внедренная эффективная система управления, которая нацелена на обеспечение информационной поддержки принимаемых управленческих решений.

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ANALYSIS OF THE INFLUENCE OF A TECHNOLOGICAL FACTOR ON THE DEVELOPMENT OF THE INDUSTRIAL SECTOR IN RUSSIA AND THE FEDERAL DISTRICTS

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Abstract. This article addresses the problem of the transition of the Russian economy to an innovative path of development, in this regard; the task is to identify factors that can increase the efficiency of the industrial sector in conjunction with the introduction of innovative technologies in the production process. The methodology for constructing production functions taking into account traditional factors and an innovative indicator for Russia and eight federal districts was applied.

Keywords: industry; new economy; development factors; innovations; production functions

In modern conditions of the global economic order large-scale technological shifts are taking place. The constant increase in the cost of natural resources, caused by the exhaustion of their reserves, determines the achievement of high final results not by increasing the consumption of the resources involved in the production of these resources, but by accelerating scientific and technological progress. The intensification of economic processes covering the activities of business entities and limited resources for extensive growth, determine the need for a transition to an innovative type of development that allows for sustainable functioning through the effective use of scientific and technological potential [1, p. 14].

The main reason for such transformations lies in the fact that elements of a new economic (neo-economic) system, in which innovation is a key factor for growth, are gradually being introduced into established traditional economic models focused on resource-intensive production [15, p. 44]. The concept of neo-economics is based not on the extensive consumption of exhaustible natural reserves, but on the involvement of intellectual capital in business processes, since the needs of society are dictated by a reorientation to the realization of individual interests, expectations and needs through the consumption of unique modern products.
The influence of innovative ideas on the economic environment provides the formation of a symbiosis of high-quality interaction of engineering and technology, economic relationships and forms, institutional and social ties. The synergistic effect of this effect is reflected in the acceleration of productivity growth rates, which entails a change in certain macroeconomic parameters, in particular, in the formation of gross domestic product. Most Western and Asian countries that are imbued with the ideas of neo-economics and have changed their development guidelines for the transition to a post-industrial and information society, are currently demonstrating a steady economic recovery.

However, in Russia, the prospects for using modern innovative technologies in existing realities are difficult due to the ambiguous business climate and problems in the research field; the national economy is weakly susceptible to high-tech industrialization, which is due to the low share of allocations to science and education [14, p. 62]. In the context of the functioning of the new economy, the intensification of innovation is manifested in the form of an increase in research and development costs. In accordance with the histogram in Figure 1, according to the indicator of expenditures allocated from GDP for research and development on average from 17 years, Russia is noticeably inferior not only to countries similar in territorial scales (China, USA), but also to small states, being on par with Hungary and Italy.

In many respects, the issues of creating our own competitive high-tech industrial products are especially significant in the face of the unfavorable external situation that has developed as a result of economic sanctions against Russia. In this regard, the task aimed at determining the directions of innovative development and identifying opportunities for business entities to produce competitive products, ensuring the achievement of industrial growth, is becoming increasingly relevant.

![Figure 1](image)

**Figure 1 – The average share of domestic research and development costs in gross domestic product from 2000 to 2017 years, %**

*Note:* calculated by the author on the basis of information from Rosstat [10-12].

The main indicator reflecting the state of development of the industrial sector in Russia is the industrial production index. The graph (Figure 2) shows that significant fluctuations are observed in the dynamics of the index. Since 2000 year, a two-year decline follows, but in 2003 year the index reaches its maximum mark for the entire time range – 109%. Further, after minor changes, in 2008–2009 years a powerful failure is formed, which was corrected next year. However, after 2010 year, the dynamics of the index began to decline steadily again, and since 2016 year, it has been characterized by stable volatility, which reflects a general slowdown in the growth rate of industrial production.

A characteristic feature of the Russian industrial sector is the uneven development of the industrial structure of industrial products, which has undergone significant changes over 18 years. In 2000 year, the leading industries were fuel, machine-building and metal-working – 19.7% and 20.3% of the total output structure.

