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Development of Innovative Projects in the Field of 5G Technology: Methodology and Assessment

Desarrollo de proyectos innovadores en el ámbito de la tecnología 5G: metodología y evaluación

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ABSTRACT

The development and implementation of the latest technologies allow achieving competitive advantages in the global market and open up a wide range of prospects in various fields of activity. High risks and significant initial investments have predetermined the need to develop the most accurate methods for assessing the effectiveness of innovations. Traditional methods of investment assessment allow analyzing the economic component of these projects but do not consider specific risks that have a predominant impact on the successful result of financing. The study shows the need for an individual approach to assessing the effectiveness of each innovative project implementation, which should take into account its social significance in conjunction with maximizing economic benefits. Calculations that allow obtaining a single criterion for choosing the most optimal variant of the project implementation are presented. Recommendations on the organization of effective deployment of the 5G network in the Russian Federation are given in the study's conclusion.

Keywords: analysis of innovations' effectiveness; aggregate project assessment; acceptability of indicators; aggregate risk.

RESUMEN

El desarrollo e implementación de las últimas tecnologías permiten lograr ventajas competitivas en el mercado global y abren un amplio abanico de perspectivas en diversos campos de actividad. Los altos riesgos y las importantes inversiones iniciales han predeterminado la necesidad de desarrollar los métodos más precisos para evaluar la eficacia de las innovaciones. Los métodos tradicionales de evaluación de inversiones permiten analizar el componente económico de estos proyectos pero no consideran riesgos específicos que tienen un impacto predominante en el resultado exitoso del financiamiento. El estudio muestra la necesidad de un enfoque individual para evaluar la eficacia de la implementación de cada proyecto innovador, que debe tener en cuenta su importancia social junto con la maximización de los beneficios económicos. Se presentan cálculos que permiten obtener un único criterio para elegir la variante más óptima de ejecución del proyecto. Las recomendaciones sobre la organización del despliegue efectivo de la red 5G en la Federación Rusa se dan en la conclusión del estudio.

Palabras claves: análisis de la eficacia de las innovaciones; evaluación agregada del proyecto; aceptabilidad de los indicadores; riesgo agregado.

1. INTRODUCTION

Today, the possession of competitive advantages in the industry is a crucial factor for the successful development of any organization. In the conditions of the accelerated pace of scientific and technological progress and increased interest in high-tech enterprises on the part of the state, the main indicator of competitiveness is the fact of implementing innovations (Tarasova et al., 2017). Thus, the engine of national economic growth is the continuous improvement or creation of new technologies and inventions. Innovations are implemented in the form of large intersectoral projects on creating, developing, and spreading technologies that contribute to fundamental changes in the technological basis of the economy, as well as on developing fundamental research, scientific and technical support of social programs, and international cooperation (Bondarenko, Burdina, 2019). In this regard, innovative projects and programs are essential for the development of many areas of science and technology, which also play an important role in the state's scientific and technical policy (Ilyichev, 2018). The choice of the most effective ways of technical and technological development, based on long-term forecasting, comparison of internal and external factors, and considering resource constraints, is an innovative strategy for both the country as a whole and individual enterprises. The innovation potential of organizations is of great importance, the level of which determines the innovation strategy formation. Stimulating economic entities to implement innovations is an important task of the state. Activation of the process of introducing innovations is necessary to maintain high positions in the market, as well as the development of advanced technologies that eliminate the possibility of lagging behind world leaders.

