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Decision-Making Methods in Transport Policy: a Multi-Criteria Approach

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ABSTRACT

Transport policy includes various aspects of government regulation of transport and related industries. Decision-making in transport policy must consider a wide range of factors and evaluate options for the consequences of adoption of certain decisions based on various criteria, such as cost, environmental impact, and social effects. Two widely used decision-making tools in transport policy are multi-criteria decision analysis (MCDA) and cost-benefit analysis (CBA).

The objective of the study was to select decision support methods for transport policy that consider aspects other than monetary or hardly formalised ones.

As a practical experiment, the study selected and ranked projects currently considered promising, per as they correspond to a given target using T. Saaty's analytic hierarchy process. Several criteria developed within the framework of the study are proposed for the purpose of applied assessment of the pool of projects and their prioritisation.

Application of such criteria and AHP allowed to develop a new applied tool for evaluating projects for subsequent use in the system of state administration of the transport industry. The study concludes that although CBA and MCDA methods have their strengths and weaknesses, the choice of method should depend on the specific context of the project.

Keywords: transport policy, transport economics, decision-making methods, multi-criteria decision analysis (MCDA), cost-benefit analysis (CBA), project selection.

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INTRODUCTION

The main objective of transport policy is to ensure safety, efficiency, accessibility, and sustainability of transport systems, as well as to promote economic growth, environmental protection, and social justice.

Decision-making in transport policy involves weighing the benefits of a project against the associated costs, risks and environmental impacts. There are various decision-making tools to help policy makers make informed decisions: the key ones comprise cost-benefit analysis (CBA) and multi-criteria analysis (MCDA).

There are various systems for evaluating transport infrastructure projects, however, in most world countries, traditional cost-benefit analysis (CBA) is carried out to one degree or another [1–3].

This is the most common methodology used to date to assess transport systems. The CBA methodology is applied based on specific models and provides decision-makers with a monetary estimate of project feasibility. Socio-economic analysis in this regard is further development of the traditional CBA, which is the monetary expression of social effects («benefits») by transforming social goals into financial indicators of benefits [4].

In recent years, scientific literature and government regulations in Western countries have increasingly concluded that, in addition to the social costs and benefits associated with transport, other impacts that are more difficult to express in terms of monetary effects should also influence the decision-making process. It is widely recognised that decisions regarding infrastructure projects are often influenced by other types of impacts besides monetary ones [5; 6]. However, as a rule, strategic guidelines are not formalised within the evaluation process; various documents only propose to describe individual priorities and take them into account in the decision-making process.

This strategy can be implemented in public transport planning institutions in various forms. Accordingly, project evaluation methodologies in various countries are evolving to better match this trend [7].

Essentially, the CBA provides decision-makers with a monetary estimate of the profitability of project alternatives. However, decision-makers often face difficulties in finding the right balance between the scores obtained as a result of the CBA and the scores

obtained as a result of analysing the opinions of various stakeholders in the decision-making process [8].

The *objective* of the study presented within the framework of this work was to analyse the possibility of evaluating development projects in the transport industry through decision-making systems alternative to the CBA.

As a research *method*, practical-experimental selection of projects currently considered as promising ones was followed by their subsequent ranking per their compliance with their respective targets using T. Saaty's analytic hierarchy process.

PROBLEM STATEMENT

There are several alternative methods that can be used to estimate benefits and costs of different transport alternatives. Most refer to cost-benefit analysis (CBA) methods, which is an *economic* evaluation method that compares the costs of a project with its benefits. On the other hand, multi-criteria decision analysis (MCDA) is also used. This is a method that considers many criteria when making decisions [9]. It involves evaluating and comparing alternatives based on a set of predetermined criteria.

