Scenario approach in forecasting the efficiency of infrastructure projects for transport supply of international trade

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Abstract. In the current conditions for the development of the world economic system and against the backdrop of growing contradictions of various participants in trade and economic relations formed under the influence of both purely economic and political factors, when making investment decisions for the development of international business and projects, including infrastructure ones, it is necessary to take into account associated risks. Using the methodological approaches of system analysis of large-scale investment projects, which use expert methods to reduce the level of influence of risk factors and uncertainty, an analysis of the sensitivity of individual infrastructure projects to the influence of environmental factors was carried out. As a result of the study, it was shown that scenarios for the development of the external environment differently affect the infrastructure projects of different purposes that are allocated in the work. Each type of infrastructure projects has its own peculiarities: projects of transit value serve the trade and economic relations of European and Asian countries, infrastructure projects of regional importance contribute to strengthening trade and economic relations of border areas, and certain commercial railway lines provide access to mineral deposits. The findings can be used in forecasting the development of continental trade and economic relations, both in general and in individual industries, as well as in substantiating large-scale infrastructure projects that solve the problem of transport supply of international trade.

1 Introduction

The globalization of the world economic system and changes in corporate strategies for the development of international business over the past decades have transformed the international geography of modern trade and economic relations. The deepening processes of the international division of labor, the building of technological chains, and the struggle for global sales markets largely determined the development of international trade in this period of time. The rejection of protectionism and radical protection of our own producers after the crisis in 2008 and the joint search for an optimal development path as a part of the

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G-20 allowed us to look optimistically at the prospects for the development of the world economy and international trade in the future.

But over the past few years, experts have begun to characterize the state of the development of the world economy as a crisis of globalization. Brexit, the actions of the USA President D. Trump to protect his producers and a focus on the rollback of previously achieved conditions of free trade, the expansion of sanctions often determined by political reasons or competitive struggle created a lot of uncertainty in the future development of trade and economic relations. Thus, “The turbulence of globalization” described by Professor Avidokushin E.F. can hardly be a testament to its end. In the case of the UK, it may be about the country's desire for a greater degree of globalization than is possible within the framework of European integration. As for the actions of D. Trump, they can be more characterized by moving to more favorable conditions in bilateral agreements, then the less preferable in the multilateral framework, with the undoubted interest in maintaining their role as a global economic leader. [1]

Nevertheless, such changes in the world economic system leave an imprint on the efficiency of implementing certain projects for the development of international business, and on the efficiency of the development of the accompanying infrastructure that provides international trade. The uncertainty of the development of the external environment in many respects determines the relevance of this study.

The purpose of this study is to determine the sensitivity of the development of individual infrastructure projects aimed at servicing the continental trade and economic relations to scenarios for the development of the external environment.

Structuring the problem of studying the efficiency of implementing infrastructure projects with a purpose to study the influence of development factors of external environment on them will increase the scientific validation of the decisions made. The forecasts of the International Monetary Fund can serve as confirmation of the need for such studies. Thus, according to IMF experts, a short-term forecast for the development of national economies shows a steady growth of 3.9% on average. At the same time, for the euro area, this figure is 2.4%, 1.2% for Japan, 6.6% for China, and 2.9% for the United States. But in the long-term, forecasts are less favorable, primarily because of the problems of population aging, lower levels of labor force participation, and low productivity growth.

Also, significant risks for the development of the world economy are caused by trade restrictions and counter measures that undermine confidence and significantly affect global economic growth [2]. It is possible to take into account the influence of such factors by applying scenario analysis methods, involving experts in assessing the possible influence of scenarios on the forecasted indicators of the development of trade and economic relations, and justifying infrastructure investment projects. But the nature of the impact on infrastructure projects that are different in scope, geographic and conceptual features, as well as the trade and economic relations served by them, will be different.

As a part of this study, the problem of assessing the sensitivity of infrastructure projects will be considered in the context of continental relations. This is due to the choice of the railway infrastructure as the object of influence, on the example of various projects of which sensitivity to scenarios of the external environment is analyzed. Railway transport serves mainly continental trade and economic relations or takes into account the specifics of the goods flows served by railway transport.