2. MATERIALS AND METHODS

The process of introducing innovations is risky due to the presence of a high share of uncertainty in combination with large amounts of capital investment (Bondarenko, Burdin, 2020). The indicators of an innovative project include groups of economic, social, scientific, technical, environmental, and other criteria that will have different levels of priority depending on the moment of innovation implementation or importance for the state or consumers. The project may be unprofitable from a commercial point of view but have a high significance in the field of scientific and technical breakthroughs. The analysis of innovations should assume a comprehensive assessment, combining both quantitative and qualitative indicators. Quantitative indicators should include the following criteria: profit in absolute terms, costs level, return on investment, return on assets after the project completion, net present value of investments, static and dynamic payback periods, internal rate of return, and other standard indicators of the economic efficiency of investments. Qualitative indicators include such characteristics as compliance with the enterprise's strategic goals, social significance level, risk factors, possibility of obtaining long-term market advantages, state support, number of participants and stakeholders, etc. Quantitative indicators are universal for all projects, however, the set of qualitative criteria may differ fundamentally. Besides, the methodology for assessing innovations should be flexible and applicable at each stage of the project life cycle to ensure that the initial results of the analysis can be compared with intermediate data, considering current conditions. This approach will allow us to obtain objective results with the restrictions on minimizing the associated risks of implementing innovations.

The main emphasis in this study is placed on the option of assessing a specific innovative project in the field of information technology. The project on the 5G technology introduction will provide a platform for existing communication services and contribute to the emergence of new business models and scenarios for their use. The key role of 5G is to support the government and regulatory authorities in transforming large settlements into smart cities and enabling citizens and communities to take advantage of the socio-economic benefits provided by the advanced digital economy that requires the use of large amounts of data, as well as

to participate in the creation of these benefits (Kokurin, 2018; Kafidov, 2019). The new generation network will provide a high quality of service to end users, offering new applications and services at high data transfer speeds, which will increase work efficiency and reliability. The conditions for the implementing innovative project are currently being actively prepared, besides, the first commercial 5G networks, which are operating in a test mode, have already appeared in Russia. The implementation of the 5G network will affect the following processes:

1. Growing indoor wireless broadband coverage. New technologies will make it possible to ensure the availability of cellular communications in any part of the room, which is currently a problem with existing networks.

2. Improving wireless broadband communication in the open air. This advantage will be manifested in improving Internet access in urban transport, increasing the capacity for holding public events outside the premises, etc.

3. Expanding the possibilities of remote work.

4. Introducing distance education widely. High-quality communication will increase the number of students through the use of special educational platforms that do not require full-time presence.

5. Developing intelligent agriculture. It is possible to track the level of humidity, the chemical composition of the soil, etc. by connected sensors.

6. Creating a smart city. Control over lighting, security in the city, and environmental monitoring will be provided with the help of 5G networks. Regulation of transport on the roads. Prospects for police intelligence and the fight against terrorism and riots are opening up.

7. Remote production monitoring. The use of new technologies is advisable to prevent the risks of security breaches, leaks, and explosions.

In addition to these advantages, the project to introduce a 5G network is profitable from a strategic perspective. According to the results of a study by the Radio Research Institute (RRI), the revenues of Russian mobile operators from the implementation of an innovative project will reach about 320 billion rubles by 2030. Figure 1 shows the forecast of operators' revenues from the provision of 5G services in the period from 2023 to 2030.

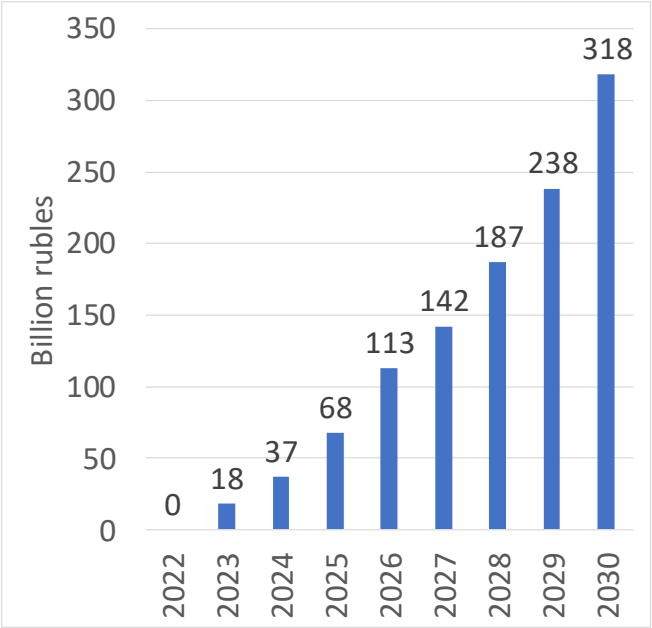

Figure 1. Forecast of the Russian operators` revenue from the provision of 5G services

To implement the project, it is necessary to consider all possible options for its implementation in conjunction with the associated risks to avoid loss with maximum benefit.

