METHODOLOGY DEVELOPMENT FOR ASSESSING INNOVATION LEVEL SPREAD IN THE STATE ECONOMIC AREA

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ABSTRACT

The article proposes a methodological approach to the formation of indicators system for assessment of diffusion and penetration innovations level in the national economy. The aim of the study is to provide comparative analysis of theoretical and methodological innovation activity effectiveness on their basis. According to the study purpose the following tasks are formulated and solved: a comparative analysis of macro and microeconomic approaches of innovation interpretation and its processes including influence on direction and pace of economic development; knowledge and information characteristics as assets, and their role in innovation production and dissemination; essence definition of innovations diffusion process and methodical approach to assessment of diffusion level of innovation in the national economy. General scientific research methods along with multidimensional statistical analysis method are applied to solve the tasks. The study confirmed the multi-aspect nature of innovation processes, leading to alternative interpretations of implementation mechanisms. The proposed methodology for assessment of innovation diffusion level is based on a macroeconomic approach to their interpretation and on the provisions of the theory of innovation diffusion by Hagerstrand. The proposed method may be applied in the development of programs for socio-economic development of territories by public administration bodies and in forecasts construction indicators of their dynamics.

Keywords: Innovation Cycle, Innovation Processes, Macro-And Microeconomic Approaches to Innovation, Knowledge and Information, Indicators of Innovation Dissemination Level, Economic Growth.

INTRODUCTION

One of the modern economy attributes is its innovative orientation, which is expressed in the transformation of innovation into an endogenous economic growth factor, a source of competitiveness of an individual enterprise and the national economy as a whole, as well as a tool for improving population's quality of life. Recognition of the significant role of innovation in ensuring the socio-economic development of society necessitates the development of economic and social indicators system that reflects the results of innovative processes implementation. The solution of this problem, in turn, involves an appeal to the innovation cycle, in which innovations initiators interact with the recipients of their external effects, as well as with the state, which designs institutions for conducting fundamental and applied research, pilot production and diffusion of innovations in the economic space.

Numbers of studies in this area makes it necessary to typologies theoretical and methodological approaches to the essence of innovation processes and clarify innovation activity indicators system. The development of economic science, characterized by the presence of alternative positions in relation to economic phenomena and processes, is reflected in the formation of various concepts of innovation. The multiplicity of innovation activity indicators is explained, first, by rapid changes and the emergence of new phenomena and processes in the growing turbulence of the external environment, and secondly, by innovations variety and the complexity of their impact on aggregate economic indicators mechanism. The system of innovation activity indicators may be used by public administration bodies when developing programs and forecasts of socio-economic development, by business community entities when determining the content of competitive strategies and conducting a comparative analysis of the product and process innovation implementation results. All this determines the choice of the research topic, its theoretical and practical significance.

LITERATURE REVIEW

The study allows us to identify macro-and micro-economic approaches to the interpretation of innovations and its processes. Proponents of the macroeconomic approach view economic growth as a result of spending by private investors and budget funding for basic research and education by the state. Private investment in R & D leads to the production and commercialization of new products and processes, while public spending on human capital accumulation leads to increased productivity. The realization of innovation potential as an endogenous growth factor causes *"creative destruction"* (Shumpeter, 1982), or leads to the implementation of economic development model characterized by the productive use of all factors of production. Innovations take the form of reducing production costs, creating new goods and services, new materials and components, improving quality, new forms of labor organization, etc. (Kudryavtseva et al., 2016). The latter position shows the relationship between micro-and macro-economic approaches to the interpretation of economic growth and innovations impact on economic development direction and pace.

The macroeconomic approach to the essence of innovation is reflected in the works of Aghion & Howitt (1990); Encaoua et al. (2000 & 2004); Shinkevich et al. (2016), who proposed a model of step-by-step innovation. The consequence of this model is the coexistence of different technological structures within the same sector of the economy recognition. Empirical data shows that industry market competition encourages the introduction of innovations, along with catching up, based on the outsider enterprises' own database, and outperforming, based on the use of tools for transmitting (exchanging) intellectual activity results by leading enterprises. This leads to outsiders withdrawal from the market and to the strengthening of the leaders market powers, and due to high level of investment risks, is accompanied by an increase of uncertainty level in environmental factors. The positive external effect of innovation becomes visible after significant time lag, during which resources are diverted from traditional activities and organizational changes are carried out, leading to a decrease in the growth rate of total income in the short-term.