The application of the scenario approach in planning the development of its trade and economic relations is of particular relevance for Russia. This is due to the negative consequences of the introduction of trade and financial restrictions on the country. Proceeding from this, the work is modeling the scenarios of the development of the external environment at several levels reflecting changes at the international, Russian, and regional levels. The description of possible scenarios for the development of the external
environment is based on the studies of Russian economists. In this case, unlike the classical approach of describing three scenarios for the development of the external environment: optimistic, pessimistic, and most likely, we will introduce another “joker” scenario. This approach is based on the theory of the “black swan” proposed by N. Taleb in his book “The Black Swan: The Impact of the Highly Improbable” [3]. This theory considers difficult-to-predict and rare events, which have significant consequences, both negative and positive. As a part of the study, the scenario reflecting the emergence of events such as the “black swan” will reflect the positive effects for Russia, so the term “joker” was used as its designation.

The necessity of this approach in forecasting can be traced on the example of publications of Russian scientists for two decades assessing the consequences of globalization for the Russian economy, as well as predicting different scenarios of economic development.

Thus, in his work “Globalization and Asian Regionalism: Challenges for Russia”, V.V. Mikheev in the early 2000s called the main challenges of globalization for Russia: the ability of the state to adapt the national economic strategy to the dynamics of globalization, to the development of European and Asian regionalism, as well as its correct understanding and balanced and reasonable attitude towards it [4, p. 188]. In the following decades, we could see that the Russian economy had adapted quite effectively to the conditions of globalization in terms of the possibilities of developing transnational business. But, nevertheless, it did not carry out the necessary reforms and did not diversify the structure of the economy in favorable years, and in this regard it faced new economic challenges.

In the work under the editorship of Academician A.A. Dynkin “Strategic Global Outlook 2030” published in 2011, the foreign policy risks of exacerbation of relations with the USA and NATO countries are noted, but there is no correlation with economic risks and the consequences of these exacerbations [5, p. 443-447].

During the period of anti-Russian sanctions in early 2017, Academician of the RAS S.Yu. Glazyev outlines seven possible scenarios for the development of Russia [6]. These scenarios are already more accurately and broadly considering the alternative opportunities for the development of the Russian economy in modern conditions. Partly drawing on these scenarios, we formulated four scenarios for the development of the external environment, with respect to which the sensitivity of individual infrastructure projects will be assessed.

The identified problem will be studied with the involvement of Russian experts, which will reflect the Russian assessment of the development of trade and economic relations and the necessary infrastructure.

2 Methodological approaches to research

The problem of assessing the efficiency of infrastructure projects that support the development of trade and economic relations is largely related to the high degree of influence of risk factors and uncertainty determined by environmental conditions. Theoretical aspects of accounting for the influence of uncertainty factors are elaborated in the studies. It is enough to mention two Russian fundamental works belonging to Academicians of the Russian Academy of Sciences Petrakov N.Ya. [7] and Moiseev N.N. [8]. In these works, uncertainty factors were classed in a general way, and two key reasons for its occurrence were identified: firstly, an accident that reflects the complex nature of the object, and secondly, the incompleteness of information associated with a lack of knowledge and understanding about an object of research and about its external environment.

This problem largely determines the lack of existing official Russian methodologies for assessing the efficiency of infrastructure projects. Thus, in the “Methodological
recommendations for the assessment of the efficiency of investment projects: (Second Edition)” [9] and “Methodological recommendations for the assessment of investment projects in railway transport” [10], the problems of accounting for uncertainties are indicated, but methods for their solution are not regulated. At the same time, for a different class of projects, both small and large-scale, the same approach is applied in these methods, which is reduced to the assessment of commercial efficiency by indicators calculated using the economic and mathematical model of cash flow.