At the level of the Ministry of Digital Development, Communications, and Mass Communications of the Russian Federation, a study, which considers three possible scenarios for the introduction of a 5G network in cities with millions of people in Russia, is being conducted:

1. Mainly autonomous development of the 5G network by each operator.

2. Intensive sharing of network infrastructure.

3. Emergence of a single infrastructure operator.

Using the example of this project, the article develops a sequence for assessing innovations. Due to the presence of several implementation options, it is necessary to analyze each scenario for the most effective implementation (Nikolenko et al., 2018). To assess the success of the work, it is advisable to carry out the following stages, which are clearly presented in Figure 2.

The presented sequence is based on the assessment of innovations considering traditional methods of analyzing the economic efficiency of investments in conjunction with an expert study of the risk level. This approach will allow us to choose the most profitable scenario for implementing the project in terms of profitability with minimal threats of disruption.

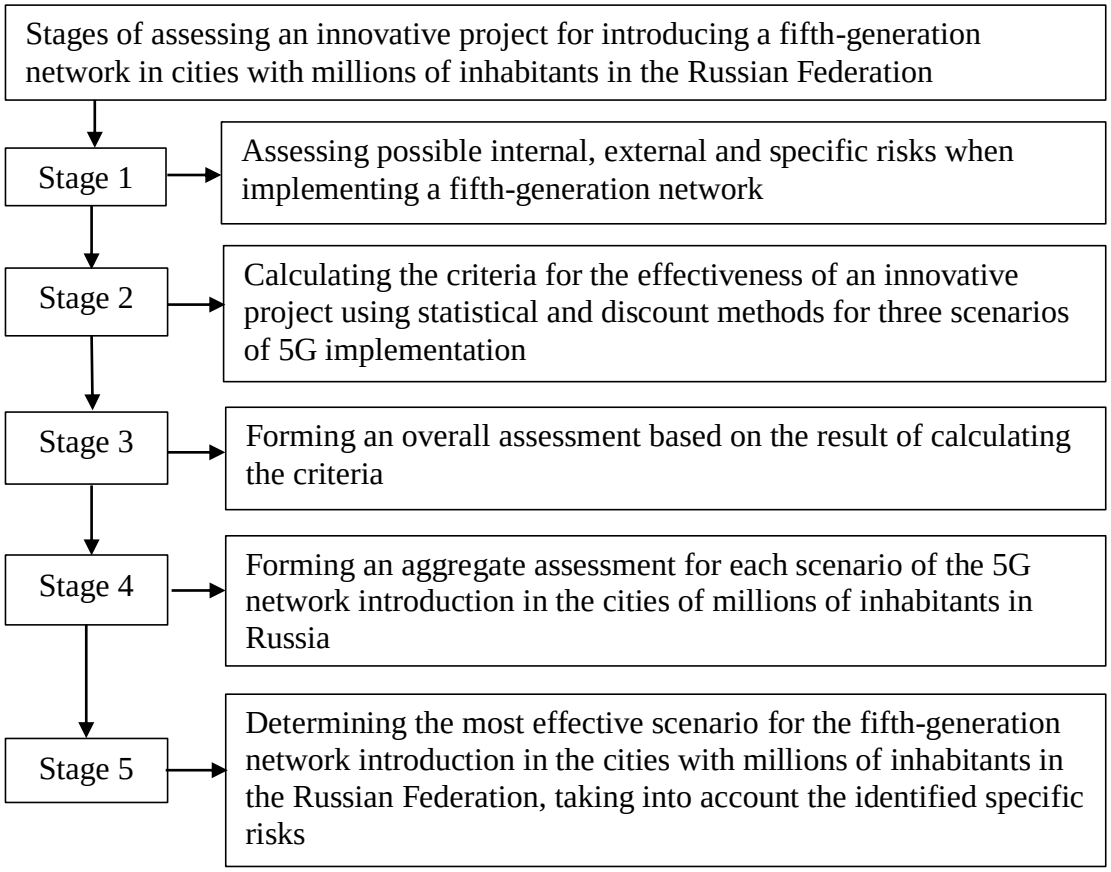

Figure 2. Stages of assessing an innovative project in the field of information technologies

