Journal of Management & Technogy
e-ISSN: 2177-6652

THE METHODOLOGY FOR THE MULTI-PROJECTION ANALYSIS OF SUSTAINABLE DEVELOPMENT OF THE REGIONS OF THE NORTHERN SEA ROUTE

Sergey Mityakov
Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Russia
E-mail: snmit@mail.ru

Dmitry Lapaev
Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Russia
E-mail: dnlapaev@mail.ru

Pavel Zakharov
Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Russia
E-mail: pav_zah@mail.ru

Zhanna Zakharova
Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Russia
E-mail: zjane77@mail.ru

Olga Mityakova
Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Russia
E-mail: omityakova@list.ru

Abstract
The purpose of this article is to develop the methodology for the multi-projection analysis of sustainable development of the regions of the Northern Sea Route, as well as its approbation according to statistical indicators for 2019-2021. The author's system of indicators contains three projections in accordance with the principles of ESG: the projection of the economy, the projection of the environment and the social projection. The methodological approach proposed in the paper includes seven stages, which are highlighted to reflect the specifics of each region. In the course of the study, the software package for the multicriteria benchmarking analysis of economic systems developed by the authors was used, which includes software and graphical implementation of algorithms for finding the effective set and ranking solutions for n criteria of optimization. The article tested the declared methodology according to the statistical data of the regions of the Northern Sea Route for 2019-2021. The proposed methodology can be effectively used in the practical activities of government bodies to ensure the proper level of socio-economic development of the regions of the Northern Sea Route.

Keywords: Multi-projection analysis; region; sustainable development; the Northern Sea Route; logistics infrastructure; sea freight.

Editor Científico: José Edson Lara
Organização Comitê Científico
Double Blind Review pelo SEER/OJS
Recebido em 20.03.2023
Aprovado em 11.06.2023

INTRODUCTION

The studies aim is to develop methodological foundations for Northern Sea Route regions sustainable development analysis using multi-criteria optimization principles. The article presents the methodological foundations, as well as the results of the multi-projection analysis of the level of socio-economic development of the regions of Russia, through the sea coast of which the Northern Sea Route passes. Northern Sea Route development has been carried out since the end of the 19th century due to the widespread use of icebreaking technology. It is an alternative maritime transport route connecting Europe with the regions of the Far East (Fig. 1). A significant part of the Northern Sea Route is located on the territory of Russia.

Figure 1. Sea route from the Far East to Europe by the Northern Sea Route (blue) and the Suez Canal (red)

The Northern Sea Route is a promising direction for development of logistics infrastructure in the Arctic region and allows you to significantly save on the distance of sea transportation when moving goods from Asia to Europe (Antrushina, 2022, Valentinova & Vorotnikov, 2021). Naturally, the operation of the Northern Sea Route is accompanied by more difficult climatic conditions for maritime transport compared to the other options for implementation of international maritime transport of goods. The potential advantages of the Northern Sea Route are possible reduction in transport costs for cargo carriers due to fuel savings, lower labor costs for hired personnel and ship charter costs, absence of vessel passage fees and long queues, as well as absence of the risk of attack on a pirate merchant ship.

The Northern Sea Route passes through the sea coast of twelve regions of Russia, the socio-economic development of which was the object of study. The paper suggests that the further development of the specified logistics route in the form of the increase in the number of passing ships, the increase in cargo traffic and implementation of investment facilities for the development of infrastructure are important factors that have a significant impact on the level of the socio-economic development of the studied sample of the regions. On the other hand, protected regions socio-economic development positive dynamics, revealed as a result of a multi-criteria analysis, will contribute to Northern Sea Route high-quality and personnel development.

At the same time, the multi-projection analysis is used from the point of view of the concept of the sustainable development in terms of the comparative assessment of the regions in terms of quantitative indicators from three projections (the economy, the ecology and the social sphere).

Although the approach presented in the paper is not fundamentally new from a mathematical point of view, the analyzed indicators are Northern Sea Route sustainable development regions characteristic indicators, which distinguishes this technique from those previously known.

The rest of the paper is organized in the following way. Section 2 reviews the literature on the use of the multi-criteria analysis in the economic research. Section 3 outlines the key components of the methodology: approaches, stages and methods. Section 4 presents the main results obtained in the course of the multi-criteria analysis of indicators of the socio-economic development of the regions of the Northern Sea Route in 2019-2021. Section 5 contains the practical conclusions, limitations and perspectives of the study.

LITERATURE REVIEW

Multi-criteria methods of decision-making in economics

A significant number of works by different domestic and foreign authors are devoted to optimization of selection procedures in economics. The current system of economic and mathematical methods for optimizing economic decisions already makes it possible to rationalize many areas of the economic activity. Since the 1950s a large number of advanced multi-objective decision optimization methods have been developed that differ from each other in the quality and amount of the required additional information, its methodology, usability, sensitivity tools used and mathematical properties they test (Perova et al., 2023).

The multi-criteria methods are widely used for decision-making in the economic activity of socio-economic systems. Many decision-making studies have shown usefulness of using multiple criteria (see, for example, Govindan & Jepsen, 2016; Kabašinskas et al., 2019).

In the field of multi-criteria decision making two scientific schools can be distinguished: the French and American schools. The French school is mainly based on the concept of superiority in evaluating discrete alternatives. The American school is based on multi-argument utility functions (Zavadskas, Turskis, 2011).

The classical methods of multicriteria optimization were first applied in the works of Pareto. The used multicriteria procedures were closely related to the economic theory. In the works of Pareto the author defines the conditions necessary to achieve optimal social welfare. He considers various aspects of economic life such as production, consumption, money, prices, inflation and trade and shows how they interact with each other in the economic system. Pareto's main contribution to economics is that he introduced the concept of "Pareto optimality" which describes the state in which it is impossible to improve the position of one person without worsening the position of another. He also proposed his own method of analysis, known as the "Pareto method" which allows you to compare different socio-economic systems and evaluate their effectiveness (Pareto, 2017).

Multicriteria decision making methods are an important part of decision theory and analysis. According to Marqués et al. (2020) multi-criteria decision-making methods can be divided into two groups: (1) methods based on theoretically infinite alternatives number assumption (multipurpose), and (2) methods that require alternatives finite set evaluation. The main purpose of their use is reduced to four types problems solving: choosing the best solution from a set, ranking and sorting solutions, describing and systematizing solutions and their implementation consequences evaluation, further management.

To date, there are no universal methods for multi-criteria decision making (Valipour et al., 2018). However, there are studies that provide guidelines for their selection (Wątróbski et al, 2019). The monograph by D. Lapaev outlines the methodology and methodological tools for decision-making in economy based on the set of indicators. The material is based on the systematic approach to study of the problem. The scientific results obtained by the author in the field of multi-criteria choices and taking into account positions of various parties are widely used (Lapaev, 2010).

In the monographs of O.N. Lapaeva development of the methodology of multicriteria optimization is presented. The first of them outlines the basics of single-criteria and multi-criteria decision-making in economics. Different classical principles of multi-objective optimization are given – the principle of dominance and Pareto principle. The inconsistency of traditional tools for selecting preferred alternatives is revealed. The author's approach to disclosure of uncertainty caused by inconsistency of indicators is presented. The scope of application of the method for selecting the main indicator is clarified. The multi-criteria method for determining the single enterprise (industry) through fine structure analysis is outlined (Lapaeva, 2015). The second monograph outlines theoretical and methodological foundations and decision-making tools in economics within the framework of the projection approach. The principles of comparative evaluation of alternatives by totality of projections are disclosed. The optimization model for projection comparative evaluation of options is developed. The corresponding classification is given, reflecting multiprojectivity of the choice (Lapaeva, 2017). The third monograph presents different principles and methods of projective comparative assessment of the state of industrial economic systems. The projection system of indicators of the economic state of industries is developed. The state of manufacturing industries in the Nizhny Novgorod region is studied in terms of performance efficiency, innovation activity and economic security (Lapaeva, 2018).

Saaty et al. (2003) showed global importance of solving problems with conflicting goals using multi-criteria models and introduced decision models with incomplete information. In the recent works Saaty et al. (2003) analyzed measurement problems in assignments associated with uncertainty conditions.

Saleev (2013) analyzed a significant number of methods for multicriteria optimization of the process of finding Pareto-optimal set of solutions. It is shown that use of convolution methods is limited by need to initially assign weight parameters for each of the criterion functions. The most preferred method in terms of possibility of application in the new technological process turned out to be the method of the main criterion which allows you to set tolerances for parameters that affect the quality of business processes, rather than their exact value.

Egorova & Ivanov (2015) developed modified iterative procedures for coordinating economic interests in two-level systems using the concept of Pareto-optimality and the method proposed by O. Larichev for analyzing correctness of heuristic procedures. These procedures can be used in multicriteria optimization problems with presence of criteria that are difficult to formalize which makes it possible to take into account informal aspects in the final solution that are quite significant in the real practice of coordinating economic interests.

Buravlev (2021) analyzed approaches to solving multicriteria problems using various convolutions of partial criteria and special procedures for constructing Pareto-optimal solutions. Solutions to these problems depend on the art of choosing the objective function that reflects its goal and associated phase variables. The example of the correct choice of the target criterion and the corresponding phase variables is considered which excludes the need to solve the multicriteria problem.

