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Promoting Sustainable Development through Innovative Approaches and Regional Management Strategies

In today's changing economic landscape and market conditions, the development of socio-economic systems in states and regions has become a priority. Modern conditions call for sustainable approaches to managing and developing various aspects of the economy. In Russia, studies of the factors influencing its socio-economic development require individualised approaches to risk management and accounting, considering the unique characteristics of each region in the country.

In the first issue of the journal Sustainable Development and Engineering Economics for 2024, the authors examined various aspects of sustainable development and management models in different sectors.

The first section, 'Economics of Engineering and Innovation Decisions as a Part of Sustainable Development, presents the article entitled 'Risk Assessment Model for Innovative Projects Based on Fuzzy Sets and Bayesian Networks' by Smirnova. The author suggests a model that is based on fuzzy sets and Bayesian networks and that allows for the effective analysis and management of the risks inherent in innovative projects. The study presents an innovative approach to assessing the risks of innovative projects and contributes to more effective risk management and informed decision making in complex projects. This can promote the sustainable development of the innovation sector and increase companies' competitiveness.

The section 'Enterprises and Sustainable Development of Regions' presents the article entitled 'Study of the Factors Relevant to the Management Model for Developing Russia's Regional Socio-Economic Systems' by Karpenko, Viktorova and Tran. The aim of this study is to fill the gap in understanding the factors contributing to the development and outcomes of regional socio-economic systems while considering the need for social security. It develops a model for managing the socio-economic development of Russian regions using the city of St. Petersburg as a case study. The authors conclude that management decisions made at the federal and regional levels have a significant impact on economic actors' activities in the regions and the population's well-being in different ways. Therefore, developing methods and instruments to ensure the socio-economic development of regional systems while considering the specific characteristics of each region is essential.

An independent analysis of the human development index (HDI) is reflected in the article entitled 'Management of Socioeconomic Development: National Planning and Its Impact on the Human Development Index in Russia' by Volodin and Degtyareva. The authors highlight the urgent need for improvements and articulate the range of potential challenges and solutions. They use a statistical analysis of the correlation between the HDI and indicators of project management costs in Russia, as well as conduct a regression evaluation of project implementation indicators.

The third section presents the article entitled 'Peculiarities of Sustainable Development of Transport Infrastructure of Tourism in St. Petersburg Agglomeration' by Tanina and Tanin. The authors use various transportation types in the majority formation of tourist products. The study defines the relationships between tourist flow dynamics and the transportation system development indexes of St. Petersburg and the Leningrad region. It then proposes the development and implementation of a transportation tourist map with advanced features.

The section 'Management of Knowledge and Innovation for Sustainable Development' includes the article entitled 'Capital Flight as a Threat to the Country's Economic Security' by Tatevosyan, Garmysheva and Akhmedov. This study considers the phenomenon of capital flight as a threat to the economic security of the country. It highlights the differences between the concepts of capital outflow and capital flight, assesses the scale of capital flight and outflow, analyses the causes of these phenomena and explicates the goals of capital flight.

Irina Rudskaya, *Editor-in-Chief of SDEE Journal, Doctor of Economics, Professor*

TABLE OF CONTENTS

СОДЕРЖАНИЕ

SECTION 1

ECONOMICS OF ENGINEERING AND INNOVATION DECISIONS AS A PART OF SUSTANABLE DEVELOPMENT

РАЗДЕЛ 1

ЭКОНОМИКА ИНЖЕНЕРНЫХ И ИННОВАЦИОННЫХ РЕШЕНИЙ КАК ЧАСТЬ УСТОЙЧИВОГО РАЗВИТИЯ

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Risk Assessment Model for Innovative Projects Based on Fuzzy Sets and Bayesian Networks

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Abstract

With the rapidly changing economic environment and inherent market conditions, risk assessment is becoming a major priority for companies involved in innovative projects. Innovative projects are characterized by great uncertainty and their success largely depends on a variety of factors. To improve the quality of risk assessment for such projects, it is essential that you use methods that consider the complex relationships between many variables. This paper suggests a model based on fuzzy sets and Bayesian networks that allows you to effectively analyse and manage the risks of innovative projects. Using fuzzy sets can help you take into account the uncertainty in the data and work with fuzzy information, which is of prime importance, as there are a lot of diverse data that must be considered in innovative projects. With Bayesian networks, you can model probabilistic relationships between risks and project factors, which gives you a more accurate idea of potential risks and helps you predict possible scenarios for the project. Our model represents an innovative approach to assessing the risks of innovative projects and contributes to more effective risk management and informed decision-making in the case of complex projects. It can also facilitate sustainable development of the innovation sector and increase the competitiveness of companies due to the more efficient use of resources and a higher probability of successful innovative initiatives in the long run.

Keywords: innovative project, risk in an innovative project, risk assessment of an innovative project, theory of fuzzy sets, Bayesian networks

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Модель Оценки Рисков Инновационных Проектов на Основе Нечетких Множеств и Байесовских Сетей

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Аннотация

В условиях быстро меняющейся экономической среды и взаимосвязанных рыночных условий оценка рисков инновационных проектов становится приоритетной задачей для компаний. Инновационные проекты характеризуются высоким уровнем неопределенности и разнообразием факторов, которые могут повлиять на их успешность. Для повышения качества оценки рисков в таких проектах важно использовать методы, способные учитывать сложные взаимосвязи между различными переменными. В статье представлена модель, основанная на нечетких множествах и байесовских сетях, которая позволяет эффективно анализировать и управлять рисками инновационных проектов. Применение нечетких множеств помогает учесть неопределенность в данных и работать с нечеткой информацией, что особенно важно в условиях большого объема и разнообразия данных в инновационных проектах. Байесовские сети позволяют моделировать вероятностные взаимосвязи между рисками и факторами проекта, что дает более точное представление о потенциальных рисках и позволяет прогнозировать возможные сценарии развития проекта. Предложенная модель представляет инновационный подход к оценке рисков инновационных проектов, способствуя более эффективному управлению рисками и принятию обоснованных решений в контексте сложных проектов. Она также может способствовать устойчивому развитию инновационной сферы и повышению уровня конкурентоспособности компаний, обеспечивая более эффективное использование ресурсов и увеличение вероятности успешной реализации инновационных инициатив в долгосрочной перспективе.

Keywords: инновационный проект, риск в инновационном проекте, оценка рисков инновационного проекта, теория нечетких множеств, байесовские сети

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1. Introduction

With the rapid development of technology and constant changes in the market, innovative projects play a key role in the strategic development of organizations. However, when new ideas and technologies are introduced, there is a lot of uncertainty and risk. Thus, it is important to assess the risks of innovative projects to anticipate potential threats and develop effective risk management strategies.

Assessing the risks of innovative projects helps you prevent possible investment losses, identify potential threats to the successful completion of the project, and improve decision-making based on real information. In this way, you can identify opportunities for growth and development, which makes this process an integral part of strategic management in modern business.

One of the main problems in assessing the risks of innovative projects is uncertainty. New ideas and concepts can incur high risk, since statistics are often unavailable and expert assessments can vary. Thus, the possible outcomes and effects are difficult to predict. In addition, the complexity of innovative projects creates more obstacles to risk assessment. These can include various technical, financial, market and strategic aspects, which make the identification and analysis of potential risks and opportunities more complicated. Due to these problems and the difficulties of risk assessment for innovative projects, there is a need for new approaches and methods of risk assessment that could effectively consider the high uncertainty and complexity of such projects.

The sustainable development of innovation is an important aspect of today's economy, so innovative projects call for effective risk management. Having a well-developed methodological and instrumental basis for risk management contributes to a more informed management of innovative projects, which opens the way for achieving sustainable development in the innovation sector. Focusing on risk assessment and using a model based on fuzzy sets and Bayesian networks allow companies to make informed decisions and develop management strategies that increase the sustainability and success of innovative projects.

Fuzzy sets and Bayesian networks are good to use, as they take into account complex and fuzzy relationships and patterns that are often a feature of innovative projects. Thus, you can manage risks more effectively, make informed decisions and increase the chances of success for such projects.

This paper is aimed at developing and studying a risk assessment model for innovative projects based on fuzzy sets and Bayesian networks. The main objective is to build a model that can take into account various types of risks and provide a more accurate and comprehensive assessment of the possible negative effects experienced by innovative projects. To build the model, we applied a methodology for forming fuzzy sets based on expert assessments and data analysis. It includes the definition of probabilities for each risk and its factors in the form of fuzzy terms, given uncertainty and various probabilities.

To model the relationships between risks and factors, we used a Bayesian network-based technique, which considers possible scenarios and the probability of risks under various conditions.

2. Literature review

There are a number of approaches to determining innovation risk, varying from the probability of loss caused by an incorrect strategy to a probabilistic assessment of whether an innovative project can be accomplished successfully.

Researchers such as Valdaytsev (2001), Tapman (2002) and Glukhov, Korobko and Marinina (2003) emphasize the need to cover all stages of the project lifecycle for effective risk assessment, as uncertainty and risks can arise at any stage of the project. Akulov (2012) argues that the individuality of each project requires that uncertainty and risk factors be considered at all stages.

The world literature highlights the difficulty of developing a detailed classification of the risks of innovative projects since this task is subjective. Risk assessment is one of the targets of risk management

in innovative projects. Various methods can be used for making such an assessment, including statistical, expert and analytical approaches as well as the analogy method.

The statistical method involves analysing the statistics of the losses incurred in the project and determining the frequency of the occurrence of various levels of losses. However, this approach has its constraints, as, in many cases, statistics are unavailable due to the novelty of projects. Expert methods based on the consideration of specialists' opinions can be used, but this requires checking the competence of the experts and the consistency of their assessments (Ashinova, Chinazova, Kadakoeva and Gisheva, 2020).

Among the analytical methods, sensitivity analysis is worth highlighting. It is aimed at determining the impact of changes in individual variables on the efficiency of the project. However, this method has its own limitations, such as the ability to change only one factor in isolation from the rest.

Risk assessment can be carried out for innovation and investment projects in various ways, which are selected depending on the time frame, information available, software and the current stage of the project. For example, Delphi and expert assessment methods best suit projects at the research development stage (Babordina, Garanina, Garanin and Chirkunova, 2021; Jin, Liu, Long, 2021). Modelling, scenario and decision tree methods can be used, for example, for projects aimed at having a competitive advantage on the market (Lytvynenko and Naumov, 2021; Pupentsova and Livintsova, 2018). By classifying and distributing risks into groups, it is possible to identify possible risk scenarios and develop risk management strategies.

Choosing the risk analysis method depends on the objectives and aims of the enterprise. Various factors, such as the importance of the project, the information available, the expertise of the participants, the depth of the analysis and access to necessary tools, have a bearing on which approach to choose for the analysis. There is no universal method, and it cannot be argued that qualitative or quantitative methods are preferable to others. It is often advisable to combine different methods and apply an integrated approach so that the best results can be achieved in risk analysis (Vyatkin, Gamza and Maevsky, 2018).

At the moment, there are disadvantages in the attempts to create effective models describing the risk of innovative projects since expert methods for assessing these risks are far from being perfect. Another issue is that there is no single universal method, while a variety of methods can often be applied only at the initial stage to choose the project. At the same time, when some parameters are being determined, such as manageability and attainability, the initial data are mostly approximate and can be obtained either by estimating plans without taking into account the dynamics of the transition process or by using an expert opinion.

Analytical assessment methods allow you to estimate the value of the unknown parameters using the available data and system characteristics based on theorems, models and algorithms. The common problem in this case is caused by the fact that the task must clearly coincide with the model (a certain set of known functions and parameters). Only then do the methods become applicable and give you an accurate answer. Given that in the case of innovative projects, you work in a situation of uncertainty, such methods are mostly unsuitable for assessments. If the task is about examining random variables, a probabilistic approach should be used because now deterministic models are not applicable (since they cannot be built for this kind of task).

The probabilistic approach is characterized by distributions of random variables, their averages, values of variance and standard deviation, which can be found using statistical methods. However, in most cases, these methods are elaborated only for one-dimensional quantities. If you want to consider the relationship between several factors, you need to build a multidimensional statistical model, which may require either too much time or computational resources. Moreover, such models frequently assume a Gaussian distribution or are not justified by theory. Anyway, with the probabilistic approach, some probabilistic model of the task must be known initially. Quite often, multidimensional statistics, lacking a theoretical basis, entail the use of poorly substantiated heuristic methods.

This problem can be resolved by applying complex expert analytical assessment methods using mathematical methods of fuzzy sets and Bayesian networks.

3. Materials and methods

Assessing risks of innovative projects is a difficult task due to the lack of statistical information about a new idea, technology or product that is being developed. Drawing analogies with similar projects is also complicated. Therefore, the risks of innovative projects can be determined using a combination of expert and quantitative methods, since participants in the innovation process are forced to rely on their subjective assessments and feelings rather than on solid data and calculations based on past experience (Samokhvalov, 2021).

An important step in assessing the risk of an innovative project is to conduct a qualitative risk analysis. The purpose of this analysis is to identify the main risk factors of a particular project and assess their probability and potential damage. According to Gracheva and Sekerin, a qualitative risk analysis is most commonly presented as a table that includes the name of the risk, risk factors, effects, possible damage, prevention measures and their estimated cost (Gracheva, 2009). However, when assessing the risk of a project, calculating prevention measures is important but not mandatory for risk assessment. In this regard, only the first three columns must be filled in to assess the risk.

An expert performing a modified qualitative analysis of an innovative project must first identify the main types of risks specific to the project. This procedure requires a thorough analysis of all information materials, including the business plan, financial model and marketing research. Only after experts have fully understood the essence of the project will they be able to identify all the risk factors specific to this innovation (Boris, Parakhina, 2020).

Determining the risks specifically for an innovative project, as opposed to applying a general risk classification, is usually a more appropriate approach. Innovative projects often have unique features that can entail specific risks that differ from general risk categories. These unique features may include new technologies, unexplored markets and new market positions. In this regard, there is a need for a thorough analysis aimed at identifying all the main risks associated with a particular innovative project. The comprehensive risk of an innovative project is an integral assessment of the riskiness of the project and depends on the totality of all the risks that may arise in the process of its implementation.

To speed up the analysis process, the expert can, if necessary, use a generally accepted risk classification. The following risk categories can be considered:

1. Political risk is the risk of the restriction or termination of the project activities due to the actions of the authorities caused by a change in the political situation in the country. This may include factors such as changes in legislation, tax policy and other regulatory measures, which may lead to higher project costs and reduced project effectiveness. Political risk may also cause obstacles to the project, such as delays in obtaining construction permits or other restrictions imposed by the authorities.

2. Environmental risk is associated with the impact of the project on the environment and human health. It may be caused if environmental requirements are ignored, there are violations of ethics or there is insufficient control over the use and disposal of waste.

3. Market risk is caused by changes in consumer demand and the competitive environment, the entry of new players into the market, changes in government regulations or possible fluctuations in interest rates of national and foreign currencies (Mamiy, 2018). They may arise if the project does not comply with market requirements or if the competitive environment has not been analysed correctly.

4. Social risk is associated with the negative impact of a project on the social sphere, including changes in the living conditions of the population, deterioration of health and relationship problems in society. As a result, the project may have the effect of change rejection (Dalevska, Khobta, Kwilinski, Kravchenko, 2019).

5. Investment and financial risk is the risk of possible depreciation, as well as loss of the investment portfolio of securities (owned and attracted ones) (Kireeva and Pupentsova, 2012).

6. Institutional and legal risk is caused by changes in legislation, non-compliance with rules and regulations, violations of intellectual property and patent rights, and risks of legal litigation.

7. Production risk is caused by the possibility of failures in the production process arising from unsuccessful production planning or other factors, which can lead to a complete shutdown of the production, a higher level of defects, greater current costs of the enterprise and other negative consequences (Boev, 2020).

8. Financial risk arises from financial transactions (servicing debt or other loans), including those related to investing in projects or financial instruments, as a result of which the financial stability of the enterprise or its profitability is declining (Samis and Steen, 2020). It may be caused by varying exchange rates, reduced financing or higher costs.

9. Project management risk is the possibility of errors at various stages of the project (varying from the pre-investment stage to dissolution). This is caused by an insufficiently high level of management in the enterprise or the low qualifications of management personnel. These errors can result in the failed production or marketing of products, problems with the purchase, installation and start-up of equipment, and other similar problems (Pchelintseva, Gordashnikova, Goryacheva and Vasina, 2020).

For further risk analysis, experts need to assess the probability of each risk factor. They can assess the probability of each risk factor based on their professional experience, statistics collected and expert assessments. They can use statistical analysis and modelling techniques, conduct interviews with stakeholders and analyse research studies in the field related to the project.

Bayesian networks are a graphical model in which nodes represent random variables, while edges between nodes indicate probabilistic relationships between these variables. Each node in the network corresponds to a specific random variable, which can take different values, depending on the conditions of the model. The major principle of Bayesian networks is the use of Bayes' theorem to update probabilistic information about the variables in the network based on new data. By combining the probability distributions and conditional probabilities of the nodes and edges of the network, it is possible to draw conclusions about the probabilities of the possible states of the variables.

The structure of the Bayesian trust network is a directed acyclic graph with n nodes, where the nodes correspond to random $X_1, X_2, \ldots, X_n$ elements. Each of these random elements is described by a probability distribution function, and each node of the network stores a tensor of conditional probabilities. For example, these random elements can symbolize different types of risks that can affect the system. These risks are often interrelated; for example, the human factor can influence the probability of certain risks. To analyse and assess the overall risk of the system, it is critically important to consider all risks and their interrelationships (Musina, 2013).

"One of the key aspects of Bayesian confidence networks as probabilistic graphical models is the application of the decomposition rule based on the d-separability property. Formally, this rule can be described as follows:

$$f_0\left(x_1, x_2, \ldots, x_n\right) = \prod_{i=1}^{n} f_i\left(x_i | pa\left(X_i\right)\right), \quad (1)$$

where $f_0\left(x_1, x_2, \ldots, x_n\right)$ is the joint probability distribution of all random elements, $f_i\left(x_i | pa\left(X_i\right)\right)$ is the probability distribution of the random element X_i subject to the designation of random elements—the parents of the node corresponding to the random element X_i" (Musina, 2013).

Thus, to assess the risks of an innovative project, a Bayesian network must be built using the fol-

lowing rules:

1. Identify key variables that can influence the success of an innovative project and represent the potential inherent risks of the project. The project's own risks can be formulated using generally recognized classifications or by the expert.

2. For each of your own risks, identify a variety of factors that may affect this type of risk. It is possible that some of the risk factors can affect several of the project's own risks. In the Bayesian network, such risk factors must be specified only in the singular.

3. Place the "Comprehensive Risk of the Innovative Project" at the centre of the network. All of the project's own risks must be located right around it.

4. Describe the cause-and-effect relationship in the form of arcs oriented between the network nodes. If a risk factor affects several of the project's own risks, an arc must be drawn from it to each of the risks that it affects. At the centre is the integrated risk of the project, which arcs can only enter. Figure 1 shows an example of such a graphical structure.

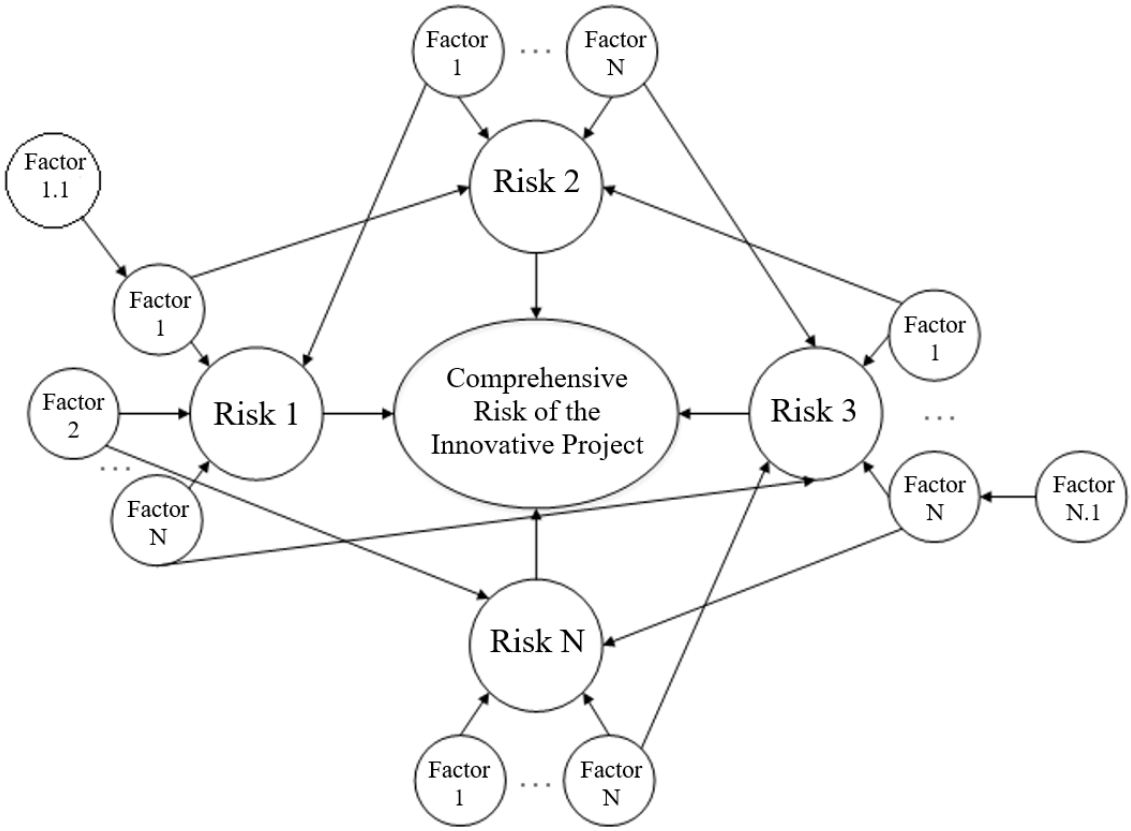

Figure 1. An example of the Bayesian network of an innovative project

To estimate the comprehensive risk of an innovative project, unconditional probabilities must be set for all the nodes of the network that do not have input arcs, and conditional probabilities must be set for all the nodes that have a "parent", that is, a node from which the connection goes to them. To do this, let us turn to the theory of fuzzy sets.

Using the theory of fuzzy sets to formalize the probabilities of risk factors is reasonable because it allows one to describe the uncertainty and blurriness in the data. When assessing risk probabilities, you often encounter situations in which accurate numerical values of probabilities are not sufficiently informative or adequate for an accurate assessment. In this case, the theory of fuzzy sets allows one to consider different levels of uncertainty and express probabilities in the form of linguistic variables, which makes them more flexible and adaptive to real conditions and uncertainty, especially in the case

of innovative projects where the data on past and expert assessments may be incomplete or blurred.

The theory of fuzzy sets, developed by Zadeh in 1965, is a mathematical theory for modelling fuzzy and incomplete data, which allows one to consider uncertainty in data and describe fuzzy concepts. This method allows you to develop expert systems and knowledge bases for storing fuzzy information. The main advantage of this approach is that both quantitative and qualitative factors are taken into account in decision-making, and they cannot be calculated as an exact number. The result is an approximate but effective method for describing the behaviour of complex and poorly structured systems. The feature distinguishing this approach is its flexibility in determining the accuracy of the decision, depending on the requirements and information available (Kuchta, Zabor, 2021).

The theory of generalized fuzzy numbers (GFN), first proposed in 1985, is an alternative to the widely used conventional fuzzy numbers in the analysis of economic problems. According to the GFN, experts have the right to change their level of confidence in various statements if they are unsure of their decisions (Kuchta, Zabor, 2021). Thus, the GFN theory expands and generalizes the concept of ordinary fuzzy numbers, and the conclusions obtained with it are applicable to standard fuzzy numbers. Formally speaking, a generalized fuzzy number can be a fuzzy number with any type of membership function. However, the variants of GFN that are most widely studied today are those based on the trapezoidal membership function. This is because this function consists of linear sections, making accurate and simple calculations easier. Moreover, the trapezoidal function describes various types of uncertainty in a good way and can be easily transformed into a triangular function. Given the above, it is trapezoidal fuzzy numbers that we will investigate further (Chen, 1985).

A trapezoidal number is designated as $\grave{A} = (a_1, a_2, a_3, a_4)$. In case $a_2 = a_3$, you obtain a triangular number (Figure 2). Correspondingly, for triangular numbers, you use the designation $\grave{A} = (a_1, a_2, a_4)$ (Gavrilenko, 2013).

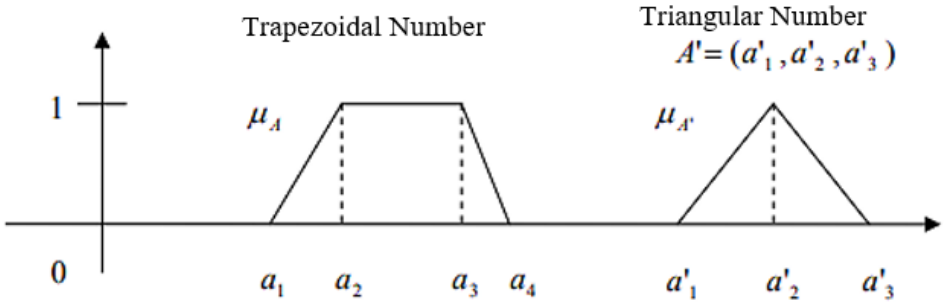

Figure 2. The representation of trapezoidal and triangular fuzzy numbers

To formalize the risk assessment model, you have to define a set of states for each risk factor, the linguistic variable, a set of values and the compliance of all variables included in the model with the numerical characteristics.

We suggest describing the degree of risk—high, low and medium—as possible states of the nodes in the Bayesian network.

For this model, we suggest setting the probability of the risk value for each of the factors as a linguistic variable. The set of terms of the linguistic variable is defined as follows:

Probability = {High, Low, Medium}.

Table 1 shows the reference value of the linguistic variable represented. The choice of coordinates for linguistic terms of risk probability was first proposed in the work of Chen S.J. and Chen S.M. (2008). Many subsequent studies related to the GFN theory also use this type of risk variable setting. This is primarily due to the need to compare the simulation results with the results of previous studies after the

development or modification of a new model. The results of these studies can be compared if they use the same formulation of the risk variable.

An alternative way of specifying the coordinates of the linguistic variable can be useful to experts, allowing them to express their individual expert opinions and preferences in a more accurate way when building membership functions. In this case, you can use the method of statistical processing of the opinions of a group of experts and the method of paired comparisons. In the first method, each expert fills out a questionnaire to express his or her opinion about the presence of fuzzy set properties in the elements. The experts provide their estimates or descriptions for various types of variables, which allows you to collectively assess the degree of belonging to each term of the variable. In the second case, the initial information for building membership functions consists of expert paired comparisons. In this method, for each pair of elements of a universal set, the expert evaluates the advantage of one element over another with respect to their fuzzy set properties (Grigorieva, Gareeva and Basyrov, 2018; Skorokhod, 2010).

Table 1. Reference value of the presented linguistic variable

No.	Term name	Coordinates
1	Extremely low	(0.0; 0.0; 0.02; 0.07; 1.0)
2	Very low	(0.04; 0.1; 0.18; 0.23; 1.0)
3	Low	(0.00; 0.1; 0.18; 0.23; 1.0)
4	Quite low	(0.17; 0.22; 0.36; 0.42; 1.0)
5	Medium	(0.32; 0.41; 0.58; 0.65; 1.0)
6	Quite high	(0.58; 0.63; 0.80; 0.86; 1.0)
7	High	(0.72; 0.78; 0.92; 1.00; 1.0)
8	Very high	(0.93; 0.98; 1.0; 1.0; 1.0)
9	Extremely high	(1.0; 1.0; 1.0; 1.0; 1.0)

Linguistic variables are advantageous since they can be standardized and then compared to other models. You can also change their accuracy, which depends on the number of linguistic values included in a set of linguistic variables.

Thus, there are nodes in the Bayesian network with three possible levels: high, low and medium. In Figure 3, which presents a part of the Bayesian network, for node F1, these three states are designated as F11, F12 and F13.

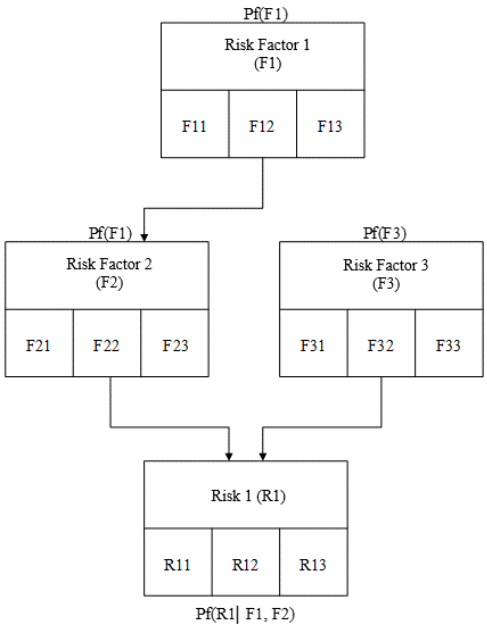

Figure 3. Part of the Bayesian network for assessing the risk of an innovative project

The expert needs to set unconditional probabilities using linguistic terms for all nodes that do not include any arcs, as Table 2 shows.

Table 2. An example of assigning linguistic terms to unconditional probabilities in the Bayesian network

Node name	Probability		
	High	Medium	Low
Risk Factor F1	Low	Medium	Quite high
Risk Factor F3	Medium	Low	Low
…	High	Low	Very low
Risk Factor N	Very low	Low	High

You need to set unconditional probabilities for all nodes that have "parents", nodes that are the cause. In the example shown in Figure x, for Node F2, the conditional probabilities will be set using the answers to the following questions:

1. What is the probability of Factor F2 if the value of Factor F1 is "High" (F11)?

2. What is the probability of Factor F2 if the value of Factor F1 is "Medium" (F12)?

3. What is the probability of Factor F2 if the value of Factor F1 is "Low" (F13)?

The unconditional probabilities for child nodes can be estimated using the formula of the full possibility of events:

$$\tilde{P}_f(Y = y_i) = \sum_i \tilde{P}_f(X = x_i)\,\tilde{P}(Y = y_i \,|\, X = x_i), \tag{2}$$

where Y is the child node, y_i – is the status of the child node, X – is the parent node and x_i – is the state of the parent node.