The key problem of this approach is the concept of “large scale” of the project and its sensitivity to scenarios for the development of the external environment. Projects can be both sensitive to environmental conditions, and not sensitive. And in the case of individual unique large-scale projects, they can considerably change the scenarios for the development of the external environment and determine the conditions for implementing other smaller infrastructure projects.

In order to overcome these difficulties, the methods for structuring of investment projects and their subsequent integration into the conditions for the development of the external environment were developed in the joint work of the SSTU and Institute of Economics and Industrial Engineering of Siberian Branch of the RAS (IE IE SB RAS). The assessment methodology will be described in detail below. As a part of the present study, special attention was paid to scenarios for the development of the external environment, in the context of which the prospects for the development of trade and economic relations and railway infrastructure were assessed.

The following four descriptions of the external environment were identified as such scenarios. Each of the scenarios is described in three levels:

- international, reflecting the geopolitical aspects of the interaction of Russia and countries in the world economic system;
- Russian, reflecting the state of development of the country's economy and its structure;
- regional, considering the territories of Siberia and the Far East, as well as interaction with key Asian partners.

2.1 Pessimistic scenario (here in after Scenario 1)

International level: political and economic isolation of Russia will grow stronger, restrictions will remain, and opportunities for rising debt capital for large-scale projects will be reduced, the quality structure of mutual foreign trade with Russia with a high share of primary commodities will remain with a general reduction in the volume of supply of raw material resources to the foreign market.

Russian level: the lack of structural reforms of the Russian economy, the preservation of the raw material orientation of exports, the lack of the necessary financial resources for the implementation of large-scale infrastructure projects in the Far East, the priority of the development of FEC projects. Close to zero or negative economic growth in the country.

Regional level: the lack of investment in the development of industrial export-oriented enterprises aimed at the increase of the added value of products. Closing up or freezing of regional investment projects.

2.2 The most likely scenario (hereinafter Scenario 2)

International level: maintaining a limited sanctions policy towards Russia for the next 5 years; defrosting and implementation of individual investment projects in demand in the European economy. The lack of significant inflows of foreign direct investment in the Russian economy. Priority of imports from Russia of raw material resources, as well as certain types of products with a greater share of added value.
Russian level: further inertial development of the Russian economy, insignificant diversification of the Russian economy, caused by a decrease in foreign currency revenues from the export of energy resources due to the preservation of their low cost. Acquisition of Asian and other financial resources in the implementation of individual investment projects in Russia, including infrastructure ones. The low growth of the Russian economy at the level of 1-1.5%.

Regional level: not systemic acquisition of Chinese investments in the implementation of certain cross-border investment projects, the implementation of infrastructure projects that slightly expand the transit potential. Encouraging entrepreneurial initiatives without proper financial support.

2.3 Optimistic scenario (hereinafter Scenario 3)

International level: relief of sanctions and the full resumption of trade and economic relations with European countries. Inflow of direct foreign investments and realization of large-scale industrial and infrastructural projects. Support for the diversification and structural reform of the Russian economy.

Russian level: implementation of structural reforms of the Russian economy and reorientation to an innovative way of its development with the increase in the number of export-oriented investment projects. System-based development and realizations of the industrial potential of Siberia and the Far East. Expansion of production of agricultural products with a consistent increase in the volume of its exports to the countries of APR. Support for infrastructure projects for the implementation of the country's transit potential. The growth of the Russian economy is 3-5% with individual peak years up to 7%.

Regional level: active development of transport infrastructure to meet the needs of a growing economy. Acquisition foreign direct investment in the implementation of export-oriented cross-border investment projects. System-based state support for regional export-oriented projects, which include the country in global production chains.

2.4 The "joker" scenario (hereinafter Scenario 4)

International level: a fundamental shift in the structure of world economic relations, caused by possible global conflicts or natural disasters and other factors, due to which the formation of the main commodity and money flows will be reduced to the continental borders of Eurasia. In the new system of world economic relations, the dominant role will be played by China, while the target will be the harmonious mutually beneficial development of the countries of Eurasia and the optimal distribution of productive forces within the continent. The policy of sanctions will be replaced by a policy of mutual involvement and non-conflict development. The transport network is developing, including due to the network of new railways, providing an efficient system for transportation of passengers and cargo.

