

Financial Mechanism for Investing in the Projects of Transport Infrastructure Development of Russian Regions

Elena Razumovskaia*, Elena Kniazeva, Larisa Yuzvovich, Irina Kotlyarevskaya and Yulia Maltseva

Ural Federal University, Yekaterinburg, Russia; rasumovskaya.pochta@gmail.com; keg55@list.ru; yuzvovich@bk.ru; kiv326@mail.ru; mlvu@mail.ru

Abstract

Objectives: This article is devoted to the actual problem of the economy of any state – finding effective formats of financing investment projects of transport infrastructure development, having significant differences in many countries. The public-private partnership is the most common worldwide financial mechanism to attract investment in the infrastructure projects. **Methods:** The authors have attempted to substantiate the main results of the research using econometric tools, along with the traditional methods of analysis – statistical monitoring, graphical method, the method of observation, measurement and analysis. **Findings:** Based on the identified needs in the construction of transport routes in Russia compared with Western countries, the authors have determined the volume of investments in this sector. Then, the mathematical model of making investment decisions on the basis of econometric equilibrium strategies of participants has been offered. The analysis of the various possibilities of strategic cooperation between the participants of investment projects on the basis of game theory (in particular, the Nash equilibrium and Cournot duopoly) allowed the authors to suggest a function of weighted average cost of project capital (WACPC), designed to improve the effectiveness of using financial resources involved in the infrastructure projects. **Improvements:** One of the practical implications of this study lies in the fact that based on the game theory it is possible to create a universal financial mechanism, which would enable to diversify investment sources and reduce the risks of infrastructure projects at all stages of their implementation. Following the principles of Nash equilibrium strategy is able to eliminate the corruption schemes in the allocation of contracts with state authorities and general contractors for transport infrastructure construction and upgrading.

Keywords: Equilibrium Strategy, Financial Mechanism, Investments, Transport Infrastructure, Weighted Average Cost of Project Capital

1. Introduction

1.1 Problem Setting

The transportation system of any country is an important indicator of the national economy situation - even Karl Marx came to this conclusion way back, marking its absolutely special role “there are certain independent branches of industry in which the product of the productive process is not a new material product, is not a commodity. Among these only the communications industry, whether engaged in transportation proper, of goods and passengers, or in the mere transmission of

communications, letters, telegrams, etc., is economically important”¹. In modern economies, the importance of transport infrastructure as a special branch is reflected in a special indicator that has been calculated in the United States since 2003 and is called Transportation Services Index (TSI). For Western Europe, which has a unique transportation system, the issue of transport infrastructure development is also quite important to be preserved inside the European and transcontinental economic relations.

In the context of significantly limited funds of national budgets of the European Union Member States

* Author for correspondence

and the EU budget, a serious problem of choosing the format of financing transport infrastructure construction and project upgrading occurs. In accordance with the “European Transport Policy”, represented in the so-called “White Paper”², the most relevant are such tasks as:

- Coping with congestion attributable to transport infrastructure;
- Overcoming negative social and economic consequences;
- Increasing in general the efficiency and competitiveness of the transport sector in Europe;
- Changing the proportion of freight traffic between the various modes of transport;
- Harmonizing the interaction between different modes of transport;
- Developing the main and local transport networks to enhance freight and passenger transportation by improving traffic management processes;
- Optimizing formats of financing the transport infrastructure construction and project upgrading;
- Implementing a complex of measures to improve the safe operation of transport and road safety;
- Creating effective mechanisms to improve the operation of passenger transport;
- Providing legislative support and implementing measures by all EU countries aimed to overcome the negative environmental impacts of the use of all modes of transport in Europe.

Recognition of the transport sector to be the most important structural element of the European Union economy is recorded in other European documents and based on the positive influence exerted by it on the rate of the economy development, the level and quality of life of the population in the entire European region. A similar position is held by the United States, where the share of transport sector grows in the Gross Domestic Product (GDP) reached 14.8% in 2015. A tendency to reduce significantly the railway network due to increased use of a more competitive road transport is common to the United States and Western European countries. The use of several modes of transport in the freight transportation sector – the so-called intermodal schemes providing accurate observance of terms and rhythmic delivery should be considered another notable tendency in the global transportation system development.

It is characteristic for Europe to create transport

corridors intended to combine cargo transport directions with the involvement of different modes of transport in transit through the territory of several countries. In Europe, nine transport corridors were created, two of which cross the territory of Russia, resulting in a single process of moving goods on the terms of a single documenting.

Considering the decades lost by Russia during the Soviet Union time, the transformation of relations between the state and the corporate sector began in 1990 with the conversion of the so-called ‘political capital’, which provided stability of the state position in economy. Opposition of the resurgent corporate community to the state control over the development of business processes and formation of a free-market environment does not allow to relate the implementation of flexible and balanced policy of the state and business relations within the sluggish reformation of the Russian economy.

The first step in building relationships between government and business was to discuss the issues of redistributing property rights and the authorities to manage the newly created infrastructure and other facilities. Business representatives initiated public procedures for the formation of financial mechanisms of investing in the Russian transport infrastructure projects, taking into account strategic objectives and policies of the state. It is absolutely obvious that it is the dominance of the state in a number of industries and strict control over market structures that have not allowed obtaining any positive results in the formation of a real market in Russia for more than 20 year period. Though there are some positive aspects in their mutual relations, the former contradictions retained relevance and new explicit and latent discrepancies appeared in the operation of the mechanism for participation of private corporate structures in the projects related to large-scale infrastructure investment, this mechanism being not integrated into the Russian financial system. The market ideology has not been assimilated yet, and therefore, the situation with the leading role of the state is not depoliticized, which prevents the conditions of a civilized market development.

1.2 Significance of the Research Task

Studies on the role of transport in the economy of any developed country are traditionally based on the following main aspects:

- The development of transport infrastructure improves accessibility of remote regions and promotes the growth of production over there;
- The development of the public and other passenger transport system provides accessibility to worksites, social, tourism and consumer facilities;
- Construction financing and transport infrastructure upgrading should be carried out on the basis of parity access to project investment and traffic management³.

The significance of transport infrastructure to the country's economy acts as a kind of lemma, being important not as such, but in relation to other sectors. Thus, the transport infrastructure financing is traditionally perceived as a stimulus for economic growth across the entire country and individual regions, thus ensuring the reduction of transport costs in the structure of the value of goods and the level of economic disparities between the regions. In addition, transport infrastructure contributes to the development of competitiveness in the access to new raw material markets, sales of goods within the new logistics systems, and also stimulates the migration of labor. All these factors cause the growth of labor productivity and the creation of competitive advantages in individual countries and regions, which is especially important for Western Europe, Russia, the USA, India and other countries.