Thus, for Risk Factor F2:

$$1)\ \tilde{P}_f(F2 = F21) = \tilde{\oplus}\,\tilde{P}_f(f1, F2 = F21) = \tilde{P}_f(F1 = F11), F2 = F21) \tilde{\oplus}\,\tilde{P}_f(F1 = F12, F2 = F21) \tilde{\oplus}\,\tilde{P}_f(F1 = F13, F2 = F21) = \tilde{P}_f(F1 = F11) \tilde{\oplus}\,\tilde{P}_f(F2 = F21 \,|\, F1 = F11) \tilde{\oplus}\,\tilde{P}_f(F1 = F12) \tilde{\oplus}\,\tilde{P}_f(F2 = F21 \,|\, F1 = F12) \tilde{\oplus}\,\tilde{P}_f(F1 = F13) \tilde{\oplus}\,\tilde{P}_f(F2 = F21 \,|\, F1 = F13);$$

$$2)\ \tilde{P}_f(F2 = F22) = \tilde{\oplus}\,\tilde{P}_f(F1, F2 = F22) = \tilde{P}_f(F1 = F11, F2 = F22) \tilde{\oplus}\,\tilde{P}_f(F1 = F12, F2 = F22) \tilde{\oplus}\,\tilde{P}_f(F1 = F13, F2 = F22) = \tilde{P}_f(F1 = F11) \tilde{\oplus}\,\tilde{P}_f(F2 = F22 \,|\, F1 = F11) \tilde{\oplus}\,\tilde{P}_f(F1 = F12) \tilde{\oplus}\,\tilde{P}_f(F2 = F22 \,|\, F1 = F12) \tilde{\oplus}\,\tilde{P}_f(F1 = F13) \tilde{\oplus}\,\tilde{P}_f(F2 = F22 \,|\, F1 = F13);$$

$$3)\ \tilde{P}_f(F2 = F23) = \tilde{\oplus}\,\tilde{P}_f(F1, F2 = F23) = \tilde{P}_f(F1 = F11, F2 = F23) \tilde{\oplus}\,\tilde{P}_f(F1 = F12, F2 = F23) \tilde{\oplus}\,\tilde{P}_f(F1 = F13, F2 = F23) = \tilde{P}_f(F1 = F11) \tilde{\oplus}\,\tilde{P}_f(F2 = F23 \,|\, F1 = F11) \tilde{\oplus}\,\tilde{P}_f(F1 = F12) \tilde{\oplus}\,\tilde{P}_f(F2 = F23 \,|\, F1 = F12) \tilde{\oplus}\,\tilde{P}_f(F1 = F13) \tilde{\oplus}\,\tilde{P}_f(F2 = F23 \,|\, F1 = F13).$$

For the node, risk 1 is R1:

1) $\tilde{P}_f(R1 = R11) = \tilde{\oplus}\tilde{P}_f(F2, F3, R1 = R11);$

2) $\tilde{P}_f(R1 = R12) = \tilde{\oplus}\tilde{P}_f(F2, F3, R1 = R12);$

3) $\tilde{P}_f(R1 = R13) = \tilde{\oplus}\tilde{P}_f(F2, F3, R1 = R13);$

Using similar calculations, you need to estimate the probabilities of all the network's own risks. In the same way, the total risk of the project has to be calculated; that is, at the output, you get three states of the total risk of the project and three fuzzy probabilities of these states.

The exact value of the probability of each integrated risk state can be calculated using the formula below:

$$P_f(R) = \frac{\int_{min}^{max} \tilde{P}_f(R) * \varphi\left(\tilde{P}_f(R)\right) d\tilde{P}_f(R)}{\int_{min}^{max} \varphi\left(\tilde{P}_f(R)\right) d\tilde{P}_f(R)} = \frac{a_3^2 + a_4^2 + a_3 a_4 - a_1^2 - a_2^2 - a_1 a_2}{3\left(a_4 + a_3 - a_1 - a_2\right)}, \quad (3)$$

where $\tilde{P}_f(R) = (a_1, a_2, a_3, a_4)$ is the calculated value of the probability of one of the states of the overall risk of the project: "high", "medium" and "Low" (Ashinova, Chinazova, Kadakoeva, Gisheva, 2020).

Thus, there is an algorithm for assessing the risk of an innovative project using fuzzy sets and Bayesian networks. It includes the following stages:

Stage 1. Experts conduct a qualitative risk analysis of the project.

At this stage, experts carry out a qualitative risk analysis of an innovative project, using their experience and knowledge in project management to identify risks.

Stage 2. Identify the set of the project's own risks.

At this stage, many of the innovation project's own risks are identified. The experts highlight the unique features of the project, which may be a source of specific risks that differ from the general categories of risk. It is advisable to identify your own risks, given the unique features of innovative projects.

Stage 3. Identify factors for each individual risk.

The experts identify the factors that can influence the incurrence of each individual risk. This allows you to assess the probability and impact of each risk on the project more accurately, considering the unique features of the project.

Stage 4. Create a Bayesian network.

At this stage, you form a Bayesian network, which is a graphical model reflecting the relationship between the risks and the factors in the project, according to the rules described above.

Stage 5. Define linguistic terms.

At this stage, the expert defines the linguistic terms that will be used to describe the probabilities and magnitude of risks.

Stage 6. Set fuzzy probabilities.

At this stage, each linguistic term is assigned a fuzzy number based on previously set reference values or alternative methods.

Stage 7. Assess the unconditional probabilities of "parent" nodes.

This stage includes the assessment of the probability of risks that do not depend on other factors. The expert analyses the main risks and assesses their probabilities, regardless of other factors.

Stage 8. Assess the conditional probabilities of child nodes.

You assess conditional probabilities for child nodes, reflecting the dependencies between the risks and project factors.

Stage 9. Calculate the Bayesian network.

Calculations are carried out based on the specified probabilities and the Bayesian network to assess the probability of risks.

Stage 10. Transit from fuzzy sets to the exact value.

This stage involves the transition from fuzzy probabilities to exact values of the probabilities of a particular risk value, using the formula above.

Figure 4 shows the algorithm for assessing the risk of an innovative project using fuzzy sets and Bayesian networks.

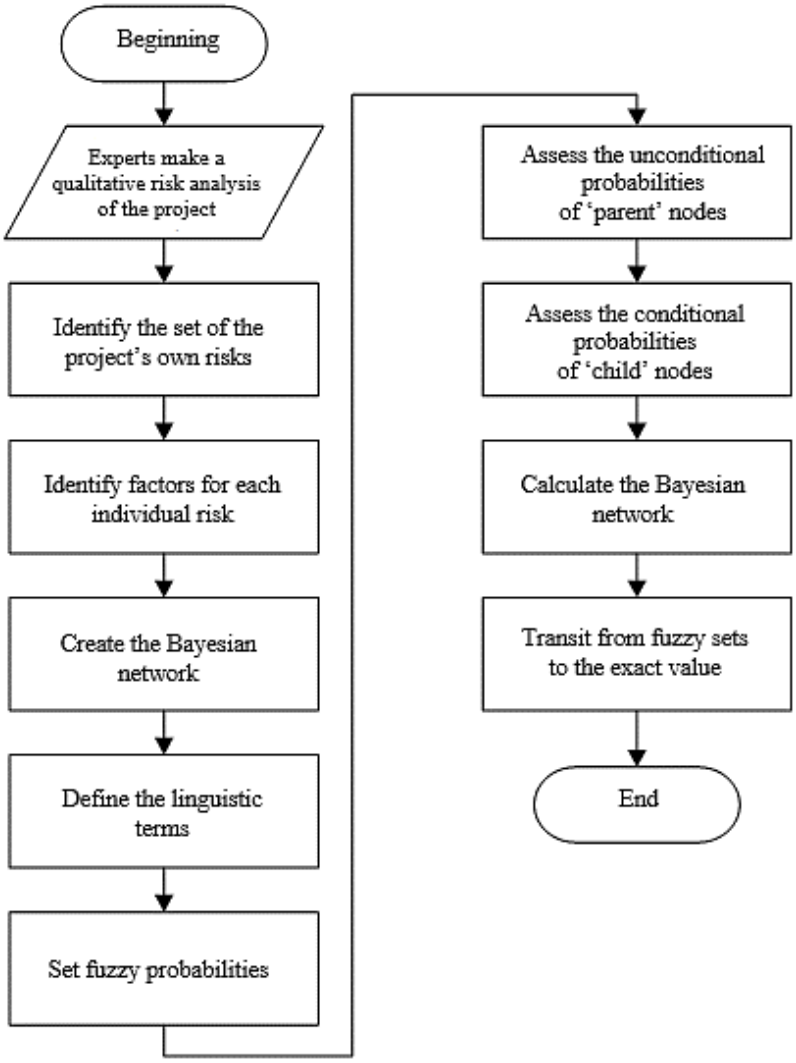

Figure 4. Algorithm for assessing the risk of an innovative project using fuzzy sets and Bayesian networks

4. Results

An example of algorithm implementation.

Step 1. Imagine that the expert faces the task of assessing the risk of a specific innovation project. The expert is familiar with all the necessary information about the project and has a sufficient level of knowledge to determine the types of risks specific to this innovative project.

Stage 2. The expert identifies four risks for the innovative project: project participant risk, sales risk, marketing risk and financial risk.

Stages 3 and 4. The expert determines a set of factors for each of the project's own risks and builds a Bayesian network based on the interrelationships between the factors and risks, as Figure 5 shows.

Figure 5. Bayesian network of the innovation project

Stages 5, 6. The risk value described by three states was chosen as the states for the nodes of the Bayesian network: high, low and medium.

For this model, it is proposed that the probability of realizing the risk value for each of the factors be set as a linguistic variable. The set of terms of a linguistic variable is assigned as follows: Probability = {High, Low, Medium}.

In addition, each linguistic term is assigned a fuzzy number of reference values, as proposed above by Chen S.J. and Chen S.M. (Babordina, Garanina, Garanin, Chirkunova, 2021). Table 3 shows the values.

Table 3. Reference values of the presented linguistic variable

№	Term name	Coordinates
1	Extremely low	(0.0; 0.0; 0.02; 0.07; 1.0)
2	Very low	(0.04; 0.1; 0.18; 0.23; 1.0)
3	Low	(0.00; 0.1; 0.18; 0.23; 1.0)
4	Quite low	(0.17; 0.22; 0.36; 0.42; 1.0)
5	Medium	(0.32; 0.41; 0.58; 0.65; 1.0)
6	Quite high	(0.58; 0.63; 0.80; 0.86; 1.0)
7	High	(0.72; 0.78; 0.92; 1.00; 1.0)
8	Very high	(0.93; 0.98; 1.0; 1.0; 1.0)
9	Extremely high	(1.0; 1.0; 1.0; 1.0; 1.0)

Step 7. You need to set unconditional probabilities using linguistic terms for all nodes that do not have arcs. For this example, the unconditional probabilities are presented in Table 4.

Table 4. Table of unconditional probabilities of the parent nodes of the Bayesian network

Node name	Probability		
	High	Medium	Low
High staff turnover	High	Medium	Low
Conflicts between participants	Medium	Quite low	Quite high
Lack of project financing	Quite high	Low	Very low
Insolvency or non-fulfilment of their financial obligations by partners	Medium	Low	Very low
Unsuccessful product positioning on the market	High	Very high	Very low
Changes in consumer needs and behaviour	Quite low	Low	Very high

Step 8. At this stage, you need to set unconditional probabilities for all child nodes. Table 5 shows an example for the node “Lack of qualification or experience of key participants”, with the parent node “High staff turnover”.

Table 5. Table of conditional probabilities of the child node “Lack of qualification or experience of key participants” of the Bayesian network

High (F11)		High staff turnover (F1)		
		Medium (F12)	Low (F13)	
Lack of qualification or experience of key participants (F2)	High (F22)	High	High	Low
	Medium (F22)	High	High	Medium
	Low (F23)	Low	Low	Medium

Step 9. Below is an example of the estimation of unconditional probabilities for the node “lack of qualifications or experience of key participants” based on the specified conditional probabilities:

$$1)\ \tilde{P}_f(F2 = F21) = \tilde{\oplus}\,\tilde{P}_f(F1, F2 = F21) = \tilde{P}_f(F1 = F11, F2 = F21)\,\tilde{\oplus}\,\tilde{P}_f(F1 = F12, F2 =$$

$$F21)\tilde{\oplus}\tilde{P}_f(F1=F13,F2=F21)=\tilde{P}_f(F1=F11)\tilde{\oplus}\tilde{P}_f(F2=F21\,|\,F1=F11)\tilde{\oplus}\tilde{P}_f(F1=$$

$$F12)\tilde{\oplus}\tilde{P}_f(F2=F21\,|\,F1=F12)\tilde{\oplus}\tilde{P}_f(F1=F13)\tilde{\oplus}\tilde{P}_f(F2=F21\,|\,F1=F13);$$

$$\tilde{P}_f(F2=F21)=(0,00;0,1;0,18;0,23)\tilde{\oplus}(0,00;0,1;0,18;0,23)\tilde{\oplus}(0,32;0,41;0,58;0,65)\tilde{\oplus}$$

$$\tilde{\oplus}(0,72;0,78;0,92;1,00)\tilde{\oplus}(0,72;0,78;0,92;1,00)\tilde{\oplus}(0,72;0,78;0,92;1,00)=$$

$$=(0,7488;0,9382;1,00;1,00);$$

2) $$\tilde{P}_f(F2=F22)=\tilde{\oplus}\tilde{P}_f(F1,F2=F22)=\tilde{P}_f(F1=F11,F2=F22)\tilde{\oplus}\tilde{P}_f(F1=F12,F2=$$

$$F22)\tilde{\oplus}(F1=F13,F2=F22)=\tilde{P}_f(F1=F11)\tilde{\oplus}\tilde{P}_f(F2=F22\,|\,F1=F11)\tilde{\oplus}\tilde{P}_f(F1=$$

$$F12)\tilde{\oplus}\tilde{P}_f(F2=F22\,|\,F1=F12)\tilde{\oplus}\tilde{P}_f(F1=F13)\tilde{\oplus}\tilde{P}_f(F2=F22\,|\,F1=F13);$$

$$\tilde{P}_f(F2=F22)=(0,00;0,1;0,18;0,23)\tilde{\oplus}(0,32;0,41;0,58;0,65)\tilde{\oplus}(0,32;0,41;0,58;0,65)\tilde{\oplus}$$

$$\tilde{\oplus}(0,72;0,78;0,92;1,00)\tilde{\oplus}(0,72;0,78;0,92;1,00)\tilde{\oplus}(0,72;0,78;0,92;1,00)=$$

$$=(0,00;0,41;0,1044;0,1495)\tilde{\oplus}(0,23;0,32;0,53;0,65)\tilde{\oplus}(0,52;0,61;0,85;1,00)=$$

$$=(0,7488;0,962;1,00;1,00);$$

3) $$\tilde{P}_f(F2=F23)=\tilde{\oplus}\tilde{P}_f(F1,F2=F23)=\tilde{P}_f(F1=F11,F2=F23)\tilde{\oplus}\tilde{P}_f(F1=F12,F2=$$

$$F23)\tilde{\oplus}\tilde{P}_f(F1=F13,F2=F23)=\tilde{P}_f(F1=F11)\tilde{\oplus}\tilde{P}_f(F2=F23\,|\,F1=F11)\tilde{\oplus}\tilde{P}_f(F1=$$

$$F12)\tilde{\oplus}\tilde{P}_f(F2=F23\,|\,F1=F12)\tilde{\oplus}\tilde{P}_f(F1=F13)\tilde{\oplus}\tilde{P}_f(F2=F23\,|\,F1=F13);$$

$$\tilde{\oplus}(F2=F23)=(0,00;0,1;0,18;0,23)\tilde{\oplus}(0,32;0,41;0,58;0,65)\tilde{\oplus}(0,32;0,41;0,58;0,65)\tilde{\oplus}$$

$$\tilde{\oplus}(0,00;0,1;0,18;0,23)\tilde{\oplus}(0,72;0,78;0,92;1,00)\tilde{\oplus}(0,00;0,1;0,18;0,23)=$$

$$=(0,00;0,041;0,1044;0,1495)\tilde{\oplus}(0,00;0,41;0,1044;0,1495)\tilde{\oplus}$$

$$\tilde{\oplus}(0,00;0,078;0,1656;0,23)=(0,00;0,16;0,3744;0,529).$$

In the same way, you need to calculate the entire Bayesian network. In this case, the values presented in Table 6 were calculated for the comprehensive risk of the innovative project.

Table 6. Fuzzy values of the probabilities of comprehensive risk

No.	Name of comprehensive risk value	Fuzzy value
1	Low	(0.00; 0.0019; 0.45; 0.6589)
2	Medium	(0.00; 0.0172; 0.3826; 0.5684)
3	High	(0.0088; 0.0977; 0.9954; 1)

Stage 10. Transit from fuzzy values to exact ones. This can be done using the following formula:

$$P_f\left(R\right)=\frac{\int_{min}^{max}\tilde{P}_f\left(R\right)*\varphi\left(\tilde{P}_f\left(R\right)\right)d\tilde{P}_f\left(R\right)}{\int_{min}^{max}\varphi\left(\tilde{P}_f\left(R\right)\right)d\tilde{P}_f\left(R\right)}=\frac{a_3^2+a_4^2+a_3a_4-a_1^2-a_2^2-a_1a_2}{3\left(a_4+a_3-a_1-a_2\right)}. \quad (4)$$

The probability that the risk value of the project is high:

$$P_f(B)=\frac{0,9954^2+1+0,9954*1-0,0088^2-0,0977^2-0,0088*0,0977}{3\left(1+0,9954-0,0088-0,0977\right)}=0,525. \quad (5)$$

In the same way, you need to make calculations for medium- and low-risk cases:

$$P_f(C)=0,245 \quad (6)$$

$$P_f(H)=0,28 \quad (7)$$

Thus, it can be concluded that with a probability of 52.5 percent, the comprehensive risk of the innovative project is high; with a probability of 24.5 percent, the risk is medium, and with a probability of 28 percent, it is low.

Based on this risk assessment, combined with other assessments, such as the feasibility of the project and its financial attractiveness, it is recommended to conduct further analysis and make an informed decision regarding the launch of the innovative project. Given that the probability of high risk is 52.5%, it is recommended to carefully study the risk management strategies in the project, develop an action plan to reduce the identified risks and assess their impact on the project.

5. Discussion

This paper presents a model for assessing the risk of an innovative project using fuzzy sets and Bayesian networks.

Methods such as Monte Carlo analysis, decision tree analysis or PERT network analysis usually operate with precise values and probabilities, which can result in simplified risk modelling based on fixed assumptions. For example, in the PERT analysis, three assessment points are used for each activity, which can lead to subjective estimates and averaged results. The model with fuzzy sets allows one to consider fuzziness and uncertainty in risk assessment, which is a more realistic approach to estimating probabilities (Ashinova, Chinazova, Kadakoeva and Gisheva, 2020).

Another significant advantage of the proposed methods is that one can operate directly with an integrated risk indicator, avoiding complex calculations for individual risk factors and analysing their interaction, which seems better for a decision maker. This allows you to make more informed and balanced decisions (Lashmanova, Maltsev and Klimchuk, 2014). Compared with other methods, such as decision tree analysis or statistical modelling, this approach has an integrated risk indicator in the assessment model of innovative projects with fuzzy sets and Bayesian networks, which reduces the need for complex calculations and simplifies the decision-making process. Instead of having to consider many individual factors and their interrelationships, with this method, you can focus on an aggregated risk

assessment as a whole, which makes decision-making more practical and efficient.

Thus, our risk assessment model based on fuzzy sets and Bayesian networks has tangible advantages over traditional methods, allowing for a deeper and more realistic consideration of uncertainty, variability and interactions in the risk management process of innovative projects.

However, it should be noted that to apply this model, you need sufficient amounts of data and expertise to identify risks and their factors correctly. Moreover, developing and updating the Bayesian network can be time- and resource-consuming.

Thus, further research and development of the risk assessment model for innovative projects using fuzzy sets and Bayesian networks opens up wide opportunities for better risk management, higher quality of decision-making and success of the project. Continuous improvement of the model, its testing in practice and adaptation to changing conditions will make it a tool that can help you to effectively cope with challenges in today's business world and ensure the sustainable development of your organization.

6. Conclusion

This paper researches a model for assessing the risk of an innovative project using fuzzy sets and Bayesian networks. The results of the study show that this model is a powerful tool for a more accurate and reliable assessment of project risks. Fuzzy sets allow for uncertainty and semantic ambiguity, and Bayesian networks help you model the relationship between risks and factors.

Effective risk management is one of the key aspects of the success of innovative projects. With proper risk assessment, you can anticipate negative consequences and make informed management decisions. The model, based on fuzzy sets and Bayesian networks, considers different levels of probability and complex relationships between risks, which contributes to a deeper analysis and risk management of the project.

Further research and experiments are necessary for the development of this model and its application in practice. The model must be tested in more detail on various innovative projects to evaluate its effectiveness and identify its possible constraints.

An important area of research is the adaptation of the risk assessment model of innovative projects based on fuzzy sets and Bayesian networks to modern technologies, such as machine learning and artificial intelligence. This approach will automate the process of risk assessment and management, which will make the model more efficient and reduce the human factor in decision-making.

By and large, the risk assessment model of an innovative project based on fuzzy sets and Bayesian networks is a promising area of research in the field of risk management. Its application can help you improve the decision-making process and increase the effectiveness of risk management and the success of innovative projects.

References

Akulov A.Ya., 2012. Innovative risks today and methods to reduce them. Innovative development of Russian economy: a new stage. 4, 152

Ashinova M.K., Chinazova S.K., Kadakoeva G.V., Gisheva S.Sh., 2020. Methods of risk assessment of innovative projects. The Scientific Heritage. 54, 13–17

Babordina, O.A., Garanina, M.P., Garanin, P.A., Chirkunova, E.K., 2021. Digitalization and project management method in improving efficiency of drilling wells construction. Lecture Notes in Networks and Systems. 139, 348–353. DOI: 10.1007/978-3-030-53277-2_42

Boev, A.G., 2020. Strategic management system of transformation of industrial enterprises. St. Petersburg State Polytechnical University Journal Economics. 1, 101–113. DOI: 10.18721/JE.13109

Boris, O.A., Parakhina, V.N., 2020. Generating models for innovation development strategy of the industrial complex with references to its management, structure and policies. Lecture Notes in Networks and Systems. 73, 615–625. DOI: 10.1007/978-3-030-15160-7_62

Chen, S.H., 1985. Ranking fuzzy numbers with maximizing set and minimizing set. Fuzzy sets and systems. 17(2), 113–129

Chen, S.J., Chen, S.M., 2008. Fuzzy risk analysis based on similarity measures of generalized fuzzy numbers. Expert systems with applications. 35, 6833–6842

Dalevska, N., Khobta, V., Kwilinski, A., Kravchenko, S., 2019. A model for estimating social and economic indicators of sustainable devel-

opment. Entrepreneurship and Sustainability Issues. 6–4, 1839–1860. DOI: doi.org/10.9770/jesi.2019.6.4(21)
Gavrilenko, M.A., 2013. Applying the theory of fuzzy sets in assessing risks of investment projects. Audit and financial analysis. 3, 75–81
Glukhov V.V., Korobko S.B., Marinina T.V., 2003. Economics of knowledge. SPb, 528, ISBN 5-88782-345-3
Gracheva, M.V., 2009. Risk management in an investment project. Edited by Grachev M.V., Sekerin A.B. Moscow, Unity, 544. ISBN 978-5-238-01506-4
Grigorieva, R., Gareeva, G.A., Basyrov, R.R., 2018. Fundamentals of fuzzy logic. Naberezhnye Chelny: Publishing house of the NCI KFU, 44
Jin, X., Liu, Q., Long, H., 2021. Impact of cost–benefit analysis on financial benefit evaluation of investment projects under back propagation neural network. Journal of Computational and Applied Mathematics. 384, 113172. DOI: 10.1016/j.cam.2020.113172
Kireeva, N.A., Pupentsova, S.V., 2012. Evaluation of investment attractiveness of real estate property using qualimetric modeling. St. Petersburg State Polytechnical University Journal Economics. 4, 163–167
Kuchta, D., Zabor, A., 2021. Fuzzy uncertainty modelling in cost and cash flow forecasting in project. Advances in Intelligent Systems and Computing. 1197 AISC, 1206–1215. DOI: 10.1007/978- 3-030-51156-2_141
Lashmanova, N.V., Maltsev Yu. K., Klimchuk, D. M., 2014. Methods of risk assessment in innovative projects introducing scientific and technical products (STP). Innovations. 5, 94–97
Lytvynenko, V., Naumov, O., 2021. Dynamic Bayesian networks application for evaluating the investment projects effectiveness. Advances in Intelligent Systems and Computing. 1246 AISC, 315–330. DOI: 10.1007/978-3-030-54215-3_20
Mamiy, E.A., Yakhimovich, E.S., 2018. Modern approaches to risk assessment of investment projects. Economics and Business: Theory and Practice. 5, 155–160
Musina, V.F., 2013. Bayesian trust networks as a probabilistic graphical model for assessing economic risks. Works of SPIIRAS. 25, 235–254
Pchelintseva, I., Gordashnikova, O., Goryacheva, T., Vasina, A., 2020. Methodological toolbox for risk assessment of innovative projects in the context of project management quality. Quality - Access to Success. 21–177, 92–95
Pupentsova, S., Livintsova, M., 2018. Qualimetric assessment of investment attractiveness of the real estate property. Real Estate Management and Valuation. 26–2, 5–11. DOI: 10.2478/remav-2018-0011
Samis, M., Steen, J., 2020. Financial evaluation of mining innovation pilot projects and the value of information. Resources Policy. 69, 101848. DOI: 10.1016/j.resourpol.2020.101848
Samokhvalov, Y., 2021. Risk assessment of innovative projects based on fuzzy modeling. Advances in Intelligent Systems and Computing. 1246 AISC, pp. 265–281. DOI: 10.1007/978-3-030- 54215-3_17
Skorokhod, S.V., 2010 On the matter of linguistic variables used for expert assessments. Technical Sciences. 7, 141–145
Tapman L.N., 2002. Risks in the economy. Edited by V.A. Schwandar. Moscow, Unity-dana, 380, ISBN: 5-238-00343-9
Valdaytsev S.V., 2001. Managing an innovative business. Moscow, Unity-dana, 343, ISBN 5-238-00252-1
Vyatkin, V.N., 2018. Risk Management, Moscow, Yurait, 343. ISBN 978-5-9916-3502-8

Список источников

Babordina, O.A., Garanina, M.P., Garanin, P.A., Chirkunova, E.K., 2021. Digitalization and project management method in improving efficiency of drilling wells construction. Lecture Notes in Networks and Systems. 139, 348–353. DOI: 10.1007/978-3-030-53277-2_42
Boris, O.A., Parakhina, V.N., 2020. Generating models for innovation development strategy of the industrial complex with references to its management, structure and policies. Lecture Notes in Networks and Systems. 73, 615–625. DOI: 10.1007/978-3-030-15160-7_62
Chen, S.H., 1985. Ranking fuzzy numbers with maximizing set and minimizing set. Fuzzy sets and systems. 17(2), 113–129
Chen, S.J., Chen, S.M., 2008. Fuzzy risk analysis based on similarity measures of generalized fuzzy numbers. Expert systems with applications. 35, 6833–6842
Dalevska, N., Khobta, V., Kwilinski, A., Kravchenko, S., 2019. A model for estimating social and economic indicators of sustainable development. Entrepreneurship and Sustainability Issues. 6–4, 1839–1860. DOI: doi.org/10.9770/jesi.2019.6.4(21)
Gavrilenko, M.A., 2013. Applying the theory of fuzzy sets in assessing risks of investment projects. Audit and financial analysis. 3, 75–81
Grigorieva, R., Gareeva, G.A., Basyrov, R.R., 2018. Fundamentals of fuzzy logic. Naberezhnye Chelny: Publishing house of the NCI KFU, 44
Jin, X., Liu, Q., Long, H., 2021. Impact of cost–benefit analysis on financial benefit evaluation of investment projects under back propagation neural network. Journal of Computational and Applied Mathematics. 384, 113172. DOI: 10.1016/j.cam.2020.113172
Kireeva, N.A., Pupentsova, S.V., 2012. Evaluation of investment attractiveness of real estate property using qualimetric modeling. St. Petersburg State Polytechnical University Journal Economics. 4, 163–167
Kuchta, D., Zabor, A., 2021. Fuzzy uncertainty modelling in cost and cash flow forecasting in project. Advances in Intelligent Systems and Computing. 1197 AISC, 1206–1215. DOI: 10.1007/978- 3-030-51156-2_141
Lytvynenko, V., Naumov, O., 2021. Dynamic Bayesian networks application for evaluating the investment projects effectiveness. Advances in Intelligent Systems and Computing. 1246 AISC, 315–330. DOI: 10.1007/978-3-030-54215-3_20
Musina, V.F., 2013. Bayesian trust networks as a probabilistic graphical model for assessing economic risks. Works of SPIIRAS. 25, 235–254
Pchelintseva, I., Gordashnikova, O., Goryacheva, T., Vasina, A., 2020. Methodological toolbox for risk assessment of innovative projects in the context of project management quality. Quality - Access to Success. 21–177, 92–95
Pupentsova, S., Livintsova, M., 2018. Qualimetric assessment of investment attractiveness of the real estate property. Real Estate Management and Valuation. 26–2, 5–11. DOI: 10.2478/remav-2018-0011
Samis, M., Steen, J., 2020. Financial evaluation of mining innovation pilot projects and the value of information. Resources Policy. 69, 101848. DOI: 10.1016/j.resourpol.2020.101848
Samokhvalov, Y., 2021. Risk assessment of innovative projects based on fuzzy modeling. Advances in Intelligent Systems and Computing. 1246 AISC, pp. 265–281. DOI: 10.1007/978-3-030- 54215-3_17

Skorokhod, S.V., 2010 On the matter of linguistic variables used for expert assessments. Technical Sciences. 7, 141–145

Tapman L.N., 2002. Risks in the economy. Unity-dana, 380, ISBN: 5-238-00343-9

Акулов, А.Я., Современные инновационные риски и методы их снижения. URL: http://www. ieay. ru/nauch/sc_article/2012/04/Akulov. shtml

Ашинова, М.К., Кадакоева, Г.В., Гишева, С.Ш. and Чиназирова, С.К., 2020. Методы оценки рисков инновационных проектов. Периодический научный журнал “The scientific heritage”.Венгрия, 7(54), с.13.

Боев, А.Г., 2020. Система стратегического управления преобразованиями промышленного предприятия. π-Economy, 13(1), pp.101-113.

Валдайцев, С.В., 2001. Управление инновационным бизнесом.

Вяткин, В.Н., Гамза, В.А., Маевский, Ф.В. Риск-менеджмент 2023, 365.

Глухов, В.В., Коробко, С.Б. Маринина, Т.В., 2003. Экономика знаний. 528, ISBN 5-88782-345-3

Грачева, М.В. и др., 2009. Риск-менеджмент инвестиционного проекта, 544. ISBN 978-5-238-01506-4

Лашманова Н.В., Мальцев Ю.К., Климчук Д.М., 2014. Методы оценки риска инновационных проектов внедрения научно-технической продукции (НТП). Инновации 5 (187), 94–97.