Russian level: Russia is strengthening its role in the new world economic system and is actively involved in the emerging system of optimal continental distribution of productive forces and global production chains. There is a structural transformation of the Russian economy and formation of the Russian segment of the transport infrastructure. The transit potential of China - the European countries is fully realized. On average, the growth of the Russian economy is 5%.

Regional level: implementation of industrial investment projects at the expense of Russian entrepreneurial capital and Chinese investments. With the support of the state and the fund assets, the transport infrastructure is being developed, aimed at expanding the transit potential of the region.
When developing these scenarios, the developments of Russian and foreign economists and experts were taken into account. The development of transport infrastructure and the implementation of transit potential were considered on the basis of the current state of the transport supply of goods exchange between Europe and Asia, described in detail in the work edited by Doctor of Sciences M. Mindur [11]. When describing possible alternatives for the development of the geopolitical situation, this study was also based on the work of Academician of the RAS S.Yu. Glazyev “The battle for leadership in the 21st century. Russia - USA - China. Seven options of foreseeable future” [12].

These scenarios in this study are used to overcome the influence of risk factors and uncertainty of the external environment using the following methodology adapted to solve the problems of this study.

The methodology for assessing the sensitivity of the development of continental trade and economic relations and infrastructural projects is based on a comparison of experts’ value judgments and the degree of their discrepancies for different classes of infrastructure projects obtained by embedding in various scenarios for the development of the external environment. This experiment is the development of the economic and mathematical model of the game “analyst – nature” formulated in the work of the scientists of the SB RAS [13] in the formulation of O. Lange [14], when rational solutions are determined on the basis of analysis of the evaluation matrix by the criteria of decision theory [15]. Later, the development of this methodology was carried out in the studies of scientists of the Siberian State Transport University in relation to various infrastructure projects.

As a part of this study, calculations have been performed consistently for three different infrastructure projects in railway transport, the description of which will be presented later. The infrastructure projects under consideration differ in the scale of the required investments and the level of their importance. The following levels of projects were singled out in the work: transit continental value, bilateral regional value, and commercial value providing access to specific objects of economic activity. Each of the projects envisages the provision of international transportation, i.e. for each of the railway projects under consideration, it is planned to transport foreign trade cargo.

This methodology involves, along with purely commercial effects, assessment of others, such as socio-economic, political, strategic, and other effects achieved from the implementation of a particular project. Together they ensure achievement of the general objective of the project. At the same time, for each of the three projects, their general objective, the effects achieved, and the problems to be solved within their framework are determined (see Figure 1). But the analysis of sensitivity to scenarios for the development of the external environment will be implemented by embedding projects in the previously described four alternative scenarios of the future.

![Diagram](image)

**Fig. 1.** An example of the structuring of an infrastructure project by the problems to be solved, ensuring the achievement of various effects and, as a consequence, of its general objective.
Each of the indicated effects collectively forms the estimated vector \((C_{0.1.1}, C_{0.1.2}, C_{0.1.3}, \ldots, C_n)\), reflecting their overall efficiency to achieve the general objective of the project. The difficulty lies in the fact that these estimation criteria, in contrast to the \(C_c\) (\(C_c\) – commercial efficiency of the project, calculated on the basis of quantitative indicators) used in the commercial approach to the estimation of infrastructure projects, do not have an unambiguous quantitative measure, since they are qualitative characteristics in their essence, and, as a result, appropriate methods cannot be applied for their estimation. To measure them, ordinal qualitative scales (Qualitative scales are formed by interviewing each of the experts in order to assign a rank from 1 to n to the estimated parameter. For example, the most important task is assigned rank 1, less significant rank 2, etc. The tasks of equal importance are assigned the same rank. In the future, the estimations of each of the experts are reduced to the averaged indicator normalized from 1) are introduced and special expert procedures are used to "convolve" the vector estimation criterion of infrastructure projects. Components of such an integral indicator are the values of various criteria and coefficients of their relative importance, determined expertly and normalized from the unit.