Recently, more and more attention has been paid to artificial intelligence methods in multi-criteria decision making. Thus, the work of Černevičienė & Kabašinskas (2022) provides the overview of multi-criteria decision-making methods in the field of finance using explainable artificial intelligence. In the work of Doumpos, Grigoroudis, (2013) various aspects of multicriteria decision making are considered, including the decision analysis, goal programming, ranking methods and fuzzy set theory. Various artificial intelligence techniques such as machine learning, expert systems and neural networks are explored and how these techniques can be used to solve decision making problems is shown.

It should be noted that, in order to increase evaluation efficiency, multi-criteria decision-making methods can be combined with artificial intelligence theory, fuzzy sets, coarse sets, Gray sets, etc. (Zavadskas, Antucheviciene, 2019).

Applied aspects of using multi-criteria methods

Currently, multi-criteria decision-making methods are actively used in the field of climate change (Doukas, Nikas, 2019), economics (Zavadskas, Turskis, 2011), sustainable engineering (Stojčić et al., 2019), supply chain management (Khan et al., 2020), corporate sustainability (Chowdhury, Paul, 2020), transport (Macharis, Bernardini, 2015), etc.

Wang et al. (2009) in the review of multi-criteria decision analysis to assist in sustainable energy decision making, noted that multi-criteria decision-making methods are becoming more popular in the field of sustainable development due to multi-dimensionality of goals and complexity of socio-economic systems.

Mityakov et al. (2021) assessed innovation processes in the regions of Russia based on the author's methodology which provides for the step-by-step definition of systems of the appropriate rank and formation of areas of acceptable indicator values. Based on the proposed methodology, innovative activity is assessed and dynamic ranking is carried out to analyze differentiation of the regions in terms of level of innovative development, to identify leading regions and outsiders.

Gusev (2018), considering the analysis of methods for solving problems of multi-criteria choices under uncertainty proposed Pareto-optimization approach as a resource management method. He gave description of the most common methods of multi-objective optimization, such as the multidimensional utility theory, the Zadeh fuzzy set theory and the Saaty hierarchy analysis method and suggested their use for analyzing the control of nuclear power plants.

Bakhtin (2019) formulated the problem of multicriteria optimization of parameters of ecological overpasses on highways with a significant number of parameters. Based on the analysis of influence of parameters on specific criteria and their scaling, the methods for determining criteria and the algorithm for the search procedure have been developed. The calculations made it possible to find the primary set of compromise solutions to the multicriteria problem, to determine the final Pareto set, which can significantly improve the quality of a new type of artificial structures.

Orazbaev et al. (2019) proposed the method for developing mathematical models of chemical formation in conditions of fuzzy initial information. New formulations of control problems for chemical engineering systems are obtained on the basis of modification of various compromise schemes for operation in the fuzzy environment which use functionality of multicriteria problems of fuzzy mathematical programming. The results were used in construction of mathematical models of the main units of the chemical-technological system for production of benzene and solving the problem of controlling modes of its operation in the fuzzy environment and indicate effectiveness of the proposed approach to solving control problems based on models in conditions of fuzzy initial information.

Lomazova (2018) considered the problem of multi-criteria assessment of transport systems and the choice of options for their development, taking into account the safety indicator of their functioning. It is proposed to use two approaches to support managerial decision-making in development of the transport system: building the set of Pareto-optimal options and building the choice set consisting of several best options according to the integral criterion.

Shubin & Suchkova (2021) considered the features of managerial decision-making based on the application of multi-criteria optimization methods at the present stage of development of the theory and practice of project management. The advantages and disadvantages of practical use of single-criteria choice models are analyzed and the algorithm for the process of optimizing managerial decisions in project management is proposed based on the application of V. Pareto method.

Bezruk et al. (2014) considered various aspects of applying the multicriteria optimization methodology for choosing design solutions that are optimal in terms of the set of dependent and contradictory quality indicators. In the algorithm proposed by them at the first stage subset of Pareto-optimal solutions is selected from the set of admissible variants of the system which are non-dominated variants of the system according to the unconditional preference criterion. At the second stage this Pareto subset is narrowed down to the single variant using the Saaty hierarchy analysis method. It is proposed to use this algorithm when designing IP telephony networks.

Lapaev & Mityakov (2014) proposed the methodology for diagnosing the energy security of regions which was tested in the Volga Federal District. The methodology uses three indicators that reflect different region's natural resources, production facilities and distribution of fuel and energy resources, as well as the balance of energy consumption and production. The algorithm for monitoring the energy security of the regions is proposed, consisting of three stages: the choice of the system of indicators, normalization of indicators, visualization using radar diagrams. It is shown that in some cases the assessment of the level of energy security should be carried out on the basis of the set of indicators, for which it is proposed to use multi-criteria Pareto analysis.

Medvedev & Pobedash (2016) developed the multi-criteria model for managing financial and investment flows in mesoeconomic systems using the standard multi-step linear programming problem for calculating profits. The model includes three economic agents: a regional producer, a consumer and a governing body. The algorithm for calculating the profit of the regional producer takes into account production of several types of products, describes the main cash flows and restrictions of the manufacturer operating, investment and financial activities that determine financial flows and restrictions of the governing body and the consumer. The package of applied programs is developed to search for Pareto-optimal investment strategies and achieve the compromise between interests of economic agents.

Soshnikov (2022) applied the multi-criteria approach to development of operational calendar plans for small-scale production, taking into account several criteria. He developed the method for finding the compromise plan using the ideology of identifying Pareto-optimal solutions and showed the possibility of using voting methods to find the compromise plan. The approach is proposed for generating the set of feasible options for plans with subsequent identification of Pareto-optimal options in it. It is shown that the desired option can be constructed using the rules of the collegial choice theory.

Gamanyuk (2017) considered the task of forming the information base for cadastral valuation of urban lands and determining the price of land plots. The land plot is characterized by many parameters, such as the area of the plot, its location and supporting infrastructures. Since the criteria are unequal and have a certain degree of significance, the problem of assessing the land plot is the optimization multi-criteria problem of the decision theory. The author proposes the method for arranging land plots in descending order of priority based on the “hard” ranking method.

Matveeva & Chernova (2017) developed the model for achieving the balance of interests of subjects of the electricity market. They considered the evolution of the concept of "efficiency in functioning of the electric power industry", analyzed various approaches to interpretation of the concept of "fair price", substantiated the need to solve this problem at the macro-, meso- and microeconomic levels. The author's idea of the fair price for electricity is based on Pareto efficiency criterion and is defined as a certain range of indicators, deviation from which leads to deterioration in the position of any category of market participants.

In the collective monograph edited by Batkovsky (2021) the actual tasks of managing military-civilian diversification of production at enterprises of the military-industrial complex are investigated. The solution of these problems is aimed at improving optimality of management decisions that determine the pace and quality of this process. In particular, the systems for multi-criteria assessment and monitoring of civilian research and development work at defense industry enterprises, as well as R&D portfolio management systems are proposed.

METHODOLOGY

Research Methodology

Traditionally, the comprehensive analysis of the economic state of alternatives is implemented in the multiprojection formulation. The scientific basis for multi-criteria comparison of alternatives is the Pareto principle. Initially, it is formulated as follows: all members of society benefit only if the individual operating in the market, deriving utility for himself, does not reduce the utility derived by the other market participants. In other words: the wealth of society increases if all its members benefit, and will never be maximum if the gain in utility by some groups of people reduces it for the others.

In relation to the problems under consideration: alternatives $s_{eff} \in S$ are called effective if there is no alternative $s \in S$ such that for all indicators for any *i* the relation exists $K_i(s) \preccurlyeq K_i(s^{eff}), i = \overline{1, I}$, and for at least one *i* the indicated preference is strict, i.e. $K_i(s) \prec K_i(s^{eff})$.

Various techniques have been developed to construct the effective set. The algorithm adapted for solving regional problems is shown in Fig. 2. The technique includes the following stages.

Stage 1. The initial set of compared regions is formed: $S = \{S_j\}, j = \overline{1, J}$. The indicators $K = \{K_i\}, i = \overline{1, I}$) are selected and calculated for each alternative. The preferred directions of change and initial ranges of valid values are set.

Stage 2. The effective regions are selected for each indicator at the first stage of the analysis S_i^{eff1}. The upper digital index denotes the sequence number of the analysis stage (iteration). The variant S_1^{eff1} with the optimal value of the exponentc K_1 will be the first to enter the effective solution. The second will be the alternative S_2^{eff1}, which is optimal in terms of K_2 and so on. The stage will be completed by the variant S_I^{eff1}, which is optimal in terms of K_I.

Stage 3. The range of valid values (RVV) of indicators is formed at the first stage of the RVV_1 analysis. To do this, the pre-dominated regions are found with respect to all the effective regions S_i^{eff1}. Next, the area of acceptable values of indicators is formed by excluding dominated areas from the original area.

Stage 4. The regions S_j are checked for belonging to the range of acceptable values. The variants included in the obtained area are subject to the additional analysis.

Stage 5. Stages 2–4 are being implemented. The difference is that the optimal values of the indicators K_i are determined among the non-dominated alternatives obtained at the previous iteration. This stage will be completed when at the last iteration $t = T$ there are less than two regions left inside the RVV_T region.

Stage 6. The effective solution is formed by combining effective options identified at all the stages of the analysis (1).

$$M_{eff} = \bigcup_{t=1}^{T} \{S_1^{efft}, S_2^{efft}, \dots, S_J^{efft}\}. \quad (1)$$

Stage 7. The effective regions are checked for compliance with the apriori requirements imposed at the stage of setting the problem. In case of discrepancies, the indicators are adjusted, and the previous calculation is repeated with the new initial data.

