

Approaches to assessing the level of innovation development in manufacturing industries

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Abstract. Sustainable long-term development of the energy sector is impossible without a developed manufacturing industry and especially machine-building enterprises. The article offers a method for assessing the level of innovation development in the manufacturing industry and identifies the factors that have the greatest impact on the development of the process of creating and implementing innovations in this sector. A multi-factor regression model is constructed to determine the degree of influence of various socio-economic factors on the level of development of innovative activity in manufacturing industries, as well as to develop proposals and recommendations for its activation.

1 Introduction

Sustainable long-term development of the energy industry is impossible without a developed manufacturing industry and especially machine-building enterprises.

The manufacturing industry is one of the drivers of innovative development of the economy, since it is in this sector that the main production of the most technologically complex and high-tech products with high added value is concentrated. The variety of technological processes focused on manufacturing enterprises, on the one hand, makes this sector the main source of innovative products, goods and services, and on the other hand, it is the main consumer of a wide range of innovative developments.

Given the recent events in Ukraine and sanctions against Russia by some developed countries, the development of innovative activities in the domestic processing industry is particularly relevant.

It should be noted that the manufacturing industry makes a great contribution to the economic development of the country. In 2013, enterprises in this sector accounted for almost 40% of GDP. Social significance is emphasized by the fact that about 15% of the total number of people employed in the economy work in the manufacturing industry.

However, in the process of market transformations, the products of domestic manufacturing enterprises have become significantly inferior in competition in international markets. There is a steady increase in imports and a decrease in exports of products of enterprises in this sector. For example, during the period 2005-2013, the share of exports of manufacturing enterprises in the total volume of Russian exports

decreased by 0.7 percentage points and amounted to 16.6% in 2013.

It should be especially noted that in 2012 Russia occupied only 0.26% of the world market of machine-building products.

The low competitiveness of products produced by the domestic processing complex is due to the weak level of innovation development. Despite the fact that manufacturing enterprises make a significant contribution (almost 72% in 2013) to the formation of the total volume of innovative products, the level of their innovation activity for the period 2005-2013 did not exceed 13%, and the share of innovative products in the total volume of shipped products – 12%. This indicates a weak interest of manufacturing enterprises in innovative developments (table 1).

To identify factors that hinder the development of innovation in the manufacturing industry, it is necessary to be able to assess the level of its development.

Currently, a large number of works are devoted to assessing the level of innovative development of countries and regions. Research in this area has started relatively recently, but a number of methodological approaches to solving this problem have already been developed. In particular, the issues of assessing the level of development of innovative activity are considered in the works of: I. Novikova, I. M. Bortnik, G. I. senchen, E. P. Amosenok, V. A. Bazhanov, L. S. Veseloy, A.V. Sokolov, V. N. Borisov, O. V. Pochukayeva, N. N. Volkova, E. Romanyuk [1, 2, 3, 7, 8].

It should be noted that most publications offer methods for assessing the innovative development of territories by aggregating individual indicators into integrated ones, while very little attention is paid to measuring the innovative development of the industrial complex, including manufacturing industries.

Table 1. Indicators that reflect the level of innovation development in the Russian manufacturing industry.

Indicator	Year					2013 to 2005 п.п.
	2005	2010	2011	2012	2013	
Level of innovation activity of MI enterprises, %	10,9	11,3	11,6	12,0	11,9	1,0
MI contribution to the total volume of innovative products, %	84,8	79,7	62,1	68,7	71,8	-13,0
Share of innovative products shipped by MI in the total volume of goods shipped, works performed, services, %	7,0	6,7	6,8	9,6	11,6	4,6
MI – manufacturing industry. Source: Federal state statistics service. Mode of access: http://www.gks.ru ;						

Table 2. Characteristics of methods for assessing the innovative development of territories and sectors of the economy.

Methodology	Availability and objectivity of source data	Simplicity of methodology and calculations	Completeness of analysis of ID results	Applicability at the regional level	Applicability to the assessment of the level of development of ID in the MI
Factor analysis of the region's innovation potential (amosenok E. P., V. A. Bazhanov)	+	-	+	+	-
Rating of regions by level of innovation development (A. B. Gusev)	+-	+	+-	+	-
Evaluation of the innovation system at the regional level (N. N. Volkova, R. I. Romanyuk)	+-	+	+-	+	-
Methods of assessing the level of development of innovative processes in mechanical engineering (V. N. Borisov, O. V. Pochukaeva)	+	+	-	+	+-
Index of scientific and technical potential of the region (I. A. Kondakov)	+	+	+	+	-
Source: compiled by the author. "++"—full compliance with the criterion; "+ -"— does not fully meet the criterion; "- -"— does not meet this criterion.					

Analysis of the advantages and disadvantages of the above methods for assessing the innovative development of territories and sectors of the economy showed that none of the developments can be used to measure the level of development of innovation in the manufacturing industry of the region (table 2).