Мамий, Е.А., Яхимович, Е.С., 2018. Современные подходы к оценке рисков инвестиционных проектов. Экономика и бизнес: теория и практика 5, 155–160.

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SECTION 2

ENTERPRISES AND THE SUSTAINABLE DEVELOPMENT OF REGIONS

РАЗДЕЛ 2

ПРЕДПРИЯТИЯ И УСТОЙЧИВОЕ РАЗВИТИЕ РЕГИОНОВ

Research article

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Study of the Factors Relevant to the Management Model for Developing Russia's Regional Socio-Economic Systems

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Abstract

The Russian economic space is characterised by a significant differentiation in the levels of socio-economic development of the country's various regions, which manifests itself in natural, territorial, socio-cultural, economic, political and other aspects. The results of socio-economic differentiation are unique regional socio-economic systems, which necessitates the formation of individual approaches to managing their development. Therefore, management decisions made at the federal centre, as well as by regional authorities, affect the activities of economic entities in the regions and the population's level of well-being in different ways. Social security is an integral element of the high quality of life of the population and is largely the basis for improving the economic status of the region, increasing the value of human capital. Thus, it is necessary to develop methods and tools for ensuring the social safe development of regional socio-economic systems, considering the specific characteristics of each region. From these perspectives, we can discuss the stability and social performance of the regional economy. Despite a broad scientific background, the factors contributing to the development and the results of regional socio-economic systems, considering the need for social security, have not been examined. The present research aims to fill this gap by developing a management model for the social and safe development of Russia's regions, using the city of St Petersburg as the case study.

Keywords: management model for regional development, tone of news flow, resource classification principles, management factors' impacts, regional social security, regional economy's stability

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Исследование Факторов Модели Управления Социально-Безопасным Развитием Региона

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Аннотация

Для российского экономического пространства характерна значительная дифференциация уровней социально-экономического развития различных регионов, проявляющаяся как в природном, территориальном, так и в социокультурном, экономическом, политическом и ином аспектах. Результатами социально-экономической дифференциации становятся уникальные региональные социально-экономические системы, что обуславливает необходимость формирования индивидуальных подходов к управлению их развитием. Поэтому управленческие решения, генерируемые федеральным центром, а также региональными органами власти, неодинаково сказываются на деятельности хозяйствующих субъектов региона и уровне благосостояния населения. Социальная безопасность является составным элементом высокого качества жизни населения, более того, социальная безопасность во многом является базисом для повышения экономического статуса региона, роста стоимости человеческого капитала. Вследствие этого необходима разработка методов и инструментов обеспечения социально безопасного развития региональных социально-экономических систем с учётом специфики регионов. Именно с этих позиций можно говорить об устойчивости региональной экономики и о её социальной результативности. Целью данного исследования является разработка модели управления социально-безопасного развития региона на примере города Санкт-Петербург. Исследовательский разрыв заключается в том, что несмотря на достаточно широкий научный задел, существует явный научный пробел в определении факторов и результатов развития региональных социально-экономических систем с учётом необходимости обеспечения социальной безопасности.

Ключевые слова: модель управления социально-безопасным развитием региона, тональный окрас новостного потока, принципы классификации ресурсов, воздействие факторов, социальная безопасность региона, устойчивость региональной экономики.

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1. Introduction

The competitiveness of a national economy is determined by the distinct capabilities of regional socio-economic systems, considered as local centres for generating benefits, in connection with which the choice of directions for regional development becomes critical. The main goal of the development of regional and national socio-economic systems is to improve the population's quality of life, based on stable economic growth and compliance with environmental restrictions. The Russian economic space is characterised by a significant differentiation in the levels of socio-economic development of the country's various regions, which manifests itself in natural, territorial, socio-cultural, economic, political and other aspects. The results of socio-economic differentiation are unique regional socio-economic systems, necessitating the formation of individual approaches to managing their development. Thus, the purpose of this study is to develop a management model for the social and safe development of the regions, based on the example of the city of St Petersburg.

Despite a fairly broad scientific background, determining the factors contributing to the development and the results of regional socio-economic systems, considering the need to ensure social security, remains a research gap. Significant differences in the results of the managerial influences of the federal centre and the regions on regional socio-economic development reveal the need for additional research in this area.

2. Literature Review

To form a conceptual model for ensuring the socially safe management of the development of regional socio-economic systems, it is necessary to identify the factor specificity. One of the key signs of differentiation can be the principle of classifying economic resources. The most complete classification of economic resources as factors influencing the development of regional socio-economic systems is presented in a previous study (Kisurkin, 2012). The author identifies five main groups – natural, labour, financial, entrepreneurial and knowledge factors. Each of the presented groups of factors can act as the core of the model for managing the development of a regional socio-economic system.

A graphic systematisation and brief descriptions are shown in Figure 1.

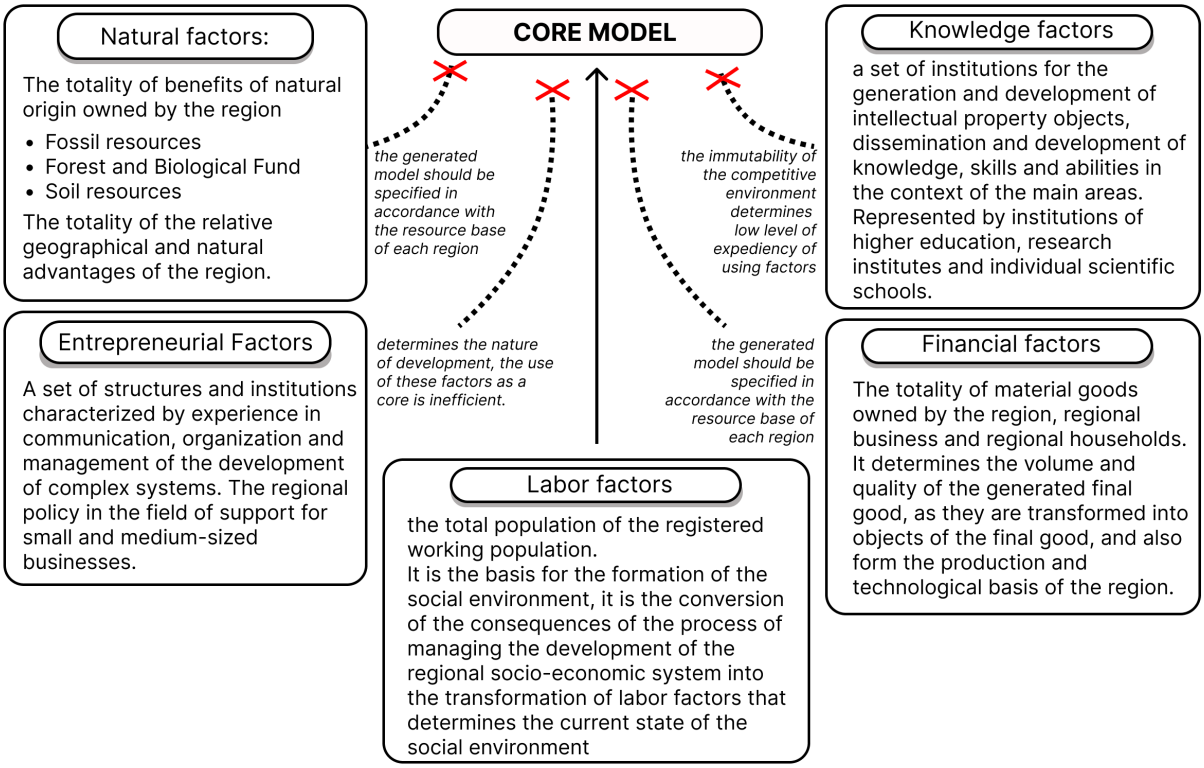

Figure 1. Systematisation of economic factors

However, taking into account this study's purpose to improve the tools for the socially safe development of regional socio-economic systems, instead of labour factors, the model will consider human factors as the group that fully covers all human resources and human potential located in the territory of a particular region. Through the reactions of human resources, people can most fully assess how socially safe their region of residence is and use this effect in strategic regional planning.

Using the state of human resources as the core of the model being developed involves the formation of a system of input impact factors and a system of input conversion results. The system of input impact factors should be understood as a set of quantifiable variables that are exogenous in relation to the state of human resources. At the same time, it should be noted that being fully or partially controllable is an invariably obligatory property of these factors. It is expedient to make these factors distinct in accordance with the specifics of the differentiation of economic resources described earlier. Thus, in the first place, natural factors can be distinguished. As a manageable indicator that characterises the impact of management entities on the development of a set of natural factors influencing the regional socio-economic system, an investment in a fixed asset aimed at protecting the environment and the rational use of natural resources can be singled out. This indicator is differentiated in accordance with the areas of investment, namely investments in the protection of atmospheric air, the protection and rational use of water resources, as well as the construction and maintenance of wastewater treatment plants. The selected set of investment areas is not exhaustive; however, these areas comprise the majority of the totality. The increment of these parameters in the medium and long terms has an impact on improving the level of environmental safety of a specific region, which in turn has a positive effect on the overall average state of the physical and moral health of the population. The presented formal–logical connection determines the conversion of the process of incremental investments in fixed assets aimed at environmental protection and rational use of natural resources into a change in the state of human resources, which in turn can potentially affect the overall development of the regional socio-economic system. In addition to the selected investment indicator, which invariably has a positive impact on the state of human resources, it is necessary to highlight indicators that reflect the negative impact on the natural resources of a region. The necessary condition of full or partial controllability determines the technogenic nature of these indicators. Thus, the most appropriate indicator in this case is the volume of emissions of harmful (polluting) substances. This indicator is multidimensionally manageable, which is determined by the possibility of reducing the volume of manufacturing products, the technological process of production, accompanied by significant emissions of pollutants, and the possibility of compensating for this impact by improving the systems for cleaning and making up for emitted pollutants. The impact of changes in this indicator on the state of human resources is reversible, which determines the need to reduce it. The combination of the above indicators is necessary and sufficient for describing natural factors' impact on human resources in the framework of the development of a regional socio-economic system. Other natural factors are neither fully nor partially controllable, forming the basis for an exclusive evaluation model that is unsuitable for managing the development of regional socio-economic systems.

Next, it is necessary to consider a set of factors that multidimensionally describe the state of material resources that form both internal and external environments. This set can be conditionally divided into production factors and infrastructure factors. The essence of production factors is determined by the state of the material resources used in the process of generating wealth. This set of resources can be divided in accordance with the sign of turnover, as well as with the nature of the participation in the production process. The general comparative state of fixed production assets can be described by the indicator of the use of production capacities. It may also be conditionally expedient to use the value of accumulated depreciation as the analysed indicator of the input influence. However, this indicator has significant industry specifics, which determines the need for an industry specification of the model, in turn contradicting the goal set in this study. The indicator of production capacity utilisation is measured as a percentage, essentially reflecting the share of the actively used production potential of the region under study. This indicator is exclusively manageable and can be largely regulated by the subjects of management of the regional socio-economic system, both directly, by placing a state order, and indirect-

ly, by setting special conditions for the functioning of regional enterprises. The increase in this indicator has a direct impact on the state of human resources, primarily due to the regional labour market saturation with supply and the decrease in social tension in this regard, as well as the creation of a socially safe environment. The GRP per capita should also be considered as a complex factor of production. This indicator is dualistic in nature, and in many respects is the result. However, in modern conditions of the development of regional socio-economic systems, the complex result, which is directly the GRP per capita, is determined not so much by the conditional efficiency of able-bodied human resources, as by the efficiency, adaptability and predictability of the process of its formation, at both the technological and administrative levels. At the same time, it is the GRP per capita that essentially reflects the population's level of well-being, which in turn directly affects the state of human resources. Thus, the GRP per capita is the most appropriate factor to use as an indicator of the input impact.

In parallel with the development of the production environment, the integrated development of regional socio-economic systems invariably involves the development of infrastructure as a connecting inter-production resource. The degradation and unsatisfactory state of the regional infrastructure determine the increase in logistics costs, in turn leading to greater complexity of the interaction between the population and the business in both the production process and the consumption process. Among the indicators reflecting the state of infrastructure factors, it is most appropriate to single out the indicator of the availability of road transport, differentiated into public (in particular, buses, representing the most versatile type of public transport) and private (in particular, cars). This indicator can also be supplemented by an indicator of the length of public roads.

The presented set of input influence factors can potentially be supplemented by a set of indicators reflecting the state of the healthcare system, education and other social indicators. As part of this study, among the indicators reflecting the state of the social environment, it was decided that the following would be used: the number of students in general education institutions receiving meal subsidies, the ratio of healthcare institutions using the internet to the total number of healthcare institutions, as well as real accrued wages as a percentage of those earned in the corresponding period in the previous year.

Next, it is necessary to consider the totality of the resulting indicators in relation to the human resources. Such an environment is manifested in a set of indicators reflecting the level of social security, such as the number of offences in the context of the main articles of the Criminal Code of the Russian Federation, as well as in a set of indicators reflecting the conditional "improvement" of society, such as the volume of consumed alcoholic beverages and drugs.

It is also essential to separately note the increase in the unemployment rate as a result of the reverse conversion of the increment in the main indicators of input influence. The totality of the resulting indicators is presented in Table 2.

The above set of indicators can be aggregated in a single conceptual model (Figure 2).

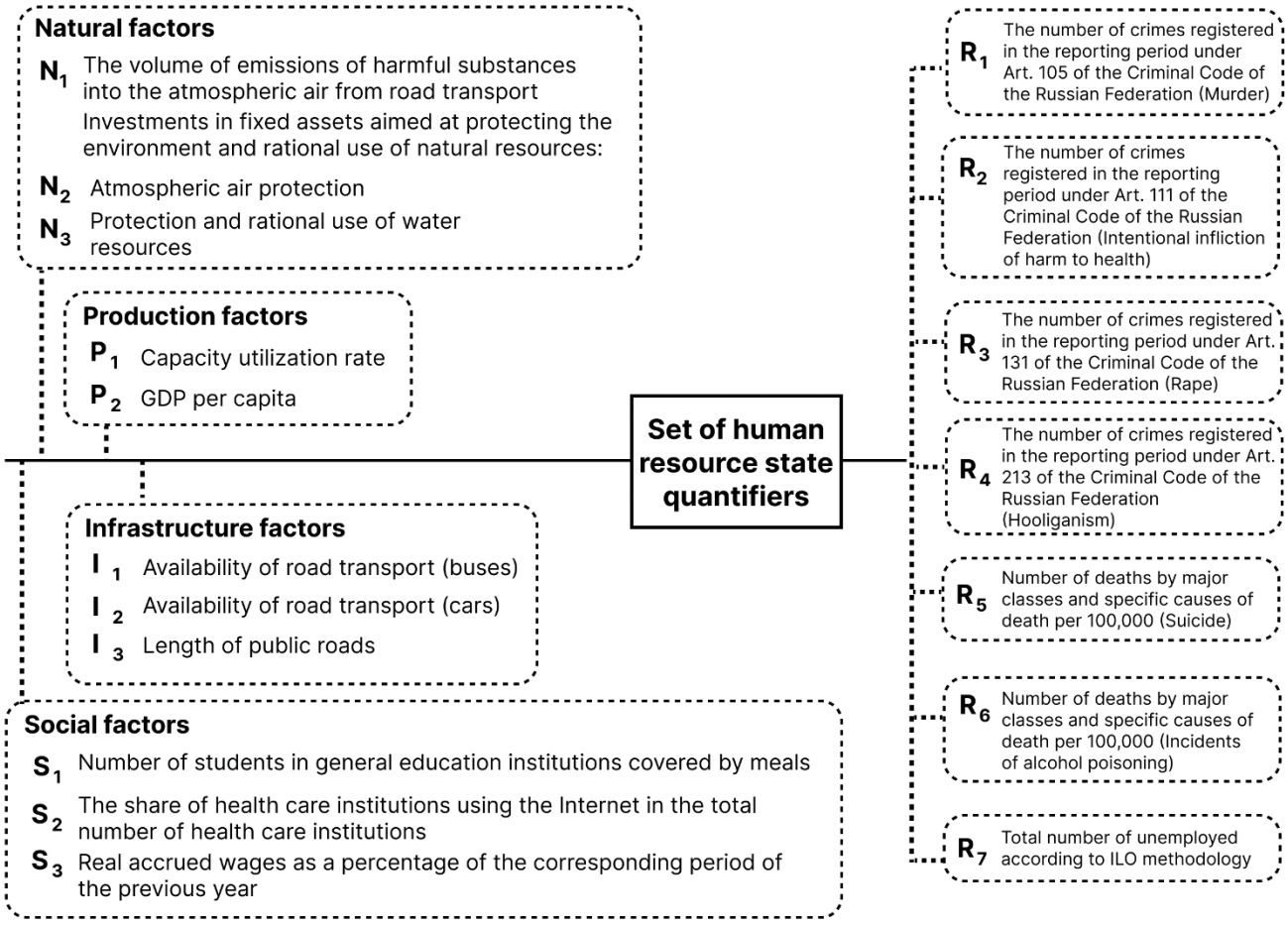

Figure 2. Conceptual model for managing the development of regional socio-economic systems (Rodionov et al., 2021)

As shown in Figure 2, the core of the conceptual model for managing the socially safe development of regional socio-economic systems is the set of quantifiers of the state of human resources. These quantifiers can be aggregated, based on the analysis of the comparative state of the communicative manifestations of a region's population. Such a thesis assumes that the psychological state of the representatives of society relates to the results of their professional activities and other social manifestations.

The state of human resources can be differentiated in accordance with a variety of classification features (Kulibanova, Teor, 2018; Kulibanova, 2018); however, the most appropriate one in this study is the allocation of social (Karpenko et al., 2018) and emotional characteristics of human resources. Two of the key properties of the process of forming these characteristics are consistency and duration, which determine the need to consider the significant time lag in the conversion of managerial impact, which theoretically takes several years.

Development requires a methodology for assessing the emotional characteristics of human resources, effectively reflecting the state of such resources. The key properties of primary information in the framework of the analysis are objectivity, relevance and universality.

As a rule, the key emotional (tonal) characteristics of natural information, include positivity, negativity and neutrality. These tonal characteristics can be called primary. The assessment of these parameters in relation to the information flow of the regional socio-economic system can be differentiated by the following indicators:

$T_{c_i}^{neut}$ – the level of neutral sentiment of information unit *i*, which describes the state of the regional socio-economic system

$T_{c_i}^{pos}$ – the level of positive sentiment of information unit *i*, which describes the state of the regional socio-economic system

$T_{c_i}^{neg}$ – the level of negative sentiment of information unit *i*, which describes the state of the regional socio-economic system

$T_{com_i}^{neut}$ – the level of neutral tone of information unit *i*, which describes the human resources' reaction to the state of the regional socio-economic system

$T_{com_i}^{pos}$ – the level of positive sentiment of information unit *i*, which describes the human resources' reaction to the state of the regional socio-economic system

$T_{com_i}^{neg}$ – the level of negative sentiment of information unit *i*, which describes the human resources' reaction to the state of the regional socio-economic system

The presented set of indicators, based solely on the analysis of primary information, may not fully reflect the dynamic changes in the state of human resources. An addition to this parameter is the general level of emotionality of the information unit, equal to the ratio of the sum of the levels of positive and negative sentiments to the level of the neutral sentiment of the information unit. The mathematical interpretation of these indicators is represented by formulas 1–4.

$T_{c_i}^{dis} = \frac{T_{c_i}^{pos}}{T_{c_i}^{neg}}$	(1)	$T_{com_i}^{dis} = \frac{T_{com_i}^{pos}}{T_{com_i}^{neg}}$	(3)
$T_{c_i}^{full} = \frac{\left(T_{c_i}^{pos} + T_{c_i}^{neg}\right)}{T_{c_i}^{neut}}$	(2)	$T_{com_i}^{full} = \frac{\left(T_{com_i}^{pos} + T_{com_i}^{neg}\right)}{T_{com_i}^{neut}}$	(4)

with the following definitions:

$T_{c_i}^{dis}$ – the level of the tonal gap of information unit *i*, which describes the state of the regional socio-economic system

$T_{com_i}^{dis}$ – the level of the tonal gap of information unit *i*, which describes the human resources' reaction to the state of the regional socio-economic system

$T_{c_i}^{full}$ – the general level of emotionality of information unit *i*, which describes the state of the regional socio-economic system

$T_{com_i}^{full}$ – the general level of emotionality of information unit *i*, which describes the human resources' reaction to the state of the regional socio-economic system

The above set of indicators allows us to describe the tonal colour as a general news flow and a reactive information flow. The key characteristic reflecting the state of human resources is the ratio of these tonal characteristics, which determines the tonal gap. The mathematical interpretation of these indicators is represented by formulas 5–9:

$$D_i^{neut} = \sqrt{\left(T_{c_i}^{neut} - T_{com_i}^{neut}\right)^2} \quad (5)$$

$$D_i^{pos} = \sqrt{\left(T_{c_i}^{pos} - T_{com_i}^{pos}\right)^2} \tag{6}$$

$$D_i^{neg} = \sqrt{\left(T_{c_i}^{neg} - T_{com_i}^{neg}\right)^2} \tag{7}$$

$$D_i^{dis} = \sqrt{\left(\frac{T_{c_i}^{pos}}{T_{c_i}^{neg}} - \frac{T_{com_i}^{pos}}{T_{com_i}^{neg}}\right)^2} \tag{8}$$

$$D_i^{full} = \sqrt{\left(\frac{\left(T_{c_i}^{pos} + T_{c_i}^{neg}\right)}{T_{c_i}^{neut}} - \frac{\left(T_{com_i}^{pos} + T_{com_i}^{neg}\right)}{T_{com_i}^{neut}}\right)^2} \tag{9}$$

with the following definitions:

D_i^{neut} – a break in the level of the neutral tone of information unit *i*, which describes the state of the regional socio-economic system and the reactive information units in relation to it

D_i^{pos} – a gap in the level of positive sentiment of information unit *i*, which describes the state of the regional socio-economic system and the reactive information units in relation to it

D_i^{neg} – a gap in the level of negative sentiment of information unit *i*, which describes the state of the regional socio-economic system and the reactive information units in relation to it

D_i^{dis} – a gap in the tone of information unit *i*, which describes the state of the regional socio-economic system and the reactive information units in relation to it

D_i^{full} – a gap in the general level of emotionality of information unit *i*, which describes the state of the regional socio-economic system and the reactive information units in relation to it

The literature review is based on the materials presented by the cited authors (Karpenko et al., 2018; Rodionov et al., 2021).

3. Methods and Materials

The above technique can be automated using the Python programming language. At the initial stage of the presented methodology, both the information describing the state of the regional socio-economic system and the reactive information in relation to it are searched and aggregated. As part of the implementation of this algorithm, it is advisable to use the social network VKontakte. This choice is primarily due to the breadth of coverage of the population, which is on average 90% at the regional level. To test the developed methodology, the city of federal significance, St Petersburg, was chosen as the case study. One of the most dynamic and widespread concentrators of news information of the regional socio-economic system in the case of St Petersburg is the Vesti St Petersburg community. As an officially registered mass media, this community exclusively contains news information of regional importance and targets the most communicatively active audience.

The Dostoevsky instrumental library was chosen for the purpose of assessing the sentiments of both news information and reactive information. Based on the results of assessing the primary characteristics of the tonality of the information units, the previously presented characteristics of the tonal gap, which directly characterise the state of human resources, are calculated and aggregated.

In accordance with the previously presented conceptual model for managing the development of regional socio-economic systems, its core determines the conversion of the set of quantifiers of the state of human resources, expressed by the tonal gap of the information environment. The average dynamics of the primary indicators of the tonal gap are formally logically justified, which indirectly confirms the feasibility of the mathematical formalisation of the built conceptual model through the classical methodology of regression analysis.

The regression quality criteria applied in this work are defined as follows:

- the significance of the models is assessed using Fisher's F-test. In the framework of this study, the limit value of this criterion is taken to be 0.1 or 10%;

- the quality of the model is determined primarily by the volume of the explained variance of the endogenous variable, as indicated by the coefficient of determination (R2);

- the level of significance of the relation between the endogenous variable and the exogenous variables included in the model is determined by the p-level of significance of each variable. In the multiple regression equations, the specificity of the sample described above determines a potentially sufficiently high p-level of significance for the studied regressors. Therefore, compared with Fisher's F-test, a significantly more significant threshold is determined for this indicator, up to 0.2 or 20%. The backward method is used as an optimisation method in this study;

- the applied quality of describing the variance of an endogenous variable by the variance of exogenous variables is determined by the average approximation error, standard deviation, characteristics of structural outliers and structural gaps, among many others;

- the most significant binary quality criterion of a regression model is the rationale for the direction of the impact of an exogenous variable on an endogenous one.

4. Results and Discussion

Let us consider the impact of natural factors on the gap in the level of the positive tone in a regional socio-economic system's information environment. Based on the results of the primary analysis and optimisation, the following regression equation is obtained (formula 10):

$$D_i^{pos} = -0,037 + 0,0004 * N_{1_i} + (1,3-06) * N_{3_i} \quad (10)$$

In the framework of the resulting equation, the p-significance level of all regressors corresponds to the established criterion. The value obtained from Fisher's F-test is 0.0018, indicating the high significance of the resulting regression equation. The coefficient of determination of this equation is 0.955, from which it can be concluded that the variance of the "volume of emissions of harmful (pollutant) substances into the atmospheric air from road transport" and the variance of "investments in fixed assets aimed at protecting the environment and rational use of natural resources (protection and rational use of water resources)" explain about 96% of the dispersion of the gap in the level of positive sentiment in the regional socio-economic system's information environment. Of course, a significant part of the uniformity of variances is determined by systemic changes; however, even taking into account possible errors, this value indicates the high quality of the generated regression equation. To assess the applied quality of the model, we should compare the theoretical and actual values of the endogenous variable, as well as the boundaries of the acceptable interval (Figure 3).

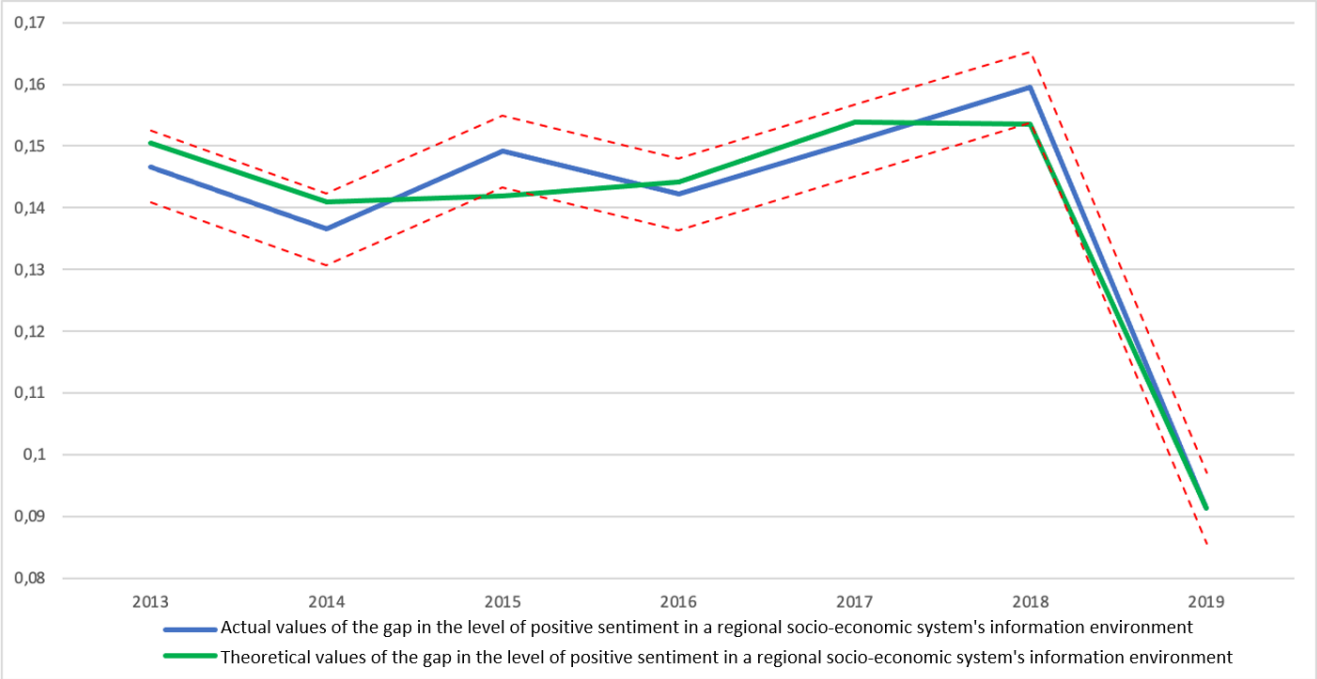

Figure 3. Dynamics of actual and theoretical values of the gap in the level of positive sentiment in a regional socio-economic system's information environment, depending on natural factors (Karpenko, 2021)

As shown in the graph (Figure 3), the overall dynamics of the actual and theoretical values of the gap in the level of positive tonality in a regional socio-economic system's information environment are comparable, indicating the high quality of the generated regression equation. Of course, an insignificant structural outlier appears in 2015, primarily due to the insignificant value of the standard deviation because of which the boundaries of the permissible interval are extremely strict. Due to this specificity, the corresponding structural outlier can be ignored.

The above equation determines the direct nature of the impact of the "volume of emissions of harmful (pollutant) substances into the atmospheric air from road transport" and "investments in fixed assets aimed at protecting the environment and rational use of natural resources (protection and rational use of water resources)" on the gap in the level of the positive tone in a regional socio-economic system's information environment. Regarding the first factor, a formal–logical connection is observed, while the impact of the second factor shows a contradictory nature. This impact can be substantiated by a potential lag in the impact on the specifics of the use of water resources. Consequently, from the management perspective, the "volume of emissions of harmful (polluting) substances into the air from road transport" is primary (indicator N1). The coefficient of elasticity of this indicator is 1.008%.

Let us consider the impact of production factors on the gap in the level of positive tonality in the regional socio-economic system's information environment. Based on the results of the primary analysis and optimisation, the following regression equation is obtained (formula 11):

$$D_i^{pos} = 2,269 - 0,021 * P_{2_i} \quad (11)$$

In the framework of the resulting equation, the p-significance level of the residual regressor corresponds to the established criterion. The value obtained from Fisher's F-test is 0.07, indicating a sufficient significance of the resulting regression equation. The coefficient of determination of this equation is 0.5, from which it can be concluded that the dispersion of "GRP per capita" explains about 50% of the dispersion of the gap in the level of positive sentiment in the regional socio-economic system's information environment. This value is insufficient to interpret the model as having high quality but enough to accept the model. For a paired regression model with macrospecificity, such value is acceptable for further re-

search. To assess the applied quality of the model, the theoretical and actual values of the endogenous variable, the boundaries of the acceptable interval, are compared (Figure 4).