The development of a macroeconomic approach to the interpretation of innovation role in society has led to a rethinking of the problem of income inequality. A number of authors (Cahuc Postel-Vinay, 2002) analyze the connection between labour market imperfect structure (difficulties in coordination, wage rigidity, etc.) and creative potential destruction. Others (Wigniolle, 2001) point to the conditions for technological innovations successful

implementation, which may increase labor productivity only when highly qualified employees are attracted, making it available for successful enterprises. The latter is accompanied by compensation level volume of individual business and production costs structures increase. A significant place in innovation theory, based on a macroeconomic approach, is occupied by issues of unemployment that is shown either as a result of technological innovations introduction or as a consequence of the development of international trade relations. Using the principles of neoclassical synthesis allowed researchers to identify innovation role in the transformation of assets and their management tools, leading to an innovation shock and market imbalance. The latter can lead to a drop in total product volumes when market adjustment mechanisms are ineffective and wages are inflexible (Amendola & Gaffard, 1998).

Using the principles of the microeconomic approach has led to an understanding of the differences between the technological and product innovations diffusion models. In the first case, new technologies affect the amount of added value, while product innovations affect the consumer choice area. To understand the mechanisms of innovations diffusion, it is important to identify the factors that determine the pace of their spread. In his work of Kleinknecht (1990) presents two types of innovation that differ in the source of the innovation impulse, namely, demand opportunities and technology opportunities. The process of knowledge dissemination under the influence of external factors is studied in the framework of works on the processes of information exchange Ulph (1991); Shinkevich et al. (2017). One of the most well-known theories of innovation, based on a microeconomic approach to its interpretation, is the theory of innovations diffusion by Hagerstrand (1968), which takes into account the space-time factor of this process implementation. Innovations diffusion is recognized as a set of repeated reproduction sequential processes of an innovation, its acceptance (or rejection)by the consumer with subsequent routine.

The innovations diffusion rate is studied in the works of Rogers (2002), who considers this problem in relation to differences between consumers in the propensity to innovate and the intensity of interpersonal communications, Mahajan & Peterson (1985) studied the dependence between innovation consumer's numbers on time and distance from the source of origin (*"core"*), etc.

The analysis showed that micro-and macro-economic approaches have a certain heuristic potential for explaining their mechanism and developing methods for evaluating innovation activity to the interpretation of innovation processes. To achieve the objectives of the study and to define innovative activity indicators system, the innovations diffusion theory is applied, along with the macroeconomic approach principles to innovation taking into account human capital changing role and R&D in industry and the innovation diffusion and the role of the latter in ensuring economic growth.

METHODOLOGY

In order to assess the innovations level of spread and penetration, it is necessary to develop a system of indicators that characterize the innovative dynamics of territorial development (Tamashevich, 1999). In our opinion, the proposed system of indicators should include the following indicators: the number of organizations that performed research and development, units (X1), the number of personnel engaged in research and development, people. (X2), the share of domestic expenditure on research and development in % of GDP (X3), share of expenditure on technological innovations in GDP, % (X4), the number of patents issued, units (X5), the number of created advanced technologies in the country, units (X6), the number of

used advanced technologies in the country, units (X7), share of innovative goods, works, services in total volume of shipped goods, performed works, services, % (X8), labor productivity, expressed in monetary units, billion. (X9), growth rate of labor productivity, % (X10), volume of services to the population, million rubles (X11), volume of emissions of pollutants into the atmosphere, million tons (X12), volume of wastewater to surface water bodies, billion m3 (X13), turnover of enterprises (organizations) of the territory, billion rubles (X14), growth rate of turnover of enterprises (organizations) of the territory, % (X15) (Table 1).