3. RESULTS AND DISCUSSION

Before starting work on the analysis of an innovative project, it is important to carry out organizational measures that should include the following: building an analytical group, preparing workplaces and conditions, supplying experts with the necessary tools and documents, checking the quality of initial information, etc. The heads of an innovative project should pay special attention to setting goals and objectives, as well as communicating their exact formulations to the performers for assessing innovations. It is necessary to identify priority factors for the introduction of innovations, identify the most significant criteria for analysis, as well as distribute the range of responsibilities, forming responsibility centers. The task of the analytical group is to properly organize the process of assessing the effectiveness of innovations. The responsibilities of the group's specialists include selecting experts and identifying their competence. It is advisable to apply a two-stage procedure for selecting experts, which includes documentary control and mutual assessment. The first step is to verify the documented information about each candidate, which relates to education, position, work experience in the field of innovations, availability of scientific articles and research, as well as other significant achievements. All assessment criteria are assigned non-normalized weights determined by the analytical group participants. Mutual assessment is carried out based on specialists interviewing to determine the experts' general erudition. At the end of this stage, based on a collective discussion, each expert is assigned a score from 0 to 1. After two stages of selection, a rating of candidates for the expert group is formed. The rating of each expert is determined by the analytical group according to the formula 1:

$$R_i = \sum_j R_{ij} / \sum_i \sum_j R_{ij} \quad (1)$$

where R_i is the rating of the i^{th} candidate or their normalized weight;

R_{ij} is the weight of the i^{th} candidate by the j^{th} criterion.

$$R_{ij} = r_i \times s_j \quad (2)$$

where $r_i$is the rating of the i^{th} candidate, obtained using the mutual assessment method;

$s_j$are non-normalized weights of the assessment criteria.

The candidates with the highest normalized weights are included in the expert group. The recommended number of experts in the group should not exceed ten. This will allow us to obtain objective results of the project assessment at an acceptable cost for organizing the work of the group.

In addition to the selection of experts, the analytical group should monitor the reliability of the initial information about the innovative project, the final decision on the feasibility of implementing the project will depend on the quality of the data provided. The experts should be provided with such means as paper forms for entering the evaluation results, equipment, and the necessary software in advance for the speed and convenience of work. Besides, due to the high level of the subjectivity of decisions made, which is characteristic of expert analysis, it is advisable to check the compatibility of assessments at each stage of the project study. After the experts finish their work, the specialists of the analytical group process the results and present the conclusions in a convenient format to the heads of the innovation project, who make the final decision on how to implement the goal.

After the completion of all preparatory activities and the formation of a group of experts, the work on the assessment of innovations starts. At the first stage, the possible risks of an innovative project, including specific ones, are analyzed. For the project as a whole, a set of negative situations that can significantly affect the course of its execution is formed (Burdina, Bondarenko, 2019). The main risks include the following groups:

1. Organizational risks. Threats related to errors in the organization of the procedure for analyzing the project effectiveness; lack of preparation of conditions for the start of work on the innovation introduction. Moreover, these risks include the fact of an incorrectly selected methodology for the project implementation, low speed of the organization in the transition and development of a new IT system, etc.

2. Technical risks. This group includes sudden changes in the requirements for the project implementation; increase in the complexity level of implementation associated with changing conditions; lack of experience in the technologies used, which is natural when introducing innovations; incompatibility of equipment due to its obsolescence, etc.

3. Financial risks. Because of the lack of experience in implementing similar projects due to innovation, it is impossible to predict the exact amount of funding at each stage of its implementation. Thus, there may be significant discrepancies between the planned and actual current costs of the project. Such a situation will require an urgent search for sources of investment, in the worst case - the suspension of work on the project.