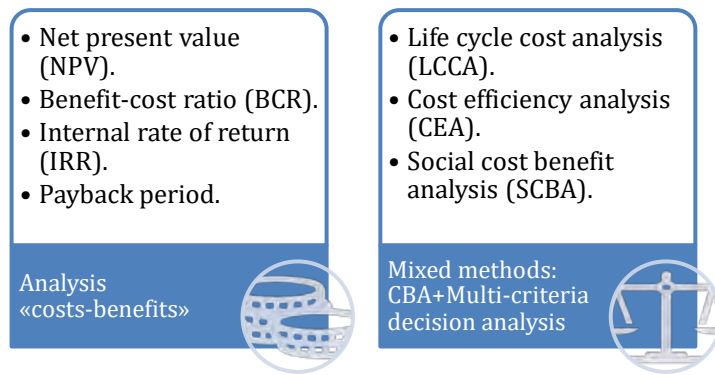
Alternative methods of evaluating projects through the prism of strategic goals are often based on multi-criteria decision analysis (MCDA), which in most cases can be combined with CBA. Many researchers in several countries and in Russia have already studied this issue [10–12]. Summarising their works, it can be concluded that MCDA improves quality of decisions and enhances involvement of those who make them into the analysis of the situation.

In this case, both methods either mixed methods can be used within the comparison, for example [13; 14]:

1. *Life Cycle Cost Analysis (LCCA)*: LCCA is a method for evaluating the total costs and benefits of a transport project throughout its life cycle, from construction to decommissioning. LCCA can provide a more complete picture of project's costs and benefits than a CBA, which typically only considers costs and benefits over a relatively short period of time.

2. *Cost Efficiency Analysis (CEA)*: CEA is a method of evaluating costs and benefits of various alternatives based on the results achieved rather than on the monetary value of those results. CEA can be especially useful for evaluating transport projects that have significant non-





Pic. 1. Main methods of CBA and MCDA [developed by the author].

monetary benefits, such as improved air quality or reduced traffic congestion.

3. *Social Cost Benefit Analysis (SCBA)*: SCBA is a method for assessing social costs and benefits of transport projects. It can include analysis of both monetary and non-monetary impacts, such as impacts on community health and well-being, as well as on local businesses.

At the same time, several methodologies are used within the framework of MCDA [15; 16]:

1. Analytical Hierarchy Process (AHP).

2. Method of ordering preferences by similarity to the ideal solution (TOPSIS).

3. Élimination Et Choix Traduisant la Réalité (Elimination and Choice Expressing Reality, ELECTRE).

4. Simple additive weighting (SAW).

A brief description of the main methods of MCDA can be presented as follows.

1. *Analytical Hierarchy Process (AHP)*: AHP is a structured multi-criteria decision-making method that involves breaking down a complex decision into smaller parts, creating a hierarchy of decision criteria and alternatives, and then evaluating the relative importance of each criterion and the effectiveness of each alternative with respect to each criterion. AHP uses pairwise comparisons and mathematical algorithms to calculate the final score for each alternative.

2. *Method of ordering preferences by similarity to the ideal solution (TOPSIS)*: TOPSIS is a multi-criteria decision-making method that involves creating a matrix of alternatives and criteria, and then determining the similarity of each alternative to the ideal solution and the distance of each alternative to the worst solution. TOPSIS uses a mathematical formula to calculate a final score for each

alternative option based on its relative similarity to the ideal solution.

3. *Elimination and choice expressing reality (ELECTRE)*: ELECTRE is a multi-criteria decision-making method that involves creating a set of criteria and then comparing each alternative against each criterion. ELECTRE uses mathematical algorithms to rank alternatives based on how well they meet criteria. ELECTRE also allows decision-makers to set thresholds for each criterion, so alternatives that fall below the threshold are excluded from consideration.

4. *Simple additive weighting (SAW)*: SAW is a multi-criteria decision-making method that involves assigning weights to each criterion and then evaluating each alternative against each criterion. SAW calculates a final score for each alternative by multiplying each criterion's score by its weight and summing the results. SAW is easy to use and understand but it can be sensitive to changes in criteria weights.

Each of these alternative methods has its own strengths and weaknesses, and the most appropriate method will depend on the specific decision-making problem, available data and information, as well as on transport policy goals and objectives. By using a combination of methods, a complete and more reliable estimate of costs and benefits of various transport alternatives can be obtained.