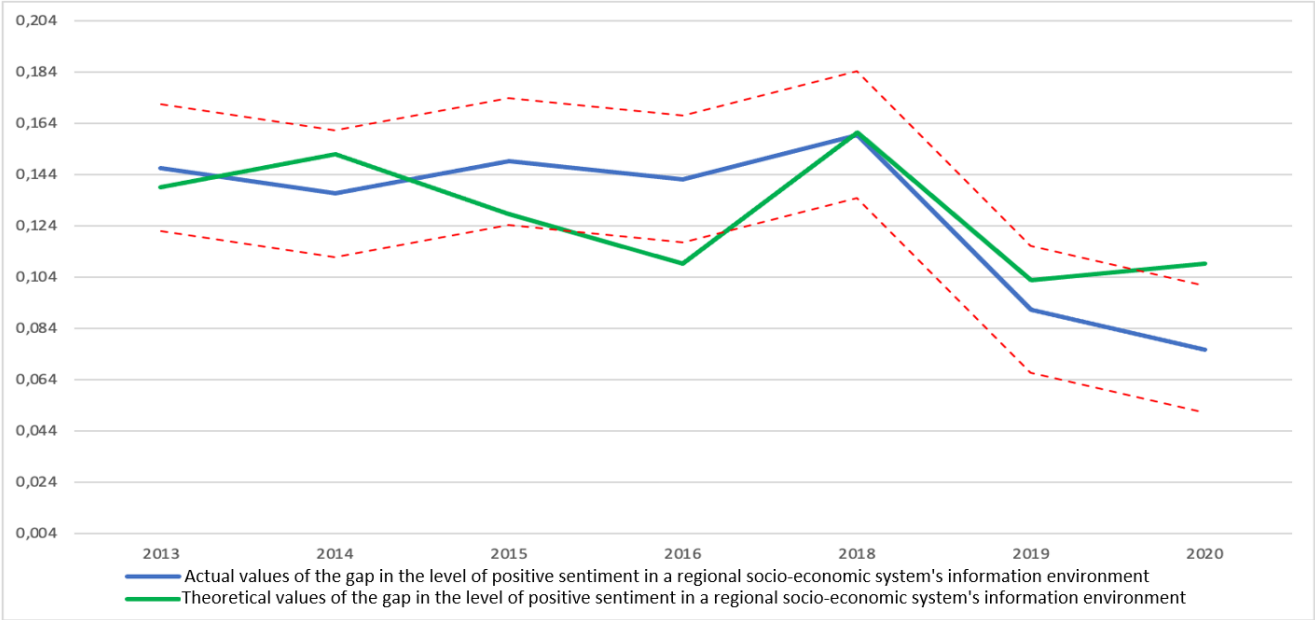

Figure 4. Dynamics of actual and theoretical values of the gap in the level of positive sentiment in a regional socio-economic system's information environment, depending on production factors (Karpenko, 2021)

As shown in the graph (Figure 4), the overall dynamics of the actual and theoretical values of the gap in the level of positive tonality in the regional socio-economic system's information environment are comparable, indicating the sufficient quality of the generated regression equation. However, structural gaps are observed in 2016 and 2020. This specificity is due, first of all, to significant non-economic shocks in these periods, particularly the COVID-19 pandemic. Due to this specificity, the corresponding structural outliers can be ignored.

The given equation of pair regression (formula 11) reflects the reverse effect of the change in the "GRP per capita" on the gap in the level of positive tonality in the regional socio-economic system's information environment, which in turn is formally and logically substantiated. At the same time, the coefficient of elasticity of this indicator is -16.6%, indicating an extremely strong influence of production specifics on the change in the gap in the level of positive sentiment. Thus, this indicator is primary in terms of managing the development of the regional socio-economic system.

Let us consider the impact of infrastructural factors on the gap in the level of positive sentiment in the regional socio-economic system's information environment. Based on the results of the primary analysis and optimisation, the following regression equation is obtained (formula 12):

$$D_i^{pos} = 0,589 - 0,00013 * I_{3_i} \quad (12)$$

In the framework of the resulting equation, the p-significance level of the residual regressor corresponds to the established criterion. The value obtained from Fisher's F-test is 0.14, indicating the insufficient significance of the obtained regression equation. This fact determines the need to exclude this model from the previously formulated conceptual equation. However, the coefficient of determination of this equation is only 0.32, which indicates the relative secondary nature of factor I3, "length of public roads". Moreover, the relation is inverse, which is not logically interpreted. Thus, it can be established that infrastructural factors have no significant impact on the gap in the level of positive sentiment in the regional socio-economic system's information environment. This fact may be due to the extreme differentiation of the infrastructural conditions of the regions, as well as the human resources' relative

adaptation to these conditions.

In conclusion, it is necessary to consider the impact of social factors on the gap in the level of the positive tone in the regional socio-economic system's information environment. Based on the results of the primary analysis and optimisation, the following regression equation is obtained (formula 13):

$$D_i^{pos} = -3,54 + 0,038 * S_{2_i} - 0,0007 * S_{3_i} \quad (13)$$

In the framework of the resulting equation, the p-significance level of the residual regressor corresponds to the established criterion. The value obtained from Fisher's F-test is 0.017, indicating the sufficient significance of the obtained regression equation. The coefficient of determination of this equation is 0.71, from which it can be concluded that the variance of the "ratio of healthcare institutions using the internet to the total number of healthcare institutions" and the variance of "real accrued wages as a percentage of those earned in the corresponding period in the previous year" explain about 71% of the variance of the gap in the level of positive tonality in the regional socio-economic system's information environment. This value is necessary and sufficient for the interpretation of the model as having high quality. To assess the applied quality of the model, we should compare the theoretical and actual values of the endogenous variable, as well as the boundaries of the acceptable interval (Figure 5).

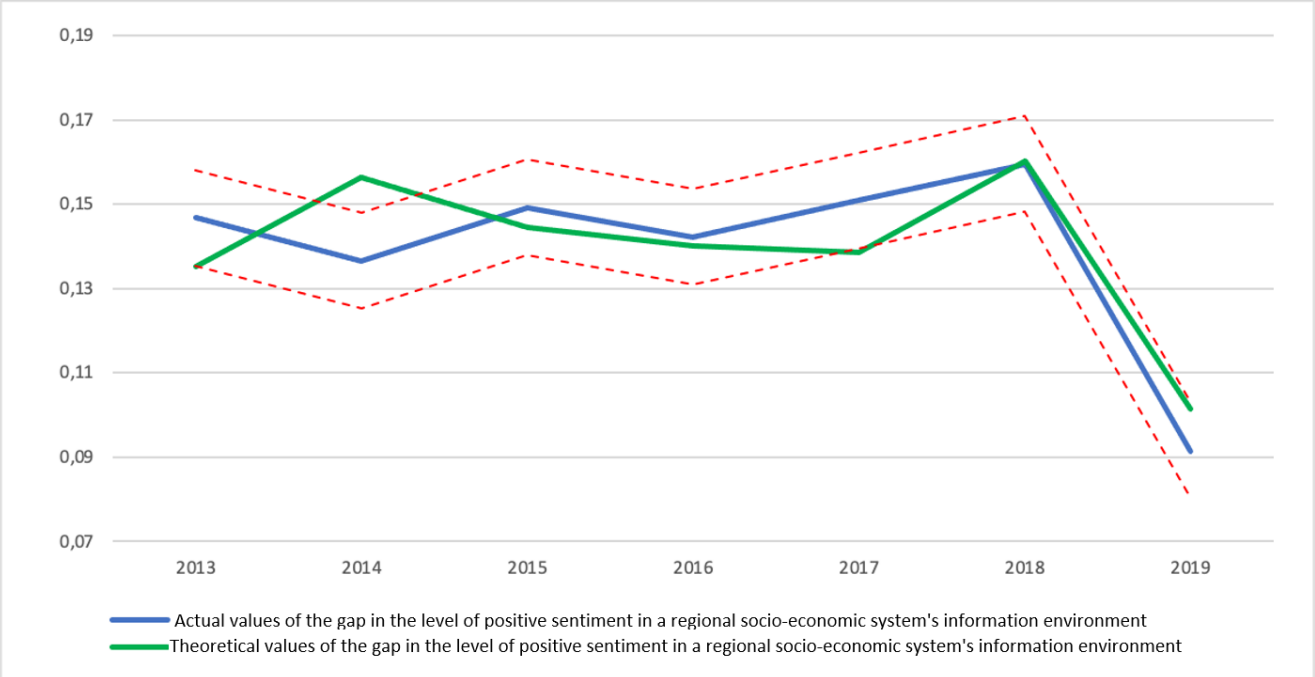

Figure 5. Dynamics of actual and theoretical values of the gap in the level of positive sentiment in the regional socio-economic system's information environment, depending on social factors (Karpenko, 2021)

As shown in Figure 5, the overall dynamics of the actual and theoretical values of the gap in the level of positive tonality in the regional socio-economic system's information environment are comparable, indicating the sufficient quality of the generated regression equation. However, a structural gap appears in 2014. This specificity is due, first of all, to economic shocks caused by fluctuations in the exchange rate of the national currency. Due to this specificity, the corresponding structural outlier can be ignored.

The above regression equation reflects the reverse effect of the change in "real accrued wages as a percentage of those earned in the corresponding period in the previous year" on the gap in the level of positive sentiment in the regional socio-economic system's information environment, which in turn is formally and logically substantiated. However, the direct impact of the change in the "ratio of healthcare institutions using the internet to the total number of healthcare institutions" determines the need to

exclude it from further analysis. Thus, in this case, indicator S3, "real accrued wages as a percentage of those earned in the corresponding period in the previous year", is decisive. At the same time, the coefficient of elasticity of this indicator is -0.52%. Based on the results of the regression analysis, infrastructural factors, as well as some natural, industrial and social factors, can be completely excluded.

Next, it is necessary to consider the resulting part of the conceptual model, which describes the impact of the core (the state of human resources) on the set of resulting indicators. The system of criteria described earlier is also preserved for these paired regression equations. First, we consider the impact of changing the gap in the level of positive sentiment in the regional socio-economic system's information environment on indicator R1, "the number of crimes (murder) registered in the reporting period under Art. 105 of the Criminal Code of the Russian Federation". Based on the results of the analysis, the following regression equation is obtained (formula 14):

$$R_{1_i} = 75,6 + 930,7 * D_i^{pos} \quad (14)$$

The value obtained from Fisher's F-test is 0.05, indicating the model's sufficient level of significance. However, the coefficient of determination is 0.49, which explains less than 50% of the variance of the endogenous variable. Since only a pairwise regression model is considered, it can be assumed that this level is sufficient in an isolated form. A comparison of the dynamics of the actual and theoretical values of the endogenous variable confirms this thesis.

As shown in Figure 6, the actual dynamics of the number of crimes (murder|) registered in the reporting period under Art. 105 of the Criminal Code of the Russian Federation are sufficiently different from the theoretical one. Thus, it can be argued that the management of this indicator through the administration of the information environment is mathematically possible but not effective enough.

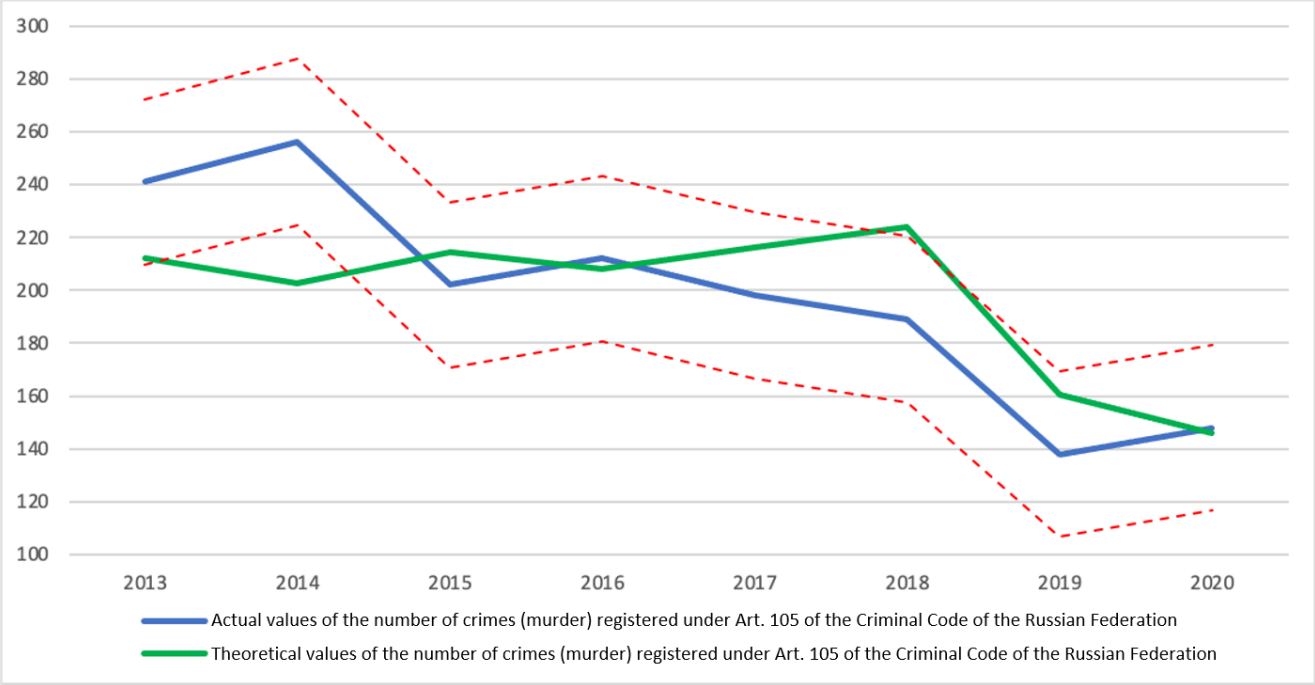

Figure 6. Dynamics of actual and theoretical values of the number of crimes (murder) registered under Art. 105 of the Criminal Code of the Russian Federation, depending on the gap in the level of positive sentiment in the regional socio-economic system's information environment (Karpenko, 2021)

The use of this approach to management is expedient only in combination with other, more effective tools. The coefficient of elasticity in this case is 0.62%, which is logically justified.

Next, we consider the impact of changing the gap in the level of positive tonality in the regional socio-economic system's information environment on indicator R2, "the number of crimes (intentional

infliction of harm to health) registered in the reporting period under Art. 111 of the Criminal Code of the Russian Federation". Based on the results of the analysis, the following regression equation is obtained (formula 15):

$$R_{2_i} = 257,7 + 1434,5 * D_i^{pos} \quad (15)$$

The value obtained from Fisher's F-test is 0.08, indicating the model's sufficient level of significance. However, in this case, the coefficient of determination is 0.41, which explains only 41% of the variance of the endogenous variable. A comparison of the dynamics of the actual and theoretical values of the endogenous variable is shown in Figure 7.

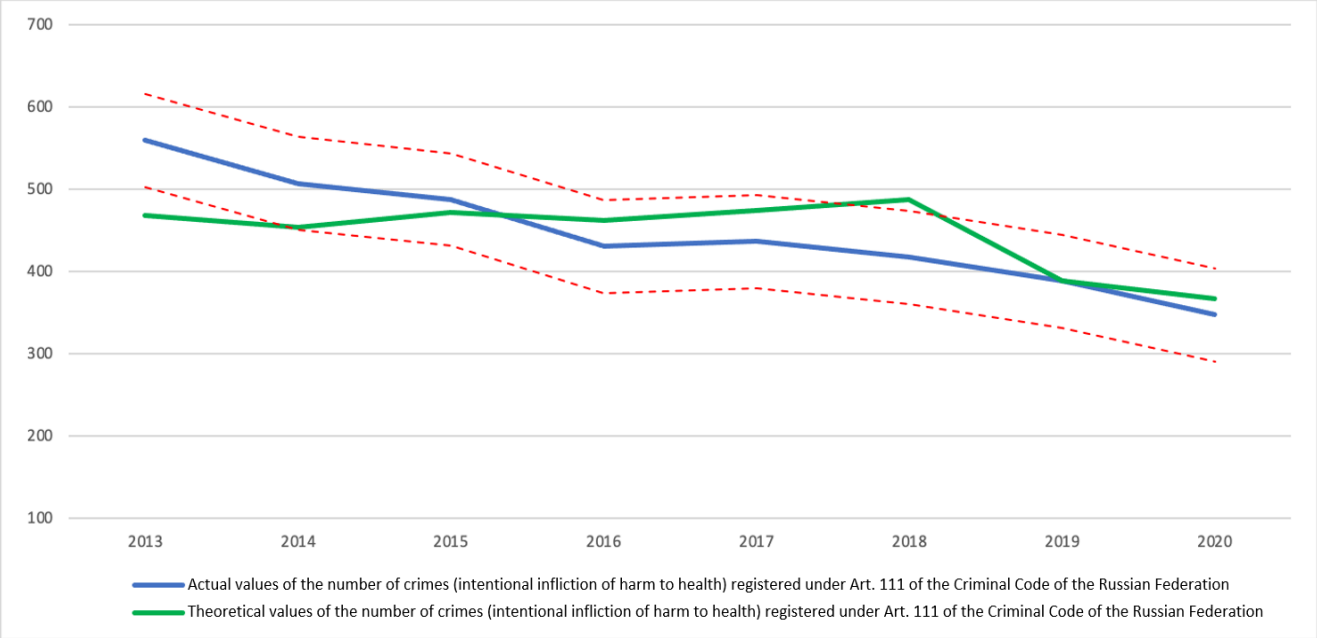

Figure 7. Dynamics of actual and theoretical values of the number of crimes (intentional infliction of harm to health) registered under Art. 111 of the Criminal Code of the Russian Federation, depending on the gap in the level of positive sentiment in the regional socio-economic system's information environment (Karpenko, 2021)

As illustrated in Figure 7, the actual dynamics of the number of crimes (intentional infliction of harm to health) registered in the reporting period under Art. 111 of the Criminal Code of the Russian Federation sufficiently differ from the theoretical one. At the same time, until 2018, the dynamics have been multidirectional, indicating a potentially extremely low efficiency of influencing this indicator by managing the region's information environment. The use of this approach to management is expedient only in combination with other, more effective tools. The coefficient of elasticity in this case is 0.42%, which is logically justified.

Next, we consider the impact of changing the gap in the regional socio-economic system's information environment on indicator R3, "the number of crimes (rape) registered in the reporting period under Art. 131 of the Criminal Code of the Russian Federation". Based on the results of the analysis, the following regression equation is obtained (formula 16):

$$R_{3_i} = 30,67 + 234,46 * D_i^{pos} \quad (16)$$

The value obtained from Fisher's F-test is 0.075, indicating the model's sufficient level of significance. The coefficient of determination is 0.43, which explains only 43% of the variance of the endogenous variable, representing an insignificant result. A comparison of the dynamics of the actual and theoretical values of the endogenous variable is shown in Figure 8.

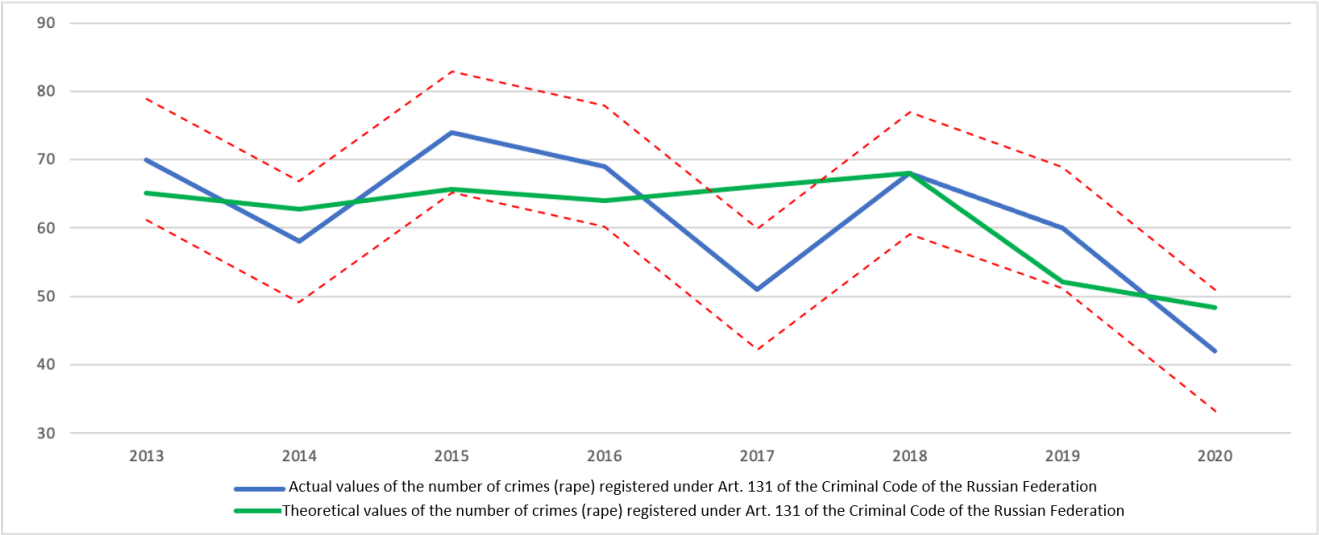

Figure 8. Dynamics of actual and theoretical values of the number of crimes (rape) registered under Art. 131 of the Criminal Code of the Russian Federation, depending on the gap in the level of positive sentiment in the regional socio-economic system's information environment (Karpenko, 2021)

As shown in Figure 8, the actual dynamics of the number of crimes (rape) registered in the reporting period under Art. 131 of the Criminal Code of the Russian Federation are comparable to the theoretical one. However, the much smaller amplitude of the change indicates a relatively low level of conversion of a potential managerial impact. The coefficient of elasticity in this case is 0.5%, which is more significant relative to the indicators considered earlier. Thus, the management of the information environment in the context of reducing the number of crimes (rape) registered in the reporting period under Art. 131 of the Criminal Code of the Russian Federation is expedient only in combination with other, more effective tools.

Next, we consider the impact of changing the gap in the level of positive tonality in the regional socio-economic system's information environment on indicator R4, "the number of crimes (hooliganism) registered in the reporting period under Art. 213 of the Criminal Code of the Russian Federation". Based on the results of the analysis, the following regression equation is obtained (formula 17):

$$R_{3_i} = 140,9 - 295,269 * D_i^{pos} \quad (17)$$

The value obtained from Fisher's F-test is 0.12, indicating the model's insignificance. In combination with the inverse nature of the established relation, it can be unequivocally stated that the management of the information environment in the context of reducing the number of crimes (hooliganism) registered in the reporting period under Art. 213 of the Criminal Code of the Russian Federation is statistically inappropriate. An identical situation applies to indicator R5, "the number of deaths (suicide) by main classes and individual causes of death per 100,000 people". The value obtained from Fisher's F-test of the generated equation is 0.17, which also reveals the model's insignificance.

Next, we consider the impact of changing the gap in the level of positive tonality in the regional socio-economic system's information environment on indicator R6, "the number of deaths (cases of alcohol poisoning) by main classes and individual causes of death per 100,000 people". Based on the results of the analysis, the following regression equation is obtained (formula 18):

$$R_{6_i} = 3,016 + 20,12 * D_i^{pos} \quad (18)$$

The value obtained from Fisher's F-test is 0.04, indicating the model's high level of significance. The coefficient of determination is 0.52, which is a relatively high result. A comparison of the dynamics of the actual and theoretical values of the endogenous variable is shown in Figure 9.

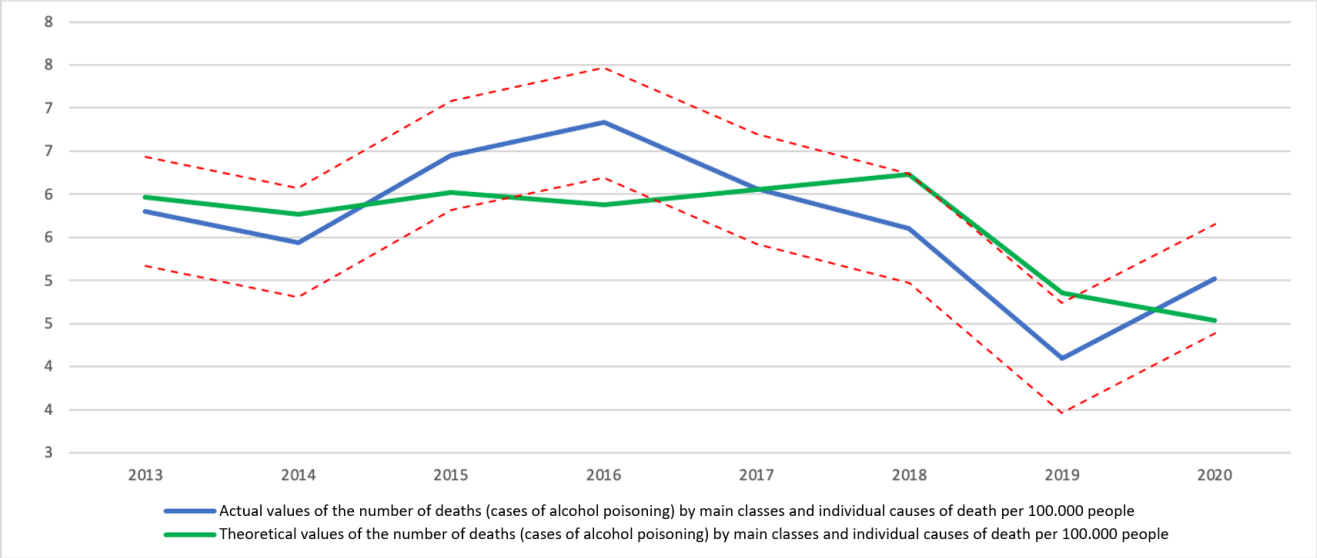

Figure 9. Dynamics of actual and theoretical values of the number of deaths (cases of alcohol poisoning) by main classes and individual causes of death per 100,000 people, depending on the gap in the level of positive sentiment in the regional socio-economic system's information environment (Karpenko, 2021)

As depicted in Figure 9, the actual dynamics of the number of deaths (cases of alcohol poisoning) by main classes and individual causes of death per 100,000 people are comparable to the theoretical one. The minor structural breaks in 2016 and 2018 most likely have economic and social underlying causes. The coefficient of elasticity in this case is 0.47%, which is significant enough. Thus, the management of the information environment in the context of reducing the number of cases of alcohol poisoning is quite appropriate.

In conclusion, let us consider a more specific indicator, which differs significantly from the previously considered "total number of unemployed in accordance with the methodology of the ILO" (R7). The value obtained from Fisher's F-test is 0.15, indicating the model's insignificance. In combination with the inverse nature of the established relation, it can be unequivocally stated that the management of the information environment in the context of reducing the total number of unemployed is statistically inappropriate.

5. Conclusion

In accordance with the confirmed conceptual model, it can be concluded that the volume of emissions of harmful (polluting) substances into the air, the GRP per capita and real accrued wages as a percentage of those earned in the corresponding period in the previous year play a decisive role in managing the region's information environment. This specificity determines the primacy of economic factors in the formation of a tonal gap in the information environment. Consequently, it is the economy that acts as the primary mediator of the development of the regional socio-economic system. Thus, a direct beneficial impact on the population's welfare outside the context of improving the infrastructure and social environment will significantly reduce the resulting indicators associated with mortality, whose conversion can be effectively managed through continuous monitoring of the tonal gap in the information environment and can affect the regional authorities' provision of social security. However, regional specifics must also be considered. Since this model is specified for St Petersburg, based on its management analysis, it is necessary to formulate a set of recommendations for the socially safe development of the regional socio-economic system.

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References

Basiago, A.D., 1998. Economic, Social, and Environmental Sustainability in Development Theory and Urban Planning Practice. Environmentalist 19(2), 145–161.

Karpenko, P.A., 2021. Mathematical Description of the Conceptual Model of Managing the Development of Regional Socio-Economic Systems of the Russian Federation. Bulletin of the Altai Academy of Economics and Law 9(1), 69–74.

Karpenko, P.A., Gazizulina, A.Y., Kikkas, K.N., Akri, E.P., Sharok, V.V., Papich L., 2018. Analysis of the Quality of Personnel Performance Based on Social Characteristics, in: Proceedings of the International Conference on Soft Computing and Measurement: FGAOU VO. St Petersburg State Electrotechnical University LETI named after VI Ulyanov (Lenina) 2, pp. 243–246.

Kharazishvili, Y., Kwilinski, A., Grishnova, O., Dzwigol, H., 2020. Social Safety of Society for Developing Countries to Meet Sustainable Development Standards: Indicators, Level, Strategic Benchmarks (with calculations based on the case study of Ukraine). Sustainability 12(21), 8953.

Kisurkin, A.A., 2012. Factors Influencing the Innovative Development of the Region and Their Classification by Management Levels. Modern Problems of Science and Education 2, 294.

Koshelev, E., 2023. Model of Motivation for the Top Management of Regional Government Agencies. Sustainable Development and Engineering Economics 4, 65–80.

Kulibanova, V.V., 2018. Investments in Human Capital as a Basis for the Innovative Development of the Region, in: Actual Problems of Labor and Human Development: University-Academic Collection of Scientific Papers, St Petersburg State University of Economics, St Petersburg, pp. 99–103.

Kulibanova, V.V., Teor, T.R., 2018. The Relevance of Identifying Groups of Stakeholders in the Context of the Regulation of Regional Socio-Economic Systems, in: Problems of Transformation and Regulation of Regional Socio-Economic Systems: A Collection of Scientific Articles. Institute for Problems of Regional Economics of the Russian Academy of Sciences, St Petersburg State University of Aerospace Instrumentation, St Petersburg, pp. 79–82.

Malakhova, L.A., Malakhov, V.P., Rakhimova, G.S., Korobkova, M.A., 2020. Management of Regional Social and Economic Systems, in: Proceedings of the First International Volga Region Conference on Economics, Humanities and Sports: FICEHS 2019. Atlantis Press, 141–144.

Nikonov, O.I., Krivorotov, V.V., Kalina, A.V., 2011. Methodological Approach to the Study of Sustainable and Safe Social and Economic Development of the Territories.

Pastushenko, P.P., Obikhod, G.O., Khvesik, Y.M., 2021. Safe Guidelines for the Sustainable Socio-Ecological and Economic Development: Regional Aspect. A Social Kaleidoscope 2(5), 102–112.