If necessary, further by analogy, the second and lower ranks are formed and the end-to-end analysis of the entire set of the study regions is carried out. To determine the second rank, the effective set (the first rank) is excluded from the original population. When forming the third rank, the first and second are excluded, etc.

The generalized solution is synthesized in the process of the multi-projection choice by means of intersection of the effective (quasi-efficient) sets of all projections.

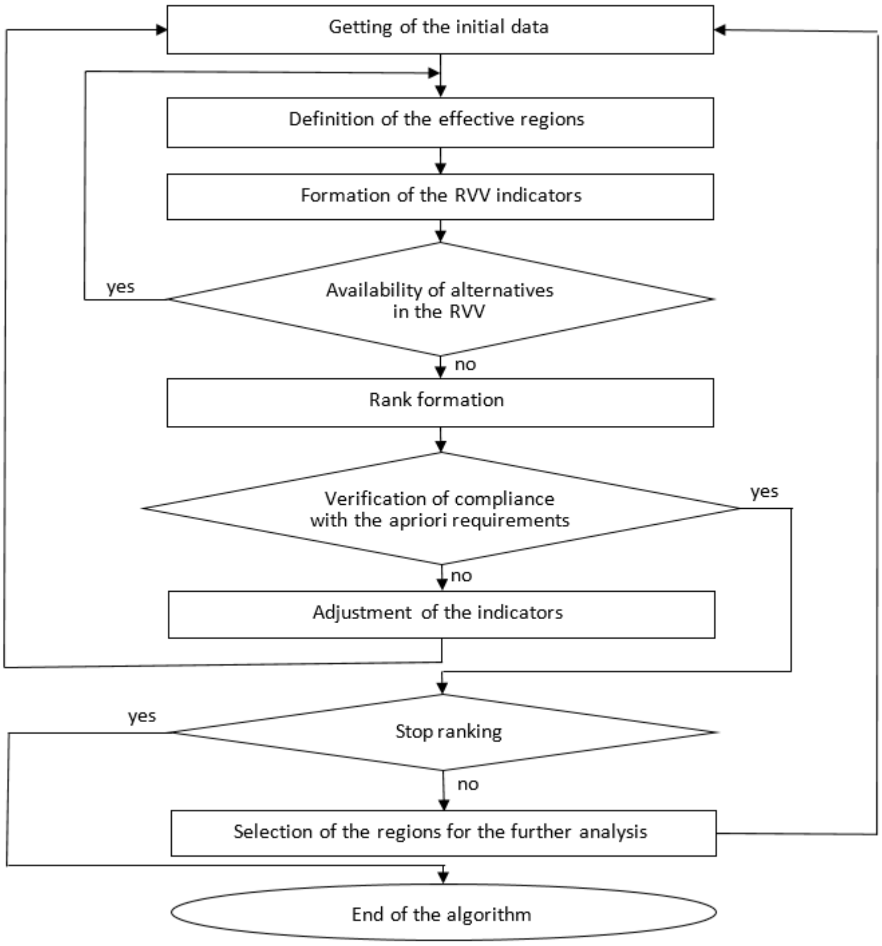

Figure 2. The algorithm for multi-criteria ranking of the regions

Research methods for the regions of the Northern Sea Route

Various aspects of the sustainable socio-economic development of the regions of the Northern Sea Route are disclosed in a wide number of studies. At the same time, the latter are characterized by a variety of methods that were used in their implementation. For example, the analysis of dynamics of official statistics makes it possible to assess the prospects for implementation of investment projects to develop the infrastructure of the Northern Sea Route (Bychkova, 2022). The use of the comparative assessment method makes it possible to compare the quantitative parameters of various shipping options as a factor in increasing the economic potential of a particular region (Karpovich, Shlafman, 2020).

The analysis of the logistical and geopolitical aspects of the functioning of the Northern Sea Route (Zhuleva, Kuzmenkova, 2020) made it possible to determine the advantages and disadvantages of this international sea route for transportation of goods compared to alternative options. At the same time, the priorities were identified in terms of the development of the port and the other infrastructure, as well as prospects for development of the icebreaker fleet with appropriate economic justification (Boruchenko, Malygin, Kaminsky, Aksenov, 2021). Undoubtedly, implementation of investment projects for development of the infrastructure of the Northern Sea Route is a significant factor that positively affects the dynamics of the socio-economic development of a particular region.

The project analysis method allows evaluating effectiveness of implementation of specific projects implemented in the regions of the Northern Sea Route (Faikov, Faikova, 2021). Using this method allows you to determine the level of differentiation of these regions with the definition of leading regions and outsider regions. The results obtained can be used to develop and implement projects aimed at bridging the gap in the level of socio-economic development between the regions of the Northern Sea Route.

The use of the geopolitical approach (Nikulin, 2019) makes it possible to determine the directions for the effective and mutually beneficial development of the Arctic region on the basis of international cooperation and cooperation. The use of this approach is of particular relevance in terms of the formation of solutions aimed at maintaining the ecology of the regions of the Northern Sea Route. In addition, the geopolitical approach makes it possible to justify the effectiveness of international cooperation in joint international projects for the development of the Northern Sea Route (Gribanova, Magdalyuk, 2022; Ushakova, 2021; Veselova, 2022; Kolzina, Mindubaeva, 2020; Sazonov, 2021).

The method of the technical and economic analysis allows us to describe the factors that reduce the efficiency of cargo transportation along the Northern Sea Route (Khorev, 2020). The obtained results can be used in making managerial decisions aimed at eliminating inefficient costs in the transportation of goods along the Northern Sea Route. In addition, the use of this method allows us to evaluate the efficiency and prospects of transporting a specific type of raw material along the Northern Sea Route (Mazurchuk, 2023).

It is very promising to use the method of expert assessment of the territorial development of the region (Denisov, Svetlova, 2021), since it allows taking into account both quantitative and qualitative characteristics of the socio-economic development of the regions of the Northern Sea Route. As a result, it becomes possible to rank the studied group of regions in accordance with the chosen scale of expert assessment.

The system analysis method is used in the development and implementation of promising infrastructure projects in the regions of the Northern Sea Route. At the same time, its use makes it possible to take into account the environmental component in the implementation of these projects (Myaskov et al., 2018).

The feature of the study of the regions of the Northern Sea Route described in this article from the previously implemented ones is the use of the methodology of the multi-projection analysis, which allows ranking the regions of the Northern Sea Route according to several projections (the economy, the ecology and the society).

Programming

In the course of the study, the software package for the multicriteria benchmarking analysis of economic systems developed by the authors was used. It includes software and graphical implementation of algorithms for finding the effective set and ranking solutions for *n* criteria of optimization. The particular algorithms for finding the effective set and ranking solutions for cases with two and three criteria have been developed with the possibility of visual representation of the obtained solutions on the graphs to simplify the benchmarking analysis. In the case of two criteria, Cartesian coordinate system is used, and the solution is represented by a set of points, in which the corresponding values of the indicators selected according to the first criterion are plotted along the abscissa axis, and the second criterion is plotted along the ordinate axis. In case of three criteria, the points (circles) on the graph acquire different sizes, in proportion to the values of the coordinates of the indicators selected according to the third criterion. In addition, for each rank, these circles are painted over with their own color. To implement the software package, the Java programming language was chosen, one of the main advantages of which is cross-platform (Lapaev, Mityakov, Kornev, 2014). In the process of program implementation, non-index designations of indicators (K1, K2 and K3) were used.

Initial data for the analysis

For the benchmarking analysis, 12 regions of the Russian Federation that are part of the Northern Sea Route were selected (Table 1).

Table 1. The regions of the Russian Federation selected for the analysis

No.	Title 2
1	The Republic of Sakha (Yakutia)
2	The Yamalo-Nenets Autonomous District
3	The Nenets Autonomous District
4	The Chukotka Autonomous District
5	The Kamchatka Region
6	The Krasnoyarsk Region
7	The Primorsky Region
8	The Khabarovsk Region
9	The Arhangelsk Region
10	The Magadan Region
11	The Murmansk Region
12	The Sakhalin Region

Three projections were chosen for the analysis in accordance with the concept of the sustainable development and the principles of ESG: the economy, the social sphere and the ecology.

The projection of the economy is represented by the following indicators: K1 - average per capita income of the population, rubles / month, K2 - the degree of depreciation of fixed assets (at the end of the year; in percent), K3 - the share of unprofitable organizations (in percent of the total number of organizations).

The projection of the social sphere includes the following indicators: K1 - change in the population (growth per year; in percent), K2 - the level of employment of the population (according to sample surveys of labor force; in percent), K3 - the number of students enrolled in bachelor's, specialist's, and master's programs per 10,000 people.

The projection of the ecology combines the following indicators: K1 - the share of captured and neutralized pollutants in the total amount of pollutants emitted from stationary sources, (percent), K2 - the index of the physical volume of environmental expenditures (in comparable prices; in percent to the previous year), K3 - discharge contaminated wastewater into surface water bodies (million cubic meters).

The choice of the indicators in the projections is due to their representativeness and accessibility for the analysis (the official statistics). The composition of the indicators is not rigid and can be adjusted.

RESULTS AND DISCUSSION

Figures 3-5 show the results of multicriteria optimization in the projection of the economy in dynamics by years for 2019-2021. On the graphs, K1 and K2 indicators are plotted along the abscissa and ordinate axes, respectively. K3 exponent value is proportional to corresponding circle radius. In addition, for each rank, these circles are painted over with their own color, as shown in the figure captions.

The corresponding data containing distribution of the regions by ranks is given in Tables 2-4.

