METHODOLOGICAL APPROACH TO ASSESSMENT OF TRANSPORT INFRASTRUCTURE DEVELOPMENT IN MEGAPOLITAN CAPITAL CITIES: CASE STUDY OF MOSCOW

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Abstract

The objective of the study is to identify and analyze the connection between the trends of the social and economic development of Moscow and the factors of transport infrastructure (TIS) development. The main research methods are the index method and the economic and mathematical modeling. This method helped to specify the infrastructure factors that determine the spatial development of the city and rationalize management decisions aimed at optimizing the development of various types of transport, communications and types of transportation to ensure a sustainable social and economic development of the capital. The author's approach to calculating the quality of TIS index is presented, which allows, in contrast to similar methodologies, a deeper analysis of the way the environmental factor influences the spatial development of the territory. Using the index, the most general patterns in the development of Moscow's TIS for the period of 2000 to 2020 were identified. An algorithm for the development of the TIS of a megalopolis is proposed, which suggests the differentiation of management decisions to increase the level of the social and economic state of the territory. The practical value of the method consists in determining the impact of TIS development on the trends of investment and economic growth in the region. It has been ascertained that the development of TIS and the improvement of its quality are currently the main reserves of the economic growth of the regions.

Keywords: Transport Infrastructure; Spatial Development; Megalopolis; Social and Economic Regional Development; Index Method.

ABORDAGEM METODOLÓGICA PARA A AVALIAÇÃO DO DESENVOLVIMENTO DAS INFRAESTRUTURAS DE TRANSPORTE NAS CAPITAIS MEGAPOLITANAS: ESTUDO DE CASO DE MOSCOU

Resumo

O objetivo do estudo é identificar e analisar a ligação entre as tendências do desenvolvimento social e econômico de Moscou e os fatores de desenvolvimento das infraestruturas de transporte (IET). Os principais métodos de investigação são o método do índice e a modelação econômica e matemática. Este método ajudou a especificar os fatores de infraestrutura que determinam o desenvolvimento espacial da cidade e racionalizar as decisões de gestão destinadas a otimizar o desenvolvimento de vários tipos de transporte, comunicações e tipos de transporte para assegurar um desenvolvimento social e econômico sustentável da capital. É apresentada a abordagem do autor ao cálculo do índice de qualidade das IET, que permite, em contraste com metodologias semelhantes, uma análise mais profunda da forma como o fator ambiental influencia o desenvolvimento espacial do território. Utilizando o índice, foram identificados os padrões mais gerais no desenvolvimento das IET de Moscou para o período de 2000 a 2020. Propõe-se um algoritmo para o desenvolvimento da IET de uma megalópole, o que sugere a diferenciação das decisões de gestão para aumentar o nível do estado social e econômico do território. O valor prático do trabalho consiste em determinar o impacto do desenvolvimento das IET sobre as tendências de investimento e crescimento econômico na região.Conclui-se que o desenvolvimento e melhoria da qualidade das IET são atualmente os principais fatores do crescimento econômico das regiões.

Palavras-chave: Infraestrutura de Transporte; Desenvolvimento Espacial; Megalópole; Desenvolvimento Social e Econômico Regional; Método do Índice.

ENFOQUE METODOLÓGICO PARA LA EVALUACIÓN DEL DESARROLLO DE LAS INFRAESTRUCTURAS DE TRANSPORTE EN LAS CAPITALES MEGAPOLITANAS: ESTUDIO DE CASO DE MOSCÚ

Resumen

El objetivo del estudio es identificar y analizar la conexión entre las tendencias del desarrollo social y económico de Moscú y los factores de desarrollo de las infraestructuras de transporte (IET). Los principales métodos de investigación son el método de índices y la modelización económica y matemática. Este método ayudó a especificar los factores de infraestructura que determinan el desarrollo espacial de la ciudad y a racionalizar las decisiones de gestión encaminadas a optimizar el desarrollo de los distintos tipos de transporte, las comunicaciones y los tipos de transporte para garantizar un desarrollo social y económico sostenible de la capital. Se presenta el enfoque del autor para calcular el índice de calidad de las IET, que permite, a diferencia de otras metodologías similares, un análisis más profundo de la forma en que el factor ambiental influye en el desarrollo espacial del territorio. A partir del índice, se identificaron las pautas más generales del desarrollo de la IET de Moscú para el período de 2000 a 2020. Se propone un algoritmo para el desarrollo de la IET de una megalópolis, que sugiere la diferenciación de las decisiones de gestión para aumentar el nivel del estado social y económico del territorio. El valor práctico del método consiste en determinar el impacto del desarrollo de las IET en las tendencias de inversión y crecimiento económico regional. Se concluye que el desarrollo y la mejora de la calidad de las IET son actualmente las principales reservas del crecimiento económico de las regiones.

