statistical significance of the obtained coefficients of the regression model

3) Fisher's criterion also speaks about the adequacy of the regression equation, since its p-value was 0.0021 (less than 0.05).

Using trend lines for independent variables, we will construct a forecast of the volume of shipped goods of our own production, work performed and services performed on our own by the type of economic activity "manufacturing" for 2020 (Figure 4). According to this forecast, it is expected that the volume of production will increase due to digital development by 7.2% and in 2020 will amount to 47012 trillion. rubles.

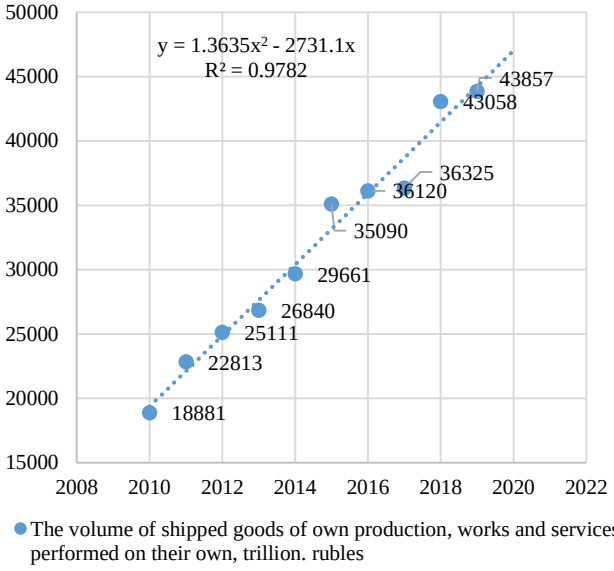

Fig. 4. Forecast of the volume of shipped goods of own production, works and services performed on their own by type of economic activity "manufacturing" for 2020 (compiled by the author based on data [14])

IV. Conclusion

Despite the variety of technological processes of industrial enterprises, their scale, types of products, etc., they all have common properties, namely: they are structurally complex, consisting of separate parts; consume large amounts of energy resources and are connected with other neighboring industries. The peculiarity of the production complex is the multi-connectivity of its elements with a relatively large number of individual types of raw materials, intermediate products and energy carriers. At the same time, industrial enterprises are both large consumers of various types of energy and its producers.

Manufacturing enterprises consist of the following subsystems:

- supply of auxiliary materials;
- power supply;
- main production;
- auxiliary and service industries;
- transport and storage infrastructure;
- disposal and recycling of waste.

The elements of production are connected with each other and the environment by transportation subsystems, and also contain subsystems for storing raw materials, products, etc. have a powerful logistics infrastructure that has its own specific specifics. The elements of the logistics system are characterized by subsystems with a large unit capacity, which can reduce the volume of investments in industrial installations. At this level, the following important tasks are solved (due to the strong connectivity of the subsystems):

- optimal distribution of enterprise resources;
- optimization of the capacities of new subsystems;
- the time of their commissioning;
- selection of the type of technology for the production of new products.

According to the obtained forecast, along the trend lines, an increase in the volume of shipped goods of its own production, work performed and services performed on its own by the type of economic activity "manufacturing" for 2020 is expected. To achieve this goal, a business model "Spatial development of an industrial complex in the context of digital transformation of the economy ".

<table>
<tr><td rowspan="2">Partners
State regulation: Relevant ministries and departments

Enterprises and organizations of the industrial complex, IT-sphere, science and education</td><td>Activities
study of the experience of spatial development of the industrial complex; infrastructural support for digital transformation of the economy; achieving compliance with user requirements</td><td>Interaction
ensuring coordinated actions of federal executive authorities, state authorities of the constituent entities, local governments, subjects of natural monopolies to implement the priorities of spatial development</td><td rowspan="2">Target customer groups:
enterprises and organizations of the industrial complex, population, leadership of the subjects</td></tr>
<tr><td>Key Resources:
specialists in the development of innovative infrastructure</td><td>Sales channels:
Media, regulation and regulation</td></tr>
<tr><td colspan="3">Cost structure:
Creation of infrastructure and projects in the field of digitalization and spatial regulation of the industrial complex</td><td>Income structure:
Increasing the competitiveness and profitability of industrial enterprises</td></tr>
</table>

Fig. 5. Business model "Spatial development of the industrial complex in the context of digital transformation of the economy (compiled by the author based on data [1])"

Business model value proposition:

- providing conditions for the development of industries in the branches of promising economic specializations of the constituent entities of the Russian Federation;
- ensuring the expansion of geography and acceleration of economic growth, scientific,

technological and innovative development of the Russian Federation;
- formation and development of mineral resource centers;
- ensuring improvement of the environment, conservation and restoration of the biological diversity of the Russian Federation, cultural landscapes and reduction of negative consequences from climate change.

