Effective risk management of transport facilities construction

E S Spiridonov\textsuperscript{1*}, A A Logvinenko\textsuperscript{2} and A A Dukhov\textsuperscript{3}

\textsuperscript{1}Department of Design and Construction of Railways, Russian University of Transport (MIIT), Obrazcova St., 9b9, Moscow, 127994, Russia
\textsuperscript{2}Department of Roads and Railways, Belgorod State Technological University named after V.G. Shukhov, Kostyukov St., 46, Belgorod, 308012, Russia
\textsuperscript{3}Department of Design and Construction of Railways, Russian University of Transport (MIIT), Obrazcova St., 9b9, Moscow, 127994, Russia

E-mail: a.logvinenko534@gmail.com

Abstract. From the point of view of the resource intensity of creating communication tools (investment, labor, materials, energy, time), the leading place in production belongs to transport, and in it – railways and highways. This study examines various aspects of the application of the risk management system in the management of transport construction. Methods of risk minimization depending on the type of risk are presented: the risk of legal error, the risk of the customer’s insolvency, the risk of a suboptimal loan portfolio, and the risk of non-fulfillment of financial indicators. A matrix form of comparison of identified risks is proposed for the development of the most effective methods of managing them. Using the example of the insolvency risk, which is one of the most characteristic for transport construction, the possibility of assessing the risk by a quantitative method is shown. The risk was quantified using the G. Markowitz model. To assess risks, it is proposed to use a coefficient method that allows determining the criteria that characterize their solvency based on an express assessment of the financial condition of customers, and justify recommendations for concluding contracts with them for the construction of a transport facility. The proposed matrix form of comparison of the identified risks allows formulating recommendations for reducing the impact of risks on the stability of the construction production process in a more reasonable way.

1. Introduction
A high degree of uncertainty and a risk factor are essential attributes of a market economy, especially for developing countries. Risk in the construction of a transport facility is the probability of losing part of the revenue of each organization and industry as a whole, or the possibility of obtaining part of the additional profit compared to the existing option because of activities related to overcoming uncertainty. Risk research in the construction industry is mainly divided into two categories: (1) risk identification and (2) risk assessment [1].

In the first category, the problem of research is related to risk recognition. The researchers proposed dividing risk factors into the following categories: financial risk, legal risk, management risk, market risk, social risk, political risk, technical risk, and climate risk [2-5]. When implementing international railway construction projects, the number of risks is even greater. So Liu and co-authors [6]
identified twenty important risks that affect the cost of an international project, including price fluctuations, contractor experience, and management skills. The research team looked at even more specific risk factors. In work [7] it was suggested to include the level of bureaucracy, the country’s credit rating, security as risk factors, and in works [8-11] delays in the delivery of materials, rising prices for materials, construction regulations, and corruption. Social unrest, strict environmental requirements, and immaturity of the country’s legal system are recognized as risk factors[10, 12]. These risk factors significantly affect the cost of construction and price indices[7, 13, 21].

In the second category of research, the risks of construction projects are assessed. Risk assessment inevitably depends on the decision makers, namely their individual experience, judgment, and ability to use different models and methods of risk measurement [14-15]. Lack of accurate and general methods for assessing the cost of risks leads to inconsistencies and uncertainties in the preparation of risk ratings. In research conducted by Dikmen I. with co-authors [16] it is pointed out that instead of a quantitative approach, it is necessary to use fuzzy approaches to risk assessment, using previously obtained knowledge about the risks that occurred. In a number of studies, researchers have combined some quantitative tools with qualitative methods for measuring risk. In a number of studies, researchers have combined some quantitative tools with qualitative methods for measuring risk. Lee K. P. and co-authors [17] applied a genetic algorithm to optimize the extracted cases and evaluate the estimated cost coefficients of construction projects. Attempts were made to assess project risks using agent-based modeling, combined with system dynamics [18] and fuzzy analytic hierarchy [19], Monte Carlo modeling [1]. An analysis of the literature suggests that the understanding of the importance of risk assessment has increased significantly over the past time. However, there is still no single and convenient method or model for risk assessment.