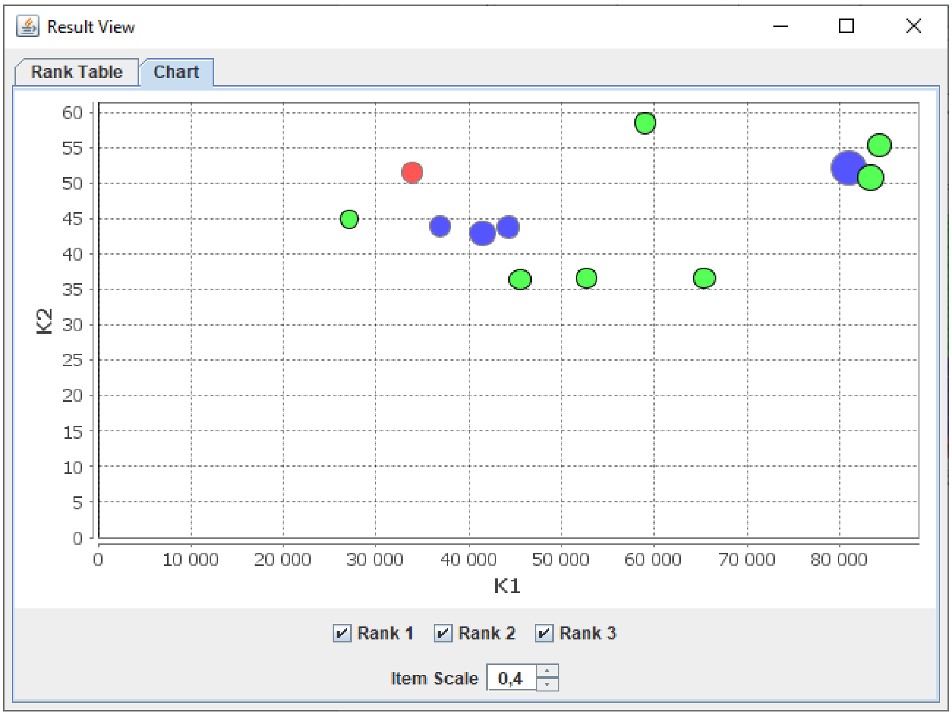

Figure 3. Decision in the projection of the economy in 2019. First rank - green, second rank - blue, third rank - red

Table 2. Decision in the projection of the economy, 2019.

No.	Regions	Rank	K1 - average per capita income of the population, rubles / month	K2 - the degree of depreciation of fixed assets, %	K3 - the share of unprofitable organizations
1	The Yamalo-Nenets Autonomous District	1	84273	55,3	39,3
2	The Republic of Sakha (Yakutia)	1	45528	36,4	35,4
3	The Krasnoyarsk Region	1	27053	44,9	29,9
4	The Chukotka Autonomous District	1	83385	50,7	43,4
5	The Kamchatka Region	1	52674	36,6	34,5
6	The Magadan Region	1	65367	36,6	36,2
7	The Sakhalin Region	1	59016	58,5	35,7
8	The Nenets Autonomous District	2	81041	52,1	59,6
9	The Khabarovsk Region	2	41460	42,9	43,3
10	The Primorsky Region	2	36884	43,9	35,4
11	The Murmansk Region	2	44261	43,8	37,7
12	The Arhangelsk Region	3	33907	51,5	35,8

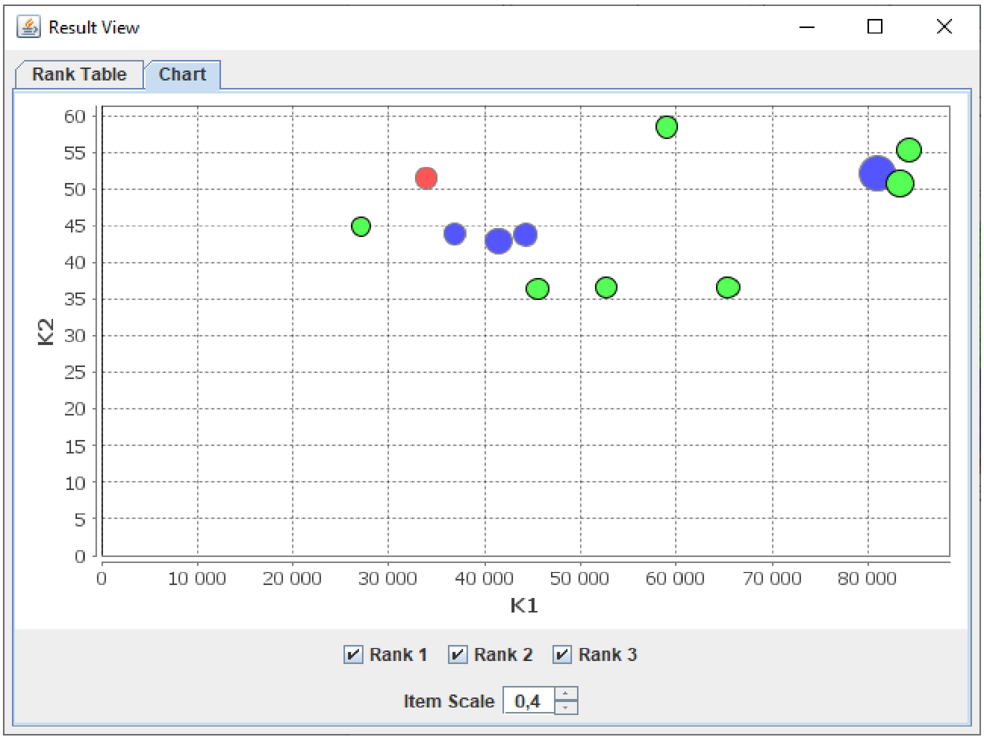

Figure 4. Decision in the projection of the economy in 2020. First rank - green, second rank - blue, third rank - red

Table 3. Decision in the projection of the economy, 2020.

No.	Regions	Rank	K1 - average per capita income of the population, rubles / month	K2 - the degree of depreciation of fixed assets, %	K3 - the share of unprofitable organizations
1	The Yamalo-Nenets Autonomous District	1	90130	57,3	40,2
2	The Republic of Sakha (Yakutia)	1	46344	36,9	36,2
3	The Krasnoyarsk Region	1	31755	46,7	29,8
4	The Chukotka Autonomous District	1	89548	48,9	34,1
5	The Magadan Region	1	70982	40	35,8
6	The Arhangelsk Region	1	34857	53,8	32,7
7	The Kamchatka Region	1	55381	40,6	35
8	The Nenets Autonomous District	2	84171	55,6	48,4
9	The Murmansk Region	2	46621	42,7	39,9
10	The Primorsky Region	2	37349	44,5	38,2
11	The Sakhalin Region	2	60797	63,2	41,7
12	The Khabarovsk Region	3	41751	42,8	45,2

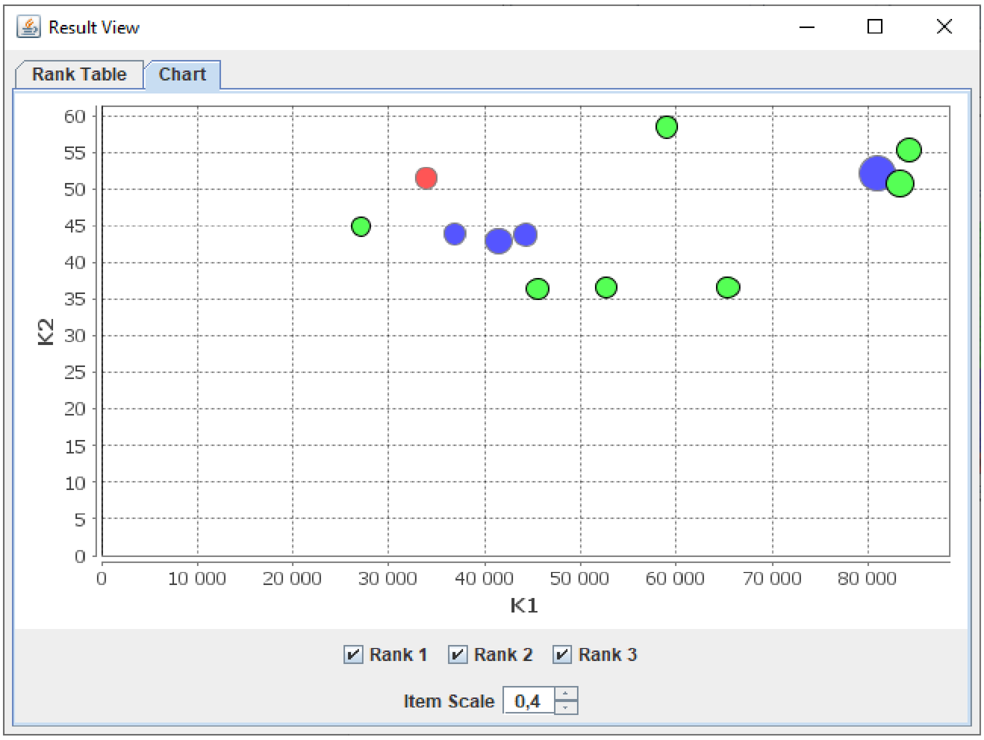

Figure 5. Decision in the projection of the economy in 2021. First rank - green, second rank - blue, third rank - red

Table 4. Decision in the projection of the economy, 2021.