Rodionov, D.G., Karpenko, P.A., Konnikov E.A., 2021. The Method of Quantification of the State of Labor Resources in the Context of Managing the Development of a Regional Socio-Economic System. Economic Sciences 197, 171–179.

Rodionov, D.G., Karpenko, P.A., Konnikov, E.A., 2021. Conceptual Model of Managing the Development of Regional Socio-Economic Systems. Economic Sciences 197, 163–170.

Tatarkin, A.I., Doroshenko, S.V., 2011. Region as a Self-Developing Socio-Economic System: Crossing the Crisis. Economy of Regions 1, 15.

Voit, D.S., 2019. Management Models of the Region's Economic Development in the Conditions of Socialization. Economic horizons 3(10), 83–93.

Список источников

Basiago, A.D., 1998. Economic, Social, and Environmental Sustainability in Development Theory and Urban Planning Practice. Environmentalist 19(2), 145–161.

Karpenko, P.A., 2021. Mathematical Description of the Conceptual Model of Managing the Development of Regional Socio-Economic Systems of the Russian Federation. Bulletin of the Altai Academy of Economics and Law 9(1), 69–74.

Karpenko, P.A., Gazizulina, A.Y., Kikkas, K.N., Akri, E.P., Sharok, V.V., Papich L., 2018. Analysis of the Quality of Personnel Performance Based on Social Characteristics, in: Proceedings of the International Conference on Soft Computing and Measurement: FGAOU VO. St Petersburg State Electrotechnical University LETI named after VI Ulyanov (Lenina) 2, pp. 243–246.

Kharazishvili, Y., Kwilinski, A., Grishnova, O., Dzwigol, H., 2020. Social Safety of Society for Developing Countries to Meet Sustainable Development Standards: Indicators, Level, Strategic Benchmarks (with calculations based on the case study of Ukraine). Sustainability. 12(21), 8953.

Kisurkin, A.A., 2012. Factors Influencing the Innovative Development of the Region and Their Classification by Management Levels. Modern Problems of Science and Education 2, 294.

Koshelev, E., 2023. Model of Motivation for the Top Management of Regional Government Agencies. Sustainable Development and Engineering Economics 4, 65–80.

Kulibanova, V.V., 2018. Investments in Human Capital as a Basis for the Innovative Development of the Region, in: Actual Problems of Labor and Human Development: University-Academic Collection of Scientific Papers, St Petersburg State University of Economics, St Petersburg, pp. 99–103.

Kulibanova, V.V., Teor, T.R., 2018. The Relevance of Identifying Groups of Stakeholders in the Context of the Regulation of Regional Socio-Economic Systems, in: Problems of Transformation and Regulation of Regional Socio-Economic Systems: A Collection of Scientific Articles. Institute for Problems of Regional Economics of the Russian Academy of Sciences, St Petersburg State University of Aerospace Instrumentation, St Petersburg, pp. 79–82.

Malakhova, L.A., Malakhov, V.P., Rakhimova, G.S., Korobkova, M.A., 2020. Management of Regional Social and Economic Systems, in: Proceedings of the First International Volga Region Conference on Economics, Humanities and Sports: FICEHS 2019. Atlantis Press, 141–144.

Nikonov, O.I., Krivorotov, V.V., Kalina, A.V., 2011. Methodological Approach to the Study of Sustainable and Safe Social and Economic Development of the Territories.

Pastushenko, P.P., Obikhod, G.O., Khvesik, Y.M., 2021. Safe Guidelines for the Sustainable Socio-Ecological and Economic Development: Regional Aspect. A Social Kaleidoscope 2(5), 102–112.

Rodionov, D.G., Karpenko, P.A., Konnikov E.A., 2021. The Method of Quantification of the State of Labor Resources in the Context of Managing the Development of a Regional Socio-Economic System. Economic Sciences 197, 171–179.

Rodionov, D.G., Karpenko, P.A., Konnikov, E.A., 2021. Conceptual Model of Managing the Development of Regional Socio-Economic Systems. Economic Sciences 197, 163–170.

Tatarkin, A.I., Doroshenko, S.V., 2011. Region as a Self-Developing Socio-Economic System: Crossing the Crisis. Economy of Regions 1, 15.

Voit, D.S., 2019. Management Models of the Region's Economic Development in the Conditions of Socialization. Economic horizons 3(10), 83–93.

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Research article

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Management of Socioeconomic Development: National Planning and Its Impact on the Human Development Index in Russia

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Abstract

This research focused on the quality assessment of national project management in the Russian Federation as one of the most significant tools aimed at implementing an effective policy for socioeconomic development. The hypothesis was that increased investment in national programmes and their prioritisation in the framework of public administration could improve socioeconomic development in Russia. The human development index (HDI), which directly assesses the level of human development in different countries based on indicators such as life expectancy, education, and well-being, shows this level. This research aimed to assess the efficiency of Russian socioeconomic programmes based on an independent analysis of the HDI. The authors highlight the urgent need for improvement and articulate the range of potential challenges and solutions through a statistical analysis of the correlation between the HDI and indicators of project management costs in Russia and a regression evaluation of project implementation indicators. When implemented, these recommendations can improve the spending efficiency of federal funds, estimated at 8.5 trillion rubles, as well as regional and local funds allocated for executing national projects.

Keywords: socioeconomic development, innovation, national planning, national projects, human development index

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Научная статья

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Государственное Планирование Управления Социально-Экономическим Развитием и Его Влияние на Индекс Человеческого Развития в России

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Аннотация

В основе данной части лежит анализ качества государственного проектного управления в Российской Федерации, как одного из наиболее значимых инструментов реализации политики эффективного социально-экономического развития. Рассматривается гипотеза о том, что увеличение вложений в инструмент государственных программ и выделение его в общей схеме государственного управления является значимым фактором улучшения уровня социально-экономического развития России, выраженного в индексе человеческого развития, который непосредственно оценивает уровень человеческого развития в разных странах на основе таких показателей, как продолжительность жизни, образование и благосостояние. Целью работы является оценка эффективности проведения государственных программ по улучшению социально-экономического положения России на независимую оценку данного развития. В результате проведенного статистического анализа корреляции индекса человеческого развития и показателей затрат на проектное управление в России, а также регрессионной оценки показателей выполнения проектов, авторы приходят к выводам о необходимости их серьезной доработки и формируют перечень проблем и точек роста. При реализации предложенных авторами рекомендаций следует ожидать с экономической точки зрения улучшения эффективности трат средств федерального бюджета, оцениваемых в 8,5 трлн. рублей, а также средств регионального и местного бюджета, определяемых для исполнения национальных проектов.

Ключевые слова: социально-экономическое развитие, инновации, государственное планирование, национальные проекты, индекс человеческого развития

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1. Introduction

This research assessed the quality of public project management in the Russian Federation as one of the most significant tools for implementing an effective policy for socioeconomic development. The leading hypothesis was that increased investment in national programmes and their prioritisation in the overall framework of public administration could improve the level of socioeconomic development in Russia, as expressed by the Human Development Index (HDI).

This research aimed to assess the efficiency of Russian socioeconomic programmes based on an independent analysis of the HDI. In Russia, the blueprint for socioeconomic development is based on the system of the National Projects of the Russian Federation, approved by the Presidential Council for Strategic Development and National Projects on December 24, 2018. The system of projects is classified as type 3 in the state's socioeconomic policy, which is the development of conditions that allow citizens to have the opportunity to eliminate economic inequality.

Researchers worldwide have addressed issues of quality in the management of several projects related to interorganisational knowledge. Researchers from Finland have focused primarily on strategies, resources, management, and training (Martinsuo, Ahola, 2022). Those from South Africa (Silvius, Marnewick, 2022) and Europe (Todorov, 2014) have also considered the conceptual framework and the importance of sustainability in organisational strategy and project management.

The scientific literature often raises issues of economic development in regions and states, for instance (Skhvediani, Kudryavtseva, 2018; Demidenko, Kulibanova, Maruta, 2018; Didenko, Skripnuk, Mirolyubova, 2018). Many studies have been devoted to detecting additional ways of increasing economic efficiency. The article by Rudskaya and Rodionov (Rudskaya, Rodionov, 2018), in particular, lists the development of human potential (Rodionov, Kudryavtseva, Skhvediani, 2018; Shabunina, Shchelkina, Rodionov; 2018) and the improvement of housing (Zaborovskaia, Plotnikova, 2016) among the solutions that can ensure regional economic growth. However, they do not address problems that arise in the digital development of society to invite proportional growth.

Moreover, economic analysis often emphasises neural networks. For instance, Babkin et al. (Babkin, Karlina, Epifanova, 2015) stressed them. However, they did not focus on these tools' applicability to the state apparatus; they also observed ex ante and ex post approaches (Degtereva, Ivanova, 2018). Economic modelling is commonly applied to help effectively predict a region's future development, the associated problems, and how to manage them (Rudskaya, Rodionov, 2017; Sokolitsyn, Ivanov, Sokolitsyna, 2017). Simultaneously, developed economic models can be used for environmental assessments (Shabunina, Shchelkina, Rodionov, 2017). However, one must consider that many models created to improve the socioeconomic conditions in the Russian regions following the innovations defining their development (Rudskaia, 2017; Rodionov, Rudskaia, Degtereva, 2020) often neglect solutions to existing problems. For example, the scientific literature emphasises citizens' social development separately to create a balanced demand in the regional economic system (Farvaque, Mihailov, Naghavi, 2012; Stroeva, 2016).

Issues of digitalisation of the economy are common in business, but in the public sector, they tend to be neglected and, in practice, the issue of digitising the state apparatus is not prioritised. Simultaneously, many scientific papers theoretically address the problems of digitalisation at the societal level, for instance, Bataev and Plotnikova's study. They discussed the upsides and effectiveness of digital banking, assessed its inaccessibility among the middle aged and the elderly, and the risks that they are likely to encounter when attempting to use it, which younger generations do not (Bataev, Plotnikova, 2019). However, the digital component in economic assessments is reduced to the level of enterprises in different areas. For example, Demidenko, Kulibanova, and Maruta used the parameters of digitalisation to assess the capitalisation of companies (Demidenko, Kulibanova, Maruta, 2018), and Gromova employed it to assess Russia's automobile industry (Gromova, 2019).

The scientific community frequently provides research on the development of different kinds of

rating systems, in particular (Diaz-Sarachaga, Jato-Espino, Castro-Fresno, 2017) (for global assessment), and a number of works with a similar methodology (Balios, Thomadakis, Tsipouri, 2016) and (Holly, 2017) (for applied tasks). Despite a wide range of research on the global picture, few works consider the country-wise character of socioeconomic development. Thus, this article is especially relevant and significant for the world community and for a better understanding of Russia's position.

2. Materials and Methods

The National Projects of the Russian Federation look ahead to 2030 and represent 14 directions for developing the main societal sectors, with an overall allocation of over 25 trillion rubles and 7.5 trillion rubles of funds acquired from non-budgetary sources. The following categories comprise the National Projects framework:

1. Health Care

2. Education

3. Demography

4. Culture

5. Safe Quality Roads

6. Housing and the Urban Environment

7. Ecology

8. Science and Universities

9. Small- and Medium-Sized Business and the Support of Individual Entrepreneurs

10. Labour Productivity

11. International Cooperation and Exports

12. The Digital Economy of the Russian Federation

13. The Tourism and Hospitality Industry

14. A Comprehensive Plan for the Modernisation and Expansion of Trunk Infrastructure[1].

Due to this policy, socioeconomic inequality in Russia can be significantly reduced by boosting the competitiveness of citizens and the country itself in the global arena.

This expert method allowed for a selection of the most promising indicators of socioeconomic development in Western countries for the final assessment. The range of indicators includes the following:

1. Reduction in mortality among the working-age population (to 350 cases per 100,000 people)

2. Reduction in mortality from cardiovascular diseases (to 450 cases per 100,000 people)

3. Reduction in mortality from neoplasms, including malignant tumours (to 185 cases per 100,000 people)

4. Reduction in infant mortality (to 4.5 cases per 1,000 newborns)

5. Representation of Russian universities in the TOP-500 global university rankings

6. Number of students involved in public associations on the basis of educational institutions of general, secondary, higher, and vocational education (one million people cumulative total)

7. Increase in the total birth rate (to 1.7 children per woman)

[1]National projects: key goals and expected results. Official website of the Government of Russia. URL: http://government.ru/projects/selection/741/35675/.

8. Number of people recommended with individual health plans (health passports) in health centres (in millions of people)

9. Share (percentage) of citizens systematically engaged in physical activity and sports

10. Share (percentage) of small- and medium-sized businesses in the GDP

11. Share (percentage) of exports of small- and medium-sized businesses, including individual entrepreneurs, in the total volume of non-resource exports

12. Domestic spending on the development of the digital economy from all sources by share (percentage) in the GDP

13. Share (percentage) of households with broadband access

14. Share (percentage) of socially important infrastructure facilities equipped with broadband access

15. Share (percentage) of the Russian Federation in the global volume of data storage and processing services

16. Number of data processing centres in federal districts

17. Average hours of downtime of state information systems caused by computer attacks

18. Value share (percentage) of domestic software purchased or leased by federal executive authorities, executive authorities of constituent entities, and other public authorities

19. Value share (percentage) of domestic software purchased or leased by state corporations and companies with state participation

20. Labour productivity growth in medium-sized and large enterprises in the basic non-resource sectors of the economy (percentage compared to the previous year)

21. Export volume of non-primary non-energy goods (in billions of USD)

22. Effectiveness of support measures for industrial exports (minimum increase in exports per one ruble of state support)

23. Export volume of agro-industrial products (in billions of USD)

24. Effectiveness of support measures for exports of agro-industrial products (minimum increase in the volume of exports per ruble of state support)

25. Export volume of services (in billions of USD per year)

26. Share of manufacturing, agricultural products, and services exports in the country's GDP (percentage)

27. Volume of trade turnover between Russia and EAEU member states (in billions of USD)

The principles and requirements of the Fourth Industrial Revolution, with its focus on digital transformation, explain the significance of meeting all the previously mentioned indicators for Russia to ensure socioeconomic development. Meanwhile, one should not forget that the prospects for implementing an effective management model are burdened by many negative factors in the Russian context, creating a unique impediment for the Russian model of ensuring the effective implementation of even the most promising, widely proven global practices of socioeconomic development.

The analysis of the prospects for such an instrument as national projects (earlier, state programmes) will be based on the ratio of investments in this instrument of socioeconomic policy, expressed as a portion of the consolidated budget of the Russian Federation, to the growth of the HDI, with an average

growth rate of 0.52% per year (based on indicators from 1991 to 2021), which ranks 168 in the global ranking and slightly lower than the world rate of 0.72%[2].

This index is calculated by experts in the United Nations Development Program, along with a group of independent international experts who invite analytical methods and statistical data from national institutions and international organisations. It is applied in editions of a special series of UNDP reports on human development[3].

When calculating the HDI, three types of indicators are considered:

1. Life expectancy

2. Literacy rate (the average number of years spent on education) and the expected duration of education

3. Standard of living, estimated via gross national income per capita at purchasing power parity in US dollars[4].

The hypothesis of this research was that a more significant investment in national programmes and their prioritisation in the framework of public administration could improve the model of socioeconomic development. The HDI was selected because it is one of the most informative, time-based assessments of all available aggregate indicators of socioeconomic development. Since the time series of the consolidated budget of the Russian Federation began in 2003[5], the Federal Treasury has been conducting an accurate calculation of this indicator. The centralised implementation of financing these programmes began in 2011; thus, the sample contains indicators from 2003 to 2018, with the investments before 2011 assessed as zero. The raw data collection for this research is presented in Table 1.

Table 1. Summary indicators of expenditures on national programmes and their comparison with the growth of HDI

Year	Expenditures of the consolidated budget of the Russian Federation (mln. rubles)	Federal budget expenditures on the implementation of national programmes (mln. rubles)	Share in expenditures on state programmes	HDI in Russia	Percentage increase in HDI
2003	3,964,872		0.00%	0.754	1.07%
2004	4,669,654		0.00%	0.761	0,93%
2005	8,406,812		0.00%	0.764	0.39%
2006	8,375,228		0.00%	0.775	1.44%
2007	11,378,578		0.00%	0.786	1.42%
2008	14,157,027		0.00%	0.791	0.64%
2009	16,048,336		0.00%	0.789	-0.25%
2010	17,616,656		0.00%	0.796	0.89%
2011	13,747,779		0.00%	0.808	1.51%
2012	16,714,058		0.00%	0.811	0.37%
2013	18,338,453	1,144,843	6.24%	0.817	0.74%
2014	20,320,103	3,348,542	16.48%	0.818	0.12%
2015	22,205,323	3,538,295	15.93%	0.824	0.73%
2016	31,323,679	2,431,452	7.76%	0.828	0.49%

[2]Official website of the UN Human Development Index. URL: http://hdr.undp.org/en/data#.
[3]GDP per capita, PPP (constant dollars based on 2011. Official website of the World Bank. URL: https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD? most_recent_value_desc=false.
[4]Official website of the UN Human Development Index. URL: http://hdr.undp.org/en/data#.
[5]Consolidated budget of the Russian Federation and the budgets of state off-budget funds. Federal Treasury, official website. URL: http://www.roskazna.ru/ispolnenie-byudzhetov/konsolidirovannyj-byudzhet/.

2017	34,284,709	4,828,688	14.08%	0.833	0.60%
2018	34,284,709	9,068,390	26.45%	0.841	0.96%
2019	37,382,242	12,597,491	33.70%	0.845	0.48%
2020	42,503,030	14,135,065	33.26%	0.83	-1.78%
2021	47,072,682	6,747,263	14.33%	0.822	-0.96%
2022	34,284,700	18,691,351	54.52%	0.754	

Source: compiled by the author based on data from the UN Human Development Index, Federal Treasury, Portal of state programs of the Russian Federation.

4. Results

Graphs (Figures 1 and 2) based on the data from Table 1 reflect the hypothesised assumption that such a mechanism of socioeconomic development improves the population's welfare, thus raising the HDI compiled by the UN.

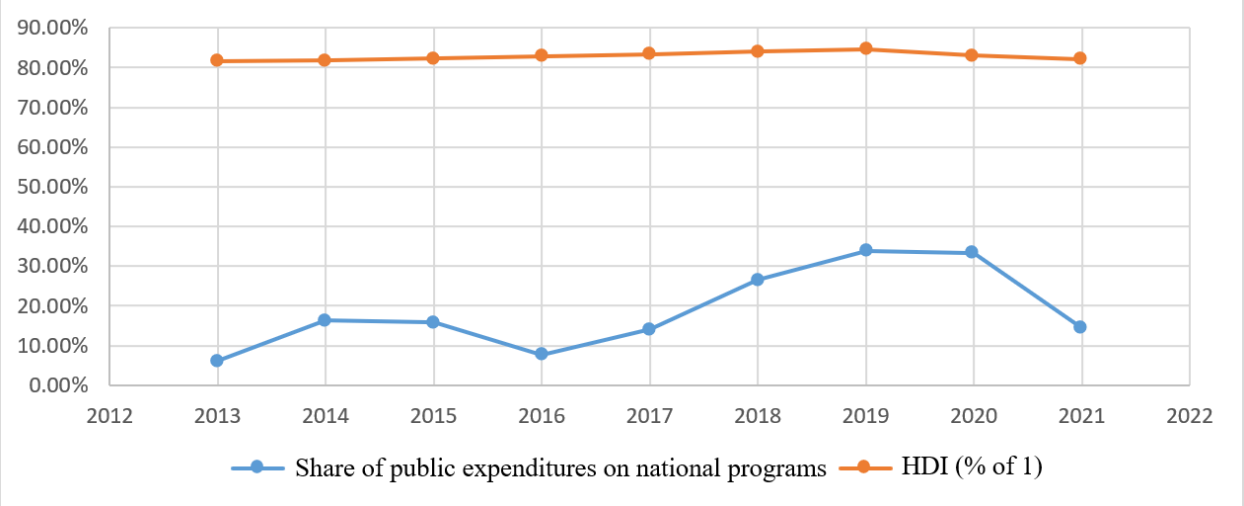

Figure 1. Graph of the share of public expenditures by year against the level of the HDI

Source: compiled by the author based on data from the UN Human Development Index, Federal Treasury, Portal of state programs of the Russian Federation

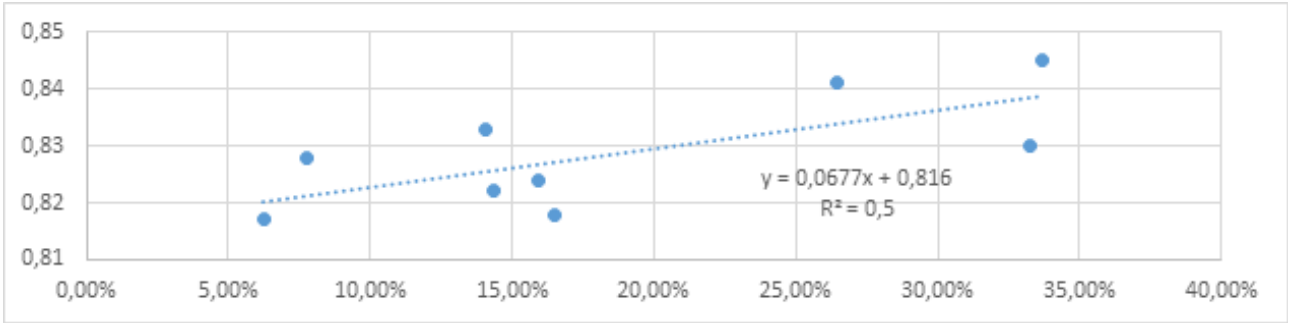

Figure 2. HDI indicator of the share of total expenditures on national programmes since 2013

Source: compiled by the author based on data from the UN Human Development Index, Federal Treasury, Portal of state programs of the Russian Federation.

Figures 1 and 2 show that the greater the share of expenditures invested in national programmes, the greater the rate of HDI growth in Russia. However, the coefficient of determination was small—only 0.5. Therefore, it can be concluded that despite having a certain correlation between the presented values, financing solely through project management cannot fully describe the growth or decline trends in

the HDI. However, it should be noted that at least half of this trend is described. Thus, the hypothesis suggested for this research was confirmed only partially, but conceptually, the mechanism of national programmes in the modern management system is complex and confusing. It nevertheless has a favourable impact on Russia's socioeconomic development. Moreover, the share of its implementation in the structure of expenditures has recently been declining, along with the overall HDI. In essence, it is reformed at the global level into national projects because it can show positive results in the socioeconomic development of Russia, but due to a number of problems and incorrect assessments, it does not sufficiently justify itself.

5. Discussion

Throughout this research on the project management of socioeconomic development in Russia, the authors identified the following areas for improvement:

1. Managers and supervisors are not personally responsible for national programmes, which leads to a lack of order on their implementation.

2. International experience in the area of the implementation of national projects is not considered, resulting in an insufficient level of efficiency.

3. No control body has been properly established to run national programmes, resulting in haphazard solutions to developing and implementing these programmes.

4. Expanding on point 3, the implementation of national programmes and projects lacks clear economic and social efficiency.

5. When national programmes are implemented, unachieved target indicators are often ignored, leading to a lack of flexibility.

6. Insufficient opportunities to revise indicators and a lack of clear criteria and terms result in unsystematic adjustments.

To improve the efficiency of national programmes in the Russian Federation, and to eliminate the identified shortcomings, ensuring the following steps are taken is necessary:

1. The introduction of personal responsibility for the implementation of programmes for department heads, the establishment of a payment and bonus system, and the introduction of a public control commission to track the effectiveness of national programme implementation

2. The development of a globally competitive innovation system and the acceleration of innovation processes in the national economy and society

3. The transition to a model of strategic target programme planning is based on the formation of an institutional system of national target programmes. This system will ensure transparent mechanisms for the revision of target indicators in response to external economic changes.

4. Strengthening requirements for the precise fulfilment of national programmes by their executors

5. The evaluation of the economic and social efficiency of national programmes using world-ranking systems

6. The transition to a fully project-based method of managing national programmes since it is currently not used full-scale

The actual percentage of fulfilment of the required indicators confirms the complexity of the mechanisms for the implementation of national programmes and projects. A total of 968 milestones were planned for 2019, the pre-pandemic year, when their fulfilment was not potentially hindered by serious external circumstances, and only 619 were conducted, making the overall fulfilment percentage of 63.94%. The biggest problem involves the following socioeconomic indicators:

1. Healthcare – 0 out of 92 milestones

2. Education – 0 out of 70 milestones

3. Social support of citizens – 25 out of 48 milestones

4. Employment promotion – 33 out of 58 milestones

5. Economic development and innovative economy – 76 out of 86 milestones, which occurred mostly because of objective economic prerequisites

6. Socioeconomic development of the Far Eastern Federal District/Kaliningrad Oblast/Arctic Zone of the Russian Federation (effectiveness of territorial management is assessed) – 38 out of 60 milestones.

7. Conceptual conditions for modern, effective socioeconomic development expressed in the programme Information Society are fulfilled by 30 out of 38 milestones[6].

Figure 3 presents the conducted regression analysis and shows a downward trend in the percentage of milestones completed when managing national programmes. This observation again confirms the presence of significant imperfections in the existing mechanism. Logically enough, it calls for changes in the current concept of national project management in general and national programmes in particular. Figure 3 shows the percentage of milestones completed by year.

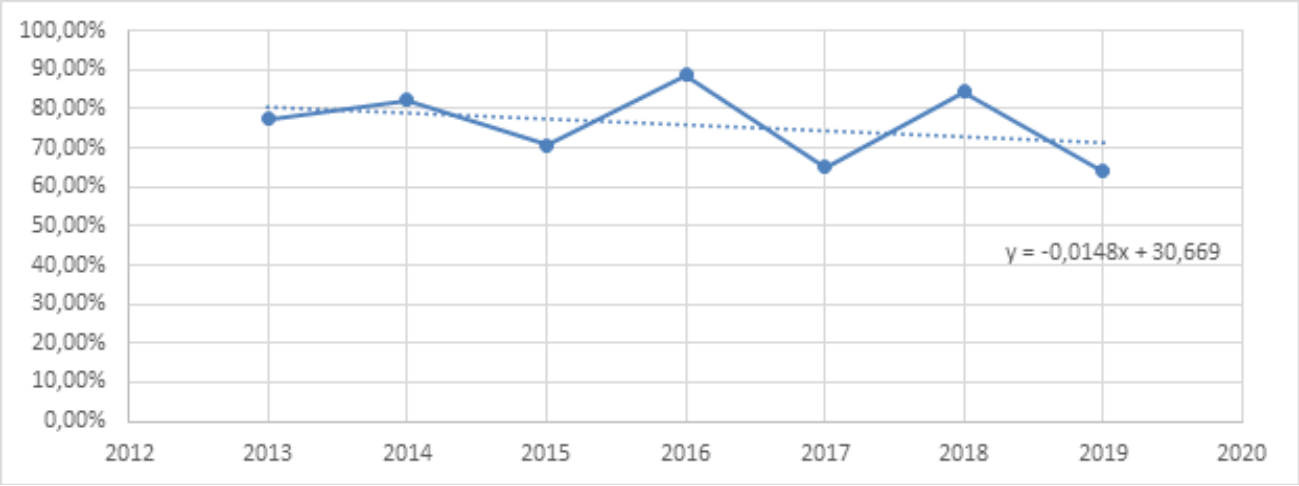

Figure 3. Percentage of milestones completed for national programmes5

Interestingly, due to the low execution efficiency, the section of the official website5, on which data on the execution of and expenditures on programmes are posted based on resolutions of the Government of the Russian Federation, is currently available only by direct link without redirection from the site's main page.

The assessment used can be refined and detailed when considering specific areas of the national programmes of the Russian Federation and other independent indicators of socioeconomic development that affect the HDI. This analysis is characterised by a certain consolidation and generalisation of both the quality of project management and its dependence on the HDI. Therefore, it provides broad prospects for more detailed consideration and deeper results. As previously indicated, the expenditures of federal funds of the Russian Federation on national project management in the consolidated budget were an average of 22.35%. Moreover, using this tool results in numerous economic and managerial difficulties, leading to lower HDI levels.

6. Conclusion

Following the authors' proposed recommendations, one should expect to improve the efficiency of spending federal funds (currently estimated at 8.5 trillion rubles), along with regional and local funds

[6]Financing of state programs. The portal of state programs of the Russian Federation is the official website. URL: https://programs.gov.ru/Portal/analytics/federal_budget_expenditure.

allocated for the implementation of national projects. From a social perspective, one should expect a more comprehensive fulfilment of social development obligations, which have been almost completely ignored since late 2019. Positive change is also likely to be seen in Russia's overall socioeconomic development, accompanied by the opportunity to minimise Russia's losses from the global economic crisis and regain the growth of the HDI caused by the pandemic.

References

Babkin A. V, Karlina E.P., Epifanova N.S., 2015. Neural networks as a tool of forecasting of socioeconomic systems strategic development. Procedia. Soc. Behav. Sci. 207, 274–279.

Balios D., Thomadakis S., Tsipouri L., 2016. Credit rating model development: An ordered analysis based on accounting data. Res. Int. Bus. Financ. 38, 122–136.

Bataev A., Plotnikova E., 2019. Assessment of digital banks' performance. Espacios. 40 (20).

Degtereva V., Ivanova M., 2018. Ex ante and ex post regulatory impact assessment in Russia: Framework and practice.

Demidenko D., Kulibanova V., Maruta V., 2018. Using the principles of "digital economy" in assessing the company's capitalization. Proceedings of the 31st International Business Information Management Association Conference, 6087.

Diaz-Sarachaga J.M., Jato-Espino D., Castro-Fresno D., 2017. Methodology for the development of a new sustainable infrastructure rating system for developing countries (SIRSDEC), Environ. Sci. Policy. 69, 65–72.

Didenko N., Skripnuk D., Mirolyubova O., 2017. Big data and the global economy, 1–5.

Farvaque E., Mihailov A., Naghavi A., 2012. The grand experiment of communism: Discovering the trade-off between equality and efficiency. SSRN Electron. J.

Gromova E., 2019. Digital economy development with an emphasis on automotive industry in Russia. Espac. 40 (6).

Holly D. et al., 2017. Development of a behaviour rating system for rural/remote pre-hospital settings. Appl. Ergon. 58, 405–413.

Martinsuo M., Ahola T., 2022. Multi-project management in inter-organizational contexts. Int. J. Proj. Manag. 40 (7), 813–826.

Rodionov D., Kudryavtseva T., Skhvediani A., 2018. Human development and income inequality as factors of regional economic growth. Eur. Res. Stud. J. 21, 323–337.

Rodionov D., Rudskaia I., Degtereva V., 2017. Regional foresight as a technology for development of the regional innovation system. Proceedings of the 29th International Business Information Management Association Conference. Education Excellence and Innovation Management through Vision 2020: From Regional Development Sustainability to Global Economic Growth. 2699–2705.