This model assumes state regulation of the spatial development of the industrial complex by relevant ministries and departments and their close cooperation with enterprises and organizations of the industrial complex, IT-sphere, science and education. Their activities will be aimed at studying the experience of the spatial development of the industrial complex; infrastructural support for digital transformation of the economy; achieving compliance with user requirements, creation and integration with existing digital systems.

Thanks to the available knowledge, experience and organizational and technical resources, industrial enterprises are able to produce products and services of any complexity and with a quality that meets international standards. In Russia and abroad, Russian industrial enterprises have a reputation as a reliable partner oriented towards long-term cooperation and maintaining close business relations with each of their partners and clients.

Modern organizational management structures and a project-based approach to solving non-standard tasks allow enterprises to adequately respond to the challenges of the market.

The peculiarity of the organizational principle lies in the division of management functions into two components: management of core activities (services, works, technologies, etc.) and resource management (personnel, material resources, financial flows, etc.) between, respectively, functional and administrative directions.

The functional areas include all operational divisions (sales, forwarding and customs clearance of goods) and divisions that ensure the conduct of core activities (transport, finance, personnel, legal support). The service (support) divisions include personnel records management, document management and administrative support. Areas of activity are structurally assigned to services and departments.

Problems of industrial enterprises:
- shortage of production and warehouse space;
- high dependence on the customer for finished products;
- high rhythm of production;
- lack of automated technologies for managing the warehouse and production complex;
- lack of an integrated performance assessment system using a balanced scorecard;
- uneven workload of production personnel;
- lack of cost accounting for logistic functions.

To assess the quality of using the business model "spatial development of the industrial complex in the context of digital transformation of the economy" it is proposed to analyze the efficiency of enterprises in 5 projections, assessment of the quality of:
- production management and inventory management of the enterprise;
- manufactured products;
- technical equipment of the enterprise;
- the logistics system;
- personnel management.

An analysis of the production activities of an enterprise based on a balanced scorecard allows identifying problem areas with the aim of more targeted and targeted application of the business model. Let's highlight the main stages of the business model implementation:

1. Evaluation of the balanced scorecard in 5 enlarged groups.
2. Identification of problem areas of production activities of the enterprise based on the results of a comprehensive assessment.
3. Elimination of problems of the enterprise through the use of appropriate tools of the business model.
4. Monitoring the effectiveness of the implementation of the proposed measures.

The stimulation of the development of promising economic specializations of the constituent entities of the Russian Federation stipulated by the Strategy will be carried out through [1]:
- creation of a new mechanism for the development of territories (investment sites) with a special mode of doing business, taking into account the promising specializations of the constituent entities of the Russian Federation and other features of the territories;
- development and approval of the procedure for the implementation of priority investment projects, including requirements for the composition and content of agreements on the implementation of such projects, the rights and obligations of project participants;
- development and approval of a methodology for assessing the effectiveness of tax benefits provided to manufacturers of products in accordance with promising economic specializations of the constituent entities of the Russian Federation, for regional and local taxes, as well as federal taxes in the part credited to regional and local budgets for the purpose of accounting for them when providing subsidies from the federal budget to equalize the level of budgetary provision of the constituent entities of the Russian Federation;
- development and approval of methodological recommendations for the determination by the constituent entities of the Russian Federation of priorities for the innovative development of branches of promising economic specializations ("smart specialization").

Thus, the proposed business model will provide conditions for the development of industries in the industries of promising economic specializations of the constituent entities of the Russian Federation and can be used in the development of management decisions aimed at increasing the efficiency of the spatial development of the industrial complex in the context of digitalization.

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