It is important to note that MCDA methods are often more complex and allow for a more holistic evaluation of projects, while cost-benefit methods are more focused on financial feasibility.

Unfortunately, the results of the analysis when applying MCDA are largely dependent on the opinion of experts and therefore seem less objective than in case of the cost-benefit analysis

(CBA) either of cost efficiency analysis. The algorithm of MCDA method is as follows:

1) Scenarios for achieving the goals of regulatory impact are developed.

2) Criteria for achieving the goals and objectives of regulation are selected (a prerequisite is that the criteria must be measurable).

3) Depending on the importance of the goals of regulation, each criterion is assigned a certain weight (usually from 0 to 1).

4) For each scenario, an assessment is carried out for each of the criteria on a certain scorecard (usually from 0 to 100 points).

5) Scores for each scenario are summed up, considering weights of criteria.

6) An optimal scenario is selected.

At all stages of MCDA, especially at the third and fourth, an expert group is actively involved in the analysis, the members of which have sufficient qualifications and experience in the field of regulation. Despite some subjectivity of the results of MCDA, this method can be successfully applied with a limited number of monetised consequences of the regulatory impact.

Despite the fact that the practices of using MCDA for project evaluation are widespread globally, today, this process is not an integral part of the infrastructure project evaluation scheme. In countries with developed CBA evaluation institutions (e.g., Sweden and Denmark [17]), the methodology is only being explored as a probable decision-making support tool due to its reliance on subjective qualitative input [18].

RESULTS

Decision-Making Model Based on MCDA. Theoretical Part

To determine the priorities of state policy, expressed in implementation of practical measures, it is possible to apply the adapted method of analytical hierarchy process (hereinafter – AHP), which was proposed in the late 1970s by American mathematician Thomas L. Saaty [19].

The method consists in decomposing the problem into simpler component parts and step by step prioritisation using pairwise comparisons.

The application of this method for formation of rational decisions in the field of transport policy is determined by *unformalised principles of state priorities* in the field of transport development projects, technological platforms and other large-

scale elements used in implementation of transport policy, for example, the principles of geopolitics, technological sovereignty, etc.

The difficulties in formation of transport policy are associated not only with the magnitude of decisions, but also with diversity of the consequences of their implementation and, as a result, with several criteria, not all of which may have quantitative values.

A number of principles for development of projects have been declared within the framework of the Transport Strategy of the Russian Federation¹ regarding thus the implementation of the country's transport policy. They can be conditionally grouped as follows:

1) Development of infrastructure for cargo traffic.

2) Increasing the population mobility.

3) Ensuring technological sovereignty.

4) Compliance with the principles of ESG (environmental principle).

5) Increasing the accessibility of remote areas.

These principles and their applicability differ significantly depending on the cases of specific projects, so traditional decision support methods, as in case of individual investment projects [20], cannot be applied. In the framework of this study, for the purpose of applied assessment of the pool of projects and their prioritisation based on the adapted methodology of T. Saaty, we will supplement the existing set of criteria form our own one (Table 1).

In the AHP method by T. Saaty, elements of the same levels must be comparable with each other in terms of the possibility of setting priorities. The criteria for all levels of the hierarchy in the analytical hierarchy process must have a common direction, either positive or negative.

Depending on the global goal, the significance of the vectors will change.

For example, if the priority is development of transportation with friendly countries, then the focus of development will shift in favour of criterion 4 (geopolitical effects). With priority in the social aspect the focus will shift in favour of criterion 5 (population mobility).

¹ Transport strategy of the Russian Federation until 2030 with a forecast for the period until 2035. Approved by the Decree of the Government of the Russian Federation dated November 27, 2021, No. 3363-r. [Electronic resource]: <http://static.government.ru/media/files/7enYF2uL5kFZIOOpQhLl0nUT91RjCbeR.pdf>. Last accessed 05.12.2022.