By the end of 2018 year, the specific gravities of these industries increased to 21.6% and 21.8%. It is also worth noting the high growth rate of the share of the chemical and petrochemical industries – from 6.9% to 22.7%. At the same time, a number of industries recorded a decrease in concentration in the country's gross output. The share of the food industry decreased to 9.6% (the level of 2000 year was 15.2%), in the electric power industry – to
8.1% (10.4%), in the production of textiles and clothing – to 0.6% (1.6%), in the extraction of metal ores and other minerals – up to 2.5% (8.2%).

Considering the situation with the industrial sector of Russia, one should pay attention to the situation in its federal districts, where not only the dynamics of the industrial production index, but also the total gross output is the main indicator of the scale of production activity. This indicator from 2000 to 2018 years in the federal districts there is a significant differentiation. The lowest volumes of industrial production were recorded in the North Caucasus, Southern and Far Eastern Federal Districts, which together account for about 11% of Russian production. The most industrially developed can be considered the Central, Volga and Ural federal districts, providing approximately 66% of the total. Nevertheless, the industrial production index in these federal districts is quite low, while the values of this indicator in the federal districts with weak industrial development are the highest.

Despite the federal government in Russia the experience of developing and implementing regional policy measures aimed at supporting regions with a low level of industrial development is poorly adapted. Most preference is given to regions with a single-industry economy and the presence of vertically integrated corporations. This situation causes a high degree of territorial inequality and contradicts the features of neo-economics aimed at transforming established phenomena and ensuring the processes of modernization and the technological revolution in industrial sectors. Overcoming the inequality between territorial entities and eliminating the inhibition of the level of industrial development should be ensured by increasing their intellectual and production-technological potential. Based on this hypothesis, the task of identifying the optimal combination of factors that can ensure that the industrial sector achieves the final result obtained by effectively introducing innovations in conjunction with other factors of production becomes relevant.

To solve this problem, the author implemented an approach based on the use of the apparatus of production functions in order to build models describing the dependence of gross output of industrial products on the main factors of production and the indicator of innovation. The introduction of a scientific and technical indicator as an independent factor in the production function is explained by the impact of this resource on the efficiency of the production cycle, the ability to influence the intellectual level of development of labor personnel and opens the way to assessing the contribution of innovation to industrial growth.

The time range of the study was 18 years (2000–2018). The initial statistics were the main indicators of continuous monitoring of the activities of enterprises and organizations of the manufacturing sector in Russia and 8 federal districts, officially published in Rosstat sources [5-9]. The preparation of the information base and the processing of statistical information were carried out in the Microsoft Excel environment, and the computational procedures were performed using EViews 6.0.

The econometric expression of the dependence of gross industrial output on the studied factors was calculated in two variants. In the first variant, one of the three arguments involves an indicator of the value of fixed assets. In the second variant, this argument is replaced by the indicator of investment in fixed assets [2, p. 51]. Such a technique will reveal the degree of impact on the dynamics of the release of these factors in combination with the
innovative component, which are important for industrial development. The proposed production functions are power multiplicative and are presented in the form of the following models:

\[ Y = K^\alpha \cdot I^\beta \cdot T^\gamma, \]
\[ Y = I^\alpha \cdot L^\beta \cdot T^\gamma, \]

where: \( Y \) – gross industrial output, million rubles; \( K \) – the cost of fixed assets, million rubles; \( I \) – investments in fixed assets, million rubles; \( L \) – average annual number of employees, people; \( T \) – costs of technological innovation, million rubles; \( \alpha, \beta, \gamma \) – coefficients taking into account the influence of factors included in the model on gross output.

In the proposed econometric models, there is no factor taking into account the influence of technological progress (Solow residual), which is usually used in the Cobb-Douglas classical production function to assess the qualitative changes in labor and capital [2, p. 22; 13, p. 56]. Elimination of the total factor productivity in the construction of these dependencies is explained by the goal of introducing the technological factor (innovations) into the production functions and evaluating their role in the formation of industrial output. The initial statistical indicators used in the construction of production functions, expressed in monetary terms at current prices, have been translated into comparable constant prices. For this purpose, conversion factors were calculated taking into account consumer price indices and 2000 was chosen as the base year. To evaluate the parameters of the models, all variables were subjected to the linearization procedure.

The calculations were carried out in accordance with the implementation of two options (taking into account different factors of production) in Russia and eight federal districts. As a result, 18 alternative production functions were obtained that reflect the dependence of gross industrial output on the proposed factors, the results of which are presented in table 1.