Palabras clave: Infraestructuras de Transporte; Desarrollo Espacial; Megalópolis; Desarrollo Social y Económico Regional; Método del Índice.

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1 INTRODUCTION

Transport infrastructure has a significant impact on the social and economic development of large and major cities, metropolitan capital cities as well as the maintenance of their competitive advantages and the availability of social services; it also determines the trends of spatial development and the quality of life of the population.

Moscow is the largest metropolis of the Russian Federation, however, having the highest population density (100.3 people / ha), the density of its road network is significantly inferior to those of the metropolitan capitals of other countries. There is 0.31 km of roads per 1,000 people living in Moscow, while large European capitals (Berlin, Paris, London) have over 1 km of roads per 1,000 citizens (1.50 km, 1.37 km and 1.24 km respectively) (Pricewaterhouse Coopers, 2012).

The purpose of the study is to identify and analyze the connection between the trends of the social and economic development of Moscow and the factors influencing the development of its transport infrastructure. The research hypothesis is that the use of the quality of transport infrastructure index, where infrastructure is understood as a set of its characteristics which can satisfy the established and contemplated functions and economic needs of the users, serves as the grounds for a reasonable assessment of the impact that transport infrastructure has on the spatial development of a megapolis.

2 LITERATURE REVIEW

Methodological approaches to the development of transport infrastructure should be devised in the light of modern factors affecting the economic growth of a megapolis and ensuring its sustainable development. Russian and foreign scientists study this problem in a number of papers.

Russian and foreign researchers confirm the thesis that an efficiently functioning transport infrastructure is a prerequisite of the integrity and unity of the economic space of territories. According to Zhukov (1990), transport infrastructure can have a serious impact on the efficiency and competitiveness of the Russian economy.

Transport infrastructure can function efficiently if the economic sectors of a megapolis are developed. These sectors can create a single interaction chain of resource endowment and consumer demand for the results of an activity, including within the framework of interregional exchange.

The effective operation and development of transport infrastructure is determined by its organization structure and depends on (Mottayeva, 2014):

1) goals and objectives;
2) the methods of organizing the transfer;
3) the existing and predicted traffic intensity of the transport system of the region;
4) the correspondence between production facilities and the organization of transportation and management;
5) the introduction of innovative technologies;
6) the provision of effective communications between regional industries.

The role of transport infrastructure in the territorial integrity of the region and the unity of its economic space is elaborated by Galaburda (2017), who proposed a system of transport service quality indicators and a methodology for comprehensive quality assessment already in the 1980s; he developed and improved it during the 1990s 2000s. He devised a methodology, proposed algorithms for quality management of railway transport, methods of assessing the efficiency of quality improvement in transport services.

Foreign scientists especially emphasize finding the proper balance between the social and economic development of a region and the parameters of its transport system. For instance, Heins (2013) rationalized the role of transport in the globalization of American infrastructure; E. Weiner (1987) argued the importance of planning the transport development in cities; Sumantran et al. (2017) view the problem through the prism of ecology of a city and the impact of transport on the life quality of the population.

Russian scientists studying the development of transport infrastructure consider the factor of the quality of transport services. For instance, according to Zadvorny (2008), developing transport infrastructure means improving the geographical and economic accessibility and the quality of transport services, increasing the turnover capacity of transport systems and reducing the transport burden on the consumers of such services.

According to recent studies, transport infrastructure is the interaction of systemic and complex objects of engineering networks and structures between themselves and with production, the life of the society, which have an impact on the economy of a megapolis. At the same time, the questions of assessing the impact of transport infrastructure on the spatial dynamics of territories are still open.