Optimization of the transportation process, based on the improvement of the qualitative characteristics of high-speed highways and railways, transport infrastructure repair and upgrading and the efficient use of the existing transport capacities is also a very costly task, given that it can be carried out only under the terms of integrity and systematicity⁴.

The complex nature of investments in transport infrastructure was emphasized the French economist⁵ who considered the external positive externalities of the transport sector development as indirect incentives for the development of many other sectors of the economy. In particular, reduction of transportation time and lowering logistics costs may be of paramount importance. In addition, according to Berechman, economic well-being of the population is directly dependent on benefits, which are received by the transport sector itself, such as improving transport accessibility for remote areas, reducing the ticket costs, and many others.

Regarding the transport sector situation in Russia, one should mention its extremely weak development and

uncertain prospects. Among the fundamental causes of this situation, the authors consider it necessary to note insufficiently consolidated nature of the relationship of the state with corporate entities in matters of creating a financial mechanism of investing in transport infrastructure development projects.

Permanent mutual distrust which arose between the independent business community and the authorities in Russia as far back as in the period of the beginning of market reforms and significantly strengthened after the presidential election of 2012 led to the type of patron-client relations. For a productive interaction in the field under consideration, it is absolutely necessary to start creating an effective competitive environment in Russia, as is done in the majority of the developed countries. Invalid and futureless format of today's relations between the state and business is obvious today for the entire society⁶. Integration of financial relations between the state and the corporate sector binds together political and economic order which is rather a 'state capitalism' and which has fixed the issue of the economic and political status of the state corporations with exclusive access to government contracts and programs of financing the real sector of the economy. Unfortunately, precisely state corporations in Russia possess the status of privileged structures, while private business plays the role of the economic and financial outsider. This applies equally to the matters of availability of financing, state support, opportunities to participate in government projects and contracts, obtaining significant funding. Among such projects and contracts a special place is occupied by the transport infrastructure development projects which are traditionally relevant to all Russian regions.

In addition, there is practically no methodology for building an effective and transparent mechanism for funding projects ensuring development of the entire national economy. Search for the ways to involve small and medium-sized private companies in the process of investment in transport infrastructure projects in most cases completely falls out of the focus of scientific and applied research.

Socially-oriented and community-focused angle of approach to the issue of the transport infrastructure importance is rarely considered in the research and analytical works, which determines the limitedness of the analysis of this issue. The authors' opinion, on the contrary, is that the most significant studies are those dealing with

the analysis of the forms of financial mechanisms aimed at investment in strategic projects such as the development of the Russian transport infrastructure. Co-financing and joint investing by the state and private companies of big-budget projects in the format of public-private partnership (PPP) may become a basis of such mechanisms.

1.3 Practical Application

Basic provisions and results of the study were discussed and approved at the international and Russian research and practical conferences and published in scientific journals, including peer-reviewed ones. The research materials are used in the teaching process at the Ural Federal University named after Boris Yeltsin, in the activities of the Regional Ministry of Transport and the Ministry of Finance of the Sverdlovsk Region of the Russian Federation.

The materials used in writing the article can be helpful in scientific research and practical projects, such as highly adapted to the format of public-private partnerships (in Russia). These include large-scale projects for the construction of transport infrastructure: the airport in St. Petersburg; Moscow - St. Petersburg and Moscow - Kazan highways; bridge in Russky Island, Primorski Krai; M-5 federal highway in the Sverdlovsk and Tyumen Regions; construction of a road to the village of Yamalsky-2 (Yamalo-Nenets Autonomous District); construction of a bridge across the Kerch Strait, the Trans-Siberian Railway, designed to bind Russia and China (using the US experience)⁷ and many others.

Russian transport infrastructure has a special social and economic significance and contains the potential for economic growth that can generate a synergistic effect that stimulates the integration processes in the regions and may contribute to the solution of national problems⁸. This is especially urgent for Russia, which has enormous continental territory and totally insufficient development of highways and other main means of communication. Socio-economic and financial profitability during implementation of investment projects for the development of transportation system and infrastructure facilities differ greatly the projects in this area from the others⁹. Considering the possibility of applying the results of the study in an international perspective, they may be useful for authors investigating the issues of financing transport infrastructure projects in the conditions that are similar to the Russian ones¹⁰.

1.4 Research Hypotheses

The authors presume that when making any investment decisions, including those with regard to investments in transport infrastructure projects, it is necessary to substantiate the selection of a specific project based on the fundamental scientific methods, rather than on the current situation. Decisions on the selection of investors' structure, share of their participation, other conditions should be weighed without the personal interest of certain departments or individuals. This approach is able to neutralize the corruption schemes in the tenders, which is essential for financing capital-intensive projects, such as are realized in the form of public-private partnership (PPP), making them much more efficient for all the participants. From the standpoint of economic efficiency concession and operator agreements, lifecycle or investment lease contracts, decision-making as to which can also be based on scientific principles, may become similarly attractive. All the above formats have their own features, enabling to adapt the financing mechanism for the specific project conditions.

Methods of mathematical modeling and game theory, which are universal application tools of the widest range of applications, may serve to these goals. The hypothesis of the authors' team proceeds from the fact that to make the really best investment decision it is required to fully weigh all possible options of consequences for each project participant. Search for the optimal best decision has been considered for decades and is reflected in the works of renowned experts in the field, such as¹¹ who enunciated the theory of finding equilibrium in mixed strategies. Modern views on the application of mathematical methods are still relevant, in particular, Professor of economics at Princeton University Avinash K. Dixit and Professor of economics at Yale University School of Management Barry J. Nalebuff in their work *The Art of Strategy* illustrate the multitude of situational decisions in different areas of application of game theory for business, politics and other situations¹².

The authors proceed from the fact that, financing mechanisms applied in practice, having mutual differences and being insufficiently coordinated, prevent joint activities of the state and corporate sectors. These differences lead to the fact that in a number of countries, including in Russia, the investment projects are unable to intensify efforts to provide the financial resources for the most important areas – construction and transport infrastructure.