Rudskaia I., 2017. A regional innovation system: Formation features and growth areas (case study: St. Petersburg). Proceedings of the 30th International Business Information Management Association Conference, IBIMA. Vision 2020: Sustainable Economic development, Innovation Management, and Global Growth, 541–547.

Rudskaia I., 2017. Regional innovation foresights: Drivers and barriers for development. Proceedings of the 30th International Business Information Management Association Conference, IBIMA 2017. Vision 2020: Sustainable Economic Development, Innovation Management, and Global Growth, 889–903.

Rudskaya I., Rodionov D., 2017. Econometric modeling as a tool for evaluating the performance of regional innovation systems (with regions of the Russian Federation as the example). Acad. Strateg. Manag. J., 16.

Rudskaya I.A., Rodionov D.G., 2018. Comprehensive evaluation of Russian regional innovation system performance using a two-stage econometric model.

Shabunina T. V, Shchelkina S.P., Rodionov D., 2018Regional Habitat as a Factor of the Human Capital Assets Development in Russian Regions. J. Soc. Sci. Res. 313–317.

Shabunina T. V, Shchelkina S.P., Rodionov D.G., 2017. An innovative approach to the transformation of eco-economic space of a region based on the green economy principles. Acad. Strateg. Manag. J.

Silvius G., Marnewick C., 2022. Interlinking sustainability in organizational strategy, project portfolio management and project management; A conceptual framework. Procedia Comput. Sci. 196, 938–947.

Skhvediani A., Kudryavtseva T., 2018. The socioeconomic development of Russia: Some historical aspects. Eur. Res. Stud. J. 21, 195–207.

Sokolitsyn A., Ivanov M., Sokolitsyna N., 2017. Statistic modeling industrial enterprises production process parameters. Proceedings of the 30th International Business Information Management Association Conference: Sustainable Economic Development, Innovation Management, and Global Growth, 1041–1052.

Stroeva O.A. et al., 2016. Peculiarities of formation of socially oriented strategy of economic growth of national economy. 19, 161–170.

Todorov T.S. Evaluating project and program management as factor for socio-economic development within EU, 2014. Procedia – Soc. Behav. Sci. 119., 819–828.

Zaborovskaia O.V., Plotnikova E.V., 2016. Assessment of the housing stock condition as an element for estimating the conditions for human capital development in the regions of the Russian Federation. Proceedings of the 28th International Business Information Management Association Conference – Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth. 1218–1225.

Список источников

Babkin A. V, Karlina E.P., Epifanova N.S., 2015. Neural networks as a tool of forecasting of socioeconomic systems strategic development. Procedia. Soc. Behav. Sci. 207, 274–279.

Balios D., Thomadakis S., Tsipouri L., 2016. Credit rating model development: An ordered analysis based on accounting data. Res. Int. Bus. Financ. 38, 122–136.

Bataev A., Plotnikova E., 2019. Assessment of digital banks' performance. Espacios 40 (20).

Degtereva V., Ivanova M., 2018. Ex ante and ex post regulatory impact assessment in Russia: Framework and practice.

Demidenko D., Kulibanova V., Maruta V., 2018. Using the principles of "digital economy" in assessing the company's capitalization. Proceedings of the 31st International Business Information Management Association Conference, 6087.

Diaz-Sarachaga J.M., Jato-Espino D., Castro-Fresno D., 2017. Methodology for the development of a new sustainable infrastructure rating system for developing countries (SIRSDEC), Environ. Sci. Policy. 69, 65–72.
Didenko N., Skripnuk D., Mirolyubova O., 2017. Big data and the global economy, 1–5.
Farvaque E., Mihailov A., Naghavi A., 2012. The grand experiment of communism: Discovering the trade-off between equality and efficiency. SSRN Electron. J.
Gromova E., 2019. Digital economy development with an emphasis on automotive industry in Russia. Espac. 40 (6).
Holly D. et al., 2017. Development of a behaviour rating system for rural/remote pre-hospital settings. Appl. Ergon. 58, 405–413.
Martinsuo M., Ahola T., 2022. Multi-project management in inter-organizational contexts. Int. J. Proj. Manag. 40 (7), 813–826.
Rodionov D., Kudryavtseva T., Skhvediani A., 2018. Human development and income inequality as factors of regional economic growth. Eur. Res. Stud. J. 21, 323–337.
Rodionov D., Rudskaia I., Degtereva V., 2017. Regional foresight as a technology for development of the regional innovation system. Proceedings of the 29th International Business Information Management Association Conference. Education Excellence and Innovation Management through Vision 2020: From Regional Development Sustainability to Global Economic Growth. 2699–2705.
Rudskaia I., 2017. A regional innovation system: Formation features and growth areas (case study: St. Petersburg). Proceedings of the 30th International Business Information Management Association Conference, IBIMA. Vision 2020: Sustainable Economic development, Innovation Management, and Global Growth, 541–547.
Rudskaia I., 2017. Regional innovation foresights: Drivers and barriers for development. Proceedings of the 30th International Business Information Management Association Conference, IBIMA 2017. Vision 2020: Sustainable Economic Development, Innovation Management, and Global Growth, 889–903.
Rudskaya I., Rodionov D., 2017. Econometric modeling as a tool for evaluating the performance of regional innovation systems (with regions of the Russian Federation as the example). Acad. Strateg. Manag. J., 16.
Rudskaya I.A., Rodionov D.G., 2018. Comprehensive evaluation of Russian regional innovation system performance using a two-stage econometric model.
Shabunina T. V, Shchelkina S.P., Rodionov D., 2018Regional Habitat as a Factor of the Human Capital Assets Development in Russian Regions. J. Soc. Sci. Res. 313–317.
Shabunina T. V, Shchelkina S.P., Rodionov D.G., 2017. An innovative approach to the transformation of eco-economic space of a region based on the green economy principles. Acad. Strateg. Manag. J.
Silvius G., Marnewick C., 2022. Interlinking sustainability in organizational strategy, project portfolio management and project management; A conceptual framework. Procedia Comput. Sci. 196, 938–947.
Skhvediani A., Kudryavtseva T., 2018. The socioeconomic development of Russia: Some historical aspects. Eur. Res. Stud. J. 21, 195–207.
Sokolitsyn A., Ivanov M., Sokolitsyna N., 2017. Statistic modeling industrial enterprises production process parameters. Proceedings of the 30th International Business Information Management Association Conference: Sustainable Economic Development, Innovation Management, and Global Growth, 1041–1052.
Stroeva O.A. et al., 2016. Peculiarities of formation of socially oriented strategy of economic growth of national economy 19, 161–170.
Todorov T.S. Evaluating project and program management as factor for socio-economic development within EU, 2014. Procedia – Soc. Behav. Sci. 119., 819–828.
Zaborovskaia O.V., Plotnikova E.V., 2016. Assessment of the housing stock condition as an element for estimating the conditions for human capital development in the regions of the Russian Federation. Proceedings of the 28th International Business Information Management Association Conference – Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth. 1218–1225.

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SECTION 3

SUSTAINABLE DEVELOPMENT OF REGIONAL INFRASTRUCTURE

РАЗДЕЛ 3

УСТОЙЧИВОЕ РАЗВИТИЕ РЕГИОНАЛЬНОЙ ИНФРАСТРУКТУРЫ

Research article

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Peculiarities of Sustainable Development of Transport Infrastructure of Tourism in St. Petersburg Agglomeration

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Abstract

The complicated geopolitical situation has become a factor in domestic tourism development in the Russian Federation. A significant number of objects of tourist interest have generated increased competition between Russian regions to attract tourists. A necessary condition for increasing tourist flow is the development of tourist infrastructure, including transport. The authors used various types of transport in the vast majority formation of tourist products, as well as in independent tourism. The purpose of this study is to analyse the relationships between tourist flow dynamics and the transportation system development indexes of St. Petersburg and the Leningrad region. Comparative, correlation and regression analyses showed a strong positive correlation between tourist flow and passenger transport by buses and suburban railway transport (especially in St. Petersburg). The study confirmed the problem of data reliability and availability for analysing tourist flow within the St. Petersburg agglomeration, although the palace suburbs, which are popular with tourists, are located within agglomeration boundaries. To solve the problem of tracking tourist flows when using transport in the agglomeration, the authors propose the development and implementation of a transport tourist map with advanced functionality. This digital tool application will allow not only the reliable tracking of tourist flows but also the optimization of the transport system of the St. Petersburg agglomeration. In addition, the analysis of tourist flow dynamics should be used to increase the positive effects of tourism development and reduce the negative effects of overtourism in achieving the sustainable development goals of St. Petersburg and the Leningrad region.

Keywords: tourist flow, transport, transport system, agglomeration, sustainable development, tourism infrastructure, region

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Особенности Устойчивого Развития Транспортной Инфраструктуры Туризма Санкт-Петербургской Агломерации

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Аннотация

Сложная геополитическая ситуация стала фактором развития внутреннего туризма в РФ. Значительное количество объектов туристского интереса приводит к росту конкуренции между регионами России за привлечение туристов. Необходимым условием увеличения туристского потока является развитие туристской инфраструктуры, в том числе транспортной. Различные виды транспорта используются при формировании подавляющего большинства туристских продуктов, а также в самостоятельном туризме. Целью исследования является анализ взаимосвязей между динамикой туристского потока и показателями развития транспортной системы Санкт-Петербурга и Ленинградской области. Сравнительный, корреляционный и регрессионный анализ показали сильную положительную корреляцию между туристским потоком и перевозками пассажиров автобусами и пригородным железнодорожным транспортом (особенно в Санкт-Петербурге). Исследование подтвердило проблему достоверности и доступности данных для анализа туристского потока в рамках Санкт-Петербургской агломерации, хотя популярные у туристов дворцовые пригороды находятся в границах агломерации. Для решения проблемы отслеживания туристских потоков при использовании транспорта в агломерации авторы предлагают разработку и внедрение транспортной туристической карты с расширенным функционалом. Использование такого цифрового инструмента позволит не только достоверно отслеживать туристские потоки, но и оптимизировать транспортную систему Санкт-Петербургской агломерации. Кроме того, анализ динамики туристских потоков необходимо использовать для увеличения положительных эффектов от развития туризма и снижения негативных эффектов от овертуризма при достижении целей устойчивого развития Санкт-Петербурга и Ленинградской области.

Ключевые слова: туристский поток, транспорт, транспортная система, агломерация, устойчивое развитие, туристская инфраструктура, регион

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1. Introduction

The object of this study is the transportation system within the St. Petersburg agglomeration. The study scope is the dependence of sustainable tourism development on the development of the transportation system of St. Petersburg and the Leningrad region. The study will examine the relationship between tourism development, considering the requirements of sustainable development and transport infrastructure development. The study's relevance appeals to the potential development of domestic and inbound tourism in the St. Petersburg agglomeration. It is also vital to note the unrealized potential of recreational travel for residents of St. Petersburg and the Leningrad region due to problems in the transportation system.

Researchers have studied various aspects of transportation, tourism and sustainable tourism development.

Tourism has become a significant factor in the economic development of multiple regions and countries, so the number of studies on regional tourism systems is growing (Gintciak et al., 2023, 2022; Liu and Wu, 2019; Darani and Asghari, 2018). The tourism development infrastructure impacts the possibility of creating tourist products (Berawi, 2016).

Transportation is one of the most significant branches of the region's infrastructure. Transport infrastructure development provides tourist mobility, especially in the independent tourism framework (Chen and Haynes, 2015; Liu et al., 2023; Van Truong and Shimizu, 2017; Zhang and Wen, 2023). Transport objects and elements of transport infrastructure can be objects of tourist interest (e.g. station buildings and retro trains).

However, there are no studies on the impact of transportation on tourism development regarding the requirements of sustainable development in the agglomeration.

Using the example of St. Petersburg and the Leningrad region, the authors will test the hypothesis of whether transport system development impacts tourist flow growth.

2. Literature review

It is vital to monitor the types of preferred transportation by tourists for the development of the territorial tourism market.

In addition, it is vital to analyse tourist satisfaction with different types of transport, route schedules, locations of public transport stops and road conditions. The development of the digital economy makes it possible to obtain a significant amount of data for analysis (Konyshev et al., 2023; Popova et al., 2023; Rodionov et al., 2023; Tan and Ismail, 2020).

The growth of tourist flows impacts the development of the territory in general and the transportation system in particular. On the one hand, transportation is a vital condition that impacts tourist flow. Regional governments improve the comfort of tourists' stays and maintain road infrastructure facilities by repairing roads and constructing parking lots for personal vehicles and tourist buses. Thus, the transportation system ensures the growth of GRP and employment and provides an opportunity to implement entrepreneurial initiatives. In some cases, it leads to accelerated urbanization of the territory (Feng, 2023; Kuchumov et al., 2023; Yu et al., 2023).

On the other hand, the expansion of the road network, the increase of anthropogenic factors in the territory, and the growth of passenger traffic may have insufficient effects on the regional environment. Therefore, it is vital to develop the transport infrastructure of tourism considering the sustainable development requirements to maintain a favourable environment (Buckley and Underdahl, 2023; Deng and Chen, 2024; Gössling et al., 2016; A. Tanina et al., 2023; Tanina et al., 2021; Yan and Phucharoen, 2024).

State aid has a significant impact on the development of transport as an infrastructural element of tourism, so it is vital to operate opportunities for interregional cooperation to form a unified agglomera-

tion transportation system (A. V. Tanina et al., 2023; Xu et al., 2023; Zhao and Dong, 2017).

3. Materials and methods

To realize the article's purpose, the authors operated St. Petersburg and the Leningrad region's statistical data, representing the development of the transportation system, together with the data of regional budget expenditures on tourism development. The authors used these sources to obtain the data: St. Petersburg Committee for Tourism Development[1], Leningrad Oblast Committee for Culture and Tourism[2], EMISS State Statistics Portal[3], St. Petersburg Open Budget[4], and Leningrad Oblast Open Budget[5].

The authors compared collected data with tourist flow as the prominent index of tourist activity in the territory. The authors chose data from 2015 to 2022 because in 2015, regional authorities began introducing state programmes, which more comprehensively describe the expenditures of budget functions on tourism and transportation system development. The authors chose correlation and regression analyses as the optimal research methods.

It is worth noting that from 2015 to 2017, the framework of programmes for cultural field development included tourism expenditures in both regions. St. Petersburg had the programme "Development of the Culture Field and Tourism", while the Leningrad region had the programme "Development of Culture". The authorities of both regions prioritized cultural industries; therefore, it is challenging to establish the exact budget performance for tourism development. The trend changed in 2018 when Russia declared the "Year of Tourism" in the run-up to the FIFA World Cup, and the authorities of both regions revised their views on the tourism sector, declaring it as an independent branch of the economy and forming separate state programmes for it. This significant change is also reflected in both datasets.

The authors labelled certain variables as follows: X1 – Budget expenditures for transportation, rubbles. X2 – Total length of public roads, km. X3 – Passenger turnover of public buses, people-kilometre. X4 – Suburban rail transportation, people. X5 – Budget expenditures for tourism development, rub. Y – Tourist flow, people (Tables 1–2).

Table 1. Saint Petersburg dataset

Year	X1	X2	X3	X4	X5	Y
2015	1,069E+11	3412,1	3191380300	47622000	17826222800	6500000
2016	1,31876E+11	3489,2	3236909000	48839000	21499788200	6900000
2017	1,44025E+11	3508,2	3417939600	48864000	24961534800	7500000
2018	1,32663E+11	3536,4	3507240600	51609000	709569200	8200000
2019	1,40122E+11	3566,7	3578578900	55853000	814034500	10400000
2020	1,26913E+11	3580,2	2445963500	39301000	458584600	2900000
2021	1,67798E+11	3574,9	3344299200	48739000	806451000	6100000
2022	2,80155E+11	3583,9	4217304900	56298000	1710870200	8100000

Table 2. Leningrad region dataset

Year	X1	X2	X3	X4	X5	Y
2015	7720000000	22286,9	1284058500	26393000	1510000000	2000000
2016	9560361900	22298,938	1246684700	26425000	1470000000	3000000
2017	8531100000	22374,8	1248140600	26338000	2315400000	4200000
2018	8482600000	22559,57	1267334600	27446000	175100000	5230282
2019	7907300000	22879,617	1398296200	28485000	183500000	5734691
2020	10835900000	23129,604	979189900	21541000	297900000	4760016
2021	15273500000	23166,312	1086139500	24994000	331100000	4907605
2022	15490900000	23340,596	1550227100	27077000	166500000	6019015

Then the authors calculated the correlation of both datasets (Tables 3–4)

Table 3. Correlation of the Saint Petersburg data

[1]Tourism Market Development. St. Petersburg Tourism Development Committee URL:https://www.gov.spb.ru/gov/otrasl/c_tourism/statistic/
[2]Statistics. Committee for Culture and Tourism of the Leningrad Region URL: https://kit.lenobl.ru/ru/statistika/
[3]EMISS. URL: https://fedstat.ru/
[4]Open Budget of St. Petersburg. URL: https://budget.gov.spb.ru
[5]Open Budget of the Leningrad Region. URL: https://budget.lenobl.ru/budget/people/

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Column1	1					
Column 2	0,538298694	1				
Column 3	0,738441797	0,156963231	1			
Column 4	0,546152163	0,146969737	0,93765709	1		
Column 5	-0,334782265	-0,76292982	-0,091650061	-0,149100943	1	
Column 6	0,229150742	-0,0035942	0,77850986	0,930023964	-0,00521077	1

Table 4. Correlation of the Leningrad Oblast data

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Column 1	1					
Column 2	0,793385629	1				
Column 3	0,030654363	0,01601861	1			
Column 4	-0,265933094	-0,308474264	0,818652809	1		
Column 5	-0,444802406	-0,768127082	-0,05957913	0,05419715	1	
Column 6	0,453568903	0,763510687	0,260011295	0,12335531	-0,7140079	1

After calculating the correlation, the author also conducted regression analysis (Tables 5–6).

Table 5. Regression analysis of St. Petersburg data

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,994950345
R Square	0,989926188
Adjusted R Square	0,964741659
Standard Error	403319,8175
Observations	8

ANOVA

	df	SS	MS	F	Significance F
Regression	5	3,19697E+13	6,39393E+12	39,30691631	0,024994571
Residual	2	3,25334E+11	1,62667E+11		
Total	7	3,2295E+13			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-40662820,87	18300893,86	-2,221903541	0,156385799	-119405211,8	38079570,06	-119405212	38079570,1
X Variable 1	-1,92995E-05	9,23746E-06	-2,089265524	0,171879767	-5,90451E-05	2,04461E-05	-5,9045E-05	2,0446E-05
X Variable 2	7595,458296	5249,248573	1,446961063	0,284846887	-14990,2354	30181,152	-14990,2354	30181,152
X Variable 3	0,000136933	0,002076806	0,065934461	0,953427885	-0,00879884	0,009072706	-0,00879884	0,00907271
X Variable 4	0,466002592	0,143438419	3,248798995	0,083104671	-0,151163114	1,083168299	-0,15116311	1,0831683
X Variable 5	3,3664E-05	2,28987E-05	1,470124699	0,279321772	-6,48613E-05	0,000132189	-6,4861E-05	0,00013219

Table 6. Regression analysis of Leningrad region data

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,895806653
R Square	0,802469559
Adjusted R Square	0,308643457
Standard Error	1141199,267
Observations	8

ANOVA

	df	SS	MS	F	Significance F
Regression	5	1,05815E+13	2,1163E+12	1,625004339	0,423138683
Residual	2	2,60467E+12	1,30234E+12		
Total	7	1,31862E+13			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-106020016,2	72339013,1	-1,465599428	0,280390527	-417269668,4	205229636	-417269668	205229636
X Variable 1	-0,000178111	0,000247036	-0,720991256	0,545802734	-0,001241021	0,000884799	-0,00124102	0,0008848
X Variable 2	4541,199504	3042,014408	1,492826428	0,274036863	-8547,532093	17629,9311	-8547,53209	17629,9311
X Variable 3	-0,002485852	0,005372948	-0,462660792	0,6890658	-0,025603781	0,020632076	-0,02560378	0,02063208
X Variable 4	0,459486867	0,493700869	0,930698923	0,450261784	-1,664736525	2,583710259	-1,66473653	2,58371026
X Variable 5	0,000215179	0,001010635	0,212914366	0,851124579	-0,004133233	0,004563591	-0,00413323	0,00456359

Further, interpreting the results is worthwhile.

4. Results

The authors formed diagrams to assess the prominent trends of the selected transportation and tourism development indexes (Figures 1–3).

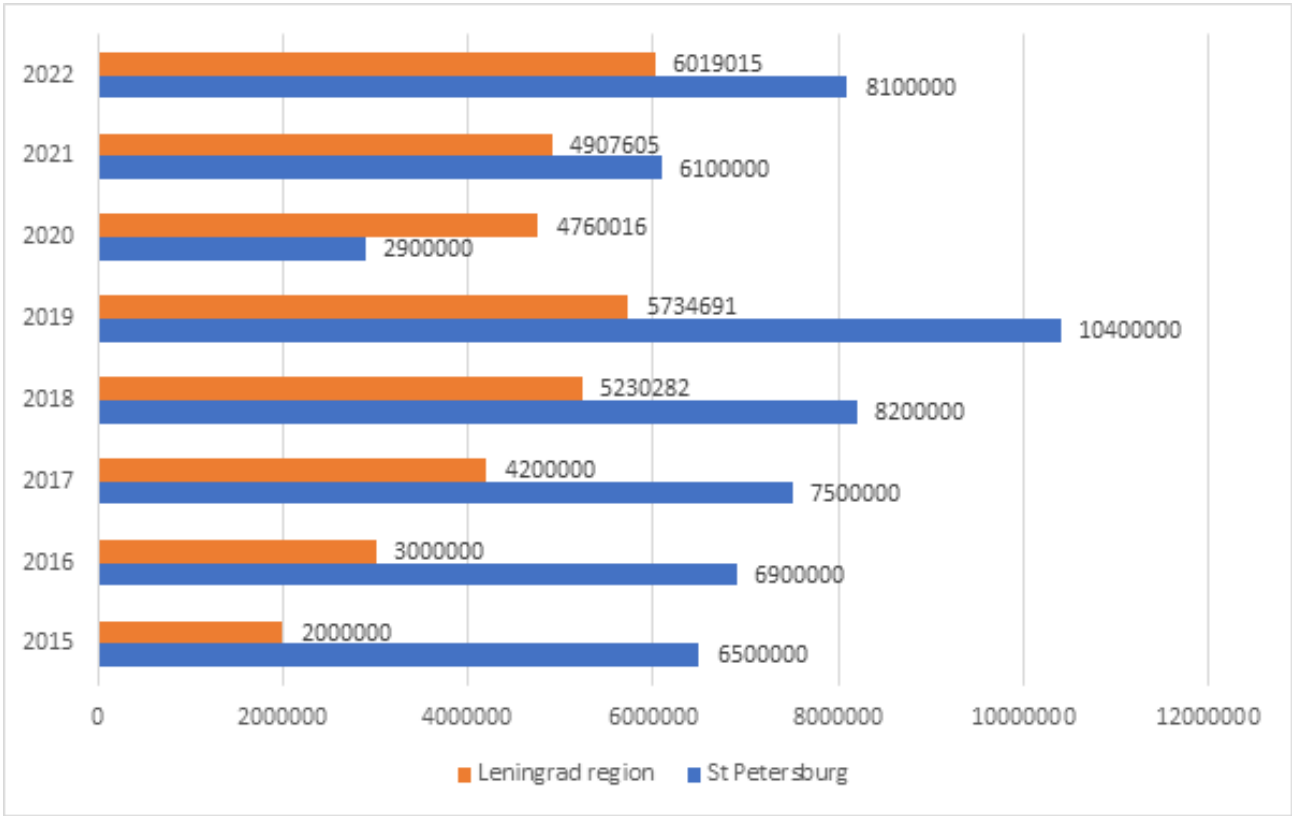

Figure 1. Tourist flow in St. Petersburg and the Leningrad region 2015–2022, people

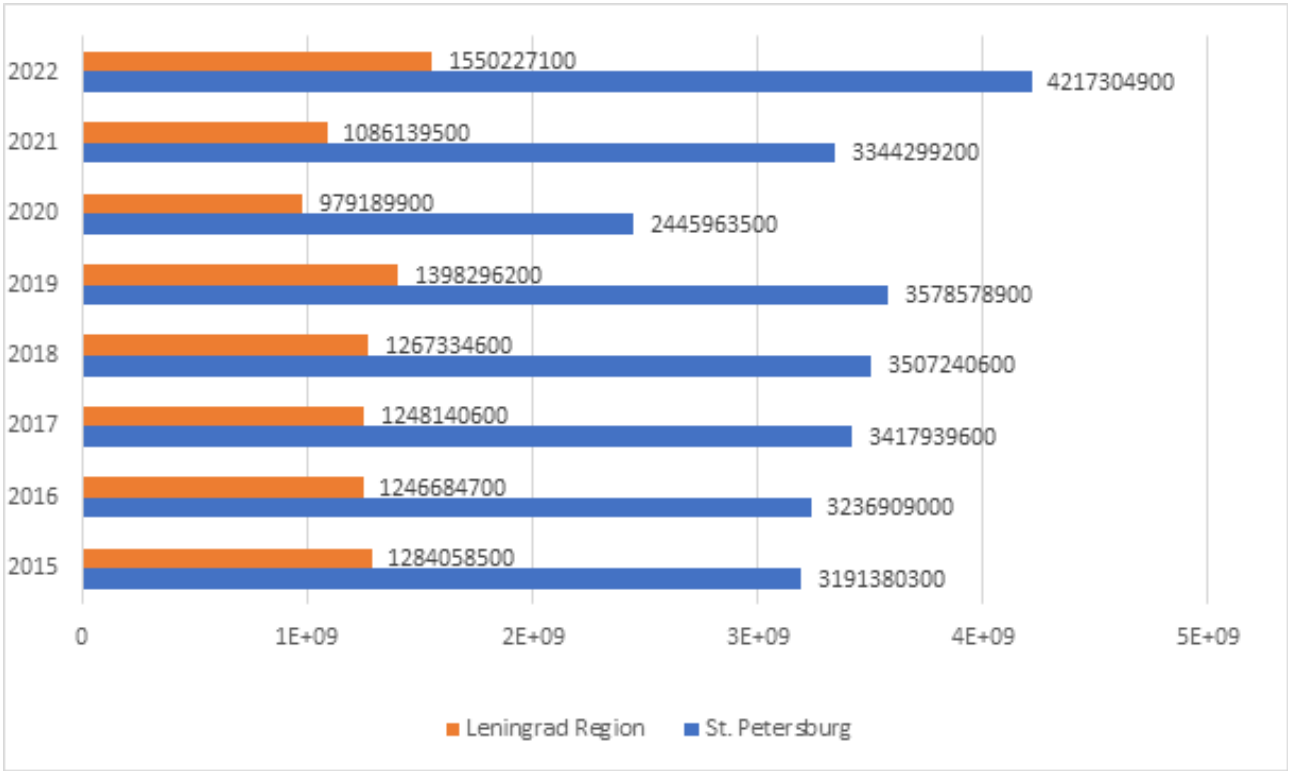

Figure 2. Passenger turnover of public buses in St. Petersburg and the Leningrad region 2015–2022, passenger-kilometre

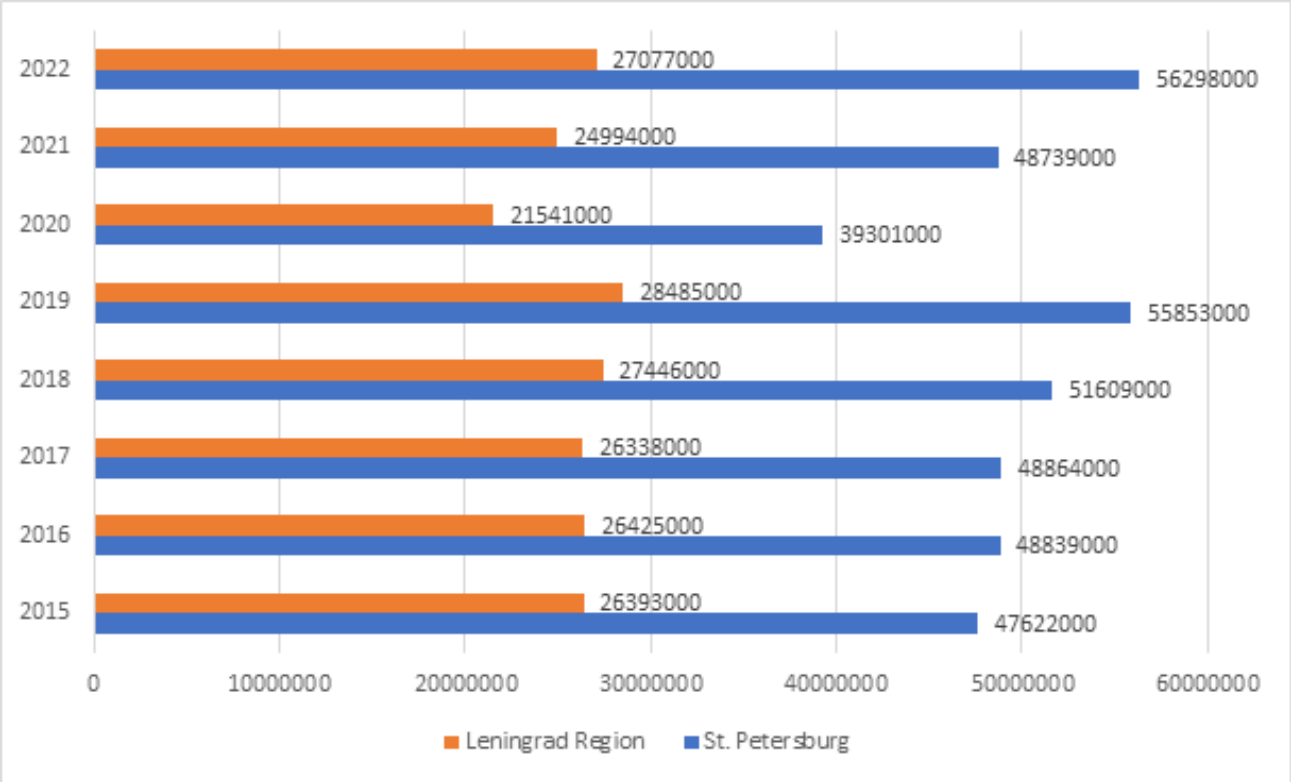

Figure 3. Suburban rail transportation in St. Petersburg and the Leningrad region 2015–2022, people

Figures 1–3 show that, in general, it is possible to observe general patterns between passenger movements and tourist flows. During the COVID-19 pandemic in 2020, there was a significant decrease in the number of tourists in St. Petersburg (more than 3.5 times), but tourist flows to the Leningrad region did not decrease as much (about 20%). According to the authors, this is due to the region's popularity as a territory where it was possible to leave St. Petersburg during travel restrictions, especially for the population with remote work. When the officials revoked pandemic restrictions, the Leningrad region increased its popularity as a region for ecological, rural, health and other types of tourism, which are less developed in St. Petersburg.