There are different models of "convolution", but they all do not have a rigorous mathematical justification, that’s why they are called logical; for the case when all of the aspect criteria are maximized, the most convenient is the linear “convolution” used in our study:

\[
U(u) = C_{0.1.1} \times U_{0.1.1} + C_{0.1.2} \times U_{0.1.2} + C_{0.1.3} \times U_{0.1.3} + \ldots + C_n \times U_n ,
\]

where \(C_{0.1.1}, C_{0.1.2}, C_{0.1.3}, \ldots, C_n\) – coefficients of relative importance according to the aspect criteria for achieving the general objective are obtained by multiplying the normalization results from 1 for each level up to the general objective;

\(U_{0.1.1}, U_{0.1.2}, U_{0.1.3}, \ldots, U_n\) - the criteria for the degree of utility of a particular infrastructure project for solving the problem 0.1.1, 0.1.2, 0.1.3, ..., n, are obtained by expert estimation from 1 to 5 degree of project utility for solving each of the problems;

\(U(u)\) - the integral indicator of the relative efficiency of the estimated infrastructure project for achieving the general objective.

Group estimation obtained from experts can be considered sufficiently reliable only if the answers of the interviewed specialists are well coordinated. Therefore, along with the processing of individual questionnaires and the identification of a group judgment on the problem, it is necessary to estimate the concurrence of expert opinions. The introduction of a quantitative measure of the concurrence of expert opinions makes it possible to interpret the results more reasonably. In this study, the estimation of concurrence was conducted selectively.

Further comparative analysis of the obtained integral indicators for each of the scenarios and comparison of the sensitivity of various infrastructure projects to the scenarios for the development of the external environment will allow drawing certain conclusions on the conducted study.

3 Study of the sensitivity of infrastructure projects to scenarios

Three infrastructure projects of different scale and values for international trade were selected as modeling objects.

1. The project implemented under the auspices of China – “One belt, one way” (hereinafter Project 1). The Chinese initiative to create a global transport and investment infrastructure “One belt, one way” unites two projects - “Silk Road Economic Belt” and “Sea Silk Road of the XXI century”. This project is aimed at creating a transport network that provides trade and economic relations between China and the countries of South-East
Asia with Europe. Table 1 presents the structuring of the system of tasks and objectives of this project.

Table 1. Structuring of the system of tasks and objectives of the Project 1.

<table>
<thead>
<tr>
<th>0 General objective - To formulate and promote a new model of international cooperation and development by strengthening existing regional bilateral and multilateral mechanisms and structures of interaction involving China</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 Economic effects</td>
</tr>
<tr>
<td>0.1.1 Expansion of the directions of trade and economic cooperation</td>
</tr>
<tr>
<td>0.1.4 Provision of revenues from through transportation</td>
</tr>
<tr>
<td>0.2.3 Expansion of market outlets</td>
</tr>
<tr>
<td>0.3.2 Ensuring leadership in the global economic system</td>
</tr>
</tbody>
</table>

2. Complex of projects “South-East vector of the Strategy for the development of the railway transport of the Russian Federation” (hereinafter Project 2) [16]. This group of projects is oriented both on the implementation of transit potential and on strengthening cross-border and regional cooperation of the territories of Siberia and the Far East with China. Table 2 presents the structuring of the system of tasks and objectives of this project.

Table 2. Structuring of the system of tasks and objectives of the Project 2.