Need of transportation system of any state in the financing the created infrastructure facilities does not weaken, on the contrary, each new project requires additional investment. The format of financing large-scale projects at the expense of private companies is practically unimplemented. The highest capital-intensive projects, a long period of operation, the extreme complexity (for Russia, due to lack of methodology and lack of strong legal framework) for calculating and charging for the use of automobile, general purpose roads - all combine to exclude determination of the criteria of recoupment of such projects and to obtain private investors financial results in the traditional form. The highest capital-intensive character of projects, a long period of operation and of depreciation determined by this operation period, the extreme complexity (for Russia, due to lack of methodology and lack of strong legal framework) for calculating and charging for the use of general purpose roads - all these reasons jointly exclude determination of the payback criteria for such projects and for obtaining financial results by private investors in the traditional form. These reasons make the demand on the part of the state and the public for transport infrastructure facilities not backed up by any adequate demand for investments from private investors, while the objective need, based on technical and economic norms and projections, exists and keeps increasing. Overcoming this situation could be possible by applying mathematical modeling techniques aimed to optimize the structure of participants of investment projects on the basis of the search for balance in mixed strategies, when all parties are satisfied with the results.

2. Research Method

2.1 Statistical Monitoring Method

In this study, the authors used analytical and logical-structural approaches, statistical and graphical methods

of data processing and presentation, as well as the method of comparative economic analysis and mathematical modeling based on the game theory. First of all, the authors gave the statistical and estimated data characterizing the baseline situation in the transportation system of the state: the length and density of the roads around the world are compared in the physical values and graphical analysis is presented. Then, the need for the amounts of financing for the Russian transport infrastructure projects is justified in the context of individual regions and projects, enabling to conclude that efforts for the construction and upgrading of transport networks made today in Russia require a different funding format. As a result, the authors have proposed a model function of weighted average cost of project capital for the two categories of participants on the basis of establishing equilibrium of their strategies.

At the first stage of the study the authors carried out a preliminary analysis of the general characteristics of the motorways over time (and in the prognostic aspect) to identify potential rate of growth of density and length of roads, the cargo and passenger loading. The results of the preliminary analysis are given in Table 1.

As can be seen from Table 1, the period from 2008 to 2014 was a breakthrough in putting motorways into operation in Russia - as a result, the density of transport routes per 1,000 square kilometers increased by 51.5%, and less than over ten years - from 2005 to early 2015 - by 58%. Considering the average cost of constructing 1 km of roads to be USD 8 mln per 1 km at the rate of RUB 35 per USD 1¹³, investments according to this indicator exceeded 280 million rubles (per 1 km). This amount of financial resources would be absolutely impossible to attract only from the private sector - no company, even with the support of the largest domestic financial institutions and commercial banks would be able to implement such significant investments in the sector, not implying the traditional investment income.

Table 1. General characteristics of motorway use in the Russian Federation

Parameter	1995	2000	2005	2008	2012	2013	2014	2015	2020*
Density of transport routes (km of roads per 1,000 km ² of the territory)									
Total motorways, including	43.9	44.1	42.3	44.1	60.9	64	66.8	67.9	75.4
public roads	28.3	31.2	31	36.8	54.1	57.6	60.4	-	-
reserved roads	15.6	12.9	11.3	7.3	6.6	6.4	6.4	-	-
Passenger transportation intensity (mln passenger-km per 1 km of route)									
Public and reserved	339	231	196	202	128	114	116	114	122-
hard-surfaced motorways									

* The authors' forecast

Regarding the carriage of passengers, according to Table 1, the indicator of passenger transportation intensity, which is defined in millions of passenger-km per 1 km of route, decreased significantly by 2014 compared to figures of 2000 - (from 231 to 116) and compared to figures of 2008 - (from 202 to 114), that is, 47.5% and 42.6%, respectively.

According to the amendments introduced by the Order No.1734-p, of the Government of the Russian Federation of November 22, 2008, the mobility of the population will increase under the innovative variant up to 15.56 thousand passenger-km per 1 person a year (which is 2.4 times more than in 2010), and under the basic variant - up to 13.3 thousand passenger-km per 1 person a year.

In 2015 the Government of the Russian Federation allocated RUB 60 billion for the repair and rehabilitation of motorways in the regions, these funds being provided by the Resolution No.193 of the RF Government dated 05.03.2015 within the State Program "Development of the Transportation System" with allowance for doubling the volume of construction and reconstruction of regional, municipal and local highways. Under this decree in the first half of 2015 the Federal Road Agency concluded agreements on the provision of subsidies for 44 subjects of the RF¹⁴. For other RF subjects, where provision for transportation system development program is also made, such agreements will be concluded as funding opportunities appear.

Large-scale financing of road construction and the country's transport infrastructure upgrading implies the

increase in the number of jobs that could reach 270,000 by 2030, according to the optimistic scenario, while the base case scenario foresees an increase up to 180,000 jobs, which is also essential.

The implementation of a civilized financial mechanism for investing in transport infrastructure development projects would allow achieving the growth of overall economic performance, in particular:

- The competitive level of unit transport costs in the structure of the final product price provides for the reduction from 15 to 30% (depending on the scenario variant);
- The commercial speed of goods delivery by road in the interregional and international traffic from 750 to 1,100 km/day (depending on the scenario variant);
- Gross domestic product (GDP) growth – in the context of the complicated geopolitical and domestic situation from 0.3 to 0.45% (depending on the scenario variant).

2.2 Method of Analysis and Measurement

Such a high influence of the transport sector on the GDP dynamics is determined by providing the corporate sector and the public with the full amount of the required high quality transport services. Thereby, the key issues related to the implementation of any investment project: search for funding sources and formats, are highly important. The starting point in this case shall be considered the transport infrastructure financial requirements, which are presented in Table 2.

Table 2. Amount of Russian transport infrastructure financial requirements in 2020-2030, RUB trillion¹⁵

Type of infrastructure	Assessment of the investment volume	Use of financial resources
Automobile roads	21.6	Construction of 451,000 km of new public roads; reconstruction of 14,600 km of federal highways; 35,400 km of regional highways
Railways	3.1	Construction of 16,600 km of new railways; reconstruction of the 44,200 km of railways; laying of 659 km of high speed railway track
Sea ports	1.3	Growth of the total cargo turnover of sea and river ports in Russia by 5% each year; port capacity growth by 620 million tonnes by 2020
Airports	0.4	Reconstruction and upgrading of 24 airports in the territory of the Russian Federation
Energetics	2.7	Increasing the energy efficiency of all sectors of the economy, requiring more than RUB 175 billion annually
Total	29.1	

Table 3. Indicators of the importance of road infrastructure in the Ural regions, 2014

Indicator	Sverdlovsk Region	Tyumen Region (without autonomous okrugs)	Chelyabinsk Region	Perm Krai
1. Share of road infrastructure in the GRP of the subject, %	12.8	11.6	9.8	8.6
2. Volumes of financing of the construction, improvement and maintenance of the road transport infrastructure units, RUB billion	48.644	16.312	16.422	25.828
3. Financial efficiency of the road transport infrastructure development, %	7.12	6.32	5.26	3.22
4. Share of GRP in RF GDP, %	2.25	1.21	1.25	1.27
5. GRP of the subject, RUB billion	1595.72	859.94	884.48	898.76