Due to the more developed transportation system of St. Petersburg (the prominent types of passenger transport are metros, buses, trolleybuses and trams), the pandemic impacted passenger traffic. The drop in passenger traffic by buses in the pandemic in 2020 amounted to 46%. A similar situation happened in the Leningrad region, with a drop in passenger traffic of 42.8%.

On April 1, 2022, city officials implemented a transport reform in St. Petersburg. The primary purpose was the abolition of commercial shuttle cab routes (in which city transportation cards were not valid) and the enactment of new social routes (in most of them, only cashless fare payment is possible). The result of the reform was the growth of bus transportation, which is observable from the 2022 statistics (26% growth).

The situation in the Leningrad region is not evident. In 2015–2018, there were slight fluctuations in passenger traffic in bus transportation. Then, there was growth in 2019, followed by a decrease in 2020. The region reached pre-pandemic values only in 2022.

Compared with bus transportation, suburban rails lost fewer passengers in the pandemic. For St. Petersburg, the decrease amounted to 42%, and for the Leningrad region, it was 32.2%. In 2022, suburban rail did not return to pre-pandemic values.

The lack of reliable data on other modes of transportation and movements of residents of St. Petersburg and the Leningrad region for tourism purposes makes it difficult to obtain objective information on the results of the comparative analysis. Therefore, the authors conducted regression and correlation

analyses on the available data.

First, the authors conducted the correlation of Saint Petersburg and the Leningrad region datasets. There are some curious observations:

The tourist flow of Saint Petersburg has a strong positive correlation with the passenger turnover of public buses ($r > 0.6$) and a very strong positive correlation with suburban rail transportation ($r > 0.8$). Also, these stated variables (X3 and X4) have very strong correlations among themselves ($r > 0.8$).

Budget expenditures for transportation of Saint Petersburg have a strong positive correlation only with the passenger turnover of public buses ($r > 0.6$). The rest have moderate and weak correlations.

The tourist flow of the Leningrad region has a surprisingly strong negative correlation with the budget expenditures for tourism ($r < -0.7$). This means that officials may spend less budget money and tourist flow may rise.

Also, budget expenditures for transportation in the Leningrad region have a strong correlation with road length. This statement is worthwhile because this budget item aims to build new roads.

According to both datasets, there are two common trends. First, there is a very strong correlation between suburban rail transportation and passenger turnover of public buses. Second, there is a strong negative correlation, with almost identical values between budget expenditures for tourism and road length.

In the regression analysis of St. Petersburg data, R square exceeds 0.95, so there is a high degree of approximation. The significance of F does not exceed 0.05; therefore, the regression model is statistically significant, but the independent p-values exceed 0.05.

In interpreting the results of the Leningrad region dataset, it is worth noting that F significance exceeds 0.05 and p-values exceed 0.05, but the R square value corresponds to the average approximation.

The authors appealing to correlation and regression analysis results show that the values of both analyses are more significant and worthwhile for the Saint Petersburg dataset, but both datasets at the same time have two common trends in correlation values. We assume that the prominent causes of such results are different territory administration modes, other quantity and quality of economic resources and infrastructural ties between regions.

5. Discussion

The article's authors faced several problems while studying the primary topic of the article.

1. Insufficient data to draw more accurate conclusions about the transportation system. For example, there are no data on regional bus passenger transportation before 2021, so the authors did not include it in the datasets.

2. Different approaches to tourist flow assessment by regional officials and Rosstat, including Rosstat implementing its assessment methodology only in 2022.

3. Lack of a unified data pool by sector of life in the St. Petersburg agglomeration. If the data pool existed, it would presumably have facilitated the research work.

4. Different numerical indexes of tourist flow from the regional authorities Rosstat and EMISS on tourist flow. For example, the tourist flow calculated according to the Turbarometer of St. Petersburg for 2023 was 9.4 million, and the EMISS value was 15.2 million. Therefore, the authors chose the tourist flow data issued by the authorities of both regions.

Official statistics, information from tourist market participants, and data from cell phone operators and banks issuing credit and debit cards are prominent data sources on tourist movements. The data obtained from different sources are quite different, which does not allow us to conclude something reliable

but to make only evaluative judgments. The lack of reliable statistics on the usage of different modes of transportation by tourists does not allow us to offer a comprehensive solution to the problems of transport accessibility, at least within the St. Petersburg agglomeration, for visiting the palace suburbs.

It is vital to actively use digital technologies to track the movements of tourists to solve this problem.

The transport reform implementation in St. Petersburg with digital technologies in the transportation system integration (from payment systems to the construction of multimodal routes and real-time tracking of a particular transport object) allows for obtaining information about the movement of passengers. This information is applicable for forming routes and making public transport schedules to optimize passenger flow.

The Leningrad region is not so actively using digital technologies in the transportation system—only recently has the possibility of paying fares with bank cards on buses emerged. The absence of a unified digital fare payment tool for St. Petersburg and the Leningrad region reduces the tourist attractiveness of regional attractions.

6. Conclusion

In general, the authors revealed a regularity between the growth of tourist flows and the development of the transportation system in St. Petersburg and the Leningrad region.

There is a conclusion that the regression model for St. Petersburg has statistical significance with the same variables but not in the model of the Leningrad region. Further research, when more relevant and complete data become available, will make it possible to find out more about interrelations and draw conclusions.

A promising research area for the joint development of transportation and tourism in St. Petersburg and the Leningrad region may be the study of the tourist flow growth impact on the implementation of sustainable development goals in the regions. The growth in the number of tourists has positive and negative consequences for agglomeration.

On the one hand, the increase in tourist travel (almost any tourist product includes the use of one or another mode of transportation) impacts the gross regional product, provides employment and facilitates business initiatives. It allows the implementation of such sustainable development goals as “decent work and economic growth”, “industrialization, innovation, and infrastructure”, and “partnership for sustainable development”.

On the other hand, there is a significant increase in tourist flow to the overtourism level, leading to harmful effects on the environment, a decrease in the share of green spaces and natural objects in general for tourist infrastructure construction, an increase in prices of real estate and consumer goods, an increase in the amount of garbage, excessive load on the transportation system, and a reduction of recreational areas for residents, which all cause dissatisfaction among the population. Such unsuitable effects reduce the possibility of realizing such sustainable development goals as “responsible consumption and production”, “clean water and sanitation”, “conservation of marine ecosystems”, and “conservation of terrestrial ecosystems”.

Under the Sustainable Development Goal “responsible consumption and production”, the Russian Federation is developing index 12.b.1 “implementation of standardized accounting methods to track economic and environmental characteristics of tourism sustainability”. However, according to the Federal State Statistics Service, this index is presented only for the country without defining data by region.

The authors believe it is vital to use Moscow’s experience in integrating fare payment by any mode of transportation within the boundaries of the metropolis and on suburban electric trains using the “Troika” card[6]. Here are engaging and applicable additional services on the Troika card: visiting zoos,

[6]Troika card. URL: https://www.mosmetro.ru/payment/tickets/troyka

skating rinks, museums and traveling on the cable car and Aeroexpress trains. Such functionality can be appropriate to produce a tourist transportation card for the St. Petersburg agglomeration (in the future – for the entire territory of St. Petersburg and the Leningrad region).

This digital service will not only increase the attractiveness of travel in the two regions but also help track the movements of tourists to:

1. Optimize the route network;

2. Develop new routes and change the schedule of existing routes during peak demand periods in the high tourist season (white nights, etc.);

3. Formulate investment proposals within the framework of public-private partnership for the construction of transport infrastructure facilities for tourism in places near the objects of tourist interest; and

4. Determine the traffic load on the road network, considering the increased load on the roadway and railroad during the visit of tourists by personal and public transport.

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References

Berawi, M.A., 2016. Accelerating Sustainable Infrastructure Development: Assuring Well-Being and Ensuring Environmental Sustainability. International Journal of Technology 7, 527. https://doi.org/10.14716/ijtech.v7i4.3829

Buckley, R.C., Underdahl, S., 2023. Tourism and Environment: Ecology, Management, Economics, Climate, Health, and Politics. Sustainability 15, 15416. https://doi.org/10.3390/su152115416

Chen, Z., Haynes, K.E., 2015. Spatial impact of transportation infrastructure: A spatial econometric CGE approach. Regional Science Matters: Studies Dedicated to Walter Isard 163–186. https://doi.org/10.1007/978-3-319-07305-7_10

Deng, G., Chen, H.H., 2024. The Spatiotemporal Characteristics and Driving Factors of Regional Ecological Efficiency in the Tourism Sector. Sustainability (Switzerland) 16, 982. https://doi.org/10.3390/su16030982

Feng, X.B., 2023. Coupling and coordinated development of traffic accessibility and regional tourism economy. Research in Transportation Business and Management 49, 101010. https://doi.org/10.1016/j.rtbm.2023.101010

Gintciak, A., Burlutskaya, Z., Zubkova, D. 2023. Complex Modelling of Regional Tourism Systems. Sustainable 3. https://doi.org/https://doi.org/10.48554/SDEE.2023.3.5

Gintciak, A.M., Bolsunovskaya, M. V., Burlutskaya, Z. V., Petryaeva, A.A., 2022. High-level simulation model of tourism industry dynamics. Business Informatics 16, 53–67. https://doi.org/10.17323/2587-814X.2022.3.53.67

Gössling, S., Ring, A., Dwyer, L., Andersson, A.-C., Hall, C.M., 2016. Optimizing or maximizing growth? A challenge for sustainable tourism. Journal of Sustainable Tourism 24, 527–548. https://doi.org/10.1080/09669582.2015.1085869

Konyshev, E. V., Safarian, A.A., Veprikova, A.A., Shpengler, A. V., Kolesova, Y.A., Smetanina, A.I., 2023. The Study of the Perception of the Tourist and Recreation Space of the Region by Textual Data Analysis Method. Lecture Notes in Networks and Systems 622 LNNS, 334–346. https://doi.org/10.1007/978-3-031-28086-3_27

Kuchumov, A., Testina, Y., Egorova, S., Kulakova, N., 2023. Prospective Avenues for Digitalization of Tourism in Russia, in: Lecture Notes in Networks and Systems, pp. 230–247. https://doi.org/10.1007/978-3-031-32719-3_17

Liu, A., Wu, D.C., 2019. Tourism productivity and economic growth. Ann Tour Res 76, 253–265. https://doi.org/10.1016/j.annals.2019.04.005

Liu, W., Zhao, Q., Tian, X., 2023. Study on the Coupling and Coordination of Transportation and Tourism Development in Weinan City. Academic Journal of Management and Social Sciences 2, 77–82. https://doi.org/10.54097/ajmss.v2i2.7538

Popova, S., Koroleva, E., Efremova, M., 2023. Digitalization and Economic Development of Territories, in: Lecture Notes in Networks and Systems, pp. 320–330. https://doi.org/10.1007/978-3-031-32719-3_24

Rafiei Darani, H., Asghari, H., 2018. Study of international tourism demand in Middle East by panel data model. International Journal of Culture, Tourism, and Hospitality Research 12, 80–88. https://doi.org/10.1108/IJCTHR-03-2017-0030

Rodionov, D., Grishacheva, A., Shmeleva, A., Chertes, P., Melnikova, Z., Markevich, V., Konnikov, E., Kryzhko, D., 2023. The Information Environment Cluster Distribution of the Regional Socio-Economic Systems in Transition Economy, in: Lecture Notes in Networks and Systems, pp. 203–217. https://doi.org/10.1007/978-3-031-32719-3_15

Tan, P.Y., Ismail, H.N., 2020. Reviews on interrelationship between transportation and tourism: Perspective on sustainability of urban tourism development. IOP Conf Ser Earth Environ Sci 447, 012065. https://doi.org/10.1088/1755-1315/447/1/012065

Tanina, A., Konyshev, E., Abidova, D., Kryzhko, D., 2021. Strategic approaches to the management of sustainable tourism development: The Russian and German experience, in: Proceedings of the International Conference on Tourism Research, pp. 520–529. https://doi.org/10.34190/IRT.21.050

Tanina, A., Orel, A., Zaborovskaia, O., Tanin, E., 2023. Integral Indicator Assessment of Municipalities Sustainability in the Leningrad Region. International Journal of Technology 14, 1694–1705. https://doi.org/10.14716/ijtech.v14i8.6835

Tanina, A.V., Tashenova, L.V., Mamrayeva, D.G., Konyshev, E.V., 2023. State Support Measures for the Tourism Industry During the Covid-19

Pandemic: Digital Solutions, in: Lecture Notes in Networks and Systems, pp. 66–86. https://doi.org/10.1007/978-3-031-32719-3_6
Van Truong, N., Shimizu, T., 2017. The effect of transportation on tourism promotion: Literature review on application of the Computable General Equilibrium (CGE) Model. Transportation Research Procedia 25, 3096–3115. https://doi.org/10.1016/j.trpro.2017.05.336
Xu, H., Zhao, J., Yu, X., Mei, X., Zhang, X., Yan, C., 2023. A Model Assembly Approach of Planning Urban–Rural Transportation Network: A Case Study of Jiangxia District, Wuhan, China. Sustainability 15, 11876. https://doi.org/10.3390/su151511876
Yan, Y., Phucharoen, C., 2024. Tourism Transport-Related CO2 Emissions and Economic Growth: A Deeper Perspective from Decomposing Driving Effects. Sustainability 16, 3135. https://doi.org/10.3390/su16083135
Yu, J., Safarov, B., Wang, C., Buzrukova, M., Janzakov, B., 2023. The Effect of Transportation Networks on Heritage Tourism and New Urbanization—Empirical Research Based on Rich Heritage Sites in a Chinese Province. Heritage 6, 7293–7315. https://doi.org/10.3390/heritage6120383
Zhang, W., Wen, L., 2023. Analysis of the Coordination Effects and Influencing Factors of Transportation and Tourism Development in Shaanxi Region. Sustainability 15, 9496. https://doi.org/10.3390/su15129496
Zhao, L., Dong, Y., 2017. Tourism agglomeration and urbanization: Empirical evidence from China. Asia Pacific Journal of Tourism Research 22, 512–523. https://doi.org/10.1080/10941665.2016.1277545

Список источников

Berawi, M.A., 2016. Accelerating Sustainable Infrastructure Development: Assuring Well-Being and Ensuring Environmental Sustainability. International Journal of Technology 7, 527. https://doi.org/10.14716/ijtech.v7i4.3829
Buckley, R.C., Underdahl, S., 2023. Tourism and Environment: Ecology, Management, Economics, Climate, Health, and Politics. Sustainability 15, 15416. https://doi.org/10.3390/su152115416
Chen, Z., Haynes, K.E., 2015. Spatial impact of transportation infrastructure: A spatial econometric CGE approach. Regional Science Matters: Studies Dedicated to Walter Isard 163–186. https://doi.org/10.1007/978-3-319-07305-7_10
Deng, G., Chen, H.H., 2024. The Spatiotemporal Characteristics and Driving Factors of Regional Ecological Efficiency in the Tourism Sector. Sustainability (Switzerland) 16, 982. https://doi.org/10.3390/su16030982
Feng, X.B., 2023. Coupling and coordinated development of traffic accessibility and regional tourism economy. Research in Transportation Business and Management 49, 101010. https://doi.org/10.1016/j.rtbm.2023.101010
Gintciak, A., Burlutskaya, Z., Zubkova, D. 2023. Complex Modelling of Regional Tourism Systems. Sustainable … 3. https://doi.org/ https://doi.org/10.48554/SDEE.2023.3.5
Gintciak, A.M., Bolsunovskaya, M. V., Burlutskaya, Z. V., Petryaeva, A.A., 2022. High-level simulation model of tourism industry dynamics. Business Informatics 16, 53–67. https://doi.org/10.17323/2587-814X.2022.3.53.67
Gössling, S., Ring, A., Dwyer, L., Andersson, A.-C., Hall, C.M., 2016. Optimizing or maximizing growth? A challenge for sustainable tourism. Journal of Sustainable Tourism 24, 527–548. https://doi.org/10.1080/09669582.2015.1085869
Konyshev, E. V., Safarian, A.A., Veprikova, A.A., Shpengler, A. V., Kolesova, Y.A., Smetanina, A.I., 2023. The Study of the Perception of the Tourist and Recreation Space of the Region by Textual Data Analysis Method. Lecture Notes in Networks and Systems 622 LNNS, 334–346. https://doi.org/10.1007/978-3-031-28086-3_27
Kuchumov, A., Testina, Y., Egorova, S., Kulakova, N., 2023. Prospective Avenues for Digitalization of Tourism in Russia, in: Lecture Notes in Networks and Systems, pp. 230–247. https://doi.org/10.1007/978-3-031-32719-3_17
Liu, A., Wu, D.C., 2019. Tourism productivity and economic growth. Ann Tour Res 76, 253–265. https://doi.org/10.1016/j.annals.2019.04.005
Liu, W., Zhao, Q., Tian, X., 2023. Study on the Coupling and Coordination of Transportation and Tourism Development in Weinan City. Academic Journal of Management and Social Sciences 2, 77–82. https://doi.org/10.54097/ajmss.v2i2.7538
Popova, S., Koroleva, E., Efremova, M., 2023. Digitalization and Economic Development of Territories, in: Lecture Notes in Networks and Systems, pp. 320–330. https://doi.org/10.1007/978-3-031-32719-3_24
Rafiei Darani, H., Asghari, H., 2018. Study of international tourism demand in Middle East by panel data model. International Journal of Culture, Tourism, and Hospitality Research 12, 80–88. https://doi.org/10.1108/IJCTHR-03-2017-0030
Rodionov, D., Grishacheva, A., Shmeleva, A., Chertes, P., Melnikova, Z., Markevich, V., Konnikov, E., Kryzhko, D., 2023. The Information Environment Cluster Distribution of the Regional Socio-Economic Systems in Transition Economy, in: Lecture Notes in Networks and Systems, pp. 203–217. https://doi.org/10.1007/978-3-031-32719-3_15
Tan, P.Y., Ismail, H.N., 2020. Reviews on interrelationship between transportation and tourism: Perspective on sustainability of urban tourism development. IOP Conf Ser Earth Environ Sci 447, 012065. https://doi.org/10.1088/1755-1315/447/1/012065
Tanina, A., Konyshev, E., Abidova, D., Kryzhko, D., 2021. Strategic approaches to the management of sustainable tourism development: The Russian and German experience, in: Proceedings of the International Conference on Tourism Research, pp. 520–529. https://doi.org/10.34190/IRT.21.050
Tanina, A., Orel, A., Zaborovskaia, O., Tanin, E., 2023. Integral Indicator Assessment of Municipalities Sustainability in the Leningrad Region. International Journal of Technology 14, 1694–1705. https://doi.org/10.14716/ijtech.v14i8.6835
Tanina, A.V., Tashenova, L.V., Mamrayeva, D.G., Konyshev, E.V., 2023. State Support Measures for the Tourism Industry During the Covid-19 Pandemic: Digital Solutions, in: Lecture Notes in Networks and Systems, pp. 66–86. https://doi.org/10.1007/978-3-031-32719-3_6
Van Truong, N., Shimizu, T., 2017. The effect of transportation on tourism promotion: Literature review on application of the Computable General Equilibrium (CGE) Model. Transportation Research Procedia 25, 3096–3115. https://doi.org/10.1016/j.trpro.2017.05.336
Xu, H., Zhao, J., Yu, X., Mei, X., Zhang, X., Yan, C., 2023. A Model Assembly Approach of Planning Urban–Rural Transportation Network: A Case Study of Jiangxia District, Wuhan, China. Sustainability 15, 11876. https://doi.org/10.3390/su151511876
Yan, Y., Phucharoen, C., 2024. Tourism Transport-Related CO2 Emissions and Economic Growth: A Deeper Perspective from Decomposing Driving Effects. Sustainability 16, 3135. https://doi.org/10.3390/su16083135
Yu, J., Safarov, B., Wang, C., Buzrukova, M., Janzakov, B., 2023. The Effect of Transportation Networks on Heritage Tourism and New Urbanization—Empirical Research Based on Rich Heritage Sites in a Chinese Province. Heritage 6, 7293–7315. https://doi.org/10.3390/heritage6120383
Zhang, W., Wen, L., 2023. Analysis of the Coordination Effects and Influencing Factors of Transportation and Tourism Development in Shaanxi Region. Sustainability 15, 9496. https://doi.org/10.3390/su15129496

Zhao, L., Dong, Y., 2017. Tourism agglomeration and urbanization: Empirical evidence from China. Asia Pacific Journal of Tourism Research 22, 512–523. https://doi.org/10.1080/10941665.2016.1277545

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SECTION 4

MANAGEMENT OF KNOWLEDGE AND INNOVATION FOR SUSTAINABLE DEVELOPMENT

РАЗДЕЛ 4

УПРАВЛЕНИЕ ЗНАНИЯМИ И ИННОВАЦИЯМИ В ИНТЕРЕСАХ УСТОЙЧИВОГО РАЗВИТИЯ

Research article

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Capital Flight as a Threat to the Country's Economic Security

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Abstract

The purpose of this study is to consider the phenomenon of 'capital flight' as a threat to the economic security of the country. This goal is achieved using general scientific methods, including analysis and synthesis, induction and deduction, abstraction, systematisation, and comparison. The study highlights the differences between the concepts of 'capital outflow' and 'capital flight', assesses the scale of capital flight and outflow, analyses the causes of these phenomena, and explicates the goals of capital flight. One of the causes of capital flight, namely tax evasion, is specified. The findings underscore the main directions of the impact of capital flight on the economic security of the country, and key measures to combat capital flight are proposed.

Keywords: capital flight, capital outflow, threat, economic security

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Бегство Капитала как Угроза Экономической Безопасности Страны

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Аннотация

Цель исследования заключается в рассмотрении явления «бегство капитала» в качестве угрозы экономической безопасности страны. Для достижения поставленной цели были применены общенаучные методы познания, такие как: анализ и синтез, индукция и дедукция, абстрагирование, систематизация, а также сравнительный метод. Основными результатами исследования являются обоснование различий понятия «отток капитала» и «бегство капитала», оценка масштабов бегства и оттока капитала, анализ причин возникновения этих явлений, анализ целей возникновения бегства капитала, подробно раскрыта одна из причин возникновения бегства капитала – уклонение от уплаты налогов, обоснованы основные направления влияния бегства капитала на экономическую безопасность страны, предложены основные меры по борьбе с бегством капитала.

Ключевые слова: бегство капитала, отток капитала, угроза, экономическая безопасность.

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1. Introduction

Capital flight is a phenomenon that draws increasing attention from the academic community as well as political and economic figures. This process is characterised by the transfer of financial resources and assets from one country to another, which is becoming an integral part of the modern global economy. Capital flight can occur for a variety of reasons, but its consequences can be devastating for a country's economic security.

In this paper, we analyse capital flight as a phenomenon and outline its causes and consequences for the economy and financial stability of the country. Modern methods and strategies for combating this threat, aimed at strengthening the economic security of the state, are also presented. This study provides a complete overview of capital flight and its importance to Russia's current economic policy and security.

Many economists and researchers have carefully studied and considered capital flight as a threat to a country's economic security. Joseph Stiglitz, Darnell Girhardt, Raghuran Rajan, and Maurice Obstfeld are among the most prominent economists and researchers whose works are relevant to this topic. Some economists equate the concepts of 'capital outflow' and 'capital flight' (Nersisyan, 2020), and others consider just one of these two phenomena. For example, researchers posited that 'capital flight is essentially a massive outflow of private capital due to the growing economic and political instability of the national economy' (Nevmovenko, Shmyreva, 2012). Another study defined the outflow of capital as 'the flow of funds beyond the economic borders of the state, where funds are poured into the turnover of foreign economies, and the state's money is invested in foreign assets' (Smirnov, Gamulinskaya, 2023). Thus, it is necessary to consider the essence of these two phenomena to distinguish between them.

2. Methods and materials

The research methodology is based on general scientific methods, such as analysis and synthesis, induction and deduction, abstraction, and systematisation, as well as comparison. The study used statistical data and materials from the Organisation for Economic Cooperation and Development, the Ministry of Finance of Russia, the Federal Tax Service of Russia, the Prosecutor General's Office of Russia, and the Bank of Russia.

It is a challenge to assess the capital flight phenomenon because it is a part of the shadow business. However, to understand the scale of shadow activities in a particular country, we can refer to the data from the 'Shadow Economies Around the World: What Did We Learn Over the Last 20 Years?' study conducted by the International Monetary Fund, which analysed the scale of the shadow economy in 158 countries for the 1991–2015 period.[1] Regarding the outflow of capital, this study used official data on the import and export of capital from Russia, which have been named financial transactions of the private sector by the Central Bank.

3. Results

Issues of the country's economic security are becoming relevant in a world where the free movement of capital has become an integral part of the world's modern economy. The net import/export of capital is one indicator of a country's economic security. This phenomenon is often confused with capital flight. In this regard, it is necessary to differentiate capital outflow and capital flight. An analysis of the scientific literature reveals that the concepts of capital outflow and capital flight are not identical. Here, capital outflow implies the balance of private sector financial transactions without suspicious transactions[2], whereas capital flight encompasses these suspicious operations. Capital flight is the process by which financial assets and capital are moved out of the country, bypassing the tax system and restrictions imposed by the government. Capital flight can take a variety of forms, such as withdrawing funds to foreign accounts, investing in foreign assets, buying real estate abroad, and other operations aimed at avoiding domestic economic risks.

[1]

[2]Nabiullina explained what the capital outflow from Russia means." Internet resource. URL: https://ria.ru/20181010/1530390761.html. Accessed October 5, 2023.

Having understood the difference between capital outflow and capital flight, it is necessary to assess the scale of these phenomena. Below are the official data on the net inflow/outflow of capital from the country. For clarity, the statistics are presented in the form of a graph (Fig. 1).

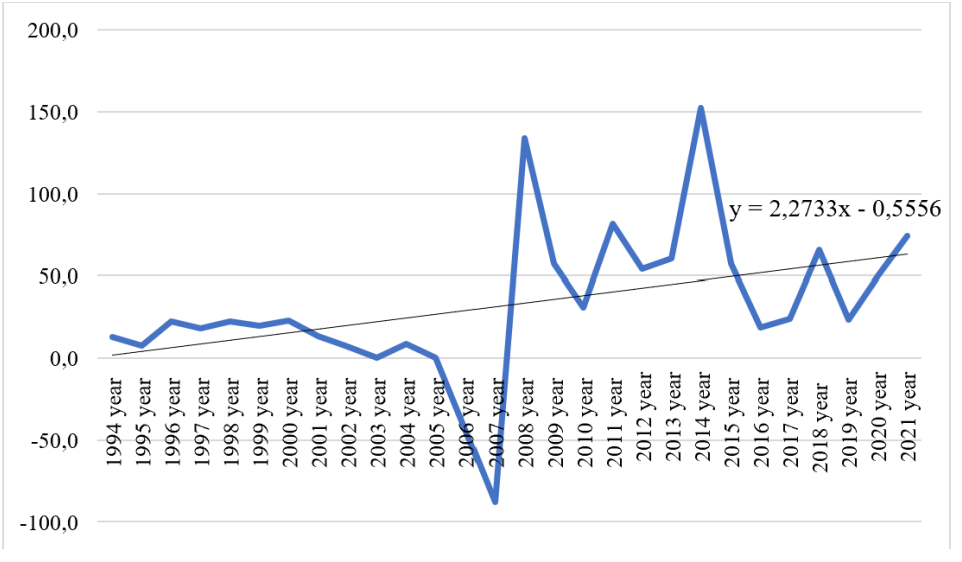

Figure 1. Net inflow/outflow of capital in Russia

Source: compiled by the author based on data from the Bank of Russia

As shown in Figure 1, the largest capital outflow was observed during 2006–2007, and the largest inflow was observed in 2014. It should also be noted that the import of capital exceeded its export from 2008 to 2021. Next, we turn to the data on Russia's shadow economy to assess the scale of capital flight.

Table 1. Data on the shadow economy in Russia for 2012–2018 (Tatevosyan, 2021)

Year	2012	2013	2014	2015	2016	2017	2018
Size of the shadow economy, trillion rubles	9.36	11.01	12.35	23.4	24.3	18.9	20.7
Share of the GDP, %	15.00	16.51	17.30	28.16	28.26	20.54	19.98

Source: compiled by the author based on data from the Federal State Statistics Service and the Federal Financial Monitoring Service

For example, the share of the shadow economy amounted to about 20% of the GDP in 2018 (Fig. 2).

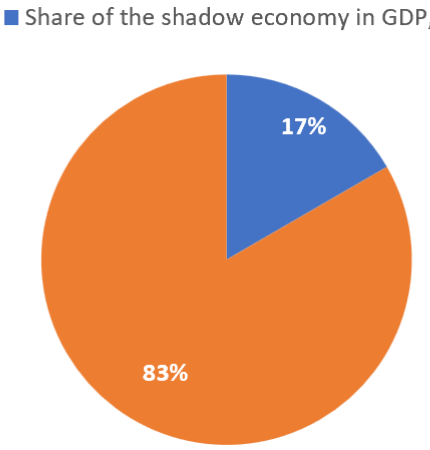

Figure 2. Share of the shadow economy in GDP

Additionally, in 2018, the International Monetary Fund published a study entitled 'Shadow Economies Around the World: What Did We Learn Over the Last 20 Years?' This study analysed 158 countries for the availability and level of the shadow economy between 1991 and 2015 and showed that the average level of the shadow economy in Russia for this period was 38.42%. For comparison, this figure was 8.34% for the United States and 60.64% for Zimbabwe.

The reasons for capital outflow and capital flight are quite similar:

1. Economic crises. They are expressed as temporary and long-term economic difficulties, for example, inflation, budget deficits, and currency collapses.

2. Political instability, which is expressed by crises, elections, revolutions, and changes in the government. Instability can create uncertainty and risk for businesses and investments.

3. Corruption and bureaucracy can also cause capital flight, as they exacerbate risks and create obstacles for businesses.

4. Abrupt changes in tax legislation (for example, an increase in tax rates) can significantly worsen business conditions and cause capital outflow abroad.

5. Unstable situations on the global stage and countries involved in conflicts are the reason for the outflow of capital from them, as they are insecure.