<table>
<thead>
<tr>
<th>0 General objective - To create new points of Russia's economic growth by intensifying the integration of its railway infrastructure into the world transport network</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 Economic effects</td>
</tr>
<tr>
<td>0.1.1 Ensuring sustainable growth in GDP</td>
</tr>
<tr>
<td>0.1.3 Provision of revenues from through transportation</td>
</tr>
<tr>
<td>0.2.3 Creating conditions for uniform population and development of the territories of Siberia and the Far East</td>
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3. The project for the construction of a 436-km long “Tavantolgoi-Saynshand” railway section with the involvement of Russian capital (hereinafter Project 3). The aim of the project is to build a technological non-electrified railway line for the transportation of coal
from the deposit in Mongolia by Tavantolga. Table 3 presents the structuring of the system of tasks and objectives of this project.

**Table 3.** Structuring of the system of tasks and objectives of Project 3.

<table>
<thead>
<tr>
<th>General objective - Ensuring socio-economic development of the country</th>
<th>Macroeconomic effects</th>
<th>Commercial effects</th>
<th>Social effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 Ensuring sustainable growth of macroeconomic indicators of Mongolia</td>
<td>0.2.1 Creation of conditions for increasing revenues from coal exports to Russia, China and South-East Asia from the Tavantolgoi deposit</td>
<td>0.2.2 Increase in the load of Mongolia’s central railway corridor and its profitability</td>
<td>0.2.3 Increase in economic performance of the Tavantolgoi deposit</td>
</tr>
<tr>
<td>0.1.1 Ensuring sustainable growth of macroeconomic indicators of Mongolia</td>
<td>0.1.2 Creation of a source of multiplicative growth of the regional economy</td>
<td>0.1.3 Creation of jobs and ensuring additional employment of the population</td>
<td>0.1.4 Development of transport accessibility of certain territories of Mongolia</td>
</tr>
</tbody>
</table>

The presented variants of structuring the system of tasks and objectives of the projects under study were processed into questionnaires for experts, by which a survey among Russian specialists was conducted. 17 experts participated in the survey. Based on the results of the questionnaire, the following summary data of the integrated indicators of the expected efficiency of the analyzed infrastructure projects to achieve general objectives by the presented scenarios for the development of the external environment were obtained (see Table 4).

**Table 4.** Results of calculations of integrated indicators of the expected efficiency of infrastructure projects.

| Infrastructure projects | Scenarios for the development of the external environment |
|---|---|---|---|---|
| | Scenario 1 “Pessimistic” | Scenario 2 “Most likely” | Scenario 3 “Optimistic” | Scenario 4 “Joker” |
| Project 1 | 0.731 | 0.735 | 0.797 | 0.801 |
| Project 2 | 0.621 | 0.711 | 0.805 | 0.845 |
| Project 3 | 0.812 | 0.815 | 0.816 | 0.816 |

Table 5 presents data on deviations of the integrated indicators obtained in different scenarios from the average project indicators.

**Table 5.** Comparative data on deviations of the integrated indicators from the average ones.

| Infrastructure projects | Average indicator | Scenarios for the development of the external environment |
|---|---|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
| Project 1 | 0.766 | 0.035 | 0.031 | -0.031 | -0.035 |
| Project 2 | 0.7455 | 0.1245 | 0.0345 | -0.0595 | -0.0995 |
| Project 3 | 0.81475 | 0.00275 | -0.00025 | -0.00125 | -0.00125 |

**4 Conclusions**

The results obtained make it possible to draw conclusions about the different sensitivity of different classes of infrastructure projects, which provide international trade. The greatest
deviation was received by Project 2 “South-East vector of the Strategy for the development of railway transport in the Russian Federation”. This can be explained by the fact that the scenarios reflect the various conditions for the development of the Russian economy, as well as the significant influence of the uncertainty factor of the external environment caused by the imposed trade restrictions.

The minimal deviation was received by the Project 3. This project, which represents the construction project of a commercial line to the mineral deposit, is the least sensitive to the presented scenarios for the development of the external environment of the project. Based on the results of the calculation, such projects can be estimated by traditional tools of investment analysis using indicators of commercial efficiency.

In general, the conducted study allows making a conclusion about the need to choose the estimation toolkit, taking into account the class of infrastructure projects to improve the degree of scientific validity of investment decisions. This can be used in practice to justify infrastructure investment projects.

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