Innovation in Supply Chain Management and Its Financing as a Factor of Economic Growth

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Abstract- **Innovation in supply chain is becoming an increasingly significant factor in the socio-economic development of national economies these days. Continuous innovation plays a crucial role in increasing the competitiveness of social production, profits made by economic entities, economic growth, and, consequently, the national economy. Innovative development cannot occur without the presence of effective mechanisms for financing innovation. The purpose of this study is to assess the impact of innovation and its financing on the economic growth of the Republic of Mordovia – one of the federal subjects of the Russian Federation. The authors conducted a correlation and regression analysis to determine the influence of factors related to innovative development on the volume of the Gross Regional Product (GRP). This method allows identifying key factors influencing the rate of economic growth in the region, as well as to build a forecast of the future GRP. Empirical results indicate that the GRP of the Republic of Mordovia is greatly influenced by the financing of research and development (R & D). The resulting regression equation indicates that the 92% change in the GRP is due to the R & D expenditures, and 8% – the influence of other factors. It was also found that the increase in domestic R & D costs by 1 million rubles results in an increase in the GRP by an average of 200 million rubles. The results indicate that it is necessary to increase R& D financing, provided that its growth is balanced at different stages of innovation.**

Key words- *innovation, supply chain management, financing of innovation, economic growth, correlation and regression analysis.*

1. Introduction

A specific feature of the current stage of global development is the transition from an industrial to post-industrial society due to the increasing influence of fundamental technological and scientific shifts. Thus, the composition of factors and sources of economic growth are also evolving. Scientific knowledge, intellectual capital, and the intensity of innovation are the most important factors for sustainable growth [1-5]. A new innovative type of economy is being formed, wherein the growth of the Gross Domestic Product (GDP) is provided mainly by the production and sale of high-tech products and services. The innovation economy has the following characteristics: the steady dynamics of economic growth rates, a social focus on improving the level and quality of people's lives, the accumulation of human and intellectual capital, increases in high-tech forms of reproduction of fixed capital through the acceleration of innovation, intensive research, the development and introduction of new technologies, and a high proportion of innovative enterprises and innovative products. Innovative development is a highly relevant issue for the whole Russian Federation and especially for its regions. With new challenges and threats to the development of the Russian economy (lower economic growth, a negative situation where global energy prices are concerned, and the aggravated geopolitical situation), the Russian Federation has an acute need for fundamental change in the model of economic development: a transition from an export-oriented model to a progressive and innovative one. At the same time, innovative development can only take place with the creation of effective mechanisms for financing innovation [6, 7]. Therefore, as different countries are actively adopting innovative economies, it seems viable to assess the impact of innovation and its financing on economic growth rates. The dependence of economic growth rates on innovation can be determined using various tools: neural modeling [8, 9], regression analysis [10], and others. In this study, the authors used regression analysis to identify key innovative factors influencing economic growth. The main advantages of this method are the simplicity of computational algorithms and the visibility and interpretability of the results.