4. Socio-economic risks. Changing consumer preferences will affect demand for the worse. Besides, a significant threat is a decline in the solvency of the population.

5. Market risks. Such risks include incorrect assessment of the expected consumer demand, changes in prices for resources, and non-compliance of the final product with the customers` requirements and needs.

6. Competitive risks. The danger lies in the rapid reaction of competitors and the loss of preferential positions in the market.

7. Risk of using innovative technologies only for state purposes. A negative factor for this project is the probability of using the 5G network only for military purposes or for providing state communications. In this case, the social benefits of new technologies for the population will be lost to a greater extent, and the high potential of the project will not be fully used to increase the welfare of the country.

8. Inability to quickly fix problems. This risk is most likely if the implementation of the 5G network will take place through a single infrastructure operator.

Experts, who are specialists in the field of information technology, assign the probability of its exclusion to each risk. Besides, within the aggregate, risks are distributed according to the degree of danger by assigning a score from 0 to 5, where 0 is the lowest risk, and 5 is the maximum risk. By multiplying the probability by the corresponding score, a weighted assessment of a specific risk is determined, and summing up all the obtained values, a general risk assessment is formed for one of the scenarios. Thus, an integral assessment of the aggregate risk level will be calculated for each scenario. The calculation results for the first scenario of the project implementation are presented in Table 1.

Table 1. Risk assessment of an innovative project implementation

Risk classification	**Risk name**	**Probability of risk exclusion**	**Degree of risk danger**	**Weighted risk assessment**
Internal	Organizational	0.8	1	0.8
	Technical	0.4	3	1.2
	Financial	0.3	5	1.5
External	Socio-economic	0.4	3	1.2
	Market	0.5	3	1.5
	Competitive	0.2	4	0.8
Specific	Use of the technology only for state purposes	0.7	1	0.7
	Inability to quickly fix problems	0.6	2	1.2
General risk assessment for the first scenario		**8.9**		

Note: Calculations are made in the same way for the other scenarios.

At the second stage of the analysis of the 5G technology introduction project, its economic efficiency is calculated using traditional static and discount methods for assessing investments. According to the results of calculations at this step, it is possible to exclude some scenarios of project implementation due to the lack of benefits from implementation. However, it is necessary to take into account the social efficiency of innovation, which may exceed the economic one due to its priority nature for the country's economy.

At the third stage, threshold values are set for each indicator of economic efficiency based on the scale developed by specialists. As a result of the correlation of the actual calculated values with the score scale, a universal assessment is formed. In addition, each criterion is assigned a weight so that the sum of all the weights gives one. Using the product of the score by weight, a weighted assessment of the corresponding investment efficiency criterion is calculated (Nikolenko, 2018). Next, by analogy with the risk analysis, the sum of all assessments by indicators is found, which forms an overall assessment of the scenario for the

innovative project implementation, considering the degree of acceptability of the criteria for the economic efficiency of investments. The final calculations for the first scenario are presented in Table 2.

Table 2. Assessment of the acceptability of the criteria for the economic efficiency of an innovative project

Indicator	**Scale**		**Criterion weight**	**Calculation**		
	Range of values	**Score**		**Actual value**	**Corresponding score**	**Weighted assessment**
NPV, bln rub	0-50	0	0.5	191.84	3	1.5
	50-100	1				
	100-150	2				
	150-200	3				
	200-250	4				
	250-300	5				
IRR, %	0-5	0	0.1	24	4	0.4
	5-10	1				
	10-15	2				
	15-20	3				
	20-25	4				
	30 and more	5				
PI	0-0.4	0	0.2	1.23	3	0.6
	0.4-0.8	1				
	0.8-1.2	2				
	1.2-1.6	3				
	1.6-2.0	4				
	2.0 and more	5				
DPP, years	7-6.5	0	0.2	6	0	0
	6.5-6	1				
	6-5.5	2				
	5.5-5	3				
	5-4.5	4				
	4.5-4	5				
General assessment of the acceptability of the economic efficiency criteria for the first scenario						**2.5**

Note: Calculations are made in the same way for the other scenarios.