The data in Table 2 suggest that the greatest amounts of funds for satisfaction of transport infrastructure financial needs are allocated for the construction and reconstruction of all type of automobile roads: 74.2% of the total investment volume. In accordance with the innovative option, for the period of 2010-2030 the Transport Strategy provides for investment financing in the amount of RUB 106.45 trillion (in prices of corresponding years), consisting of the allocations from the federal budget: RUB 31.4 trillion, from budgets of the RF subjects and local budgets: RUB 21.4 trillion and from extra-budgetary sources: RUB 53.7 trillion. Given that the innovative option for the situation development is becoming less feasible amid the low cost of hydrocarbons in the world markets causing the reduction of the Russian budget revenues, it makes sense to be guided by the conservative option of the Transport Strategy, which for the same period of time provides for financing amounting to RUB 70.6 trillion consisting of the allocations from the federal budget: RUB 19.9 trillion, from regional and local budgets: RUB 15.1 trillion and from extra-budgetary sources: RUB 35.6 trillion¹⁶.

Project activities include the stimulation of operations of the existing transport hubs and construction of new ones, construction of logistics centers and ensuring their common technological compatibility in order to improve the efficiency of delivery and distribution of goods and passenger transportation.

2.3 Method of Observation, Generalization and Reasoning

The increase in capacity of the transport network and elimination of its operating limitations are particularly important for the road network of continental regions of

Russia, such as Ural and Siberia. The research results give evidence of the insufficient effectiveness of the existing road infrastructure in the Ural Federal District (Table 3).

The data in Table 3 show the need to improve the efficiency of the use of financial resources invested in road infrastructure of the Ural Federal District, so it is absolutely necessary to increase investments in the financing of the transport infrastructure development projects. The creation of a unified system of multimodal transport and technological compatibility for all means of transport, passenger and cargo transportation carriers is extremely important for not only the region but also urban agglomerations. In particular, the Russian largest urban agglomeration is the territory of the city of Moscow, where the construction of a number of transport infrastructure units is planned to be carried out by private investors. The amount of initial investment is between RUB 4 and 5 billion from each private investor. Thus, according to the Moscow authorities' official information, the "Slavic World" and "IKEA" (together with "Kaltchuga") companies have already submitted applications for participation in the financing of investment projects on the development of the road network of the city and improvement of urban areas.

The investors of the Russia's largest metropolis are obviously motivated by the fact that the design and construction of transport infrastructure is necessary for the corporate sector in order to have new better roads to meet the growing needs of retailers and construct pieces of residential and commercial real estate. There is a plan to reconstruct and build in Moscow until 2018 about 120 km of public roads, which will connect the expanding residential areas of the capital metropolis with regional hubs and highways.

The investments provided by Gazprom PJSC for the construction of a section of the relief road from the Kaluga Highway to Ostafyevo Airport amounting to more than RUB 5 billion have a similar purpose. Announced investments, will have, of course, a commercial benefit, if the forthcoming construction of roads is supported by the construction of real estate objects of not less than 1 million square meters, when private contractors have an opportunity to cover the road infrastructure costs. Support of the Moscow authorities covers only the projects the priority of which is the investment in metropolis transport infrastructure. Mutual benefit of private investors and the government is that the format of co-financing in the framework of public-private partnership can significantly increase the capitalization of land and real estate objects that are constructed with transport infrastructure.

Financial mechanisms and the format of relations between business and government when investing in transport infrastructure projects may be different and take into account the specific features of the objects. For example, social objects require large investments and have such a long payback period, that only the co-investment can be profitable.

In this regard, we should note the United States experience in transport infrastructure development, which began in 1916 in the framework of the “Federal Road Act” State Program on the basis of the so-called ‘counterpart’ funding, which represents one of the formats of public private partnership. By 2013, the length of United States roads was 77,017 km, which makes the American road system the world’s second longest after China’s. Such large-scale construction in the US is “... the largest public project since the construction of the Egyptian pyramids”¹⁷... It is obvious that the American road system has provided a huge contribution to the US economy.

The costs of construction and upgrading of road infrastructure rank second after defense spending in the United States budget in view of their special importance as an element of the mechanism of accumulation of the material social capital¹⁸.

Talking about the use of American best practice in financing transport infrastructure projects, we should be aware that 70% of the funds have been provided and continues to be provided by the US federal budget from the revenues from gasoline and diesel fuel excise duties. Substantially smaller funding comes from the use of toll

highways used by the vast majority of American drivers. In addition, the number of vehicles per capita in the USA is significantly higher than in Russia: 810 per 1000 people, whereas in Russia this value is: one vehicle per 143 persons.

The experience of the United States is very important for Russia because of the similarity of the key parameter of the transportation system: a large continental area, which requires enormous financial investments for road construction. The Russian federal budget allocates funding for federal special-purpose programs. In particular, within the period of 2014-2015 in a framework of the federal target program of development of Russian regions, more than RUB 75 billion were allocated for the most strategic and socially significant projects:

- In the Far Eastern Federal district: RUB 16.5 billion.
- Within the program of development of the Kuril Islands: RUB 920 million.
- In the Kaliningrad region: RUB 4.5 billion.
- In the Crimean Federal District: RUB 6.4 billion.
- In the Novosibirsk region: RUB 1.8 billion (construction of a bridge across the Ob River).

In Russia, there are special rules according to which the funding for targeted programs shall be carried out through inter-budget transfers. Thus, the priority for the Federal Road Agency of the Ministry of Transport of the Russian Federation is the major projects that have a special social and strategic importance, implemented in 18 territorial entities, consisting mostly in construction of bridges and bypass roads around big cities. Another form is the co-financing of the regional road construction projects.

Reduction in the volume of inter-budget transfers and co-financing of projects of construction and upgrading of transport infrastructure in Russia occurred in 2015 due to the forced budget savings. Thus, not only there was no increase in construction during 2015, but some projects were frozen due to lack of funding. The situation requires the search for new national transport infrastructure financing mechanisms with the active attraction of private investors’ financing. The state in this situation shall create favorable conditions for businesses participation in infrastructure projects and ensure compliance with the principles of competition, as there is an annual shortage of private investment of over RUB 650 billion.

Global experience shows that there is a successful solution of problems of shortage of private investments

in the sector of transport infrastructure construction and upgrading. Financial mechanism, used in Europe, Japan and India is a public-private partnership, making it possible to attract significant amounts of private investment, which is facilitated by the guarantee of transparent conditions for the participation of all parties in the project financing.