Table 1
THE PROPOSED SYSTEM OF INDICATORS FOR ASSESSING THE LEVEL OF INNOVATIONS DISTRIBUTION AND PENETRATION IN THE RUSSIAN FEDERATION FOR THE PERIOD 2015-2019

Indicator Designation	2015	2016	2017	2018	2019
X1	4175	4032	3944	3886	3649
X2	738.9	722.3	707.9	698.5	683.1
X3	1.1	1.1	1.11	1.1	1.1
X4	2.2	2.2	2.4	2.4	2.5
X5	32 981	31 274	31 607	32 757	33421
X6	122583	127089	131440	132863	133548
X7	218018	232388	240054	254927	261468
X8	7.0	7.1	7.2	7.2	7.3
X9	145956	153857	166329	185534	191369
X10	106.2	105.4	108.1	111.5	103.1
X11	8050808	8636277	9211441	9413373	9586722
X12	31.3	31.6	32.1	32.4	32.7
X13	14.4	14.7	13.6	13.4	13.1
X14	135699.4	146376.8	169339.9	191820.6	200938.2
X15	102.5	107.8	115.7	113.3	104.7

Note: Compiled by the author on the basis of data from the Federal state statistics service.

This system of indicators is characterized by heterogeneity in respect of measurement indicators different units, thus the necessity of converting them into a single dynamic form by calculation of the chain indices of these indicators during the medium-term period (Table 2).

Table 2
THE DYNAMIC SHAPE OF THE INDICATORS TO MEASURE THE LEVEL OF INNOVATION DISTRIBUTION AND PENETRATION IN THE RUSSIAN FEDERATION AND THE MEDIAN VALUE FOR THE PERIOD 2015-2019

Indicator Designation	2015-2016	2016-2017	2017-2018	2018-2019	Median
X1	0.96575	0.97817	0.98529	0.93901	0.97196
X2	0.97753	0.98006	0.98672	0.97795	0.97901
X3	100.000	100.909	0.99099	100.000	100.000
X4	100.000	109.091	100.000	104.167	102.083
X5	0.94824	101.065	103.638	102.027	101.546
X6	103.676	103.424	101.083	100.516	102.253
X7	106.591	103.299	106.196	102.566	104.747
X8	101.429	101.408	100.000	101.389	101.399
X9	105.413	108.106	111.546	103.145	106.760
X10	0.99247	102.562	103.145	0.92466	100.904
X11	107.272	106.660	102.192	101.842	104.426
X12	100.958	101.582	100.935	100.926	100.947
X13	102.083	0.92517	0.98529	0.97761	0.98145
X14	107.868	115.688	113.275	104.753	110.572
X15	105.171	107.328	0.97926	0.92410	101.548

Note: Compiled by the author on the basis of data from the Federal state statistics service

Based on the dynamic series of selected indicators presented in Table 2, it is proposed to calculate distribution and penetration level of innovations in the Russian Federation in the medium term. To do this, it is necessary to standardize the obtained indicators (Stxi) for each particular indicator xi with n-the number of indicators (1):

$$St_{xi} = \frac{x_i - \frac{1}{n}\sum_{i=1}^{n} x_i}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \frac{1}{n}\sum_{i=1}^{n} x_i\right)^2}} \quad (1)$$

Then the average value of the mathematical distance between observations is calculated (2):

$$D_{mi} = \frac{1}{n}\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(St_{xi} - St_{ref}\right)^2} \quad (2)$$

and the maximum potential deviation from the reference value (3):

$$D = D_{mi} + 2\sqrt{\frac{1}{n}\sum_{i=1}^{n}(D_{mi} - D_m)^2} \quad (3)$$

The value of distribution and penetration of innovations indicator level in the Russian Federation in the medium term is proposed to be calculated using the formula (4):

$$I_{id} = 1 - \frac{D_{mi}}{D} \quad (4)$$

The calculations made, led to the compilation of table 3, which shows the dynamics of distribution and penetration of innovations indicator level in the Russian Federation during 2015-2019:

Table 3
DYNAMICS OF DISTRIBUTION AND PENETRATION OF INNOVATIONS INDICATOR LEVEL IN THE RUSSIAN FEDERATION DURING 2015-2019

Indicator	2015-2016	2016-2017	2017-2018	2018-2019
	0.6835	0.6921	0.6928	0.6943

The calculated values of indicators are in the range [0; 1], where 0-innovations do not spread, 1-full diffusion of innovations. According to Table 3, we can talk about the positive dynamics of innovation diffusion in the Russian Federation, almost reaching 70% by 01.01.20.