3 METHODS

Methods used in the study include systematic and comparative analysis, synthesis, systematization,

concretization and generalization, factual data grouping, expert assessments, tools for processing statistical data.

The main measuring criterion is the density of the network or the availability of transport routes, which is calculated as the ratio of the network length to the area of the territory or to the population. These indicators characterize the specificity of location and the connectivity of transport facilities, which determines the quality of transport services provision in full, and, as a consequence, the quality of transport infrastructure.

The current state of the transport network and the needs of the economy of the region require a new level of decision-making according to the quality of the transport infrastructure as a whole. In this regard, in order to resolve this issue, we have proposed a methodology for assessing the quality of the transport infrastructure of the region based on an economic and mathematical model.

The determined research objective is mostly achieved using the index method and the methods of economic and mathematical modeling. The *Quality of Transport Infrastructure Index (QTI)*, which is based on the methodology for calculating the Engel Coefficient, was used to identify the most general patterns in the development of Moscow's transport infrastructure within the period of 2000 to 2020.

The transport infrastructure development of the capital city of Russia – Moscow - will be assessed on the basis of the Quality of Transport Infrastructure Index. The Engel Coefficient (ECi) is often used to calculate the level of transport network sufficiency. It takes into account such factors as the length of roads in a given territory, the area of the territory and the population (Rudneva & Kudryavtsev, 2013).

The quality of transport infrastructure significantly depends on the environmental factor, which plays an important and growing role in consumer preferences and fully reflects the quality of the goods and services provided. The use of innovations such as the extensive application of renewable energy sources, the diversified development of "green" industry and the “smart city” information technologies create a more favorable ecological environment and contribute to the improvement of the transport infrastructure work. The indicators of environmental stress in Moscow are among the worst in comparison with similar indicators in most metropolitan regions of the world.

In order to create a favorable natural environment, innovative products should be introduced in various industries at a faster pace in the region. One of the main conditions for the development of innovative regional processes is an increase in capital investments in the high-tech industries production, which increases the percentage of applying innovations in other industries. The result of introduced innovative processes in an economic space of a region, in our opinion, is the share of high-tech products.

In this regard, it is proposed to take into account the quality of the transport system based on the Engel Coefficient, which is transformed into the following formula (Analytical Department of the Staff of the Federation Council, 2017; Sukovatova, 2008):

$$QTI = Lt \setminus \sqrt{(S \cdot H \cdot (es1 + es2) \cdot (1 - De / 100))} \quad (1)$$

where QTI is the quality of transport infrastructure index; Lt is the total length of roads on the territory in sq. km; S is the area of the territory, in sq. km; H is the population, in thousand people; es1 is the level of atmosphere pollution, in t per 1 sq. m of the territory; es2 is the discharge of polluted wastewater into surface water, in t per 1 sq. m of the territory; De is the share of high-tech products.

By means of the developed economic and mathematical model, the infrastructure factors that determine the spatial development of the city were specified, and management decisions ensuring the best development of various types of transport, communications and transport facilities for the purpose of a sustainable social and economic development of the capital were rationalized.

The data of the State Statistics Service of the Russian Federation, the results of studies made by certified rating agencies and Moscow information and analytical database were used as the information pool of the study.

4 RESULTS

4.1 Characterization of the Context and Object of Study

The characteristics of Moscow's transport infrastructure are given in Table 1.

The share of the territory under the road network in the region is about 12 %. The level of the development of the Moscow street and road network compared with that of the largest cities in the world shows that Moscow, having the highest population density (100.3 people/ha), is significantly inferior to these cities in the density of the road network. Moscow has 0.31 km per 1,000 citizens, while large European capitals (Berlin, Paris, London) have over 1 km (1.50 km; 1.37 km; 1.24 km respectively). In its current state, the street and road network lacks density; its highway system as a whole is incomplete, and the roadbed is not renewed in time.