2.4 Graphical Method for the Economic Data Analysis

Figure 1 makes it possible to compare the length of roads in the developed world countries, some BRICS countries and Russia.

This figure shows the importance of the investment in transport infrastructure ensuring the growth of international trade. According to the Central Intelligence Agency forecast, the world countries have an annual need for roads and railways, which will increase by 2019 up to

USD 225.5 billion, and by 2029 up to USD 292.6 billion.

Currently, the biggest road length is in the United States, due to the large area and the overall high level of economic development. BRICS integration group countries such as India, China and Brazil also have a very extensive land-based transportation system. In particular, the length of roads in these countries is 3.5; 3.1 and 1.25 times bigger than in the Russian Federation, respectively. An interesting situation is in Japan: length of roads in the country with a small territory is comparable with the same value in Russia.

In addition to the length, an important indicator of the degree of development of transport infrastructure of the state is the road density, showing the length of roads (in kilometers) per square kilometer of the territory (Figure 2).

As seen in Figure 2, Russia has an extremely low rate of road density, which, of course, hampers the development of economic relations between the regions

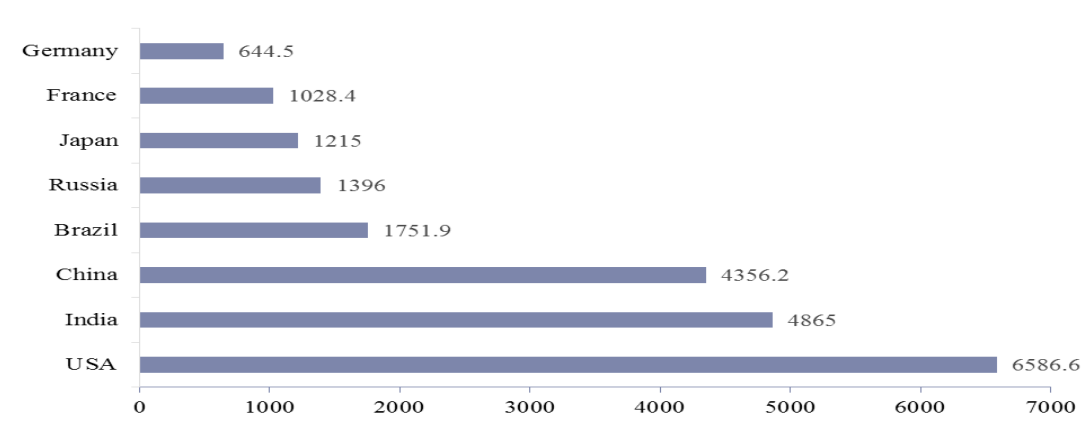


Figure 1. Road length, thousands of km¹⁹.

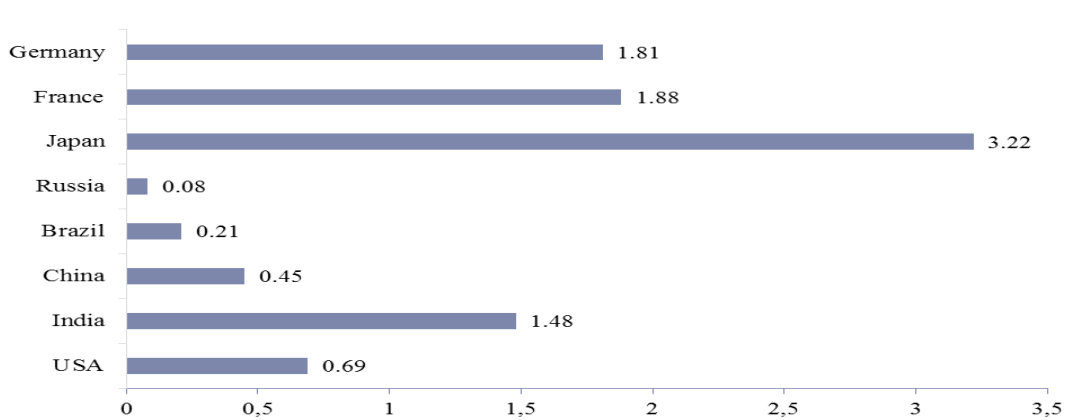


Figure 2. Road density, km/km^{2,19}.

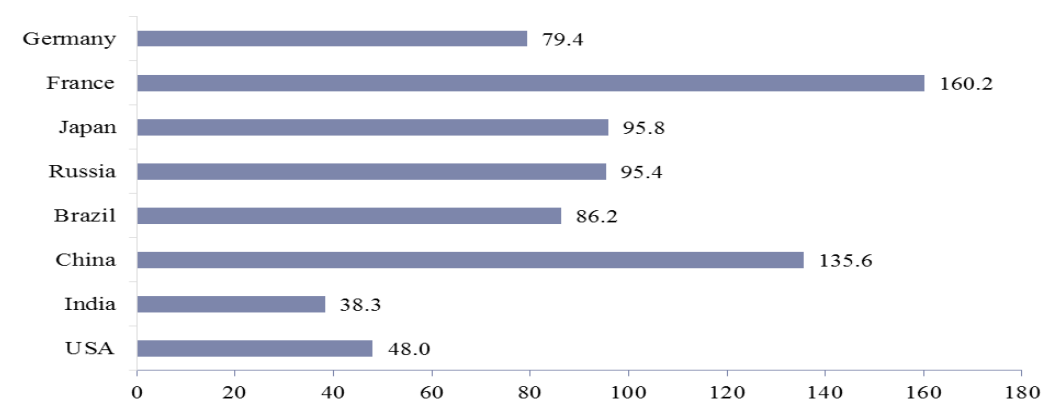


Figure 3. Motorway provision, km/1000 persons¹⁹.

and increases the transport costs of business entities and motor transport enterprises. The highest density of roads is of course in Japan: this figure is 40.25 times higher than in the RF and 4.67 times higher than in the United States.

Figure 2 shows that there are quite significant differences between the BRICS countries: the first place is occupied by India (1.48), perhaps due to a long period of colonization of India by Britain, ended only in 1947, China ranks next with the density indicator being 3.28 times lower (0.45), followed by Brazil (0.21) and the lowest value is in Russia (0.08), where the road density is 18.5 times lower than in India.

Another quite important indicator of the level of economic development is also associated with the transport infrastructure: road provision (Figure 3).

In particular, the Figure 3 shows that the rate of road provision in the Russian Federation is at the level of Japan and is greater than in Germany, as there are a lot of local roads without hard surface in Russia. For this reason, a high nominal value is not a real indicator of availability of roads, since a significant part of these roads can be used only in winter time (winter roads).

