

# Factor Analysis of the Knowledge Intensity of the Invested Capital of Russia by Filatov's Methods

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**Abstract.** The basic tool for a comprehensive analysis of economic activity is the factor analysis. The main attention in the factor analysis is paid to the study of internal causes that form the specificity of the studied phenomenon; the identification of generalized factors that are behind the corresponding specific indicators. Functional analysis is aimed at identifying the impact of individual factors on the performance indicator, so deterministic modeling of factor systems is a simple and effective means of formalizing the relationship of economic indicators, which serves as the basis for quantitative assessment of the role of individual parameters in the dynamics of changes in the generalizing indicator. The article deals with the analysis of the knowledge intensity of the invested capital of the Russian Federation. The author introduced into scientific circulation indicators: knowledge intensity of invested capital, knowledge intensity of gross regional product and investment efficiency of gross regional product. The article reveals the influence of factors affecting the change in the science-intensive invested capital of the Russian Federation and provides methodological approaches to its calculation. The article presents the author's analytical, systematic statistical material for the analysis of key indicators revealing the impact on the change in the scientific capacity of the invested capital of the Russian Federation. Based on the data on the factor analysis of the knowledge intensity of the invested capital of the Russian Federation, the article draws conclusions about the state of the country's economy and proposes a way to improve the economic situation in the country.

## 1. Introduction

The last decade of the twentieth century was marked by fundamental changes in the international economic system that took place against the backdrop of global political and technological changes. The development of high technologies in industry and the production of fundamentally new high-tech products have become key factors of sustainable economic growth for the majority of industrialized countries. State, managed to reorient their economic system on the production of knowledge, development of technologies and production of high-tech products occupy a leading position in the world and provide a high level of well-being of its citizens (Sadovskaya, T. G., Dadonov V. A., & Drogovoz P. A., 2006).

For the evaluation of objects and events, there are a large number of characteristics and parameters. One of them is the technology. This is a parameter that is used in production in product development and engineering. Knowledge-intensive technologies imply investment in research to obtain results.

It is known that science intensity is one of the leading factors of competitiveness of products. This is due to the activity of innovation. As a result, science has become not just one of the production re-

sources, but also a key factor in economic growth.

The emergence of the category of «science intensity» is the result of the natural evolution of technological development, and, as noted in studies of problems of technical, economic and technological development, explicitly or implicitly there is a functional relationship between the cost of the development of science and scientific and technical level of products (Bazhanov, V. A., & Denisova, K. V., 2011).

## 2. Problem Statement

In today's conditions, science-intensive production is the engine of the world economy. Thanks to the orientation of transnational corporations to the creation, development and introduction of high technologies, efforts are being made to carry out a technological leap or a progressive transition to a new stage of development of the world economy.

The development of knowledge-intensive production actively affects the technical level of enterprises in all sectors of the economy contributing to the renewal of production facilities through the introduction of new technologies, the use of modern materials with improved properties, product renewal and improvement of its technical and economic characteristics. In addition, it improves the standard of living of the population by increasing productivity, improving the efficiency of the use of irreplaceable natural resources, reducing relative consumption and improving the quality of life (Dmitrievskij, B. S., 2006). As a result, the analysis of the knowledge intensity of the invested capital of the country is particularly relevant.

## 3. Research Questions

The modern stage of world economic development is characterized by accelerated rates of scientific and technological progress and increasing intellectualization of the main factors of production (Trott, P., 2002). Intensive research and development on their basis of the newest technologies, to take them to world markets and the deployment of international integration in scientific and industrial sector in the emerging global economy, in fact, already become a strategic model of economic growth for major developed countries (Rugman, A. M., & Hodgetts R. M., 2003).

Currently, advanced or improved technologies, equipment and other products containing new knowledge or solutions account for 70 to 85 % of gross domestic product growth in these countries. They concentrate more than 90 % of the world's scientific potential and control 80 % of the global high-tech market.