According to the data in table 1, all econometric models turned out to be statistically significant and adequate, as evidenced by high indicators of the coefficient of determination (\( R^2 \)) and Fisher statistics. However, the values of the average error of approximation (\( \sigma \)) calculated for each model in most cases exceed the permissible threshold of 12-15%, which indicates the significance of the average deviation of the calculated and actual data in the models.

Table 1 – Assessment of the statistical significance of the parameters of production functions and the results of verification of their quality

| Production function | \( R^2 \) | \( F \) | Significance of indicators | \( \sigma \) |
|---------------------|--------|--------|-----------------|--------|
| \( Y_{RUS} \) = \( K^{0.655} \cdot L^{0.322} \cdot T^{0.209} \) | 0.9999 | 6446.7 | 1.3493 | 0.7308 | 0.7006 | 11.5 |
| \( Y_{CEN} \) = \( K^{0.749} \cdot L^{0.539} \cdot T^{-0.169} \) | 0.9811 | 277.50 | 3.8780 | -1.1268 | -0.3476 | 14.9 |
| \( Y_{NOW} \) = \( K^{0.692} \cdot L^{0.190} \cdot T^{0.179} \) | 0.9877 | 429.19 | 5.3541 | 2.1517 | 0.9987 | 9.14 |
| \( Y_{SOU} \) = \( K^{0.640} \cdot L^{0.213} \cdot T^{0.202} \) | 0.9775 | 232.09 | 2.9027 | 1.5491 | 0.8635 | 15.9 |
| \( Y_{NOC} \) = \( K^{0.855} \cdot L^{0.057} \cdot T^{0.093} \) | 0.9899 | 524.71 | 5.1993 | 0.0335 | 1.0451 | 9.72 |
| \( Y_{VOL} \) = \( K^{0.563} \cdot L^{0.199} \cdot T^{0.322} \) | 0.9810 | 275.74 | 2.1656 | 0.8089 | 1.9776 | 13.5 |
| \( Y_{URA} \) = \( K^{0.383} \cdot L^{0.330} \cdot T^{0.392} \) | 0.9849 | 347.89 | 1.2150 | 2.7808 | 2.4349 | 11.6 |
| \( Y_{SIB} \) = \( K^{0.162} \cdot L^{0.560} \cdot T^{0.366} \) | 0.9839 | 326.70 | 3.6576 | 0.4517 | 0.0483 | 11.9 |
In production functions that take into account fixed assets \((K)\), the coefficient of elasticity \(\alpha\) is the most significant (with the exception of the Ural and Siberian federal districts), which is confirmed by the values of the Student criterion. However, the inclusion of a technological factor \((T)\) in some cases reduces the rate of return of coefficient of elasticity \(\beta\). This feature is observed in the models of the North Caucasus, Volga and Ural federal districts. In Russia, as well as in the Central, North-Western, Southern, Siberian and Far Eastern federal districts, a combination of factors \(K\) and \(L\) plays a more prominent role for industrial development. However, in the above federal districts (except for the Central and Far Eastern), the influence of the innovation component is not much inferior to the labor factor, and in the Ural and Siberian federal districts it is dominant among other factors.

The production functions from the second part of table 1, taking into account investments in fixed assets \((I)\), indicate that the impact of this factor on gross output is less pronounced than that of fixed assets. This conclusion is confirmed by the elasticity of the coefficients \(\beta\) and \(\gamma\), demonstrating the contribution of labor \(L\) and innovation \(T\), the values of which are significantly higher than the coefficients \(\alpha\), which can be clearly seen in the models for Russia and a number of federal districts. Only in the Volga and Far East federal districts, the elasticity of output on investments in fixed assets exceeds other indicators, and in the Central federal district is higher than the labor factor, but lower than the technological one.

An analysis of the models made it possible to establish that, regardless of combinations of the main factors, in Russian industry from 2000 to 2018 years the technological factor also occupied an important position in the formation of gross output, the elasticity of which in both cases was 0.209 and 0.641. That is, an increase of this factor by 1% contributed to the growth of output by 0.21% and 0.64%.