According to Figure 3, the highest road provision is in the countries such as France and China, due to the similarity of the relative density of the population in these countries.

Comparative analysis of the transportation system development indicators of world countries and Russia allows us to conclude that there is a huge gap between the Russian Federation and the BRICS countries and all developed countries. This fact urges to find a solution for this problem and to develop a modern financial mechanism for attracting investment in the development of the Russian transport infrastructure.

Qualitative and quantitative analysis of the transportation system determine a wide range of parameters governing the procedure for its financing. For the Russian Federation, this problem is nationwide, and its decision consists in the search for significant financial resources, which has become difficult in a challenging geopolitical situation and amid mutual sanctions. Russia is experiencing an acute need for sources of “long” investments that can finance projects on construction and upgrading of transport infrastructure. The main task of the Russian state in terms of financing of the transportation system development is to create a civilized environment for economic growth and enhance the competitiveness of the domestic economy.

Formation of the forecasts regarding the renewal and increase of the road transport fleet in the Russian regions is based on the financial capacity of investment projects members and the status of the state budget. It is obvious that in order maintain the road construction rate in Russia, enormous costs will be needed for the financing of projects for creation of modern transport and logistics centers across the country (Table 4).

Table 4 provides a rough idea of the strategic objectives of the Transport Strategy of the Russian Federation, in accordance to which a basic network of federal roads will be created in the country, the purpose of which is to connect all the administrative centers of the constituent entities of Russia. The structure of the basic road network will eventually be transformed from a radial to a network one, and for this purpose it will be necessary to build, upgrade and put into operation 903,000 km of public roads.

Table 4. Length of Russian roads grouped by type and purpose, thousands of kilometers

Road types	1990	2000	2005	2010	2011	2012	2015
Total number of roads, including:	884	898	858	1004	1094	1439	1557
public roads	455	584	581	825	927	1278	1396
reserved roads	429	314	277	179	167	161	162
Total length of hard-surfaced roads, including:	657	752	724	786	841	1038	1094
public roads among which:	400	532	531	665	728	925	985
federal roads	n/a	46	47	50	51	51	51
regional or intermunicipal roads	n/a	486	484	450	452	461	461
local roads	n/a	n/a	n/a	164	225	413	473
reserved roads	256	220	194	121	113	113	110

Estimation of investment required for such large-scale projects makes it necessary to envisage a priori several fundraising mechanisms. The format of public-private partnership is a priority, as evidenced by the involvement of the Unified information system of public-private partnership (UISPPP), which, together with the Chamber of Commerce of the Russian Federation and the PPP Development Center studies financing mechanism for capital-intensive investment projects with the use of infrastructure bonds. Financial mechanism of infrastructure bonds is aimed at attracting external funding for infrastructure projects through public-private partnerships.

PPP Research Center also carries out works on expansion of the sources of funding for regional projects in the field of roads in conjunction with the administrations of the territorial entities of the Russian Federation, representatives of Russian ministries and departments, financial and contracting organizations, businesses and scientific experts.

The central focus of scientific and applied research is the development of financial mechanisms for attracting private investments in transport infrastructure development projects, along with public finances on the basis of mutual economic viability. As for the implementation of such important projects it is necessary to improve the legislation, there are some state institutions involved in such studies: the Federal Road Agency (FRA), administrations of territorial entities, the committee of the Ministry of Transport of the Russian Federation, PPP Research Center, Graduate School of Management of the Saint Petersburg State University, Avtodor state-owned company.

The criteria and methods for assessing the financial performance of public-private partnership projects and risk assessment make up the spectrum of scientific

interests of Russian scientists and practitioners. A new lease of life has been given to concession agreements being a financial mechanism of attraction of investments of the private sector of the Russian economy.

The forms of concession agreements are diverse, but they have a common foundation, which has been formed in the world for centuries. The transfer of state property to private entities for the creation or upgrading infrastructure, and temporary authority to manage these objects given to them, allowed the states to resolve the problem of financing of capital-intensive and long-time projects.

Careful attention to the concession agreements in the modern Russia has been determined by limited budget capacities caused by external economic and geopolitical factors. It is possible that under these circumstances, the revival of long-term relationships between the private sector and the government on the basis of concession agreements could be very promising, as the concession financial mechanism attracts private investors to the sectors and areas that are extremely important for the country²⁰.

Modern concession agreements become relevant, as they can prevent problems similar to those that arose during the market reforms in Russia in the 1990s, associated with the change of the purpose of privatized objects. Elimination of such a risk makes modern concessions more civilized and aimed at the preservation and upgrading of infrastructure and other facilities, the investment in which involves the use of the concession financial mechanism. Concession agreements providing for a step-by-step funding of infrastructure projects may be the compromise, by means of which it will possible to eliminate the lack of financial resources and mutualize the risks associated with the development of the country's transport infrastructure.

Formation of an effective financial mechanism is quite an urgent problem, and it can rely on the special financial instruments that are operational tools of investment in infrastructure projects.

3. Results

The authors are of the opinion about the need to apply methods of mathematical modeling of the decision-making process for choosing a financial investment mechanism, and to be aimed at finding the optimal combination of public and corporate participation.

According to the authors, achieving the optimal solution based on the strategic objectives of the parties participating in financing infrastructure projects can be based on the Nash equilibrium conditions. With regard to this study, Nash equilibrium is any investor strategy profile in which the solution of each participant of the project is the best answer to the partner strategy. It is important to note that we are not talking only about the formation of a strategy for a specific (private) participant or project. Simply, it is the private corporate party – ‘a player’ that performs the role of the party who chooses the strategy and accords it with the other side – the state, acting as a partner, during the initiation and conclusion of an agreement – under the conditions of a model – an investment agreement. The authors proceed from the condition that the parties seek to find a compromise; they wish to achieve an optimum combination of mutual interests. Mathematically, profile of the “s*” strategy is the Nash equilibrium, only if there is the expression for all “i” values:

$$s_i^* \in \xi_i(s_{-i}^*) \quad (1)$$

Let us assume that there is a balance, characterized by adhering to this condition. Indeed, in an environment where each of the participants will seek to dominate through the increased investment, it is impossible that each of them would have been the winner. Logic suggests that there should be a compromise, which can and should be based on the mutual readiness to make concessions. Such a compromise is shown in the figure, as the optimal solution reached in the framework of the strategies of each project participant.

Not taking into account the fact that the balance may not be unique, the authors propose to formalize the structure of private strategy on the basis of the A.A.