At the fourth stage, experts decide on the nature of the advantage between the aggregate risk level and the acceptability of a group of investment efficiency criteria for an innovative project to implement a 5G network. Experts assign a weight to each of these categories, which acts as a priority indicator for making a decision on implementing an innovative project. Based on the results obtained at the previous stages, the overall risk assessments and the acceptability of the indicators of the economic efficiency of investments are multiplied with the corresponding weights. Summing up the obtained values for each scenario will allow us to determine the aggregate estimates, which will be the only criteria taken into account when making decisions about implementation (Nikolenko, 2017). The calculation results for the considered innovation project are presented in Table 3.

Table 3. Assessment of the acceptability of the criteria for the economic efficiency of an innovative project

Criterion	**Scenario1**		**Scenario 2**		**Scenario 3**	
	Weight	**Value**	**Weight**	**Value**	**Weight**	**Value**
General risk assessment	0.6	8.9	0.3	11.7	0.4	7.1
General criteria assessment	0.4	2.5	0.7	4.8	0.6	1.5
Aggregate assessment	6.34		6.87		3.74	

At the fifth stage, based on the results obtained, the most effective scenario for the introduction of a 5G network in the cities of the Russian Federation with millions of people is identified, considering the identified specific risks.

Despite the fact that all scenarios for implementing an innovative project are effective and pay back, that is, the introduction of a 5G network in any scenario will bring profit. According to the aggregate assessment obtained, it is possible to determine the best way to implement the project. As a result of the obtained analysis criteria for each of the scenarios, the most effective option for implementing a 5G network is the intensive joint use of the network infrastructure by operators. When implementing a project in this way, there are fewer risks, and the income from an innovative project is greater.

As for recommendations for the effective deployment of the 5G network in the cities of the Russian Federation, we can distinguish the following:

1. Creating an innovative space for the development of 5G-based services. In this case, the key role is played by the state policy to support the emergence of new digital and digitalization-promoting industries that will need modern communication services that correspond to the pace of development. As a result of creating demand for the new network, the commercialization of these services will start to intensify, which, in turn, will ensure the further development and improvement of the quality of 5G communications. Moreover, it is advisable to develop a system of state support for innovative projects aimed at the development of 5G technologies.

2. Allocating frequencies for 5G. Despite the importance of the innovative project, there are significant limitations to its implementation, namely the low availability of radio frequency bands for 5G. Regulators should review the pricing policy for frequency bands, as well as the annual rates of spectrum fees. It is possible to stimulate the attraction of investments in 5G infrastructure by ensuring the flexibility of the pricing policy. Besides, the voluntary transition to the use of 5G networks by interested market participants will significantly reduce the cost of deploying this infrastructure and accelerate the process of capturing all the benefits of the implementation results.

3. Deployment procedures and conditions. The rapid pace of scientific and technological progress requires operators to accelerate the deployment and modernization of the network, using automation technologies for this purpose. It is important to create conditions for unhindered access of all participants interested in the implementation of the project to infrastructure facilities that are state-owned. It is advisable to simplify the procedures for standardization and obtaining licenses. Simplification of the administrative stages that ensure the construction and commissioning of 5G communication networks will reduce the time and current costs of the project. At the same time, it is important to unify the procedures for registering land plots and issuing permits for the construction of necessary facilities.

4. Radiation standards when using wireless communication. Due to the importance of ensuring the safety of citizens' health, an innovative project to introduce a 5G network requires checking for the radiation level and its compliance with existing standards. At the moment, the current requirements actually exclude the possibility of cost-effective deployment of 5G networks, which determines the need for legislative consolidation of modern sanitary and epidemiological standards.

5. Net neutrality and data regulation. The issue concerns the creation of a legally favorable environment that allows meeting the requirements for the protection of confidential information in conjunction with the ability to provide innovative services based on subscriber data. Excessively strict legislation should be balanced, especially if it concerns the population's welfare.

6. Encouraging investment in 5G networks. In the modern conditions of digital technology development at an increasing pace, it is relevant to stimulate investment activity in the field of the information environment. This task is considered a state-level problem. With the help of public-private partnership mechanisms, it is possible to attract capital to finance significant innovative projects.