Table 1

Prioritisation criteria for evaluating a project pool [developed by the author]

No.	Criterion	Description
1.	Resource intensity	The need for financial, personnel, land and other resources, incl. from related industries
2.	Monetary cost-benefit ratio	The result of assessment according to the cost-benefit analysis method (<i>for the purposes of this study, the assumption of a ready-made assessment was taken</i>)
3.	Contribution to technological sovereignty	Factors that contribute the most in terms of the development potential of the national own industrial base and intellectual developments
4.	Geopolitical effects	Factors that ensure that both positive and negative foreign policy impacts on the direction of cargo flows and the distribution of demand for transport services are considered, and, if necessary, the levelling of negative consequences (for example, of sanctions)
5.	Impact on population mobility	Factors affecting transport mobility of the population, its ability to travel
6.	Environmental impact	Impact on the environment, considering the geography of the project

Thus, to determine specific steps (alternatives), it is necessary to propose a methodology for selecting projects at the decision-making stage (without assessing socio-economic effects) in the context of choosing a global goal and priorities (vectors) for its implementation.

For the purposes of the study, we will propose a goal «Development of the transport system in the interests of an independent economy and citizens of the country» and try to determine the distribution of alternatives in favour of which the choice is shifted with such a goal setting.

Decision-Making Model Based on MCDA. Practical Part

As alternatives for consideration as an example of the application of this approach, we can take 4 real promising mega-projects (Pic. 2)²:

1. Dzhubga–Sochi highway is a complex project for construction of the «Southern Cluster» with a length of 152,5 km, including bypasses of Sochi, Adler microdistrict, the city of Tuapse, the township of Lazarevskoye. It also provides for construction of a completely new route from the town of Goryachiy Klyuch to the village of Agoy. The cost is estimated at over 2,4 trillion rubles³.

² Estimation of the cost of project implementation has been carried out based on the analysis of open accessed media news, is indicative and used exclusively for illustration of fundamental possibility to build a model. Below are individual references to sources.

³ Ryzhkova, E. Dead end path to the sea. The cost of Dzhubga–Sochi highway was estimated at 2,4 trillion rubles [Tupikoviy put k moryu. Stoimost trassy Dzhubga–Sochi otsenili v 2,4 trln rublei]. *Kommersant* (Krasnodar), No. 189, 15.10.2020. [Electronic resource]: <https://www.kommersant.ru/doc/4531055>. Last accessed 10.02.2023.

2. The project of a railway connection from Derbent (Samur) to the port of Bandar Abbas through the territory of Azerbaijan and Iran. The project supposes joint construction or reconstruction of a broad-gauge railway with a length of over 1,5 thousand km. The cost of its implementation on Iranian territory only, according to some expert estimates might be evaluated at 2 trillion rubles⁴.

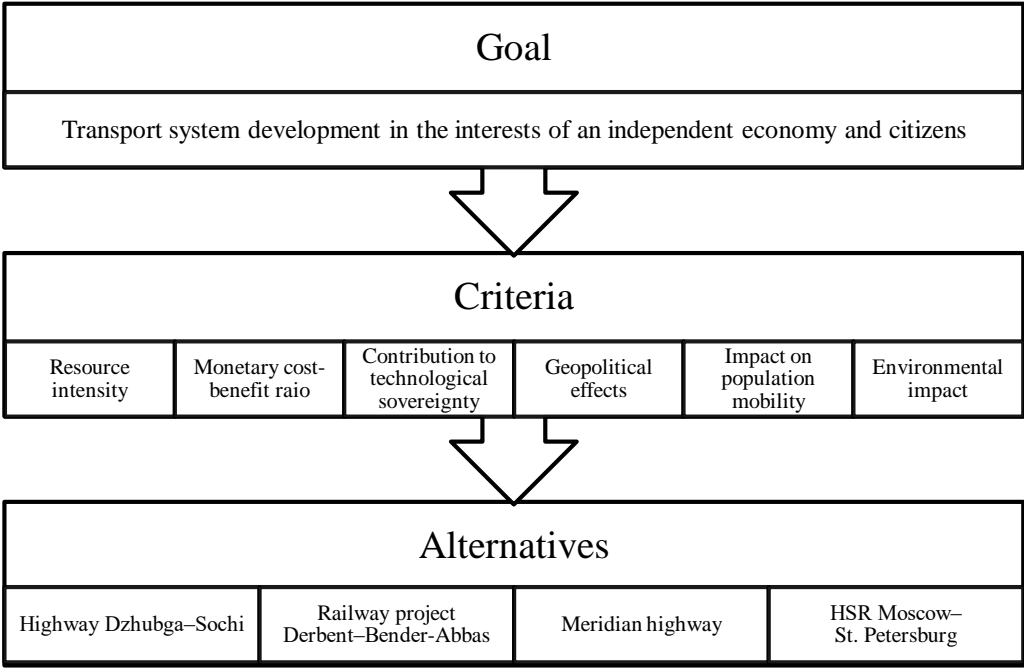
3. The Meridian highway is a project for construction of a highway from the border with Kazakhstan to the border with Belarus to organise a new transit route from Asia to Europe. The cost exceeds 0,6 trillion rubles⁵.