In the modern world, there is a new rise of interest in understanding and assessing the role of the scientific and technological factor in the process of economic development. This is primarily due to the rapid development of science in the last century, and, above all, the spread of the information revolution, which has fundamentally changed the face of the modern economy, the aggravation of global competition in the markets of high-tech products, uneven economic growth in individual countries, etc. According to expert estimates, in industrialized countries such as the United States or Japan, the growth of gross domestic product by 75-85 % is achieved due to the scientific and technical sphere, the intellectualization of the main factors of production (Ogoleva, L. N., 2015).

Today, more than ever, intellectual resources, along with the territory, population, mineral wealth, resource-saving and environmentally friendly technologies of the diversified industry, form the potential for economic growth, determine the standard of living, provide world leadership, serve as an indicator of the strategic level of the country's economic power, its national status. It is no accident that by the end of the XX century R & d expenditures in the world reached a huge amount (Ogoleva, L. N., 2015).

Japanese researchers K. Hashimoto and A. Minoue note that, since the 1960s at the macro level, the growth of Japan's gross domestic product by 54 % was provided by the introduction of science and technology. Japan in the period 1960-1995 was characterized by a high share of expenditure on science in GDP, which increased from 1.11 to 2.98 %. The share of expenditure on science in the state budget during this period was at the level of 3.5–4 %. An example of the fact that economic growth

closely correlates with the process of scientific and technological development is the fivefold increase in GDP in the 1980s in the economies of the «Asian tigers». South Korea, Taiwan, Singapore, Hong Kong have increased the knowledge intensity of gross domestic product by one and a half to two times and approached the indicators of European countries, and South Korea has already reached the us level (Ogoleva, L. N., 2015).

In the mid-1990s, some newly industrialized countries were significantly ahead of economically developed countries in terms of R & d costs. Taiwan can be considered an absolute leader. Its research and development spending during this period grew by 17 % per year in real terms. In second place – Korea (growth of 12 %). During this period, R & d spending in France and Germany grew by 2 % per year, in the US – by 0.6 %.

In the last decade, China has been an example of economic growth through the development of new and high technologies. It is for this purpose that the Shenzhen economic zone was created. The percentage of high-tech products in the gross industrial product increased from 8.1 to 35.4%. Considering the experience of the aforementioned countries, it is particularly noteworthy that the sustainable economic growth potential in these countries were formed on the updating of the structural-technological base of the economy, the transition to a higher technological paradigms (Avdulov, A. N., & Kul'kin, A. M., 2014; Czygaj, Ch, 2017).

If Russia really intends to become an active participant in global technological transformations, the shortest way to achieve this goal is to restore the knowledge-intensive industry sector as the most promising basis for sustainable development of the country and its economic security in the future. The identification of opportunities for the realization of this goal, as well as the likely nature of the projection of the trends of globalization and internationalization of the scientific and technological sphere on the Russian Federation, is of strategic importance for it, which determines the relevance of the topic in theoretical and practical terms.

#### **4. Purpose of the Study**

It is known that economic analysis is a method of knowledge of economic reality (Sydsæter, K., & Hammond, P., 2002). Therefore, in the process of analytical research should be guided by all the principles and categories of the theory of knowledge:

- analysis – division of an object or phenomenon into separate components;
- consideration of the objects of management in the aspect of the factors that led to;
- synthesis – integration of all conditions, causes, factors into a single whole;
- generalization of the results obtained in the analysis;
- the study of economic reality in development, the relationship with other realities (search for conditions for the development of the phenomenon);
- induction, deduction.