In federal districts a slightly different situation is observed. According to the models of the first variant, the influence of the technological factor is less significant, the coefficient of elasticity ranges from -0.01 to 0.39. Perhaps this effect is associated with a stronger dependence of gross output on traditional factors, while an increase in the cost of technological innovation does not provide a significant increase in output. The total coefficients of

| \(Y_{FAE} = K^{0.780} \cdot L^{0.232} \cdot T^{-0.054}\) | 0.9903 | 542.31 | 10.523 | 4.8934 | -1.4390 | 7.59 |

**Variant II**

| \(Y_{RUS} = I^{-0.133} \cdot L^{1.057} \cdot T^{0.641}\) | 0.9999 | 5894.3 | -0.5421 | 3.7731 | 7.1195 | 12.1 |
| \(Y_{CEN} = I^{0.389} \cdot L^{0.367} \cdot T^{0.411}\) | 0.9702 | 173.45 | 1.9026 | 1.0475 | 4.7712 | 18.1 |
| \(Y_{NOW} = I^{-0.263} \cdot L^{0.740} \cdot T^{0.647}\) | 0.9683 | 162.91 | -1.1376 | 2.9884 | 6.9090 | 11.9 |
| \(Y_{SOU} = I^{0.148} \cdot L^{0.513} \cdot T^{0.483}\) | 0.9690 | 166.56 | 1.2978 | 4.2312 | 5.9225 | 17.8 |
| \(Y_{NOC} = I^{-0.013} \cdot L^{0.728} \cdot T^{0.282}\) | 0.9731 | 192.97 | -0.3154 | 4.2356 | 3.7615 | 13.1 |
| \(Y_{VOL} = I^{0.502} \cdot L^{0.362} \cdot T^{0.276}\) | 0.9796 | 256.70 | 1.8133 | 2.1799 | 1.6624 | 13.7 |
| \(Y_{URA} = I^{0.048} \cdot L^{0.479} \cdot T^{0.675}\) | 0.9837 | 321.05 | 0.3852 | 2.2146 | 6.8255 | 12.8 |
| \(Y_{SIB} = I^{0.045} \cdot L^{0.640} \cdot T^{0.424}\) | 0.9718 | 183.48 | 0.8401 | 3.3151 | 5.8791 | 12.2 |
| \(Y_{FAE} = I^{0.810} \cdot L^{0.181} \cdot T^{0.151}\) | 0.9602 | 128.64 | 3.8733 | 0.1989 | 1.5826 | 15.6 |
elasticity of factors $K$, $L$ and $T$ for all federal districts included in the sample, are 4.824, 1.242, and 1.329. Thus, industrial development according to the first variant is labor-saving (intensive) nature.

The situation is different in the models of the second option, in which there is a more significant impact of innovation, as evidenced by elasticity factors ranging from 0.15 to 0.68. Probably, the economic activity of enterprises is still largely oriented towards the partial mechanization of the production process and the greater number of workers involved in it; while there is a gradual replacement of physical labor by means of automation of production, which adequately corresponds to the main directions of scientific and technological progress and the transition to an innovative development path [3, p. 21]. In aggregate, the elasticity factors $I$, $L$ and $T$ are 1.666, 4.008 and 3.348, which allows us to make a statement about the capital-saving (extensive) phase of industrial growth.

The study made it possible to establish that the increase in the efficiency and productivity of the industrial sector of Russia is largely due not only to the influence of the main production factors (material base, investment, labor), but also based on interaction with scientific and technological (innovative) resources. The obtained coefficients of production functions revealed a serious impact on the industrial output of the indicator of internal costs for technological research and development. The established relationship between the technological factor and the development of the industrial sector is explained by the gradual transition of the Russian economy to a revolutionary form of scientific and technological progress, which dictates the development and implementation of fundamentally new techniques and technologies based on scientific ideas in the production process. It is not enough attention to scientific development, or its complete absence, entails the use of obsolete technologies and equipment that are not able over time to meet the requirements for production that increase, which ultimately leads to a decrease in its efficiency. A key element is the reduction of time between the development and implementation of new technologies in the production process, since the life cycle of the used innovative inventions requires constant updating with more advanced intelligent products. The results obtained on the state and prospects of industrial production in Russia in the context of the transition of the national economy to an innovative path can help increase the efficiency of implementing state projects, programs and development strategies for this sector.

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