The issue of capital flight has two sides. The first is the outflow of foreign capital, which reduces the attractiveness of domestic enterprises to foreign investment. The second is the outflow of Russian capital abroad, which leads to an increase in the foreign assets of Russian residents (Vinnikova, Kuznetsova, Bindyukova, 2019). The total amount of foreign assets of the Russian Federation decreased by USD 42.2 billion and amounted to USD 1551.7 billion as of July 01, 2023 (Table 2).

Table 2. Foreign assets of the Russian Federation, US$ million

	Balance as of January 1, 2023	Balance as of July 1, 2023
Total	1,593,908	1,551,736
Direct investments	381,194	337,589
Portfolio investment	80,641	74,773
Derivatives	1,282	1,033
Other investments	548,801	555,924
Reserve assets	581,989	582,418

Source: compiled by the author based on data from the Bank of Russia

Fig. 3 highlights the main goals of capital flight.

Figure 3. Main objectives in exporting capital

There are various ways through which capital flight occurs, namely offshore accounts and companies, investments in real estate, funds and shares, tax havens, and business relocation. When the export of capital is carried out legally, fulfilling all obligations and requirements for paying relevant taxes and declarations, this is not recognised as capital flight. However, in practice, illegal capital flight schemes are carried out to pursue the goal of tax evasion and money laundering. Tax residents seek to reduce their tax burden, since moving funds to countries with lower tax payments allows them to save on taxes and increase profits. Capital flight can also be carried out due to the desire to protect one's assets from possible confiscation, seizure, and prosecution, especially in periods of unstable political and economic global situations.

The use of various methods of capital flight reflects the selfish motives of taxpayers for personal enrichment through hiding assets and tax evasion, thereby expressing their disagreement with the country's tax system. Their decisions are also influenced by the attractiveness of foreign investment. Some countries provide preferential conditions for foreign investors to attract capital and locate businesses under confidential and more favourable tax conditions. Tax evasion is today's global challenge that has a significant impact on the economy and social development of many countries. There are a large number of academic works that consider various reasons for the emergence and spread of this negative phenomenon. In this paper, however, we turn our attention to tax evasion as a key cause of another global process, namely capital flight.

Tax payments are one of the main sources of government revenue. The largest part of the structure of federal budget revenues belongs to the mineral extraction tax (39%) and the import value added tax (23.3%) (Fig. 4). In total, the budget system of the Russian Federation received 42 trillion rubles in January–December 2022, and the growth rate amounted to 14.68% (Fig. 5).

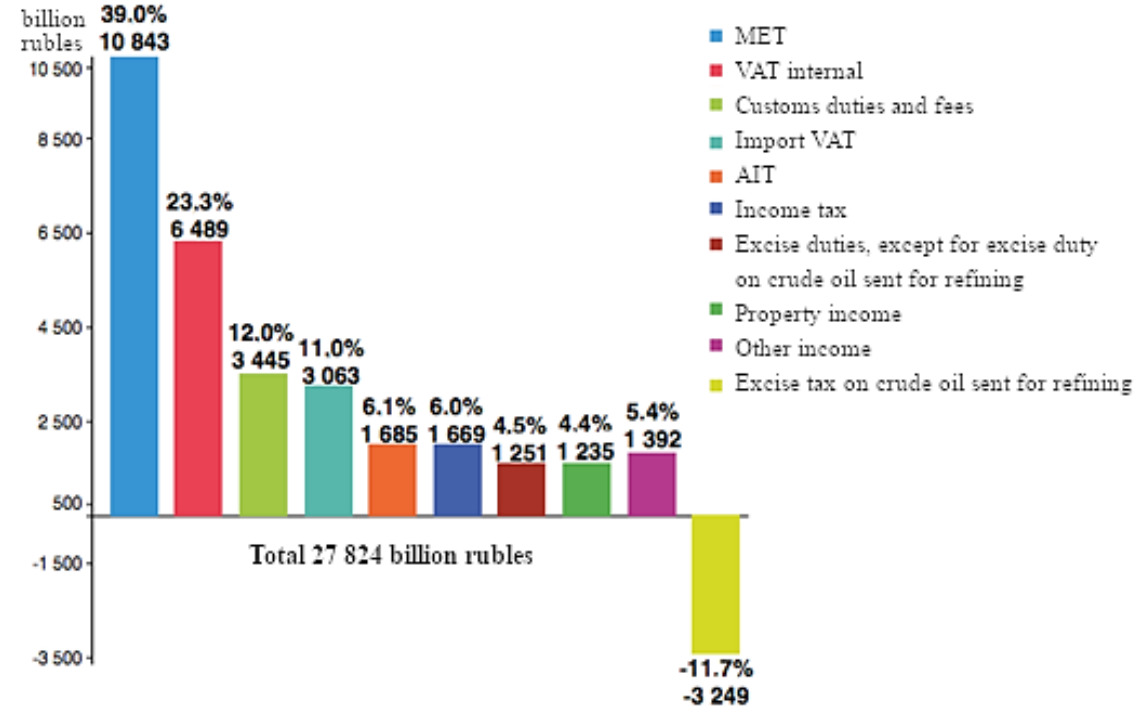

Figure 4. Structure of federal budget revenues for 2022

Source: Ministry of Finance of the Russian Federation

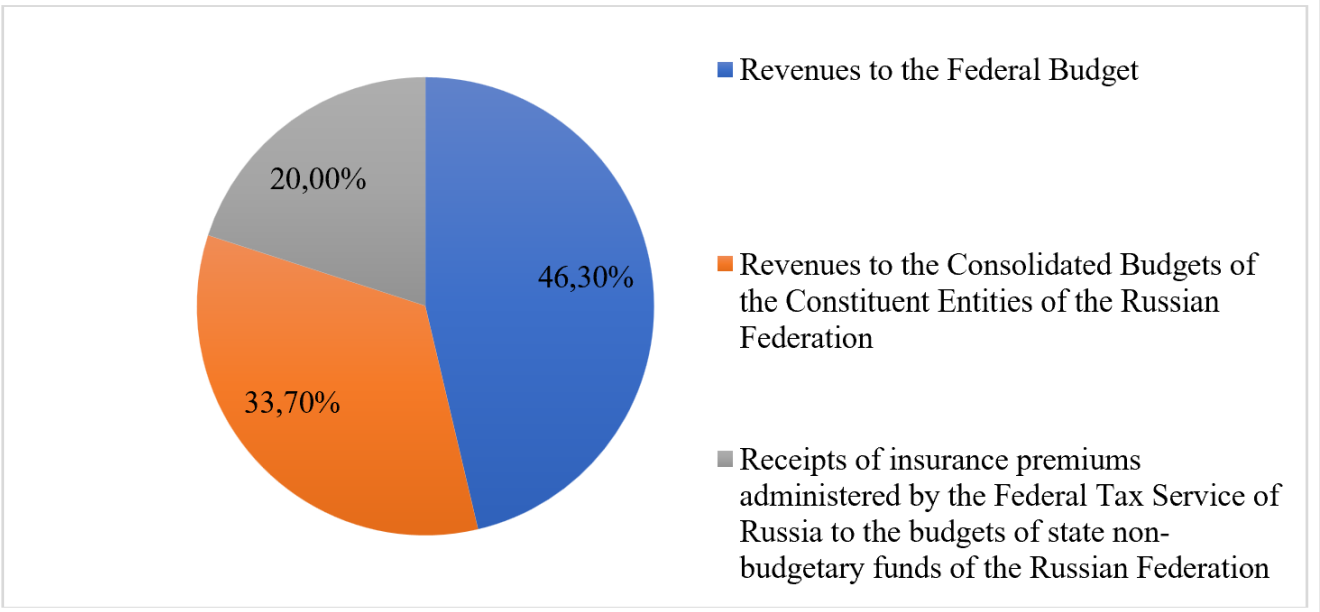

Figure 5. Revenues to the budget system of the Russian Federation in January–December 2022

Source: compiled by the author based on data from the Analytical Portal of the Federal Tax Service of Russia

However, tax payments constitute not only an important part of the state budget but also an essential part of the profits and incomes of the population and organisations. Economic entities strive to reduce costs, explaining this as a reason for personal enrichment and an opportunity to direct the freed-up financial resources to business development. When opportunities arise for offshore companies and tax havens, taxpayers may take risks to obtain greater profits and choose to hide assets and move capital abroad. In addition, problems such as high tax rates, unfair distribution of the tax burden, opacity and instability of the tax system, and corruption can encourage economic entities to search for ways to reduce tax liabilities.

There are legal ways to optimise taxation. The government provides various tax incentives and special tax regimes. Therefore, the use of illegal methods to reduce tax payments, that is, tax evasion, violates the principle of fair competition and does not justify taxpayers' desire to improve their position in the market. Capital flight undermines taxpayers' confidence in the tax system and reduces government revenues, which leads to increased social inequality and limits the country's development.

Transnational corporations have a particular impact on the problem of capital flight. Such corporations have the freedom to choose tax rules and laws to avoid paying taxes in the countries where they make profits, since they conduct their economic activities in different countries and even on different continents. In particular, some corporations use the method of 'transfer pricing', 'profit shifting', or 'thin capitalisation' (Tserenova, 2017). Tax havens serve as permanent legal addresses for more than 2 million companies and thousands of banks. Some analysts estimate the wealth in these tax havens to be around US$20 trillion[3].

Some governments have introduced 'thin capitalisation' rules to ensure that transnational corporations involved in the exploitation of their country's resources pay a fair amount of tax payments and cannot manipulate their capital structure for tax purposes. These rules are designed to counteract the cross-border movement of profits through excessive debt levels and therefore aim to protect the country's tax base. This rule was first introduced in Canada in 1972 and is currently in effect in about 60 countries[3]. In Russia, thin capitalisation rules are applied in cases where the amount of controlled debt on a debt obligation is more than 3 times higher than the equity capital of a Russian organisation[4].

[3]Risk of capital flight. URL: https://webeconomy.ru/index.php?page=cat&cat=mcat&mcat=137&type=news&p=5&newsid=1936. Accessed October 8, 2023.
[4]Controlled debt. General ledger. URL: https://glavkniga.ru/situations/k501434. Accessed October 8, 2023.

The erosion of the tax base and profit outflow into tax havens have become global problems, the solution of which requires global cooperation. The Organisation for Economic Co-operation and Development created the BEPS project to combat artificial income outflow from high-tax countries where economic activity takes place in low- or no-tax countries without such economic activity. A total of 15 measures were adopted within the project at the G20 summit, the implementation of which should allow countries to combat this phenomenon (Shelepov, 2016).

The Russian Federation has supported these measures. Russia signed an international agreement on the automatic exchange of country-by-country reports to improve information transparency[5], and started exchanging information with the CIS countries in electronic format. Further, some laws on deoffshorisation were adopted, and three stages of capital amnesty were implemented, calling for the return of residents' capital to Russian jurisdiction. Amendments were made in relation to controlled foreign companies, which toughens liability for the non-fulfilment of tax obligations. Since mid-March, the legalisation of cash has become possible in Russia, while the state has pledged not to investigate the true sources of these funds' origin (Trigub, 2022).

Recently, the issue of paying taxes by global transnational media corporations has been discussed (Markina, 2018). Particular attention is paid to the content and media sector. In addition, the emergence of new technologies that allow withdrawal of financial assets also requires a response from government agencies. The Russian Federation has already taken measures to regulate digital financial assets[6]. Measures are being developed and proposed to counteract new ways of tax evasion with the illegal withdrawal of assets abroad using such innovative technologies as cryptocurrency. Cryptographic transactions attract criminals due to their anonymity, data confidentiality, and the high speed of transactions, which makes it possible to slow down the process of finding suspects or even avoid prosecution by law enforcement agencies. Actually, a three-phase model of tax evasion has gained popularity. This model can also act as a means of committing crimes, such as legalisation of proceeds from crime (laundering), corruption-related crimes, and assistance to terrorist activities (Garmysheva, 2023).

There are several ways to deposit funds in cryptocurrency (Guseva, 2018):

– OTC transactions carried out directly outside the market;

– direct money transfer to cryptocurrency bypassing the KYC identification procedure on the exchange through a more private cryptocurrency or providing false passport data;

– using multiple accounts and accruing the maximum allowed amount that does not require identification.

Cryptocurrencies are widely used for illegal activities, including tax evasion and capital flight abroad. All these aspects require special measures to regulate cryptocurrencies and combat illegal activities related to their use. At present, there is a growing interest in ensuring economic security in the field of taxes. Tax security is a key component of the national economic security system, along with financial, investment, food, and energy security. It also serves as the basis for the functioning of all other spheres of economic security. It is impossible to protect other sectors of the economy and ensure their normal functioning without ensuring tax security. This includes such sectors as health, education, national defence, and social policy. Consequently, preventing threats to economic security in the field of taxation is a priority task to guarantee the sustainable development and prosperity of the state.

The Federal Tax Service is authorised to conduct a tax audit, the purpose of which is to control the taxpayer's compliance with the law. Tax control is an integral part of financial control, and it includes certain tools to combat tax evasion. The main instruments of tax control are taxpayer registration with tax authorities, desk tax audits, on-site tax audits, tax monitoring, and information complexes.

[5] Decree of the Government of the Russian Federation of August 14, 2014 No. 805 (as amended on February 21, 2018) 'On concluding agreements on the exchange of information on tax matters'. ATP Consultant Plus. URL: https://www.consultant.ru/document/cons_doc_LAW_167364/c672066b3deec9fb6ea9847804821ef6d4e8e374/ Accessed October 8, 2023.
[6] Federal Law No. 259-FZ of July 31, 2020. On digital financial assets, digital currency and on amendments to certain legislative acts of the Russian Federation. ATP Consultant Plus. URL: https://www.consultant.ru/document/cons_doc_LAW_358753/ Accessed October 8, 2023.

Registration of taxpayers allows monitoring of the databases of the Unified State Register of Individual Entrepreneurs and the Unified State Register of Legal Entities, track setting up shell companies, winding up of inactive organisations, etc. The problem of capital flight remains relevant, despite all the measures taken by the government to improve taxation, tax administration, and control, or to develop a comfortable environment for doing business in Russian jurisdiction. Tax evasion through capital flight is a threat to the economic security of the country, as it leads to a significant loss of budget revenues, which reduces the government's ability to finance important programs, and leads to an increase in economic crimes. Out of the crimes in the sphere of economic activity, tax evasion (including through capital flight) causes the greatest damage to the state budget. For example, the amount of identified damage from tax crimes amounted to 81.6 billion rubles in 2022[7].

It is also worth noting that with its lower-than-average fiscal burden (21.6% without mineral extraction tax), according to the Organisation for Economic Cooperation and Development, Russia has a significant share of the shadow economy (38.42% of GDP), which includes tax evasion.[8] Effective collaboration of the governmental bodies on the tax crime system yields results that are reflected in statistical data. Tax revenues to the federal budget of the Russian Federation increased by 22.35% in January–December 2022 compared to the same period of the previous year[9]. Existing anti-tax evasion tools make a special contribution to the government's efforts to combat tax evaders. There is a wide variety of criteria for classifying anti-tax evasion tools (Garmysheva, 2022).

However, statistical data confirm the need to improve the existing tools for countering tax evasion and capital flight and to introduce new ones to improve the mechanism for countering this negative phenomenon in Russia. The dynamics of the number of registered tax crimes has a downward trend with some fluctuations (Fig. 6), while the dynamics of capital outflow from the country is rapidly increasing (Fig. 7). On the one hand, this may indicate a strong influence of external factors on capital flight from Russia, apart from the desire to evade taxes. On the other hand, this indicates the need to improve tools for detecting, disclosing, and countering tax evasion due to the accelerated development of innovative technologies used to transfer assets abroad. The time lag in government decision-making to combat tax crime has a significant impact as well.

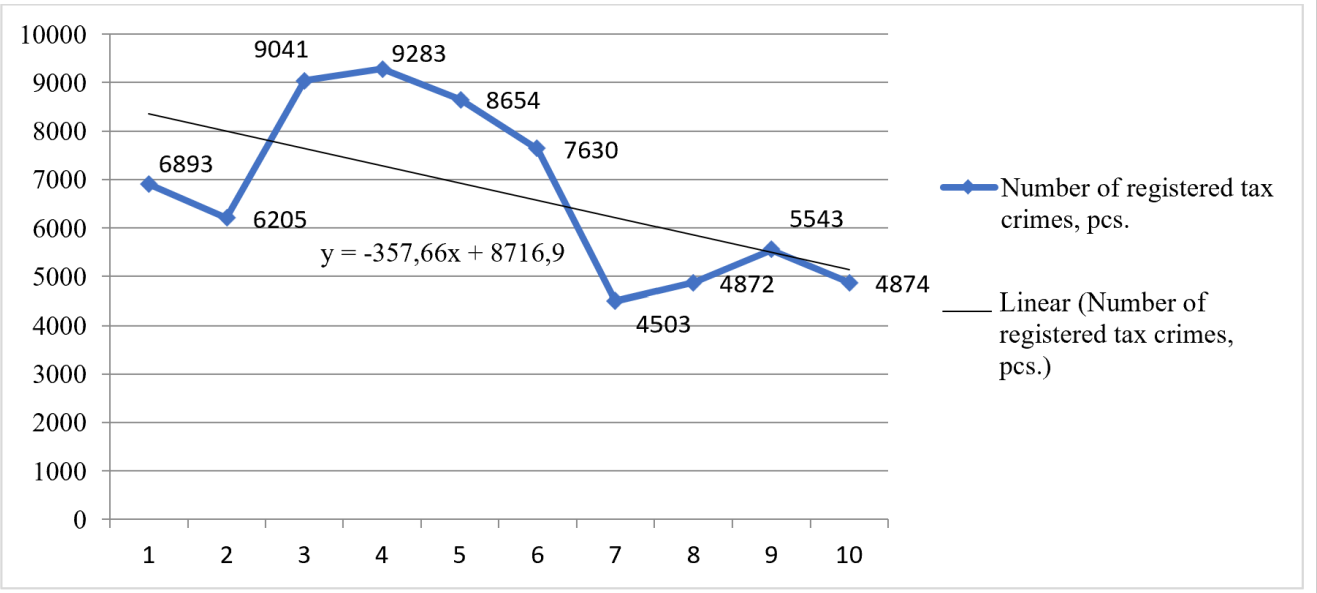

Figure 6. Dynamics of registered tax crimes in 2013-2022

Source: Compiled by the author based on the data of the portal of legal statistics of the General Prosecutor's Office of the Russian Federation

[7]The amount of reimbursed damage for tax crimes in 2022 amounted to 50 billion rubles. URL: https://www.gazeta.ru/business/news/2023/05/15/20433158.shtml?updated. Accessed October 6, 2023.
[8]Official website of the International Monetary Fund. URL: https://www.imf.org/en/publications/wp/issues/2018/01/25/shadow-economies-around-the-world-what-did-we-learn-over-the-last-20-years-45583. Accessed October 5, 2023.
[9]Analytical web portal of the Federal Tax Service of Russia. URL: https://analytic.nalog.gov.ru/. Accessed October 8, 2023.

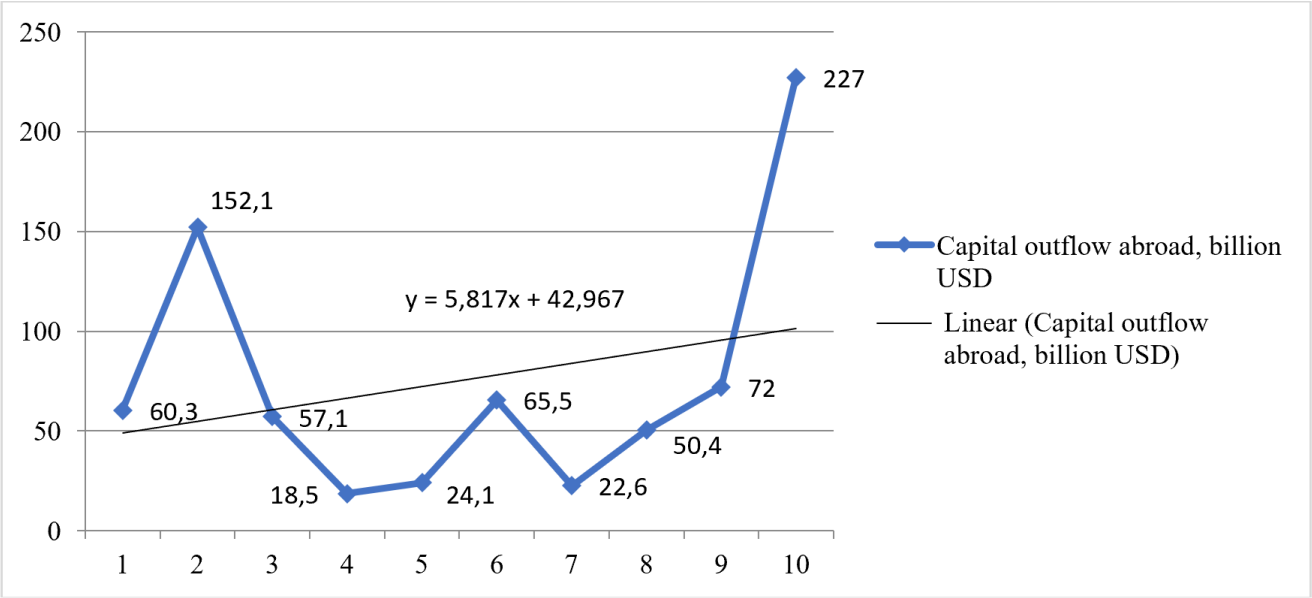

Figure 7. Dynamics of capital outflow abroad in 2013–2022

Source: Compiled by the author based on data from World Finance

Thus, statistical data confirm the need to improve the existing tools for countering tax evasion and capital flight and to introduce new ones in order to improve the functioning of the mechanism for countering these negative phenomena in Russia.

In turn, capital outflow and capital flight affect the country's economic security. The main problems influencing the country's economic security include:

1. Declining investment and slower economic growth.

Fearing economic and political instability, investors withdraw their funds from the country, reducing the volume of these investments or stopping them altogether. This, in turn, reduces capital availability for the development of new projects and businesses, hampering the country's economic growth.

2. Job cuts and rising unemployment.

Reduced investment and slower economic growth associated with capital outflow and capital flight may lead to higher unemployment. Higher unemployment can undermine the country's social stability and economic security.

3. Deterioration of financial stability.

Capital flight and capital outflow can cause a deterioration in financial stability, especially if it occurs suddenly and on a massive scale. The country may face depreciation of the national currency, a decrease in tax revenues, and an increase in public debt. These phenomena weaken the financial stability of the government and the government's ability to meet its financial obligations.

4. Threats to the financial sector of the state.

Capital flight and capital outflow can threaten the financial sector by reducing the bank deposits and assets of financial institutions, which can cause financial crises and even bank failures.

5. Impact on the exchange rate and inflation.

As mentioned above, capital flight and capital outflow can put serious pressure on the national currency, thereby devaluing it. This, in turn, can increase the cost of imports and the inflation rate. High inflation can negatively affect the citizens' standard of living and the economic security of the country.

6. Declining share of innovations.

Reduced investment and a deteriorating economic environment can reduce the research and innovation levels in the country. This can limit economic growth potential and reduce the country's competitiveness on the global stage.

4. Discussion

This paper emphasises the relevance of the capital flight problem. The presented statistical data confirm the consideration of this problem as a threat to the country's economic security. The study includes such critical aspects as the scale and dynamics of capital flight from Russia, causes and consequences of this capital flight, international cooperation in this area, examples of combating capital flight, and recommendations for the necessary actions to prevent this negative phenomenon.

The authors reveal the essence of the 'capital flight' concept and highlight its features, highlighting examples of its impact on the crime level and budget system revenues of the Russian Federation. In this regard, the need to develop and implement additional measures aimed at strengthening the investment climate, combating tax crime and corruption, and ensuring the financial stability of the country is emphasised. Such measures include the following:

1. Improving the investment climate.

Simplifying business registration procedures, reducing bureaucratic burdens, and ensuring property rights protection are the key to improving the country's investment climate.

2. Developing an effective and reasonable fiscal policy.

Developing fair and reasonable tax policies can reduce capital flight. To this end, it is possible to reduce the tax burden and provide tax benefits.

3. Controlling capital movements.

Some countries may introduce temporary capital controls, such as restrictions on capital outflows and foreign exchange transactions.

4. Protecting investors' rights.

This is the guarantee of investors' rights, including their right to judicial appeal and compensation for damages. Such measures contribute to increasing confidence in investment in the country.

5. Transparency of the tax system and the fight against corruption.

The introduction of anti-corruption measures and active support for the development of advanced technologies by the Federal Tax Service of Russia contribute to strengthening investor confidence.

6. International cooperation.

Cooperation with other countries and international organisations can be effective in combating capital flight. For example, entering into bilateral tax and investment agreements can help eliminate double taxation.

7. Supporting small and medium-sized businesses.

Incentivising and supporting small and medium-sized enterprises can make economies more diverse and resilient to capital flight.

8. Developing financial markets and much more.

Strengthening financial markets and their infrastructure can make the country more attractive to investors.

It is important to note that comprehensive and coordinated measures are needed to combat capital flight and capital outflow.

5. Conclusion

Ultimately, capital flight and capital outflow pose serious risks to the country's economic security. However, these risks can still be managed by special arrangements to combat capital flight and capital outflow. Efforts should be made to establish an open and stable economic environment that will attract investors and contribute to economic growth. Implementing measures to strengthen legal and financial institutions can reduce the risks of capital flight and ensure the country's economic security in the long term.

References

Gamulinskaya, N.V., Smirnov, F.E., 2023. Capital outflow from the country as a threat to economic security. Vector of Economics 1.

Garmysheva, A.A., 2022. Analysis of tools for counteracting tax evasion in the Russian Federation. Management Accounting 12(1), 38–45.

Garmysheva, A.A., 2023. Using cryptocurrency as a new way to evade taxes. Economic security of the individual, society, state: Problems and ways to ensure. Proceedings of the All-Russian scientific and practical conference, St. Petersburg, April 7, 2023. Compiled by Myachin, N.V., Soboleva, V.O. St. Petersburg: St. Petersburg University of the Ministry of Internal Affairs of the Russian Federation, 48–51.

Guseva, A.A., 2018. Possible ways to solve the problem of money laundering through cryptocurrency. Economics. Right. Innovation 5(2), 36–45.

Markina, Y.V., 2018. World transnational media corporations as a segment of the globalization of information activity. Scientific Bulletins of the Belgorod State University. Series: Humanities 37(3), 480–488.

Medina, L., Schneider, F., 2018. Shadow economies around the world: What did we learn over the last 20 years? IMF Working Paper, 77.

Nersisyan, R.V., 2020. Capital outflow from Russia as a threat to economic security. EurasiaScience: Collection of Articles of the XXVII International Scientific and Practical Conference, Moscow, February 15, 2020, Moscow: Limited Liability Company "Actuality. RF", 301–302, EDN IGYUJJ.

Nevmovenko, V.M., Shmyreva, A.I., 2012 Capital flight as a threat to national security. Bulletin of NSUEM 2. https://cyberleninka.ru/article/n/begstvo-kapitala-kak-ugroza-natsionalnoy-bezopasnosti. Accessed October 5, 2023.

Shelepov, A.V. 2016. BEPS project: Global cooperation in the field of taxation. Bulletin of International Organizations: Education, Science, New Economics 11(4), 36–59.

Tatevosyan, A.S., 2021. Shadow economic phenomena in the field of foreign economic activity. Economic security of the individual, society, state: Problems and ways to ensure: Materials of the Annual All-Russian Scientific and Practical Conference, St. Petersburg, April 09, 2021. Compiled by N.V. Ball. St. Petersburg: St. Petersburg University of the Ministry of Internal Affairs of the Russian Federation, 184–188. EDN BZZQQL.

Trigub, E.Y., 2022. Main stages of the deoffshorization policy in the Russian Federation. Scientific Works of the Free Economic Society of Russia 237(5), 414–432.

Tserenova, K.N. 2017. Thin capitalization in Russia: Regulatory issues and assessment of the scale of the problem. Theoretical and Applied Economics 1, 140–149.

Vinnikova, I.S., Kuznetsova, E.A., Bindyukova, A.P., 2019. Capital flight from Russia: Problems and solutions. Innovative Economics: Prospects for Development and Improvement 5(39), 100–105.

Список источников

Medina, L., Schneider, F., 2018. Shadow economies around the world: What did we learn over the last 20 years? IMF Working Paper, 77.

Винникова, И.С., Кузнецова, Е.А., Биндюкова, А.П., 2019. Бегство капитала из России: проблемы и пути решения. Инновационная экономика: перспективы развития и совершенствования 5(39), 100–105.

Гамулинская, Н.В., Смирнов, Ф.Е., 2023. Отток капитала из страны как угроза экономической безопасности. Вектор экономики 1.

Гармышева, А.А., 2022. Анализ инструментов противодействия уклонению от уплаты налогов в Российской Федерации. Управленческий учет 12 (1), 38-45.

Гармышева, А.А., 2023. Использование криптовалюты как новый способ уклонения от уплаты налогов. Экономическая безопасность личности, общества, государства: проблемы и пути обеспечения : Материалы всероссийской научно-практической конференции. Санкт-Петербургский университет Министерства внутренних дел Российской Федерации, 48-51.

Гусева, А.А., 2018. Возможные пути решения проблемы легализации денежных средств через криптовалюту. Экономика. Право. Инновации 5(2), 36–45.

Маркина, Ю.В., 2018. Мировые транснациональные медиакорпорации как сегмент глобализации информационной деятельности. Научные ведомости Белгородского государственного университета. Серия: Гуманитарные науки 37 (3), 480–488.

Невмовенко В.М., Шмырева А.И., 2012. Бегство капитала как угроза национальной безопасности. Вестник НГУЭУ 2. URL: https://cyberleninka.ru/article/n/begstvo-kapitala-kak-ugroza-natsionalnoy-bezopasnosti (дата обращения: 05.10.2023).

Нерсисян, Р.В., 2020. Отток капитала из России как угроза экономической безопасности. EurasiaScience: Сборник статей XXVII международной научно-практической конференции, 301–302. EDN IGYUJJ.

Татевосян, А.С., 2021. Теневые экономические явления в сфере внешнеэкономической деятельности. Экономическая безопасность личности, общества, государства: проблемы и пути обеспечения: Материалы ежегодной всероссийской научно-практической конференции, 184–188. EDN BZZQQL.

Тригуб, Е.Ю., 2022. Основные этапы политики деофшоризации в Российской Федерации. Научные труды Вольного экономического общества России 237 (5), 414–432.

Церенова, К.Н., 2017. Тонкая капитализация в России: вопросы регулирования и оценка масштаба проблемы. Теоретическая и прикладная экономика 1, 140–149.

Шелепов, А.В., 2016. Проект BEPS: глобальное сотрудничество в сфере налогообложения. Вестник международных организаций: образование, наука, новая экономика 11 (4), 36–59.

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