4. Project for construction of HSR Moscow–St. Petersburg. The cost of the project is over 2 trillion rubles⁶.

⁴ See, e.g., Iran accelerates the construction of North–South transport corridor [Iran uskoriaet stroitelstvo transportnogo koridora Sever–Yug]. *Zheleznnye dorogi mira*, 26.04.2022. [Electronic resource]: <https://zdmira.com/news/iran-uskoriaet-stroitelstvo-transportnogo-koridora-sever-yug>; Gaiva, E. What will be the cost of North–South logistics corridor [Vo chto oboidetsia logisticheskii korridor «North–South»]. *Rossiyskaya gazeta*, 22.11.2022. [Electronic resource]: <https://rg.ru/2022/11/22/persidskie-motivy.html>. Last accessed 10.02.2023.

⁵ Fedorova, N., Korenyako, A., Demchenko, N. Meridian highway for P600 billion from China to Europe will be redirected to the Caspian Sea [Trassu Meridian za P600 mlrd iz Kitaya v Evropu perenapravyat k Kaspiyu]. *RBC*, 16.06.2022. [Electronic resource]: <https://www.rbc.ru/business/16/06/2022/62ab0a869a7947294b7ca718>. Last accessed 10.02.2023.

⁶ Boiko, A., Volobuev, A., Grinkevich, D. The authorities will refuse to finance HSR Moscow–St. Petersburg from FNB. The project is again shelved [Vlasti otkazhutsya ot finansirovaniya VSM Moskva–Sankt-Peterburg iz FNB. Proekt vnov otkladyvaetsya v dolgiy yashchik]. *Vedomosti*, 24.03.2022. [Electronic resource]: <https://www.vedomosti.ru/economics/articles/2022/03/24/915136-vlasti-finsirovaniya-vsm-moskva>. Last accessed 10.02.2023.



Pic. 2. The logics of the decision-making model using specific examples [developed by the author].

To set the priorities of the criteria, to obtain estimates for alternative solutions, matrices of pairwise comparisons $A = || a_{ij} ||$ are built. The element a_{ij} of the matrix of paired comparisons is the result of measuring the degree of preference of the alternative A_i in relation to the alternative A_j on the fundamental scale.

The criteria scale is a numerical series from 1 to 9 with three main points:

- 1 – equivalence (equal value)...
- 5 – strong superiority...
- 9 – the great superiority.

Intermediate points 2–4, 6–8 are used for refinement within the scale.

With the help of a matrix of pairwise comparisons, the expert method helped to determine the weights of the criteria based on available data on the projects under consideration, including their cost (Table 2).

The method of expert evaluation within the framework of a given goal has shown that the criterion of geopolitics has been a key one.

Considering the given weights, based on the results of assessment, a whole range of alternatives was formed (Table 3).

According to the criterion «Resource intensity», the best project is Meridian highway due to the low cost of implementation compared to other projects.