No.	Regions	Rank	K1 - average per capita income of the population, rubles / month	K2 - the degree of depreciation of fixed assets, %	K3 - the share of unprofitable organizations
1	The Chukotka Autonomous District	1	99905	48,5	34,8
2	The Republic of Sakha (Yakutia)	1	50369	38,5	32,6
3	The Magadan Region	1	80979	40,5	27,6
4	The Yamalo-Nenets Autonomous District	1	96814	60	34,4
5	The Kamchatka Region	1	60794	39,7	31,8
6	The Nenets Autonomous District	2	86431	57,5	47,5
7	The Murmansk Region	2	51183	39,8	32,8
8	The Arhangelsk Region	2	37810	54,4	27,7
9	The Sakhalin Region	2	63854	65,3	39,4
10	The Krasnoyarsk Region	2	32872	46,4	28,3
11	The Khabarovsk Region	3	44108	42,1	40,1
12	The Primorsky Region	3	40843	40,8	35,2

Figures 6-8 show the results of multicriteria optimization in the projection of the social sphere in dynamics by years for 2019-2021. The corresponding data containing distribution of the regions by ranks is given in Tables 5-7.

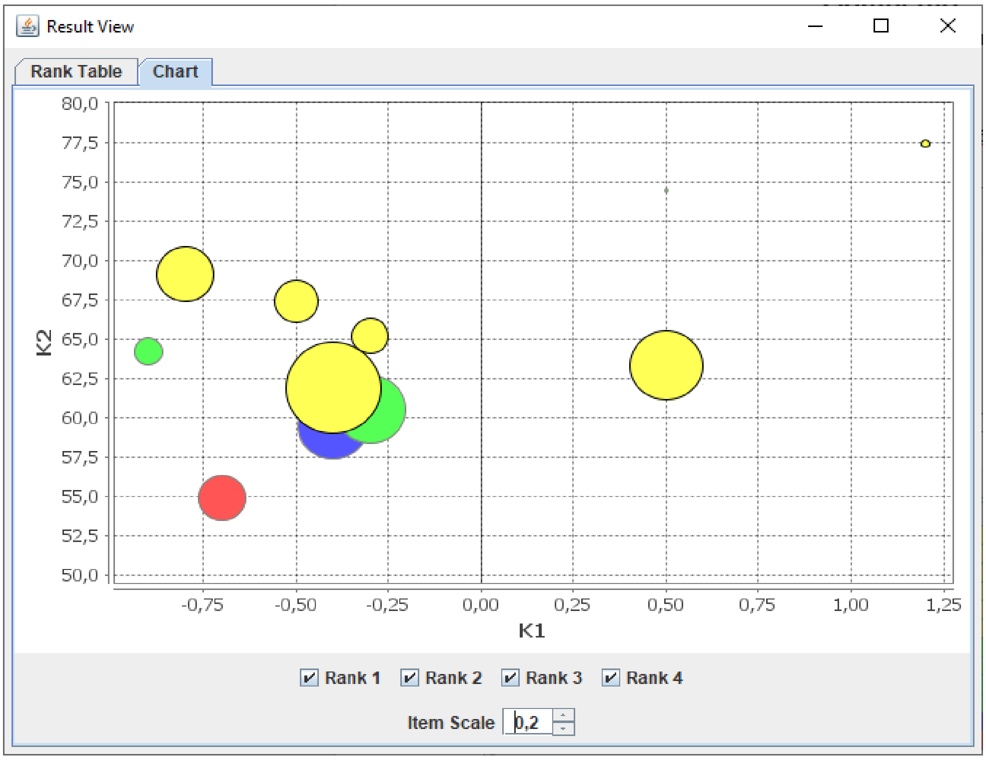

Figure 6. Decision in the projection of the social sphere in 2019. First rank - yellow, second rank - green, third rank - blue, fourth rank - red

Table 5. Decision in the projection of the social sphere, 2019

No.	Regions	Rank	K1 - change in the population per year; %	K2 - the level of employment of the population, %	K3 - the number of students per 10,000 people
1	The Chukotka Autonomous District	1	1,2	77,4	27
2	The Khabarovsk Region	1	-0,4	61,9	324
3	The Republic of Sakha (Yakutia)	1	0,5	63,3	245
4	The Magadan Region	1	-0,8	69,1	194
5	The Sakhalin Region	1	-0,3	65,2	123
6	The Kamchatka Region	1	-0,5	67,4	147
7	The Nenets Autonomous District	2	0,6	62,1	0
8	The Yamalo-Nenets Autonomous District	2	0,5	74,4	10
9	The Krasnoyarsk Region	2	-0,3	60,5	240
10	The Murmansk Region	2	-0,9	64,2	94
11	The Primorsky Region	3	-0,4	59,5	238
12	The Arhangelsk Region	4	-0,7	54,9	162

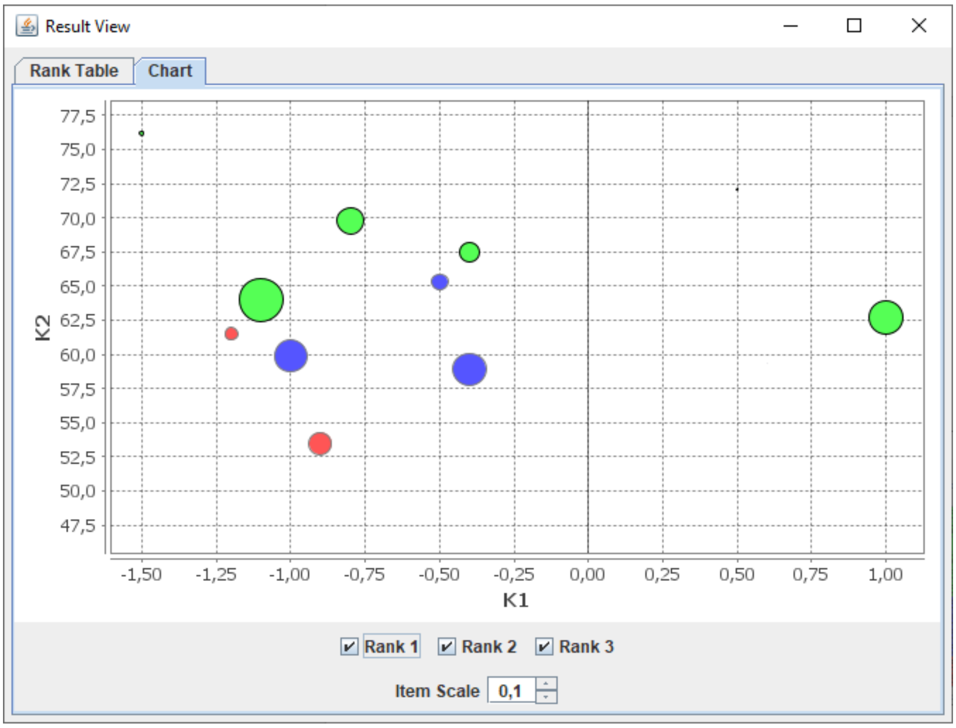

Figure 7. Decision in the projection of the social sphere in 2020. First rank - green, second rank - blue, third rank - red

Table 6. Decision in the projection of the social sphere, 2020

No.	Regions	Rank	K1 - change in the population per year; %	K2 - the level of employment of the population, %	K3 - the number of students per 10,000 people
1	The Republic of Sakha (Yakutia)	1	1	62,7	242
2	The Chukotka Autonomous District	1	-1,5	76,2	28
3	The Khabarovsk Region	1	-1,1	64	312
4	The Yamalo-Nenets Autonomous District	1	0,5	72,1	7
5	The Magadan Region	1	-0,8	69,8	185
6	The Kamchatka Region	1	-0,4	67,5	141
7	The Nenets Autonomous District	2	0,5	59,4	0
8	The Sakhalin Region	2	-0,5	65,3	113
9	The Krasnoyarsk Region	2	-0,4	58,9	233
10	The Primorsky Region	2	-1	59,9	239
11	The Arhangelsk Region	3	-0,9	53,5	160
12	The Murmansk Region	3	-1,2	61,5	90

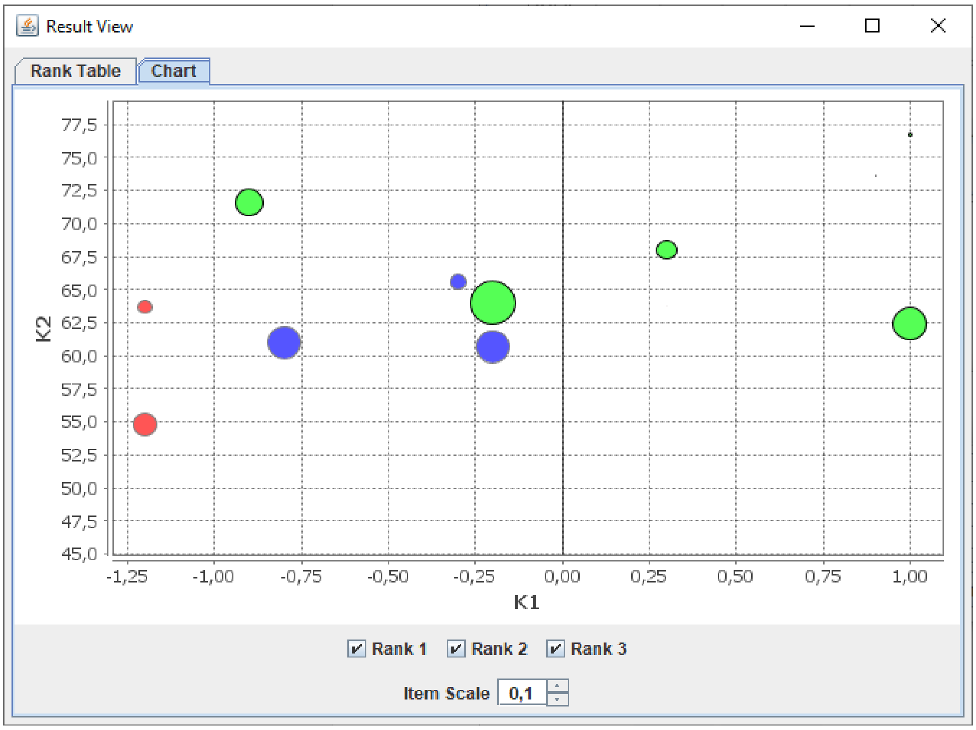

Figure 8. Decision in the projection of the social sphere in 2021. First rank - green, second rank - blue, third rank - red