Currently, in the world practice, the thesis about the importance of new knowledge accumulation for the successful economic development of individual industries and society in General does not raise serious objections (Robbins, S. P., & Decenzo, D. A., 2004). It is confirmed by the historical experience of modern civilization. However, in macroeconomic theory today there are no unambiguous quantitative criteria allowing to assess the scientific and technical potential integrally and to compare the value of scientific results (Baily, M. N., & Friedman, Ph., 1991). Even more difficult to trace causal relationships between new knowledge and economic growth, because any economic system is influenced by a large number of different but often interdependent factors (An'shin, V. M., 2017; Basovskij, L. E., & Basovskaya, E. N., 2008; Kolmykova, T. S., 2009; Kolmykova, T. S., 2018; Kekhill, M., 2018; Rimer M. I., 2010; Teplova, T. V., 2012).

Thus, the knowledge intensity of invested capital is an important factor in determining the efficiency of the economy.

#### **5. Research Methods**

The initial data for the factor analysis of the knowledge intensity of the invested capital consist of

three indicators: gross regional product, domestic current expenditure on research and development, and investment in fixed capital.

Further, based on the methods of deterministic (functional) factor analysis developed by the author (Filatov, E. A., 2018; Filatov, E. A., 2019), we estimate the degree of influence of two factors on changes in the science intensity of the invested capital of Russia.

The initial data for the alternative factor analysis of the knowledge intensity of the invested capital of the Russian Federation are presented in table 1.

**Table 1.** Initial data for factor analysis.

No.	Indicators	№ fac- tor's	2016 (0) *	2017 (I) **	Deviation (Δ) ***
1	<b>GDP</b> – gross domestic product, billion rubles		86 010.2	92 089.3	6 079.1
2	<b>VRP</b> – gross regional product, billion rubles		69 254.1	74 926.8	5 672.7
3	<b>DSK</b> – value added for non-market collective services, billion rubles (1 – 2)		16 756.1	17 162.5	406.4
4	<b>VTZN</b> – internal current expenditure on research and development, billion rubles		873.8	950.3	76.5
5	<b>IOK</b> – investments in the fixed assets, billion rubles		11 282.5	12 256.3	973.8
6	<b>NE<sub>IK</sub></b> – science intensity of the invested capital (4 / 5) = (7 * 8)		0.077447	0.077536	<b>0.000088</b>
7	<b>NE<sub>VRP</sub></b> – science intensity of GRP (4/2)	<b>F<sub>1</sub></b>	0.012617	0.012683	0.000066
8	<b>IO<sub>VRP</sub></b> – investment return of GRP (2/5)	<b>F<sub>2</sub></b>	6.138187	6.113329	-0.024858

where: \* 0 – past (base) period (year) taken as a basis for comparison; \*\* I – reporting (current) year; \*\*\* Δ – change for the period is calculated as the difference between the fact and the plan (I – 0).

The author introduced into scientific circulation the indicator of knowledge intensity of the invested capital, which is calculated as the ratio of the internal current costs of research and development to the amount of investment in fixed capital.

The indicator of the knowledge intensity of invested capital consists of the product of two factors: the knowledge intensity of GRP and the investment return of GRP.

If in 2016 the knowledge intensity of the invested capital of Russia was 7.74 %, in 2017 it increased to 7.75 % or increased by almost one hundredth of a percent. In other words, over the past year, the knowledge intensity of Russia's invested capital has remained unchanged.

The initial formula for factor analysis of the knowledge intensity of invested capital ( $NE_{ik}$ ) will be as follows (formula 1):

$$NE_{ik} = \frac{VTZN}{VRP} * \frac{VRP}{IOK} = F_1 * F_2 \quad (1)$$

The indicator knowledge intensity of gross regional product is similar to that reported research intensity of gross domestic product (**GDP**), which shows the share of R & d expenditure in GDP.

The author introduced into scientific use the indicator of knowledge intensity of GRP ( $NE_{VRP}$ ), which is calculated as the ratio of domestic current expenditures on research and development (**VTZN**) to the size of the gross regional product (**VRP**). If in 2016 the science intensity of the gross regional product of Russia was 1.26 %, in 2017 it increased to 1.27 % or increased by almost one hundredth of a percent. In other words, over the past year, the science intensity of Russia's gross regional product remained unchanged.