Cournot duopoly²¹. The authors strongly believe that this approach can become a universal platform for the development of the financial mechanism of investment in transport infrastructure projects.

Using the basis of a formal solution of the problem of the French mathematician and economist A.A. Cournot²², the setting of a baseline model of this study is as follows: two partners, the state (represented by a certain structure) and a private company, are interested in the conclusion of the investment agreement. Both partners need to decide what extent of financial commitment is required of them. As financial resources are divisible, it is possible to create and continue to use (or otherwise realize the rights) the created infrastructure object.

Assumptions of the model are as follows: let $q_{in} \in 1 [0, \infty) \in [0, \infty)$ be the investment amount of the first party – a private company in a model project, then $q_{in} \in 2 [0, \infty)$ is the investment amount in the same infrastructure project of the second participant of the project – the state. Demand function for the constructed (or modernized) facility of transport infrastructure will be of the form: $p = (1 - q_{in} 1 - q_{in} 2)$, where p is the maximum possible value that can be set for the payment of travel on the built highways for the entire period of its operation, and charged by the private company. In other words, it is the maximum value of the “sale” of the facility in the amount of: $(q_{in} 1 + q_{in} 2)$. The costs of each participant can be designated by equals “ $c_i \times q_i$ ”, where: “ $0 < c_i < 1$ ” is the cost of creating a project unit (one km of the highway). Obviously, in this case, the profits of a private company and the state will be respectively equal to:

$$Pr_1 = pq_1 - c_1 q_1 = q_1 (1 - q_1 - q_2) - c_1 q_1, \quad (2)$$

$$Pr_2 = pq_2 - c_2 q_2 = q_2 (1 - q_1 - q_2) - c_2 q_2 \quad (3)$$

This statement of the assumptions means that a set of strategies for each participant of the investment project may not be finite, because both a private company and the state can come to the conclusion about almost any amount of funding the project for a long period of its validity. Functions of the partners’ “advantages” are, of course, continuous due to the chosen strategies, then if (q_1^*, q_2^*) is the Nash equilibrium, then q_1^* should maximize Pr_1 when $(q_2 = q_1^*)$, and vice versa. The following expressions will be valid for decisions of maximization problems of the investment project participants (compiled by the authors):

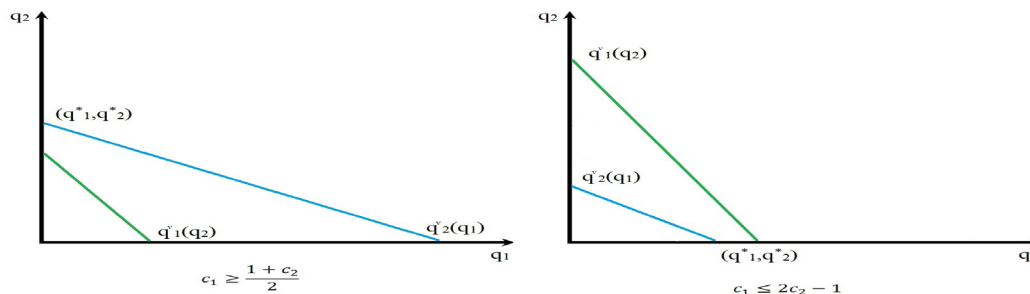


Figure 4. Modeling of the investment project participants’ strategies (compiled by the authors).

$$\tilde{q}_1(q_2) = \begin{cases} \frac{1-q_2-c_1}{2}, & q_2 < 1-c_1 \\ 0, & q_2 \geq 1-c_1 \end{cases} \quad (4)$$

$$\tilde{q}_2(q_1) = \begin{cases} \frac{1-q_1-c_2}{2}, & q_1 < 1-c_2 \\ 0, & q_1 \geq 1-c_2 \end{cases} \quad (5)$$

Expressions (4 and 5) are the functional responses of the state and a private company, respectively. Such values of “ q_1^* ” and “ q_2^* ” will correspond to the Nash equilibrium in which the volume of investment in the infrastructure project of a private company will enable it to maximize its profits from the exploitation of the facility only if the state co-finances the same infrastructure facility in a given volume, and vice versa. This means that the partners are very interested in the conclusion of the parity agreement and non-violation of its terms²³. Thus, any solution of the following equations should be considered a balance:

$$\dot{q}_1(q_2) = q_1, \quad \dot{q}_2(q_1) = q_2$$

Graphically, the strategies of the investment project participants, leading to the establishment of equilibrium for different values of the costs incurred by the partners, are shown in Figures 4 and 5.

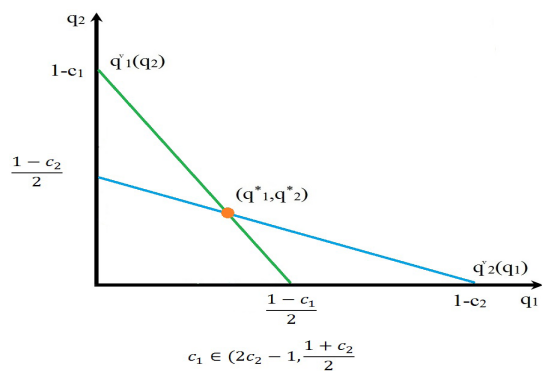


Figure 5. Modeling of establishing equilibrium of the investment project participants’ strategies (compiled by the authors).

The solid line in the figures is a graph of the reaction of the state function to the strategy executed by a private investor. The dotted line shows the graph of the reaction of the private investor function to the state strategy implementation. Figure 6 shows the intersection of solid and dotted lines, which means getting the balance – point (q_1^* , q_2^*) for which the terms of cost values are determined.

Modeling by Cournot lets us talk about the widest possible use of mathematical tools and game theory. For the purpose of forming the investor behavior strategy, the authors consider such modeling principles as a universal tool, on the basis of which a unified methodological platform can be created.

Modeling of process of investment strategies for the participants in the project of transport infrastructure construction and modernization allows the authors to offer a model function of weighted average cost of project capital (WACP):

$$WACP = \sum_{i=1}^{\infty} \omega gi \times kgi + \sum_{j=1}^N \omega cj \times kcj, \quad (6)$$

where: ωgi is the cost of investments raised by the state to finance infrastructure projects;

kgi is the share of investments raised by the state to finance infrastructure projects;

ωcj is the cost of investments raised by a private company to finance infrastructure projects;

kcj is the share of investments raised by a private company to fund an infrastructure project.

The function shows that, in reality, the financial resources that a private investor can raise are limited, which is quite logical, whereas the financial resources available to the state are not potentially limited.