RESULTS AND DISCUSSION

The research starting point is the thesis that there are no insurmountable barriers between the stages of the innovation cycle (obtaining basic knowledge (discoveries and inventions), acceptance of innovations by society and their dissemination). Therefore, the speed of innovation propagation may be considered as an integral indicator of innovation level activity in the state as a whole and in its regions. However, the analysis shows that innovation processes linear model does not reflect the complexity of interactions between participants in the cycle, united by production process and knowledge dissemination as an intangible asset in order to turn into

goods (services) and extract benefits. It is information that acts as a key input and output asset in production systems at the post-industrial stage of society's development. In this regard, understanding the essence of innovation relations implies the need to study the essence of knowledge that differs in its attribute characteristics from traditional goods and services. *"Knowledge is a product of transformation by the subject of the received information, which gives it meaning and significance"* (Stepin, 2010), i.e. knowledge has personal nature and cannot be translated. Another attribute property of knowledge is its cumulative nature, i.e. the knowledge structured by a person depends on the knowledge of other economic agents, which they reinterpret and use in solving certain tasks. This property of knowledge determines a significant positive external effect initiated by the process of their production in the course of research and development (R & D), leading to the formation of social benefits (social value). Information is objective in its nature; it may be relayed and assimilated by the individual in the process of knowledge production. At the same time, information is one of the public goods characterized by non-competition and inexhaustibility, leading to high production costs and low costs for their replication. In this regard, there are open and closed innovations, the production of which is based, respectively, on the mechanism operation of open scientific research and the private form of information assignment. The latter involves the use of patent and other methods of protecting intellectual property rights.

The presence of a positive external effect of R & D, on one hand, makes it complicated to measure its effectiveness, which has economic and social aspects, and on another hand, is an important argument for increasing the cost for basic and applied research, ensuring an increase in their intensity as an indicator of R & D ratio expenditures to the volume of value added produced. In addition, in a post-industrial society, knowledge production has become an area of intense competition at the international level, which encourages innovation diffusion, spatial reorganization, and increasing inequality between states in terms of development. The latter is due to the fact that new technologies production and transfer is concentrated in certain regions of the world, therefore, not allowing a number of states to benefit from this form of international cooperation.

Modern economics use alternative approaches to explain innovation impact on economic growth. The microeconomic approach is based on the recognition of information and knowledge features as assets, the presence of which explains the absence of dependence with economic development rate on the law of diminishing returns. Since the innovator uses previously accumulated knowledge and benefits from it, financing only the process of increasing knowledge, the production function, one of the arguments of which is knowledge, is characterized by increasing returns. At the same time, the accumulation of knowledge leads to a positive scale effect. In this approach, the state is considered as a subject of designing institutions for intellectual property rights protection in order to encourage private investment in R & D, thus, creating conditions for strengthening the market power of companies engaged in innovative activities. The market, characterized by the dominance of an imperfect type of market competition, creates conditions for covering initial investment by innovative entrepreneurs and receiving payments under license agreements regulating the use of intellectual property results. At the same time, limiting the terms of patent protection contributes to the development of competitive relations and innovation activity.

Performance of innovation processes depends not only on available factors of production employees' competence, and entrepreneur readiness to participate in the processes of creating new knowledge, it is also the state of the institutional environment that stimulates innovative

activity and provides intellectual property rights protection, and the state of objects of innovation infrastructure. At the same time, it is necessary to take into account the social value created by participants in innovative relations, which is manifested in increasing environmental safety level, which is a necessary condition for increasing the quality of life of the population.

CONCLUSION

Within the framework of the research, innovations are considered as research objects and goals of economic policy. The complexity of the problem predetermined the emergence of alternative approaches to the interpretation of the mechanism of their production and distribution, among which special attention was paid to microeconomic and macroeconomic concepts of innovation. Using the theory of innovation diffusion in accordance with the principles of microeconomic analysis and considering continuous innovation reproduction process, consumers adaptation with the subsequent routinization of new products and technologies, allowed us to propose a methodological approach to the assessment of the prevalence and penetration of innovations in the Russian Federation and the calculation of their median values for the period 2015-2019. Multidimensional analysis applied in the study conducted, showed a positive dynamics of indicators of innovation spread in the modern Russian economy.

The proposed methodological approach may be applied in program documents development for calculating the forecast values of innovation activity and justifying measures aimed at stimulating the choice of innovative strategies by business entities the Russian state.

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