The problem with using some methods (for example, the method of N. N. Volkova, E. I. Romanyuk) is that not all the indicators proposed for evaluation can be obtained from available statistical sources. The criteria proposed in the methodology can only be obtained by conducting additional research and studying the materials of accounting statements, which is quite difficult due to financial and time constraints. In addition, certain groups of indicators are assigned certain weights based on data from expert surveys, which, in our opinion, is quite controversial, since it has a subjective basis.

In the methodology of V. N. Borisov and O. V. Pochukayeva, it is proposed to assess the level of development of innovative activity in industries based on aggregation of 2 indicators: the share of products of innovative-active enterprises and innovative products in the total production volume. However, the assessment based on the presented indicators does not take into account the degree of involvement of manufacturing enterprises in innovative activities and labor productivity in the production of innovative products, which, in our

opinion, is extremely important when evaluating the results of innovative activities in industries.

In this regard, the relevance of this study is to develop a methodology for assessing the level of development of innovation in the manufacturing industry based on available data from regional and Federal statistics that do not require additional research, as well as to use this methodology to build ratings of regions by the level of development of innovation in the manufacturing industry.

Taking into account the specifics of the problem being solved, we have proposed a methodology for assessing the level of development of innovation in the manufacturing industry, which includes 5 consecutive stages (table 3).

To assess the level of innovation development in the manufacturing industry, the following indicators were selected:

1. the Share of innovative products shipped by enterprises of the processing complex in the total volume of products shipped (this indicator reflects the volume of innovative products produced by enterprises of the processing complex. The higher the value of this indicator, the more large enterprises in the manufacturing sector activate innovation activity, the more dynamic the diffusion of innovations is).

2. the Share of innovative products shipped by enterprises of the processing complex in the total volume

Table 3. Methodology for assessing the level of development of innovation in the manufacturing industry.

Stage name	Procedure
1. Identification of parameters for calculating the level of innovation development in the manufacturing industry (IDmi)	Determination of a set of statistical indicators that characterize the degree of development of innovative activity in manufacturing enterprises.
2. Determination of standardized coefficients for each observation unit (territory)	When calculating standardized coefficients, the maximum or minimum values for each parameter were taken into account, depending on whether the parameter is direct or inverse. $ID_{Mii} = \frac{xi - \min(xi)}{\Delta(xi)} \text{ or } ID_{mi} = \frac{\Delta(xi)}{\max(xi) - xi}$ (depending on whether the initial indicator is direct or reverse), where xi is the initial values of indicators for the I-th territory.
3. Determination of an integral indicator that characterizes the level of development of innovative activity in the manufacturing industry for each observation unit (territory)	Integral indicators were calculated using the following formula: $ID_{mi} = \sqrt{\frac{\sum_{j=1}^n (ID_{Mji})^2}{n}}$ where ID _{Mji} is the standardized coefficient for the i-th territory, n is the number of indicators taken into account in the calculation.
4. Defining the boundaries of intervals and determining the observation units (territories) that fall into each group.	The interval of values of the integral indicator [0; 1] was divided into 5 groups with the same interval value for each group. Since the distribution of observation units in groups does not correspond to the Gauss distribution law (it is not normal), the method of secondary rearrangement was applied with a certain proportion of population units set for each group (1st and 5th-15%, 3rd-30%, 2nd and 4th-20%). 1. High (ID _{mi} ∈ (0,56; 0,71]); 2. Above average (ID _{mi} ∈ (0,51; 0,56]); 3. Average (ID _{mi} ∈ (0,42; 0,51]); 4. Below average (ID _{mi} ∈ (0,20; 0,42]); 5. Low (ID _{mi} ∈ [0,0; 0,2]);
5. Interpretation of the results.	
Source: developed by the author	

of innovative products in the region (this indicator also reflects the volume of innovative products produced, but it allows you to determine the contribution of enterprises of the processing complex to the formation of the total volume of innovative products created in the region).

3. the level of innovation activity of manufacturing enterprises (this indicator allows you to assess the degree of involvement of manufacturing enterprises in innovation).

4. the Volume of innovative products shipped by enterprises of the processing complex per employee (this indicator allows you to measure labor productivity in terms of production of innovative products).

The choice of these indicators is also due to the fact that they allow you to determine the scale of production forces in terms of production of innovative products, comprehensively measure the results of their innovation activities and conduct analytical comparisons with production and economic results.

The presented methodology makes it possible to assess the level of development of innovative activity in the manufacturing industry, taking into account the volume of output, the degree of involvement of enterprises in the sector in innovation, as well as labor productivity in the production of innovative products.