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2. Literature Review

International and Russian scientists have studied the relationship between innovation and economic growth for quite a while. Justifying the theory of large cycles, proved that the main reason for the transition to a new cycle is the increase in the stock of capital goods, which creates conditions for the mass introduction of accumulated inventions. N. D. Kondratiev empirically confirmed the hypothesis about the important role of innovation as a crucial component of economic growth in creating positive socio-economic dynamics. J. Schumpeter is considered to be the founder of the theory of innovation [11]. He proved that economic development reaches a new stage due to the creation of innovative products. The researcher called innovations "new combinations" and considered them as a means of entrepreneurship for profit. J. Schumpeter saw entrepreneurs as "economic entities whose function is just to apply new combinations". Using Kondratiev's theory of large cycles, J. Schumpeter focused on the potential of credit for financing innovation. The works [12, 13], [14], and [15] made a great contribution to the theory, determining the relationship between innovation and economic growth. Exploring economic development in the United States and Western Europe, [12, 13] identified 23 factors that stimulated economic growth of the Western economy in the postwar period. Moreover, more than half of these are associated with the introduction of innovations, and the rest with the use of capital, land, and labor. In his studies, [12, 13] came to the conclusion that the slowdown in technological progress was one of the reasons for the decline in GDP growth in the United States in the 1970s. According to the calculations of [14], in the period of 1908–1949, the annual contribution of innovation to the economic growth of the US economy was estimated to be 3%. According to [15], scientific and technical progress is the basis of economic growth of any country. In his work "Modern Economic Growth: Pace, Structure and Distribution," he notes that innovation implies a wider application of science to solve problems of economic production [15]. Within the endogenous growth theory of [16], technological progress is seen as the third factor of production, along with the main ones (labor and capital). In his opinion, long-term growth can occur if R & D expenditures are also increasing; economic growth rates directly depend on the size of the human capital focused on obtaining new knowledge; and innovations have a positive impact not only on those who implement them, but also on society as a whole ("economies of scale"). The research conducted by some international scientists [17, 18, 19] showed that R & D expenditures have a positive impact on economic development. According to the calculations of [20], in the United States, an increase in the spending of high-tech sectors of the economy on research and development by 1% contributes to a reduction in production costs of 0.024–0.07%. Today, investment in information and communication technologies is one of the innovative technological factors of economic growth in leading economies [21], contributing to an increase in labor productivity. The leading trend of the global economy is the use of advanced technologies, platform solutions, and digital transformation, enabling the transition from mass production of standardized products to highly efficient production of individualized products. These technologies make it possible to: a) substantially increase the added value with the same (and sometimes even smaller) role of traditional factors of production; b) provide a new quality of production and technological processes; and c) switch to the release of innovative products, which opens new markets [22]. According to some analysts [23, 24], such innovations create conditions for other high-quality economic development and can ensure 60–80% of the predicted economic growth. Talking about modern Russian economists studying innovation and its impact on the sustainable development of the economy, one should mention [25, 26], [10], [9]. Having carried out econometric analysis of the dependence of the global competitiveness index on the level of innovative development of different countries, ref. [25, 26] concludes that the financing of innovation is the most important driver for ensuring sustainable economic growth. Ref. [10] performed the regressive analysis of the impact of R & D costs and the number of people employed in this field on the level of Gross Domestic Product (GDP). The results show that in the period of 2006–2015, economic growth in Russia was mainly due to factors of reproduction, rather than innovation. To assess the innovative activities of Russian regions, ref. [9] used Kohonen self-organizing maps, created in the Neural Networks module of STATISTICA software. The scientists divided the subjects of the Russian Federation into five clusters according to four indicators that characterize technological innovations: 1) research and development of new

products, services, methods for their production, and new production processes; 2) the acquisition of machinery and equipment related to technological innovation; 3) the acquisition of software; 4) education and training of personnel connected with innovation.

3. Materials and Methods

In this study, the authors assessed the impact of innovation and its financing on the rate of economic development in the Republic of Mordovia – one of the regions of the Russian Federation. This helped to identify key factors that influence the economic growth rate in the region, as well as to build a forecast of the Gross Regional Product (GRP). The main research method was correlation and regression analysis – a statistical research method that allows evaluating the influence of one or several independent variables (Xi) on a dependent variable (Y). The dependence of the volume of the GRP on a number of independent factors is determined in several steps:

1. Determining factors (indicators) describing the innovative development of the economy of the region.
2. Collecting statistical data for a certain period. In this study, the authors used empirical data provided by the Territorial body of the Federal State Statistic Service of the Russian Federation for the Republic of Mordovia for the period of 1997–2017.
3. Constructing and verifying the regression model. The volume of the GRP in the Republic of Mordovia (Y) was taken as an effective indicator with the following variables:

X_1 is the share of innovative products in the total volume of goods, works, and services shipped, %;
X_2 is the costs of technological innovation, mln rub.;
X_3 is the innovative activities of the companies, %;
X_4 is the internal costs of research and development, mln rub.;
X_5 is the number of applications for patents and inventions, each;
X_6 is the number of patents and certificates issued, each;
X_7 is the number of companies conducting research and development, units;
X_8 is the number of developed advanced technologies, units.

4. Building a matrix of paired regression coefficients to determine the factors that have the greatest impact on the effective indicator.
5. Predicting the dynamics of the GRP up to 2024, regarding changes in significant innovative factors.

The authors used the least squares method to analyze, verify and construct econometric models and to provide economic interpretation of their results. This made it possible to estimate the parameters of regressions. Next, the statistical hypotheses were proven using Fisher and Student tests.