According to the criterion «Monetary cost-benefit ratio», the best project is HSR Moscow–St. Petersburg since it implies a high level of socioeconomic benefits due to agglomeration effects [21].

According to the criterion «Contribution to technological sovereignty», the best project is HSR Moscow–St. Petersburg since it involves construction of high-speed rolling stock and production localisation in the Russian Federation.

According to the criterion «Geopolitical effects», the best project is Derbent–Bender–Abbas railway since it ensures opening of a new railway corridor to the Persian Gulf, ensuring seamless transportation of Russian goods and the

Table 2
Result of pairwise comparisons and criteria weighting [developed by the author]

Criterion	Priority
Resource intensity	0,0401
Monetary cost-benefit ratio	0,1520
Contribution to technological sovereignty	0,2497
Geopolitical effects	0,4186
Impact on population mobility	0,0841
Environmental impact	0,0554



**The result of pairwise comparisons and weighting of projects
[developed by the author]**

Priority	Resource intensity	Monetary cost-benefit ratio	Contribution to technological sovereignty	Geopolitical effects	Impact on population mobility	Environmental impact
Highway Dzhubga–Sochi	0,0578	0,2779	0,1275	0,0570	0,2304	0,0474
Railway project Derbent–Bender-Abbas	0,1359	0,0861	0,0997	0,7339	0,0308	0,2335
Meridian highway	0,6850	0,1099	0,0684	0,1571	0,1358	0,1043
HSR Moscow–St. Petersburg	0,1213	0,5261	0,7044	0,0521	0,6030	0,6147

Table 4
**The result of pairwise comparisons and weighting of projects with AHP
[developed by the author]**

Alternative	Priority
Highway Dzhubga–Sochi	0,1223
Railway project Derbent–Bender-Abbas	0,3662
Meridian highway	0,1443
HSR Moscow–St. Petersburg	0,3673

import of necessary goods into the Russian Federation.

According to the criterion «Impact on population mobility», the best project is HSR Moscow–St. Petersburg since it significantly affects the mobility of two largest agglomerations of the country with a total population of over 23 million people.

According to the criterion «Environmental impact», the best project is HSR Moscow–St. Petersburg since it allows more people to switch to a more environmentally friendly railway compared to road and air transport.

The results of matrices' pairwise comparisons are presented in Table 4.

HSR Moscow–St. Petersburg became the best alternative within the framework of the declared goal, while the gap with the project for construction of a railway to the Persian Gulf is minimal.

Both projects in the best way correspond to the dual goal «*Development of the transport system in the interests of an independent economy and citizens of the country*»: the HSR project – in terms of ensuring technological sovereignty, ecology and increasing the mobility of citizens,

the railway project to the Persian Gulf – in terms of ensuring geopolitical long-term tasks.

By clarifying the goal – for example, by shifting the weight of the criteria towards a purely geopolitical component, the project of the railway to Bender Abbas would become the winner of the selection according to the presented model. And vice versa, if the weight of «social» indicators increases with a shift in priorities in favour of improving the quality of passenger services in the country, the superiority of high-speed rail would be significant.

CONCLUSIONS

Within the framework of the study, various decision support methods were considered within the framework of CBA and MCDA systems. The possibility of using AHP on a specific example was analysed.

Through the formalisation of selection criteria within the declared goal, it was possible to prove applicability of the adapted method of analytical hierarchy process for the purposes of determining transport policy priorities.

Summing up the comparison of project evaluation methods, it should be noted that CBA provides for strict evaluation procedures, while MCDA methods are based on peer review and less formalised criteria, which gives analysts a relatively greater degree of freedom in the evaluation when using MCDA.

At the same time, it seems that, as indicated in the initial hypothesis of the study, the choice of specific project evaluation tools should be based on the specifics of a particular project, as well as of its alternatives. Obviously, the attention should also be paid to the factors of availability of objective tools of project analysis, including

such instrument as the transport and economic balance [22].

The combination of various project evaluation methods along with a clear goal-setting and formation of administrative procedures for ranking promising transport infrastructure development projects, are key factors for improving quality of transport policy implementation.

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