Table 7. Decision in the projection of the social sphere, 2021

No.	Regions	Rank	K1 - change in the population per year; %	K2 - the level of employment of the population, %	K3 - the number of students per 10,000 people
1	The Republic of Sakha (Yakutia)	1	1	62,4	229
2	The Chukotka Autonomous District	1	1	76,7	19
3	The Khabarovsk Region	1	-0,2	64	306
4	The Kamchatka Region	1	0,3	68	131
5	The Magadan Region	1	-0,9	71,6	188
6	The Yamalo-Nenets Autonomous District	2	0,9	73,6	4
7	The Krasnoyarsk Region	2	-0,2	60,7	228
8	The Sakhalin Region	2	-0,3	65,6	105
9	The Primorsky Region	2	-0,8	61	226
10	The Nenets Autonomous District	3	0,3	63,8	0
11	The Arhangelsk Region	3	-1,2	54,8	161
12	The Murmansk Region	3	-1,2	63,7	92

Figures 9-11 show the results of multicriteria optimization in the projection of the ecology in dynamics by years for 2019-2021. The corresponding data containing distribution of the regions by ranks is given in Tables 8-10.

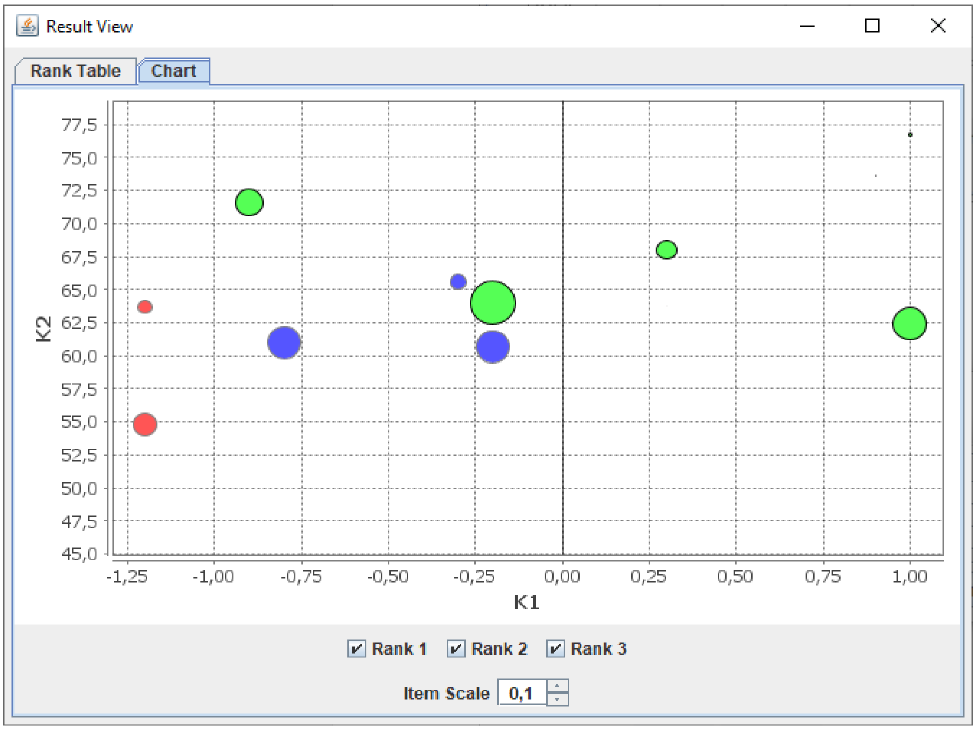

Figure 9. Decision in the projection of the ecology in 2019. First rank - green, second rank - blue, third rank - red

Table 8. Decision in the projection of the ecology, 2019

No.	Regions	Rank	K1 - the share of captured and neutralized pollutants; %	K2 - environmental expenditures, % of the previous year	K3 - discharge of polluted wastewater, million cubic meters
1	The Primorsky Region	1	91,5	129	259
2	The Sakhalin Region	1	34,9	180,1	25
3	The Nenets Autonomous District	1	65,1	68,4	0,1
4	The Murmansk Region	1	83,6	130,7	266
5	The Magadan Region	1	43,2	163,5	4,9
6	The Chukotka Autonomous District	1	56,6	160,2	3
7	The Khabarovsk Region	1	80,1	110,8	182
8	The Arhangelsk Region	2	73,5	95,7	323
9	The Kamchatka Region	2	15,7	111,8	26
10	The Krasnoyarsk Region	2	68,3	107,3	318
11	The Republic of Sakha (Yakutia)	2	56,4	94,8	83
12	The Yamalo-Nenets Autonomous District	3	0	109,2	29

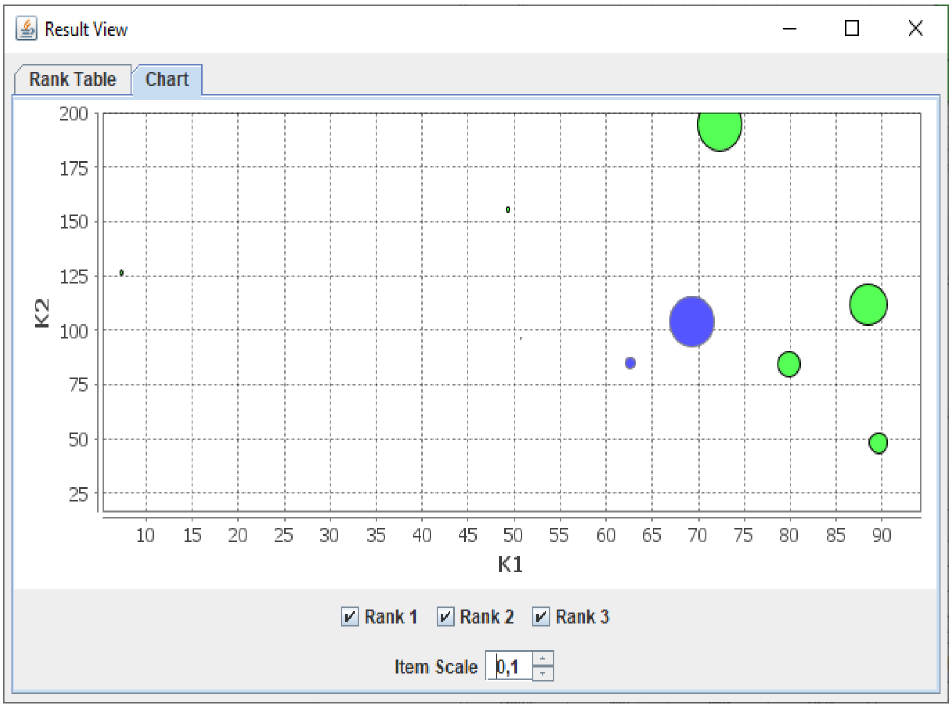

Figure 10. Decision in the projection of the ecology in 2020. First rank - green, second rank - blue, third rank - red

Table 9. Decision in the projection of the ecology, 2020

No.	Regions	Rank	K1 - the share of captured and neutralized pollutants; %	K2 - environmental expenditures, % of the previous year	K3 - discharge of polluted wastewater, million cubic meters
1	The Murmansk Region	1	89,6	48,1	127
2	The Arhangelsk Region	1	72,3	194,5	321
3	The Nenets Autonomous District	1	64,3	100,4	0,1
4	The Primorsky Region	1	88,5	111,8	261
5	The Sakhalin Region	1	49,3	155,5	26
6	The Kamchatka Region	1	7,3	126,5	25
7	The Khabarovsk Region	1	79,9	84,5	158
8	The Krasnoyarsk Region	2	69,3	104,1	322
9	The Chukotka Autonomous District	2	55	83	2,9
10	The Republic of Sakha (Yakutia)	2	62,6	84,9	74
11	The Magadan Region	2	50,7	95,3	4,5
12	The Yamalo-Nenets Autonomous District	3	0	77,5	29