Table 1. Quantitative indicators of certain types of transport infrastructure in Moscow.Types of Transport Infrastructure

By transport types:	Main Quantitative Indicators	Moscow Quantitative Indicators
motorways, railways, air and water transport	Road density	1.21 km / km^2 of the territory, which is 1.8 lower than the norm. Moscow has 0.31 km per 1,000 citizens, while large European capitals (Berlin, Paris, London) have over 1 km (1.50 km; 1.37 km; 1.24 km respectively)
	Traffic	According to the analytical study of INRIX, in 2015 Moscow car drivers spent 57 hours in traffic jams. This is less than in New-York, Los-Angeles or London (73, 81 and 101 hours respectively)
	Spacing	3.3 km / km^2 (2.2–3.6 km lower than in Chicago, Tokyo, New-York, London or Los-Angeles)
	Length	6,354.8 thousand km

Data provided by: the author based on the analysis of Investment portal of Moscow (n.d.).

The main international and domestic traffic flows pass through the transport system of Moscow, which contributes to the development of the megapolis as a major international and national transit hub for cargo and passengers, where over 50 % of the total warehouse space of the Russian Federation is concentrated. In this regard, over 50 % of the country's warehouse space is located in Moscow, and about 60 % of the total road and railway traffic exists due to the operation of such warehouses.

The Moscow Metro has one of the most complex networks in the world. It has 14 lines and 203 stations, both above and below ground. Most of the metro lines run through the entire region. There are also short lines with only 2 or 3 stations which connect parallel lines. It also has 2 ring roads, one of which is different from a traditional subway.

The development of transport infrastructure does not correspond to the high rates of housing construction. As a result, certain newly created blocks of apartments are isolated from the high-speed passenger transport system due to the inconvenient exits to the main road network.

To solve the problems of transport infrastructure development, Moscow executive authorities are introducing the following measures:

- constructing transport facilities combining various types of transport networks (metro, railway stations, etc.) into one node, i.e. transport interchange hubs;
- constructing and reconstructing various transport facilities (highways, interchanges, bridges, overpasses, etc.); raising private investments based on the principles of the state and private business partnerships;
- actively developing the metro: constructing new lines and stations (over 160 km of metro lines and 78 new stations); reconstructing the existing metro facilities, introducing innovative technologies in the operation of metro facilities and services provision;
- updating the fleet of the above ground passenger transport system.

4.2. Data Presentation

The results of calculating the quality index for Moscow for the period of the years 2000 to 2020 are shown in Table 2.

During the period of 2000 to 2011, the quality of Moscow's transport infrastructure increased 6 times (from 0.090 to 0.529). A negative trend in the indicators was observed in a 33% decrease in the quality index in 2012 due to an expansion of the region's territory by 2.3 times due to the addition of new areas shaping and forming New Moscow.

At the same time, the existing transport network on the annexed territory was underdeveloped and amounted to less than 5% of the entire length of the megalopolis transport network in 2012.

The main measures of the executive authorities were focused on ensuring transport accessibility of the added territory by constructing additional metro lines, overhead roads and highways. Meanwhile, the consistent policy of the regional authorities to increase the share of high-tech products and reduce atmosphere and water pollution remained in place.

As a result of the implementation of this policy in Moscow (for example, an increase in the length of transport routes by 12% over 5 years), there has been a positive trend in the indicators of the quality of transport infrastructure index. The difference between 2020 and the maximum indicator in 2011 (0.529) was 8%.

The curves on the graph below show how the changes in the quality of transport infrastructure index and capital investment interrelate (Figure 1). As the quality of transport infrastructure increased 5 times over 14 years, investments increased 10 times over the same period. At the same time, as the quality index reaches 0.5 and remains above this value, the investments in the regional economy grow consistently.