The author introduced the indicator of gross regional product investment return ( $IO_{VRP}$ ), which is calculated as the ratio of gross regional product (**VRP**) to the amount of investment in fixed capital (**IOK**). This indicator characterizes the efficiency of using fixed capital. If in 2016 investment return of GRP of Russia amounted to 613 %, in 2017 it dropped to 611 %. In other words, over the past year, the investment return of Russia's gross regional product remained without significant changes.

The total deviation of the resulting indicator ( $\Delta NE_{ik}$ ) is determined by the formula 2:

$$NE_{ik} = \sum_{n=1}^2 \Delta NE_{ik} (F_n) = \Delta NE_{ik} (F_1) + \Delta NE_{ik} (F_2) \tag{2}$$

Auxiliary data on comparative coefficients for the factor analysis are presented in table 2.

**Table 2.** Multiple comparative coefficients of one factor.

<b>The designation of comparative coefficient</b>	<b>Comparison of factors</b>	<b>Value</b>	<b>The product of coefficients (value)</b>
$F_{1(1)} / F_{1(0)}$	A <sub>1</sub>	1.005210	1.00
$F_{1(0)} / F_{1(1)}$	A <sub>2</sub>	0.994817	
$F_{2(1)} / F_{2(0)}$	A <sub>3</sub>	0.995950	1.00
$F_{2(0)} / F_{2(1)}$	A <sub>4</sub>	1.004066	

Author (alternative) methods of factor analysis are presented in table 3.

Method № 1.1 (formulas 1.1–1.3 in table 3) based on the difference between the performance targets, which is adjusted to the comparative coefficients (A<sub>1</sub>).

Method № 1.2 (formulas 1.1–1.3 in table 3) based on the difference between the actual performance indicators, which is adjusted by comparative factors (A<sub>4</sub>).

Method № 2.1 (formulas 3.1–3.3 in table 3) based on the ratio of the deviation of the initial factor to the initial planning factor multiplied by the planned performance indicator, which is adjusted by a comparative coefficient (A<sub>1</sub>).

Method № 2.2 (formulas 4.1–4.3 in table 3) based on the ratio of the deviation of the original factor to the original actual factor multiplied by the actual performance indicator, which is adjusted by a comparative factor (A<sub>4</sub>).

Method № 3.1 (formulas 5.1–5.3 in table 3) based on the difference between the effective actual and planned indicators, which is adjusted for comparative coefficients (A<sub>1</sub>).

Method № 3.2 (formulas 6.1–6.3 in table 3) based on the difference between the effective actual and planned indicators, which is adjusted for comparative coefficients (A<sub>4</sub>).

Method № 4.1 (formulas 7.1–7.3 in table 3) based on the ratio of the deviation of the effective factor to the difference between the effective actual and planned factors, which is adjusted by a comparative factor (A<sub>1</sub>).

Method № 4.2 (formulas 8.1–8.3 in table 3) based on the ratio of the deviation of the effective fac-

tor to the difference between the effective actual and planned factors, which is adjusted for comparative coefficients ( $A_4$ ).

Method № 5.1 (formulas 9.1–9.3 in table 3) based on the ratio of the deviation of the effective factor to the difference between the actual effective factors, which is adjusted for comparative coefficients ( $A_1$ ).

Method № 5.2 (formulas 10.1–10.3 in table 3) based on the ratio of the deviation of the effective factor to the difference between the planned effective factors, which is adjusted for comparative coefficients ( $A_4$ ).