4. Results

In the recent years, the Republic of Mordovia has been demonstrating rather high rates of innovative development, if compared to other regions. For instance, the share of innovative goods, works, and services in the total volume of goods shipped, performed work and services is almost four times higher than the average Russian one, and the level of innovative activity of companies in the region is 1.5 times higher, estimating 27% and 13.4%, respectively. In the ranking of Russia's innovative regions, over the past years the Republic of Mordovia has been in the group of medium-strong innovators. It is worth noting that the Index of Innovation Development of the Subjects of the Russian Federation was developed by the Association of Innovative Regions of Russia in cooperation with the Ministry of Economic Development of the Russian Federation and has been estimated since 2014. It represents an integral assessment of 29 indicators within four blocks: 1) research and development; 2) innovative activities; 3) the socio-economic conditions of innovation; 4) the scale of innovation.

The authors performed the correlation and regression analysis using Statistic a software and studied the impact of innovative factors on the GRP. Their impact was assessed using multiple regression which reflects the relationship between three or more related attributes. When studying the dependence by the methods of multiple regression, one should create an analytical expression representing the relation between the resultant attribute (y) and factor attributes ($x_1, x_2, x_3, \ldots, x_k$), and estimate the function:

$$y_{1,\ 2,\ 3,\ldots\ldots k} = f(x_1,\ x_2,\ x_3,\ \ldots,\ x_k) \quad (1)$$

The practice of building multi-factor relation models shows that all existing dependencies between socio-economic phenomena can be described using such types of models as: linear, parabolic, power-law, etc. Linear models are of primary importance due to their

simplicity and consistency of their economic interpretation:

$$y'_{1,2,3,\ldots,k} = a_0 + a_1x_1 + a_2x_2 + \ldots + a_kx_k \quad (2)$$

where a_i is the parameters estimated using the least squares method;

x_i is factor attributes.

The primary data for building the regression equation are presented in Table 1.

Table 1. Primary data for correlation and regression analysis.

Years	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
1997	8676.8	2	62.7	2	25.4	5	4	9	21
1998	8347.2	2.2	111.7	2.2	31.5	25	30	11	16
1999	12160.6	2.4	60.0	2.4	36.5	32	28	11	4
2000	17553.4	8.6	199.1	4.7	66.8	50	34	11	1
2001	22089.5	5.9	191.3	7.3	97.8	56	27	11	17
2002	27508.0	4.2	343.0	6.4	112	51	31	11	8
2003	33244.0	3.7	300.3	10.2	176.1	44	51	11	6
2004	38334.9	3.9	569.5	9	210.7	50	57	11	5
2005	44267.0	5.6	939.9	6.2	211	63	49	10	11
2006	57974.2	13.1	3342.9	8.8	266.1	65	54	10	15
2007	77048.8	37.3	2706.1	9.6	371.8	77	67	13	10
2008	94058.3	9.9	2851.2	8.8	532.6	93	67	14	5
2009	90862.4	20.2	597.5	10.6	647.4	106	106	14	4
2010	105343.8	23.1	988.9	9.4	520.5	109	90	13	8
2011	119955.2	22	16107.7	12.4	601.3	109	107	16	7
2012	134315.6	22.9	3621.3	13.1	671.9	84	66	15	6
2013	148705.7	23.9	3235.6	16.9	906.9	103	88	16	5
2014	173872.7	26.9	6317.0	18.3	969.1	106	80	17	5
2015	180352.3	27	5196.1	16.6	823.1	74	88	26	10
2016	198132.8	27.2	5240.4	13.4	798.8	81	60	25	6
2017	213287.8	27.5	5121.0	12.5	828.8	78	83	17	10

To assess the relationship between the indicators, the authors built a matrix of paired correlation coefficients which allowed determining the strength of the relationship of factors and the resultant attribute and among the factors themselves. The following formula was used to calculate the correlation coefficients:

$$r = \frac{\overline{yx} - \overline{y} \cdot \overline{x}}{\sigma_y \cdot \sigma_x}, \quad (3)$$

Where $\overline{yx}$ is the mean value of the product of the resultant and factor attributes;

$\overline{x}$ Is the mean value of the factor attribute;

$\overline{y}$ Is the mean value of the result ant attribute;

σ_x and σ_y are the root-mean-square deviation of the resultant and factor attributes.

The matrix of paired correlation coefficients of the indicators used to analyze the Gross Regional Product is given in Table 2.

Table 2. Matrix of paired correlation coefficients.