Thus, in addition to the proposed procedure for assessing the effectiveness of the 5G technology introduction project, it is necessary to eliminate the restrictions that prevent the network deployment. However, all recommendations are individual and are given considering the specifics of a particular project.

Due to the fact that a negative situation is understood as a possible risk of loss of resources, profits, as well as other benefits obtained during the successful implementation of an innovative project, quantitative methods for determining risk are based on the consequences of the crisis (Bondarenko & Burdin, 2020). The quantitative characteristic of the risk in the general case can be represented using the following formula:

$$R = \sum_{i=1}^{n} P_i \times Y_i \quad (3)$$

where R is the quantitative characteristics of the risk,

P_i is the probability of occurrence of the i^{th} adverse event,

Y is the amount of expected damage upon the occurrence of the i^{th} adverse event, RUB.

The degree of consistency of expert opinions significantly affects the results of the study. If disagreements are found in the process of setting the weights of indicators, the probabilities of excluding risk, as well as when developing a scale of threshold values for investment efficiency criteria, repeated work is carried out with a preliminary discussion of the details in a group of specialists. If the experts do not come to a single conclusion after repeatedly expressing their opinions, the analytical group decides to disband the expert commission, and the search for new independent specialists with the appropriate level of qualification is carried out. To assess the consistency of expert decisions, the following indicators are calculated:

1. Variation coefficient, which characterizes the degree of dispersion of expert opinions relative to the average indicator. The value of this criterion is 0.3. To obtain more accurate results, it is desirable to focus on the value of 0.2.

2. Spearman's rank correlation coefficient, which is used to evaluate the measure of proximity of rankings.

3. Concordance coefficient used to identify errors in the ranking of indicators. This criterion varies from 0 to 1, where the maximum value indicates a high consistency of expert opinions (Nikolenko, 2017).
The above indicators allow minimizing the probability of obtaining inaccurate results in assessing innovative projects.

4. CONCLUSION

In conclusion, it can be noted that due to the above sequence of innovation analysis, it is possible to assess the project with a small amount of data, while the condition of considering all possible implementation risks is met. The project assessment using traditional methods of calculating investment efficiency criteria is insufficient since these tools do not take into account the high level of uncertainty associated with the process of introducing innovations. However, it is impractical to exclude the stages of calculating economic benefits and payback periods. The disadvantage of the proposed methodology is the presence of subjective expert assessments, which can be eliminated by using quantitative methods of risk assessment and checking the consistency of specialists' decisions. A quantitative risk assessment is necessary to objectively determine the degree of danger for each negative situation that may accompany the project during its implementation. The assignment of hazard points by type of risk with the help of expert analysis should be supported by well-founded facts. The most common methods of forecasting and measuring risks include the following:

1. Probabilistic and statistical approach. This method is based on the representation of negative factors as a Poisson flow of random events.

2. Probabilistic-deterministic approach. When applying the method, stable patterns of the development of risk situations are identified, and obvious scenarios of actions are determined in case of undesirable deviations of the project from the plan based on the cyclicity of their occurrence.

3. Deterministic-probabilistic approach. It is used for short-term forecasting in the presence of operational information about technical failures, changes in the external and internal environment, negative dynamics of competitive positions and demand, there are problems with financing, etc. The task of managers of an innovative project, in this case, is to ensure the readiness of a rapid response to actions to eliminate a risky situation.

Overall, the proposed procedure for analyzing innovations simplifies the process of making managerial decisions about the start of financing, allowing people to make a choice in favor of one or another option based on only a single calculation criterion – an aggregate assessment. The stages described and tested in this study can be applied to assess projects in any industry due to the sufficient flexibility in forming a set of risks and criteria for analysis. As for recommendations for improving this methodology, it is advisable to introduce a group of indicators of the social importance of an innovative project into the criteria system. Regardless of whether the project will bring profit in the future, it is possible that when implemented, the development under study will bring significant benefits to society, stimulate the development of the national economy, and ensure the growth of the state's competitiveness at the global level.

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