**Table 3.** Methods of alternative factor analysis using comparative coefficients.

№ formulae	formulas / calculations	
	the main part of the formula	adjustment factors
1.1	$\Delta NE_{ik} (F_1) = NE_{ik0} * (A_1) - NE_{ik0}$	–
1.2	$\Delta NE_{ik} (F_2) = (NE_{ik0} * (A_3) - NE_{ik0}) *$	$A_1$
2.1	$\Delta NE_{ik} (F_1) = (NE_{ik1} - NE_{ik1} * (A_2)) *$	$A_4$
2.2	$\Delta NE_{ik} (F_2) = (NE_{ik1} - NE_{ik1} * (A_4)) *$	–
3.1	$\Delta NE_{ik} (F_1) = (\Delta F_1 / F_{10}) * NE_{ik0}$	–
3.2	$\Delta NE_{ik} (F_2) = (\Delta F_2 / F_{20}) * NE_{ik0} *$	$A_1$
4.1	$\Delta NE_{ik} (F_1) = ((\Delta F_1 / F_{11}) * NE_{ik1}) *$	$A_4$
4.2	$\Delta NE_{ik} (F_2) = (\Delta F_2 / F_{21}) * NE_{ik1}$	–
5.1	$\Delta NE_{ik} (F_1) = (NE_{ik1} * A_4) - NE_{ik0}$	–
5.2	$\Delta NE_{ik} (F_2) = ((NE_{ik1} * A_2) - NE_{ik0}) *$	$A_1$
6.1	$\Delta NE_{ik} (F_1) = (NE_{ik1} - (NE_{ik0} * A_3)) *$	$A_4$
6.2	$\Delta NE_{ik} (F_2) = NE_{ik1} - (NE_{ik0} * A_1)$	–
7.1	$\Delta NE_{ik} (F_1) = \Delta NE_{ik} - (NE_{ik1} - (NE_{ik0} * A_1))$	–
7.2	$\Delta NE_{ik} (F_2) = \Delta NE_{ik} - (NE_{ik1} - (NE_{ik0} * A_3)) *$	$A_1$
8.1	$\Delta NE_{ik} (F_1) = \Delta NE_{ik} - ((NE_{ik1} * A_2) - NE_{ik0}) *$	$A_4$
8.2	$\Delta NE_{ik} (F_2) = \Delta NE_{ik} - ((NE_{ik1} * A_4) - NE_{ik0})$	–
9.1	$\Delta NE_{ik} (F_1) = \Delta NE_{ik} - (NE_{ik1} - (NE_{ik1} * A_4))$	–
9.2	$\Delta NE_{ik} (F_2) = \Delta NE_{ik} - (NE_{ik1} - (NE_{ik1} * A_2))$	$A_1$
10.1	$\Delta NE_{ik} (F_1) = \Delta NE_{ik} - ((NE_{ik0} * A_3) - NE_{ik0}) *$	$A_4$
10.2	$\Delta NE_{ik} (F_2) = \Delta NE_{ik} - ((NE_{ik0} * A_1) - NE_{ik0})$	–

**6. Findings**

The result of methods 1.1, 2.1, 3.1, 4.1, 5.1 is presented in table 4, the result of methods 1.2, 2.2, 3.2, 4.2, 5.2 is presented in table 5.

**Table 4.** The result on methods 1.1, 2.1, 3.1, 4.1, 5.1.

No .	the main part of the formula	adjustment factors	result
1	$\Delta NE_{ik} (F_1) = 0.000404$	–	0.000404
2	$\Delta NE_{ik} (F_2) = -0.000314$	1.005210 $A_1$	-0.000315
	<b>0.000090</b>		<b>0.000088</b>

**Table 5.** The result on methods 1.2, 2.2, 3.2, 4.2, 5.2.

No.	the main part of the formula	adjustment factors		result
1	$\Delta NE_{ik} (F_1) = 0.000402$	1.004066	$A_4$	0.000404
2	$\Delta NE_{ik} (F_2) = -0.000315$	–		-0.000315
	<b>0.000087</b>			<b>0.000088</b>

Factor analysis allows to obtain a quantitative assessment of the influence of deviations of factors on the deviation of the value of the studied indicator. As can be seen from the final result of tables 1, 4, 5, the purpose of the analysis is achieved – the determination of the influence of factors is disclosed without deviations.