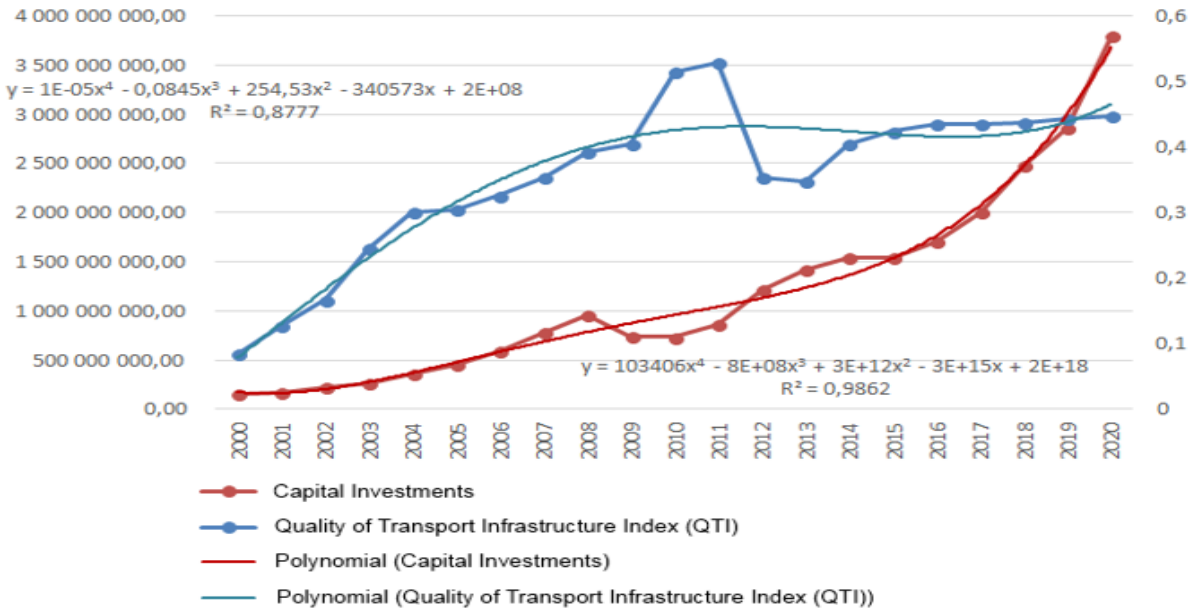
Table 2. Quality of transport infrastructure index in Moscow.

Year	Inputs						Quality of Transport Infrastructure Index QTI
	Area, sq. km S	Population, '000 people, H	Total Road Length in the Region Lt	Atmosphere Pollution, '000 tons per 1 sq. m on the territory es1	Surface Water Pollution, mln cubic meters es2	High-Tech Industry Production Share De	
2000	1,071.90	9,932.90	1,271.00	110.80	2,115.00	16.00	0.085
2001	1,071.90	10,114.20	1,900.00	93.63	2,145.00	16.50	0.127
2002	1,071.90	10,269.90	2,750.00	93.00	2,661.00	17.00	0.167
2003	1,080.83	10,386.90	3,620.30	97.30	2,015.00	17.20	0.246
2004	1,080.83	10,535.70	4,435.80	91.20	2,012.00	17.10	0.300
2005	1,080.83	10,726.40	4,416.00	89.10	1,959.00	19.20	0.304
2006	1,080.83	10,923.80	4,798.00	94.90	1,857.00	15.60	0.326
2007	1,080.83	11,091.40	4,866.00	79.00	1,726.00	20.70	0.354
2008	1,080.83	11,186.90	5,088.00	70.20	1,684.00	27.20	0.392
2009	1,080.83	11,281.60	5,180.00	60.10	1,595.00	25.40	0.405
2010	1,080.83	11,382.20	5,335.40	62.98	909.00	21.70	0.514
2011	1,080.83	11,541.10	5,602.17	62.90	908.00	19.60	0.529
2012	2,561.50	11,612.90	5,751.90	61.20	925.00	20.90	0.353
2013	2,561.50	11,979.50	5,930.40	71.64	946.00	19.50	0.347
2014	2,561.50	12,108.30	6,354.80	65.96	780.94	20.80	0.405
2015	2,561.50	12,197.60	6,392.70	67.65	739.50	24.60	0.424
2016	2,561.50	12,330.10	6,430.50	63.20	687.00	23.20	0.436
2017	2,561.50	12,380.70	6,527.40	61.00	845.00	21.5	0.435
2018	2,561.50	12,506.5	6,654.4	61.4	855.00	21.3	0.438
2019	2,561.50	12,615.3	6,681.7	75	820.00	21.8	0.444
2020	2,561.50	12,678.1	6,690.8	75	820.00	23.4	0.448

Source: calculated by the authors based on data of Federal State Statistics Service (n.d.).