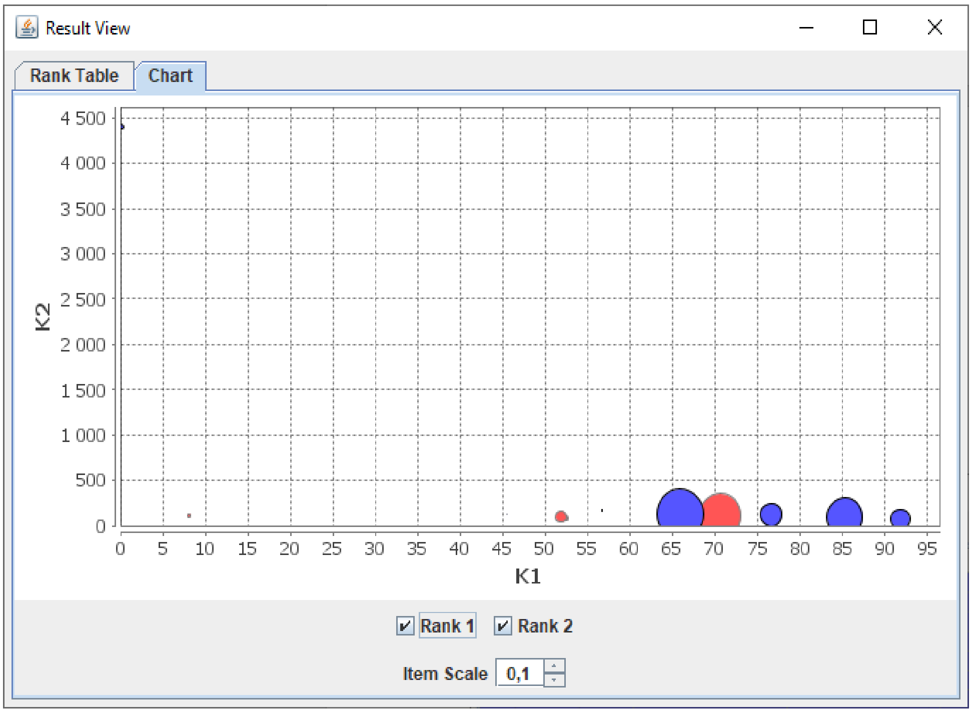

Figure 11. Decision in the projection of the ecology in 2021. First rank - blue, second rank - red

Table 9. Decision in the projection of the ecology, 2020

No.	Regions	Rank	K1 - the share of captured and neutralized pollutants; %	K2 - environmental expenditures, % of the previous year	K3 - discharge of polluted wastewater, million cubic meters
1	The Murmansk Region	1	91,8	71	131
2	The Yamalo-Nenets Autonomous District	1	0,1	4400	29
3	The Nenets Autonomous District	1	64,2	93,9	0
4	The Primorsky Region	1	85,3	94,7	251
5	The Magadan Region	1	56,7	165,5	4,3
6	The Chukotka Autonomous District	1	45,5	120,6	2,9
7	The Khabarovsk Region	1	76,6	115,9	152
8	The Krasnoyarsk Region	1	65,9	128,3	324
9	The Arhangelsk Region	2	70,6	104,1	293
10	The Kamchatka Region	2	8,1	110,1	25
11	The Sakhalin Region	2	52,5	79,4	27
12	The Republic of Sakha (Yakutia)	2	51,9	97,1	75

Analyzing the figures and tables, the following patterns can be noted. In the projection of the economy, Pareto sets included the following subjects. In 2019: the Yamalo-Nenets Autonomous District, the Republic of Sakha (Yakutia), the Krasnoyarsk Region, the Chukotka Autonomous District, the Kamchatka Region, the Magadan Region and the Sakhalin Region.

In 2020: the Yamalo-Nenets Autonomous District, the Republic of Sakha (Yakutia), the Krasnoyarsk Region, the Chukotka Autonomous District, the Magadan Region, the Arkhangelsk Region and the Kamchatka Region. In 2021: the Yamalo-Nenets Autonomous District, the Republic of Sakha (Yakutia), the Chukotka Autonomous District, the Kamchatka Region and the Magadan Region. In total, over three years, the sustainable leadership is demonstrated by: the Yamalo-Nenets Autonomous District, the Republic of Sakha (Yakutia), the Chukotka Autonomous District, the Kamchatka Region and the Magadan Region.

In the projection of the social sphere, the effective sets included the following subjects. In 2019: the Chukotka Autonomous District, the Khabarovsk Region, the Republic of Sakha (Yakutia), the Magadan Region, the Sakhalin Region and the Kamchatka Region. In 2020: the Chukotka Autonomous District, the Khabarovsk Region, the Republic of Sakha (Yakutia), the Yamalo-Nenets Autonomous District, the Magadan Region and the Kamchatka Region. In 2021: the Republic of Sakha (Yakutia), the Chukotka Autonomous District, the Khabarovsk Region, the Magadan Region and the Kamchatka Region. In total, for three years, the stable leadership has: the Republic of Sakha (Yakutia), the Chukotka Autonomous District, the Khabarovsk Region, the Magadan Region and the Kamchatka Region.

In the projection of ecology, the following subjects made up Pareto sets. In 2019: the Primorsky Region, the Sakhalin Region, the Nenets Autonomous District, the Murmansk Region, the Magadan Region, the Chukotka Autonomous District and the Khabarovsk Region. In 2020: the Murmansk Region, the Arkhangelsk Region, the Nenets Autonomous District, the Primorsky Region, the Sakhalin Region, the Kamchatka Region and the Khabarovsk Region. In 2021: the Murmansk Region, the Yamalo-Nenets Autonomous District, the Nenets Autonomous District, the Primorsky Region, the Magadan Region, the Chukotka Autonomous District, the Khabarovsk Region and the Krasnoyarsk Region. In total, for three years, the stable leadership is demonstrated by: the Primorsky Region, the Nenets Autonomous District, the Murmansk Region and the Khabarovsk Region.

Three-projection effective solutions were obtained for each year. In 2019, the Chukotka Autonomous District, the Magadan Region and the Sakhalin Region demonstrated the greatest efficiency; in 2020 – the Kamchatka Region; in 2021 – the Chukotka Autonomous District and the Magadan Region. There is a more concentrated lead here, but it varies from year to year.

The results presented in the paper indicate Northern Sea Route regions significant differentiation in terms of sustainable development indicators set. The ratings obtained can be used in analytical materials preparation for scientifically based management decisions adoption ensuring economy, ecology and social sphere effective and safe development, Northern Sea Route regions.

Thus, the multi-projection selection method provides Northern Sea Route regions sustainable development comprehensive analysis possibility. Previous studies on Northern Sea Route regions are predominantly qualitative (Nikulin, 2019; Gribanova, Magdalyuk, 2022; Ushakova, 2021; Veselova, 2022; Kolzina, Mindubaeva, 2020; Sazonov, 2021; Denisov, Svetlova, 2021). The quantitative methods used by a number of authors (Khorev, 2020; Mazurchuk, 2023; Bychkova, 2022; Karpovich, Shlafman, 2020, etc.) evaluate research objects individual characteristics and do not allow them to be ranked by the socio-economic development level according to indicators set using strict mathematical procedures. Multi-criteria approach usage is justified by the fact that objects' according to individual criteria does not provide an exhaustive idea of phenomena specifics and processes under study. This is the novelty of the presented study and its difference from the previous ones.

CONCLUSION

As a result of the study, the use of the method of the multiprojection analysis in determining the degree of sustainability of the socio-economic development of the regions of the Northern Sea Route is substantiated. The authors proposed the method of multicriteria ranking of the regions adapted to regional specifics, which includes seven stages. In the course of the study, the software package for the multicriteria benchmarking analysis of economic systems developed by the authors was used, which includes software and graphical implementation of algorithms for finding the effective set and ranking solutions for n criteria of optimization.

The system of indicators included three indicators of official statistics in three areas of the research. The projection of the economy included the following indicators: average per capita income of the population; the degree of depreciation of fixed assets; the share of unprofitable organizations. In the projection of the social sphere: population change; the level of employment of the population; the number of university students normalized to the population. In the projection of ecology: the share of captured and neutralized air pollutants; the index of physical volume of environmental expenditures; discharge of polluted wastewater into surface water bodies. The choice of the indicators is carried out according to the principle of their availability and comparability in carrying out quantitative calculations.

As a result of testing the declared methodology according to the official statistics in 2019-2021 in the regions of the Northern Sea Route, it was found that the sustainable leadership in the projection of the economy belongs to the Yamalo-Nenets Autonomous District, the Republic of Sakha (Yakutia), the Chukotka Autonomous District, the Kamchatka Region and the Magadan Region. In the projection of the social sphere the sustainable leadership had: the Republic of Sakha (Yakutia), the Chukotka Autonomous District, the Khabarovsk Region, the Magadan Region and Kamchatka Region. In the projection of the ecology the leading regions were the Primorsky Region, the Nenets Autonomous District, the Murmansk Region and the Khabarovsk Region.

The results obtained can be used by public authorities competent in the field of managerial decision-making on development and implementation of investment projects focused on the development of the infrastructure of the regions of the Northern Sea Route, which is a promising direction for development of the logistics infrastructure in the Arctic region and can significantly save on the distance of shipping.

At the same time, the tools presented by the authors cannot be used in making operational management decisions due to the presence of time lags in statistical data. Another limitation is some subjectivity in indicators system formation.

Further investigation may be related to objects' analysis structural dynamics and its balance degree. In addition, the methodology proposed in the paper can be updated in accordance with new economic realities. Also in the future, it is possible to include forecasting methods. With minor modifications, the scientific and methodological apparatus presented in the study can be used for socio-economic systems of a wide range.

REFERENCES

Antrushina, D.R. (2022). Northern Sea Route: Opportunities and Prospects. Economics: Yesterday, Today and Tomorrow, 12(1-1), 17-26. https://doi.org/10.34670/AR.2022.56.16.002

Batkovsky, A.M. (ed.). (2021). Managing the diversification of production at the enterprises of the military-industrial complex: monograph. Moscow: OntoPrint.