According to the results of the analysis, the following factors influenced the change in the knowledge intensity of the invested capital ( $\Delta NE_{ik}$ ) in the amount of **+0.0088 %**:

- increasing knowledge-intensity of GRP ( $F_1$ ) +0.0066 % increase in the analyzed index +0.0404 %;
- - reduction of investment GRP ( $F_2$ ) on -2.4858 % reduction in the studied indicator for -0.0315 %.

According to the results of the analysis, it is clear that in 2017, compared to 2016, there was a slight (almost zero) increase in the knowledge intensity of the Russian economy. This, in turn, suggests that there is no economic recovery in 2017 after the financial crisis of 2014 in the Russian Federation.

In addition, it can be concluded that the Russian economy has entered a stage of stagnation. When economic growth stagnates, it slows or goes down slowly, so there are no prerequisites for job expansion. The competitiveness of the Russian economy in the international arena has decreased. The level of the material condition of the population of Russia has sharply decreased.

The low volume of investments in science in Russia forms insignificant indicators of the knowledge intensity of the invested capital.

Innovative type of economic development is a necessary condition for sustainable economic growth. Therefore, an innovative type of economic development is a necessary condition for sustainable growth and exit from stagnation. To form an innovative type of economic development, it is necessary to create a clear strategy of innovative development of the country.

Economically competent management of the country is impossible without the ability to analyze information. All economic actions and decisions should be based on accurate calculations and a comprehensive study of the situation. And the role of economic analysis in competent and professional justification of possible actions is very great (Prosvetov, G. I., 2008).

Three indicators were used for factor analysis of the knowledge intensity of the invested capital: gross regional product, domestic current expenditures on research and development, and investments in fixed capital. These indicators seemed to show stable growth, but this growth is artificial, since the main reason for such a stable growth lies in the high volatility of the Russian currency.

The task of stabilizing the exchange rate of the national currency is not difficult. It is necessary to ensure the rational management of the balance of payments of the Russian Federation, to prevent its large deficits and sharp fluctuations in the balance. In the twentieth century, a method of balance of payments and exchange rate management, such as the regulation of cross-border movement of capital (its exports and imports), was widely used. All the more so today, all BRICS countries, except Russia, have introduced certain restrictions on cross-border capital flows.

## 7. Conclusion

The efficiency of investment activity is one of the key categories of the economy, which is directly related to the achievement of the development goal for both the individual enterprise and society as a whole.

The structural crisis initiated by the global economic imbalance raised the question of the funda-

mental cause of the crisis of the current paradigm of production and consumption, the solution of which is possible only under the condition of an accelerated increase in the knowledge intensity of modern industrial production and an increase in the knowledge-intensive segment of national industry at a rate exceeding macroeconomic dynamics (Gorodeckij, D. I., 2010).

It is possible to assume that the modern mechanism providing growth of the knowledge-intensive sector of the industry of the leading economically developed countries in the near future will face a lack of resources for the self-development. Therefore, in 2020, the «owners of world money» (the real owners of the following organizations: 1. Basel Committee on banking supervision; 2. Us Federal reserve (the most significant is the Federal reserve Bank of New York); 3. Bank Of England; 4. The European Central Bank) may provoke a global financial crisis, the way out of which will require new forms of business organization and the global monetary system.

In modern conditions, investment in innovation is the key to sustainable growth and economic development on a global scale. The ability to create and practically use innovations becomes a necessary condition for achieving high-quality economic growth and maintaining international competitiveness.

Increasing the knowledge intensity of the national economy is a priority goal of a country that wants to improve the welfare of its citizens. The implementation of this goal will lead to the expansion of the use of accumulated production assets, involvement in the production process of highly skilled labor.

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