The criterion for the efficiency of choosing the path for transport infrastructure development will be determined by the total of the correlations between the investments in transport infrastructure and the quality of transport infrastructure facilities (the quality of transport infrastructure index), i.e. the intersection point, which equals 0.5 (Figure 1). The findings, in our opinion, prove that the development of transport infrastructure and its quality are currently the main reserves for the growth of a megalopolis, which will lead to a cumulative increase in investments.

Figure 1. Quality of Transport Infrastructure Index and Investments Trends in Moscow for the period of 2000 to 2020.



Source: calculated by the authors based on the data (Federal State Statistics Service, n.d.).

When the quality index equals 0.5, target values may be determined, and the investments upon reaching such values will be at the efficiency threshold. It should be kept in mind that this threshold is an arbitrary concept, which is determined by the efficiency points (extreme intersection points).

The target values of the variables are determined by transferring inefficient investment indicators to the efficiency threshold limited by the indicator with the value of 1 (taking into account the assumption that the quality of transport infrastructure index approaches max = 1).

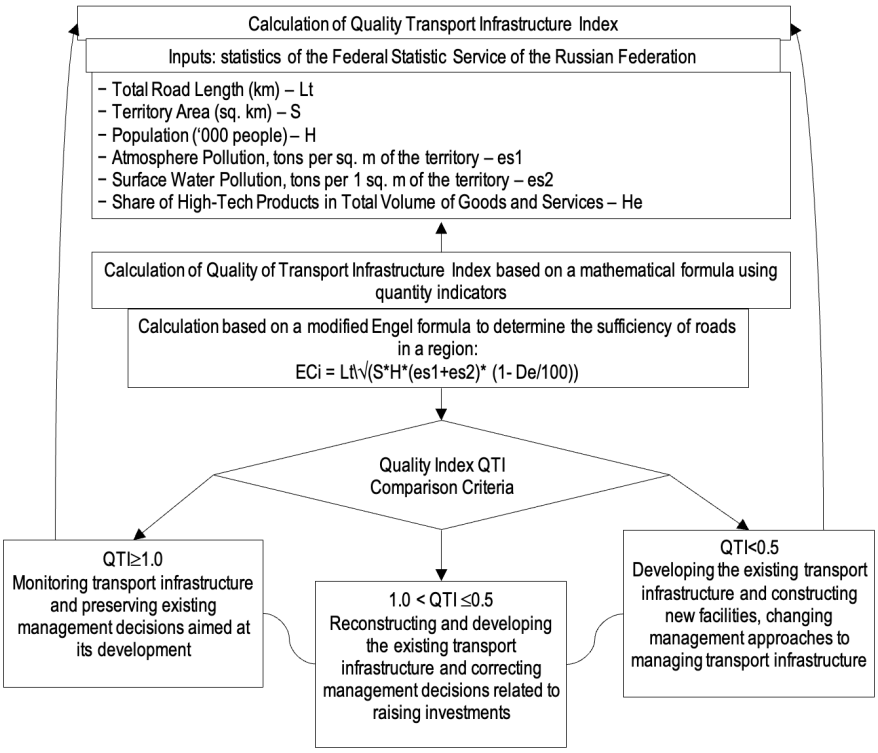
However, when the indicators improve, the maximum of 1 can be reached (the introduced restriction - the second intersection point – is an artificial threshold of the restriction). It is noteworthy that with artificial thresholds the quality of the transport infrastructure index can exceed one, because the assessed object is located in the external social and economic space.

Thus, the identified thresholds serve as a reference to determine the mechanism for the development of transport infrastructure. The degree of efficiency of the facilities is determined by the degree of their proximity to the efficiency threshold in the space of the variables in question.

The algorithm used to choose a path for the development of transport infrastructure, which is determined by the risk zone of investments in the region and the quality of the regional transport infrastructure, is shown in Figure 2.

The approach suggested here for the rationalization of the efficiency thresholds for management decisions taken to develop the transport infrastructure facilitates the rationale for the recommendations to reduce the expense and increase the effectiveness of its operation.

Figure 2. Algorithm of taking management decisions aimed at the development of transport infrastructure.



Source: developed by the authors, based on Davydova (2016).

5 DISCUSSION

The methodological issues of assessing the development of transport infrastructure are tackled in the works of a number of reputable Russian and foreign researchers. For instance, Zomarev and Rozhenko (2020) in their study "How Unmanned Vehicles Change the Faces of our Cities?" propose a methodology to assess the consequences of introducing unmanned transport technology in a city, which was developed based on documents containing planning solutions of Moscow.