	Y	*X1*	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*	*X8*
Y	1								
X1	0.82923	1							
X2	0.89671	0.75442	1						
X3	0.86562	0.76259	0.80613	1					
X4	0.95946	0.82401	0.84617	0.92109	1				
X5	0.71268	0.74267	0.54200	0.76844	0.81685	1			
X6	0.72415	0.73394	0.49450	0.73974	0.81574	0.84178	1		
X7	0.85521	0.68592	0.77178	0.73691	0.79020	0.49473	0.53544	1	
X8	-0.28398	-0.23919	-0.15404	-0.37611	-0.36613	-0.48641	-0.32805	-0.26164	1

As is well known, when performing regression analysis, it is important to select factor attributes to include them next in the regression equation. At the same time, factor attributes may depend on each other, that is, be multi collinear. However, this complicates the analysis since it is difficult to determine the most significant factors and calculate the coefficients using the least squares method. It distorts the meaning of the regression coefficients when giving their economic interpretation. Having analyzed the matrix of paired correlation coefficients, the authors identified the multi collinearity of factor attributes X_1, X_2, X_3, X_5, X_6, X_7. So, they cannot be considered when building the regression equation. Therefore, according to the rules of econometric analysis, one can build a regression equation using only one factor – X_4 (internal costs of research and development).

As a result of the analysis, the authors obtained the following regression equation:

$$Y = 2129.44305 + 197.77149\, X_4 + \varepsilon, \quad (4)$$

where Y is the resultant attribute;

ε is a possible unaccounted attribute.

F-test and t-test indicate the statistical significance of the equation obtained at a significance level of 95% (Table 3). The coefficient of determination r^2_y= 0.92 shows that the change in the Gross Regional Product by 92% is due to research and development costs and by 8% – to the influence of other factors.

Table 3. The final result of the regression analysis

Characteristics of the regression model			
Correlation coefficient r			0.95946
Coefficient of determination r^2			0.92057
F-test F_p (F_t)			220.209 (4.38075)
Characteristics of the parameters of the regression model			
Independent factors	Equation parameters	β-coefficients	t-test
Intercept term	2129.44305		0.30120
X_4	197.77149	0.959	14.83947

To assess the accuracy of the model obtained, the average approximation error was calculated using the formula:

$$\left| \bar{\varepsilon} \right| = \frac{1}{n} \Sigma \frac{\left| y_t - \hat{y}_t \right|}{y_t} 100\%, \quad (5)$$

Where, yt is the actual values of the indicator;

$\hat{y}_t$ is the theoretical values of the indicator obtained for the constructed model.

The average error of the model approximation was 11.63%, which corresponds to the established standard of 10-12% and confirms the accuracy of the obtained model.

The regression equation (4) allowed the authors to make a forecast of the GRP of the Republic of Mordovia reflecting the changes in the volume of internal research and development costs (Table 3).

Table 4. Forecast values of the GRP of the Republic of Mordovia, mln rub.

Year	Forecast values of internal research and development costs, mln rub.	Forecast values of the GRP, mln rub.
2018	975.00	194957.53
2019	1038.35	207484.97
2020	1102.85	220241.11
2021	1168.47	233220.34
2022	1235.20	246417.39
2023	1303.01	259827.34
2024	1371.87	273445.54

Thus, the results obtained do not contradict the published studies [19, 3, 27] and support the hypothesis about the significant impact of R & D costs on economic development.

5. Discussion

The built econometric model helped the authors to establish that the financing of research and

development has a significant influence on the volume of the Gross Regional Product of the Republic of Mordovia. For instance, the authors determined that an increase in domestic expenditures on research and development by 1 million rubles results in an increase in the Gross Regional Product by an average of 197.77 million rubles. Therefore, to ensure innovative economic growth in the region, it is necessary to increase budget financing of science [28, 29]. The authors believe that when developing a regional budget, research expenditures should be increased up to 2% of the GRP in accordance with the standard established by the Strategy for Scientific and Technological Development of the Russian Federation (approved by Presidential Decree of December 1, 2016 No. 642). However, an increase in the financing of research and development will have a positive effect only if this growth is balanced at various stages of the innovation process. It is important to ensure the compliance with economically reasonable shares of financing of certain types of activities (basic research, applied research, and technological development) [30, 31].

6. Conclusion

The analysis performed in this study confirmed the hypothesis about a significant impact of innovation and R & D financing on the economic development of the region. Further research should focus on developing effective mechanisms and instruments for financing innovation that will ensure sustainability of the social and economic development of the regions (countries) and the transition to a model of innovative development.

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