Based on the developed methodology, an analysis was carried out for all subjects of the Russian Federation for the period 2006-2013. It was found that a high level

of innovation development in the manufacturing industry was observed in the regions and cities of the Volga (Samara, Nizhny Novgorod and Ulyanovsk regions, the Republic of Mordovia, the Chuvash Republic and Perm Krai), Central (Lipetsk and Yaroslavl regions, Moscow) and North-Western (Saint Petersburg) Federal districts. Among the regions with the lowest level of innovation activity development in the manufacturing industry entered the territory of the far Eastern (Jewish Autonomous oblast, Republic of Sakha (Yakutia), Magadan oblast and Chukotka Autonomous district), Siberian (Tuva Republic and Zabaykalsky Krai), South (Republic of Kalmykia) and North Caucasian (Chechen Republic and Republic Ingushetia and North Ossetia - Alania) Federal districts (table. 4).

The leading positions of the regions of the Volga, Central and North-Western Federal districts are largely due to the innovation policy implemented in these territories. In the leading regions, activities aimed at creating a favorable environment for the development and implementation of innovations in the manufacturing industry were carried out. For example, in the Samara region, infrastructure organizations have been created to support and promote innovative developments (the Regional innovation center, the Innovation Fund of the Samara region, the Regional venture Fund, the Regional technology transfer center, five business incubators, the center for innovative development and cluster initiatives,

Table 4. Ranking of constituent entities of the Russian Federation in terms of development of innovative activity in manufacturing industry.

Territory	2006 – 2009 years		2010 – 2013 years	
	Index value	Rank	Index value	Rank
Samara region	0,707	1	0,692	1
Republic of Mordovia	0,570	5	0,685	2
Moscow	0,569	7	0,644	3
Lipetsk region	0,523	10	0,637	4
Chuvash Republic	0,518	13	0,622	5
Perm region	0,672	2	0,613	6
Saint-Petersburg	0,569	6	0,613	7
Nizhniy Novgorod region	0,578	3	0,612	8
Ulyanovsk region	0,572	4	0,598	9
Yaroslavl region	0,503	19	0,574	10
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Trans-Baikal Krai (Territory)	0,231	67	0,162	71
Republic Of North Osetia-Alania	0,212	68	0,153	72
Republic Of Sakha (Yakutia)	0,098	75	0,128	73
Republic Of Tyva	0,104	72	0,121	74
Jewish Autonomous region	0,101	78	0,106	75
Chukotka Autonomous region	0,092	76	0,103	76
Magadan region	0,132	72	0,078	77
Republic of Ingushetia	0,000	79	0,049	78
Chechen Republic	0,000	80	0,009	79
Republic Of Kalmykia	0,000	78	0,009	80
Source: calculated by the author based on Rosstat data.				

an Information and consulting Agency, and other organizations) [4]. Similar work was carried out in Moscow, Saint Petersburg, the Republic of Mordovia, Nizhny Novgorod and Yaroslavl regions.

References

1. V. N. Borisov, O. V. Pochukaeva, Modernization of the manufacturing industry of the Russian Federation on the basis of sustainable development of domestic engineering, Problems of forecasting, 2, 55-63 (2011)
2. I. M. Bortnik, G. I. Senchenya, N. N. Mikheeva et al., System of evaluation and monitoring of innovative development of regions of Russia, Innovations, 9, 48-61 (2012)
3. N. N. Volkova, E. I. Romanyuk, The level of development of the innovation system, and the specialization of regions of Russia, Questions of statistics, 9, 38-47 (2011).
4. Investment portal of the Samara region [Electronic resource]. - Access mode: <http://www.investinsamara.ru>
5. E. A. Mazilov, Main indicators and factors of innovative development of the region's industry, Management and business administration, 1, 166-178 (2013).
6. V. N. Makoveev, Innovative processes in domestic engineering, Management and business administration, 4, 96-106 (2013).
7. E. P. Amosenok, V. A. Bazhanov, L. S. Veselaya, A. V. Sokolov, Mechanical engineering as a dominant in innovative processes, 156 0Novosibirsk: Publishing house of ieopp SB RAS, 2008)
8. I. Novikova, Disproportions of innovative development of Federal districts, Economist, 12, 46-52 (2014)
9. A. Ayvazyan, V. S. Mkhitarian, Applied statistics. Fundamentals of econometrics. Vol. 1: probability Theory and applied statistics, 656 (UNITY-DANA, 2001)
10. I. I. Eliseeva, Statistics. Practical work, 483 (2011).
11. S. V. Terebova, Industrial complex of the region: innovative aspect of development, Problems of Economics and management, 4, 54-59 (2011).
12. Federal state statistics service. Mode of access: <http://www.gks.ru>.
13. International Merchandise Trade Statistics [Electronic resource]. - Mode of access: <http://comtrade.un.org/pb/CountryPagesNew.aspx?y=2012>.
14. D. Mazhitov, M. Ermilova, E. Altukhova, T. Maksimova, and O. Zhdanova, Development of Technologies and Processes in Environmental Management, E3S Web of Conferences 135, 04045 (2019). doi:10.1051/e3sconf/201913504045.
15. N. Ketoeva, N. Soldatova, and S. Ilyashenko, Lean Manufacturing as a Tool for Increasing Labor Productivity at the Enterprise, E3S Web of conferences 124, 04015 (2019) doi:10.1051/e3sconf/201912404015