At the same time, among the parameters of the influence of unmanned vehicles on the future development of the city, the authors distinguish blocks of transport and technological, economic, environmental, social and political indicators. Thus, Zomarev and Rozhenko also emphasize the environmental factor, which acquires a great importance in the context of implementing the "green economy".

The authors of the Analytical Report (Fedyanin et al., 2020) consider the transport complex of a modern megalopolis as a complex system with a variety of transport modes, departure and destination points, and intense traffic, which does not only lead to positive effects of transport on the social and economic system of the city, but creates negative effects as well, such as transport congestion, failures, lower environmental and safety indicators.

The authors of the report also explain the need to develop an assessment tool for the transport system, taking into account the characteristics of large cities, their problems and development trends, since the effective regulation of the system is one of the priorities of the megapolis urban policy.

The key factor in the development of the quality of transport services in Moscow over the period of 2010 2018 was to improve the quality of transport services for public transport users. This process was driven by the reduction of road and public transport congestion during rush hours, the introduction of innovative services for the users of transport services.

Notably, the opinion of the authors of the report coincides with our opinion regarding the consideration of the innovation factor in assessing the quality of the transport infrastructure of megapolises.

Lapidus and Misharin (2018) in their study came to the conclusion that it was the indicators characterizing the level of economic development of the territory that influence the characteristics of passenger and freight transport by road. Such indicators include, in particular, capital investments. This conclusion does not contradict our identified tendency of positive, impact of capital investments on the quality of transport infrastructure index, but even confirms it.

Comparing our research with the scientific works of other authors (Pimentel et al., 2021; Kalaoum & Trigo, 2021), we should mention this paper has an advantage as it contains a developed algorithm for making managerial decisions on the development of transport infrastructure. In theory, it allows the systematization of the factors affecting the development of transport infrastructure in a given region and in practice, ensures the regulation of the procedure to choose specific areas of transport infrastructure which should be developed while taking into account the efficiency of using investment funds.

6 CONCLUSIONS

The paper confirms the hypothesis that the quality of transport infrastructure index enables an adequate assessment of the impact of transport infrastructure on the spatial development of a megalopolis.

Based on the quality of transport infrastructure index, a multicriteria economic and mathematical model for Moscow was developed in the study. In theoretical terms, the model helps to systematize the factors influencing the development of transport infrastructure and, in practical terms, to regulate the procedure for choosing the path for transport infrastructure development in terms of the efficient use of investments.

The use of the proposed model is limited by the type of urban agglomeration: the model is focused on a monocentric (single-nucleus) agglomeration corresponding to the third stage of the agglomeration formation with further nucleation in peripheral areas (secondary nuclei) connected to the center of the labor and capital flow and developed transport infrastructure.

Thus, the developed methodological approach to assessing the transport infrastructure development of Moscow will contribute to taking managerial decisions based on a quantitative assessment of the quality of the transport infrastructure, which in turn will increase the rationalization and efficiency of managing the transport infrastructure development of Moscow.

In their further research, the authors will focus on the elaboration of management decisions for the development of Moscow's transport infrastructure based on assessing the quality of the city's transport infrastructure.

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Table 1. CRediT author statement

Term	Definition	Author 1	A.2	A.3	A.4	A.5
Conceptualization	Ideas; formulation or evolution of overarching research goals and aims	+			+	+
Methodology	Development or design of methodology; creation of models		+	+		
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components	+	+		+	
Validation	Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs			+	+	+
Formal analysis	Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data	+	+			+
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection		+	+	+	
Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools	+		+		+
Data Curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse	+		+		+
Writing - Original Draft	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation)	+	+	+	+	+
Writing - Review & Editing	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre-or post-publication stages	+	+	+	+	+
Visualization	Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation		+			+
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team	+		+	+	
Project administration	Management and coordination responsibility for the research activity planning and execution		+		+	
Funding acquisition	Acquisition of the financial support for the project leading to this publication	+	+	+	+	+

Source: adapted from Elsevier (2022, s/p), based upon Brand et al. (2015).

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