Borduchenko, Yu. L., Malygin, I. G., Kaminsky, V. Yu., Aksenov, V. A. (2021). Nuclear icebreaker fleet of Russia in the first quarter of the 21st century. Tasks and prospects for the development of the Northern Sea Route. Marine Intelligent Technologies, 2-1(52), 14-25. https://doi.org/10.37220/MIT.2021.52.2.001

Bychkova, V. A. (2022). Prospects for the integrated development of the Far East region associated with the implementation of projects of the Northern Sea Route. Economics and Entrepreneurship, 10(147), 477-482. https://doi.org/10.34925/EIP.2022.147.10.090

Černevičienė, J., and Kabašinskas, A. (2022). Review of Multi-Criteria Decision-Making Methods in Finance Using Explainable Artificial Intelligence. Frontiers in Artificial Intelligence, 5. https://doi.org/10.3389/frai.2022.827584

Chowdhury, P., & Paul, S. K. (2020, March 13). Applications of MCDM methods in research on corporate sustainability: A systematic literature review. Management of Environmental Quality: An International Journal, 31-2, 385–405. https://doi.org/10.1108/MEQ-12-2019-0284.

Denisov, V.V., Svetlova, M.V. (2021). Assessment of the territorial development of the subjects of Russia on the western section of the Northern Sea Route. Bulletin of the Voronezh State University. Series: Geography. Geoecology, 1, 37-44. https://doi.org/10.17308/geo.2021.1/3254

Doukas, H., Nikas, A. (2019). Decision Support Models in Climate Policy. European Journal of Operational Research, 280-1, 1–24. https://doi.org/10.1016/j. ejor.2019.01.017

Doumpos, M., Grigoroudis, E. (2013). Multicriteria decision aid and artificial intelligence : links, theory and applications. Wiley-Blackwell.

Faikov, D.Yu., Faikova, E.D. (2021). Features of socio-economic development of territories in the zone of the Northern Sea Route in the logic of ongoing investment and infrastructure projects. Economics, Entrepreneurship and Law, 11(4), 875-894. https://doi.org/10.18334/epp.11.4.111916

Govindan, K., & Jepsen, M. B. (2016, April 1). ELECTRE: A comprehensive literature review on methodologies and applications. European Journal of Operational Research, 250, 11-29. https://doi.org/10.1016/j.ejor.2015.07.019

Gribanova, G.I., Magdalyuk, A.V. (2022). Japan's Arctic Strategy and Russia's National Interests. Eurasian Integration: Economics, Law, Politics, 16-2, 148-157. https://doi.org/10.22394/2073-2929-2022-02-148-157

Kabašinskas, A., Maggioni, F., Šutienė, K., & Valakevičius, E. (2019). A multistage risk-averse stochastic programming model for personal savings accrual: the evidence from Lithuania. Annals of Operations Research, 279(1–2), 43–70. https://doi.org/10.1007/s10479-018-3100-z

Karpovich, O.G., Shlafman, A.I. (2020). The place and role of the Northern Sea Route in the formation and development of international economic relations in the context of expanding the economic potential of the regions. Russian Journal of Management, 8-1, 21-25. https://doi.org/10.29039/2409-6024-2020-8-1-21-25

Khan, S. A., Chaabane, A., Dweiri, F. T. (2018). MultiCriteria Decision-Making Methods Application in Supply Chain Management: A Systematic Literature Review. InTechOpen. https://doi.org/10.5772/intechopen.74067.

Khorev, A.M. (2020). The Northern Sea Route: Necessity and Prospects for the Transit of Natural Resources. Interactive Science, 7(53), 92-97.

Kolzina, A.L., Mindubaeva, A.A. (2020). The Polar Silk Road as a sphere of strategic partnership between the Russian Federation and the People's Republic of China. Bulletin of the Udmurt University. Sociology. Political science. International relationships, 4-2, 186-195. https://doi.org/10.35634/2587-9030-2020-4-2-186-195.

Lapaev, D.N. (2010). Multicriteria decision making in economics. Nizhny Novgorod: Volzh. state eng.-ped. un-t.

Lapaev, D.N., Mityakov, E.S., Kornev, E.A. (2014). Program complex for multi-criteria comparative analysis of economic systems. Economics, statistics and informatics. Vestnik UMO, 6(2), 466-469.

Lapaeva, O.N. (2015). Multi-criteria assessment of the economic state of enterprises and industries and the choice of preferred alternatives: monograph. Nizhny Novgorod: Nizhny Novgorod. state tech. university n.a. R.E. Alekseev.

Lapaeva, O.N. (2017). Multiprojective comparative assessment of alternatives in the economy: monograph. Nizhny Novgorod: Nizhny Novgorod. state tech. university n.a. R.E. Alekseev.

Lapaeva, O.N. (2018). Multiprojective assessment of the state of industrial economic systems: monograph. Nizhny Novgorod: Nizhny Novgorod. state tech. university n.a. R.E. Alekseev.

Macharis, C., Bernardini, A. (2015). Reviewing the use of Multi-Criteria Decision Analysis for the evaluation of transport projects: Time for a multi-actor approach. Transport Policy, 37-1, 177–186. https://doi.org/10.1016/j. tranpol.2014.11.002

Marqués, A. I., García, V., & Sánchez, J. S. (2020, September 1). Ranking-based MCDM models in financial management applications: analysis and emerging challenges. Progress in Artificial Intelligence, 171–193. https://doi.org/10.1007/s13748-020-00207-1

Mazurchuk, T. M. (2023). Economic prospects for the development of coking coal in the Arctic regions of Russia. Economic systems, 16(1), 130-137. https://doi.org/10.29030/2309-2076-2023-16-1-130-137

Myaskov, A.V., Petrov, I.V., Zaytsev, V.S., Shmelev, V.S. (2018). Systemic features of environmental monitoring in the formation of territorial projects of the northern sea route. Monitoring. Science and technology, 5, 7-14. https://doi.org/10.25714/MNT.2018.38.001

Nikulin, M.A. (2019). Great-power competition in the Arctic: geopolitical rivalry in the new political space, In: Bulletin of the Peoples' Friendship University of Russia. Series: International relations, 19-3, 392-403. https://doi.org/10.22363/2313-0660-2019-19-3-392-403

Pareto, V. (2017). Transformation of democracy: [trans. from Italian]. Moscow: INFRA-M.

Perova, J. P., Grigoriev, V. P., & Zhukov, D. O. (2023). Models and methods for analyzing complex networks and social network structures. Russian Technological Journal, 11(2), 33–49. https://doi.org/10.32362/2500-316x-2023-11-2-33-49

Saaty, T. L., Vargas, L. G., & Dellmann, K. (2003). The allocation of intangible resources: The analytic hierarchy process and linear programming. Socio-Economic Planning Sciences, 37(3), 169–184. https://doi.org/10.1016/S0038-0121(02)00039-3

Sazonov, S.L. (2021). On some aspects of the Arctic transit - a view from China. East Asia: Facts and Analytics, 4, 36-45. https://doi.org/10.24412/2686-7702-2021-4-36-45

Stojčić, M., Zavadskas, E. K., Pamučar, D., Stević, Ž., & Mardani, A. (2019, March 1). Application of MCDM methods in sustainability engineering: A literature review 2008-2018. Symmetry, 11(3). https://doi.org/10.3390/sym11030350

Ushakova E.G. (2021). Arctic Frontier: Ice Silk Road and Its Role in China's Advance to the Arctic. Arctic and North, (43), 128–143. https://doi.org/10.37482/issn2221-2698.2021.43.128

Valentinova, P. S., & Vorotnikov, A. M. (2021). Problems and prospects of the "green" development of the Northern Sea Route. Arktika 2035: topical issues, problems, solutions, 1(5), 4–10. https://doi.org/10.51823/74670_2021_1_4

Valipour, A., Sarvari, H., & Tamošaitiene, J. (2018). Risk assessment in ppp projects by applying different mcdm methods and comparative results analysis. Administrative Sciences, 8(4). https://doi.org/10.3390/admsci8040080

Veselova, D. N. (2022). Main Directions of Cooperation between the Russian Federation and the People's Republic of China in the Arctic. Administrative Consulting, (12), 42–61. https://doi.org/10.22394/1726-1139-2022-12-42-61

Wang, J. J., Jing, Y. Y., Zhang, C. F., & Zhao, J. H. (2009, December). Review on multi-criteria decision analysis aid in sustainable energy decision-making. Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2009.06.021

Wątróbski, J., Jankowski, J., Ziemba, P., Karczmarczyk, A., & Zioło, M. (2019). Generalised framework for multi-criteria method selection. Omega (United Kingdom), 86, 107–124. https://doi.org/10.1016/j.omega.2018.07.004

Zavadskas, E. K., & Turskis, Z. (2011). Multiple criteria decision making (MCDM) methods in economics: An overview. Technological and Economic Development of Economy, 17(2), 397–427. https://doi.org/10.3846/20294913.2011.593291 .

Zavadskas, E. K., Antucheviciene, J., & Chatterjee, P. (2018, December 23). Multiple-criteria decision-making (MCDM) techniques for business processes information management. Information (Switzerland). MDPI AG. https://doi.org/10.3390/info10010004

Zhuleva, O.I., Kuzmenkova, V.N. (2020). Substantiation of the strategic importance of the Northern Sea Route by analyzing the logistic and geopolitical aspects of its prospective functioning. Bulletin of the Altai Academy of Economics and Law, 5-2, 295-299. https://doi.org/10.17513/vaael.1142