Values “ kgi ” and “ kcj ” can be determined in terms of the Nash strategy profile offered by the authors, using the Cournot duopoly upgraded model. The logic of the participants’ shares in the infrastructure project financing is

that each of them will seek not to burden itself with excessive financial obligations, regardless of the potential availability of funding sources, raised to invest in a particular project. Therefore, it is likely that both the state and a private company will seek to optimize their participation in the financing of the establishment or modernization of road infrastructure facilities at the level of 50%, which will allow them to achieve a parity agreement.

Regarding the formation of the cost of financial resources, which are raised by partners to invest in the project, the value “ ωg_i ” is determined by the source of such funding for the state. This, for example, may be the opportunity cost of the use of federal budget funds and some state funds, bond yields of the regional authorities, and so on. A private company independently determines the source of the funds allocated to finance the participation in the investment project. It can be own funds, borrowed loans, the yield tranche of project bonds specifically issued for this purpose and others.

The state monopoly on the economic sources of substantial financial resources, remaining stable in the Russia, provides a unique solution – at any rate its effectiveness – only public funds can provide funding projects of this level. It is obvious that copying of the Soviet format in modern conditions brings mainly negative implications. Of course, the experience of the planned-distributed economy of the USSR period is not fully studied and comprehended, but it has a number of features that allow neutralizing some undesirable market fluctuations and ensuring the balanced development of the economy²⁴. However, in a market economy, the situation is different: the existence of private property in Russia, along with the state property, creates the need to regulate the interaction of these institutions, mainly in the financial plane. Today it is impossible to imagine a situation that as a result of reforms, which are harsh for the population, the reconstituted institution of private property would be perfect overnight. Moreover, the society requires the state to continue participating in the financing of socially-oriented projects, but on the basis of transparent mechanisms. Transport infrastructure development projects should be considered precisely the example of these.

In this study, the authors proceed from the fact that the practical feasibility of finding the optimal financial mechanism of infrastructure project investment in the transport sector bears absolutely certain social benefits – which consists in saving driving time spent by road

infrastructure users and to reduce other transport costs due to the transport network development and infrastructure performance improvement.

Taking into account the provisions of the game theory for the adoption of optimal solutions on the basis of mixed strategies equilibrium, the authors find that the total logic of financial investment mechanism selection must lie in the plane of budget constraints along with the expansion of the involvement of private investors’ financial resources. The authors’ opinion on this issue fully corresponds to the models of public participation in the strategic development process, which provide for the formation of financial mechanisms based on social, public and economic significance of the projects for the state, population and private business.

Financing large-scale and capital-intensive investment projects should be undertaken on the basis of diversified financial schemes. The authors propose to consider a range of modern formats to attract investments. Financial mechanism of investment in transport infrastructure project development should be versatile and able to ensure the effective use of financial resources both of the state and private investors, allowing for the financing strategies peculiarities (see Figure 6).

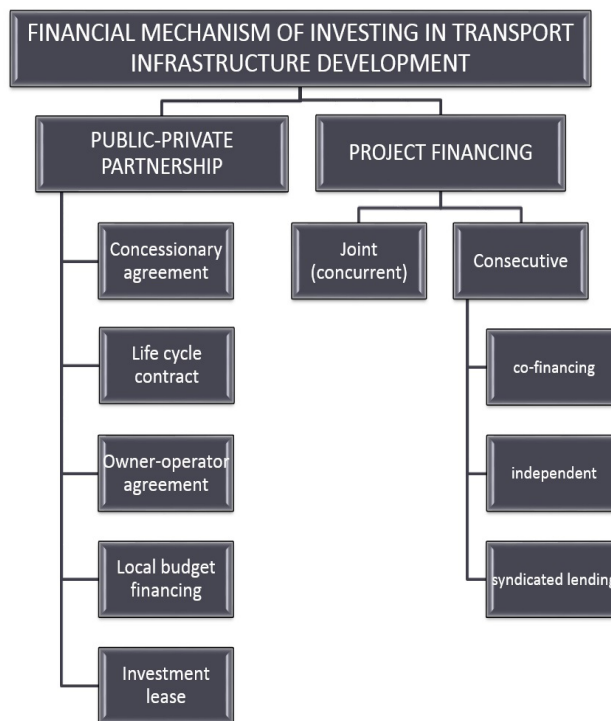


Figure 6. Formats of investment project financing (compiled by the authors).

The figure combines a set of formats of financing investment projects, which could be used as part of some universal financial mechanism that would involve a significant number of investors of different scale.

The authors' proposals for the use of the model of accepting investment decisions on the basis of equilibrium strategies, as reflected in the function of weighted average cost of project capital (WACPS), are designed to increase the effectiveness of financial resources involved in investment projects of transport infrastructure development, which is especially important for private investors.

State participation in the financing of investment projects of transport infrastructure development can continue to be implemented in the framework of targeted federal programs, which certainly has positive aspects for both the state and some private investors. The state involvement in such projects has a positive impact on the market position of all participants and increases financial guarantees of investment reliability in the public eye.

Moreover, the Russians consider projects with the state participation as much more reliable and socially responsible, which is of particular importance for Russia, as a society sharply perceives all that is connected with the state duties related to the financing of social guarantees and publicly available benefits, which include transport infrastructure. Authoritative analytical agencies polls suggest that 76% of the Russians negatively assess the results of reforms and privatization of the 1990s²⁵. Therefore, the state inevitably deals with prolonged paternalism and is forced to bear the burden of increased responsibilities towards society. The state acts economy-wide as a financial planner²⁶, taking, thus, a significant part of the responsibility to engage the resources of private investors in the financing of projects of public and social importance.

4. Conclusions

In the present study, the actual scientific task is the development of the financial mechanism of investment in transport infrastructure projects in Russia and its regions, based on the parity and the active involvement of private investors. The authors consider unacceptable the practice of extended immanent decisions of the state, regarding the administrative decisions for selecting the format of financing of capital-intensive and socially significant

projects implemented for the benefit of all. The practical implementation of the model of the investment strategies, offered by the authors, is based on the suggested model function of weighted average cost of project (WACP), which, to the authors' strong belief, is a versatile tool that can be approximated in other investment projects.

Virtually available formats of financing of the Russian transport infrastructure have their specifics and need to create the universal financial mechanism as the traditional financing channels are not able to ensure the effective use of investment funds in transport infrastructure project development. The use of the authors' model is intended to overcome the current difficulties on the basis of determining the consistency of financial strategies of all participants on a parity basis.

Financial mechanism for investing in transport infrastructure project development, based on mathematical modeling, can ensure the implementation of qualitative changes throughout the transportation system of the country on the basis of civilized market relations in the framework of financial policies across the participants of investment projects.

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