2. Materials and methods

2.1. Materials
To consider the risks arising from management in transport construction, the following methods were used: a systematic approach that takes into account the integrity and stability of the process; standardization and grouping by features that reflect the achievement of the final classification goals; comprehensive risk assessment. Figure 1 shows the main stages of risk management.

Figure 1. Main stages of risk management.

2.2. Methods
First of all, the totality of all tasks facing designers and builders is determined as a single system, and all threats are identified. After that, risks are assessed by analyzing the probability or frequency of their occurrence and their consequences are analyzed. Risk can be quantified using developed methods, such as the QRA method for quantifying risk.
There are 4 levels of risk assessment and management:
1. Global risk assessment - study of the scale of the problem and analysis of its components in order to formulate and develop risk management policies and principles.
2. Relative risk assessment in order to determine priorities and further actions in relation to the existing problem.
3. Risk assessment on a specific site to identify the main threats, risk levels, and make decisions to reduce the risk to an acceptable level.
4. Building risk maps for threat zoning and risk control planning in a given region.

Table 1 shows the risk minimization methods that can be applied when contractors work with customers.

**Table 1. Methods for minimizing risks when contractors interact with customers.**

| Type of risk                          | Methods to minimize                                                                 |
|--------------------------------------|-------------------------------------------------------------------------------------|
| Risk of legal error                  | Conclusion of the contract is possible only with legal entities registered in accordance with the current legislation; when making the contract, the employees involved carry out preparatory work with the potential customer, accepting from him a package of notarized copies of documents required for the conclusion of the contract |
| Risk of insolvency of the customer   | Operational risk-analysis of the customer’s financial condition using a coefficient method for determining the level of economic risk based on a copy of the balance sheet provided by the customer. Based on the results of this analysis, a decision is made to conclude a contract with him for the organization of construction |
| The risk of sub-optimal order portfolio | Optimization of the order portfolio, which is to determine how much of the order portfolio should be allocated to a particular customer so that the amount of expected accruals is distributed evenly over time |
| Risk of non-fulfillment of financial indicators | Improving the quality of revenue forecasts based on market research. Conclusion of an insurance contract |

The risk of the customer’s insolvency is understood as the possibility of losses of part of the income resulting from the provision of construction services to financially insolvent customers. Taking into account the specifics of transport construction and generalization of the practice of using methods of quantitative assessment of this risk in other areas of activity, a coefficient method for determining the level of the customer’s insolvency risk was chosen. It is based on the calculation of indicators of solvency, liquidity, and financial stability used in the analysis of the financial condition of the enterprise.

3. Results
When concluding a contract with the customer for the construction organization, the following rules of operational risk analysis of the customer’s solvency are proposed. The term “order portfolio of a railway transport organization implementing the construction” of a transport facility is understood as a set of customers of this division, acting as an integral management object. For example, the types of risks and the risk portfolio of Gazprom’s promissory notes are shown in tables 2 and 3, respectively.
**Table 2.** Types of promissory note risks.

| Type of risk          | Risk characteristic                                                                 |
|----------------------|-------------------------------------------------------------------------------------|
| The credit risk of the issuer | Non-payment (delay in payment) on the bill at maturity date                        |
| Intermediary’s credit risk | Non-payment or late payment of the bill. Refusal to transfer the purchased bill |
| Market risk          | Loss of asset value because of fluctuations in the market prices of promissory notes. It occurs when purchasing promissory notes in a speculative portfolio or when urgent implementation of investment promissory notes is required to maintain liquidity |
| Legal risk           | Purchase of a false promissory note                                                |
| Operational risk     | Arbitrage risk:                                                                    |
|                      | • refusal of one of the parties to sign the contract arising from the transaction concluded over the phone; |
|                      | • buyer’s refusal to purchase a promissory note purchased for an arbitration transaction. Risk of loss or theft of the bill отказ покупателя от покупки векселя, приобретенного для арбитражной сделки. Риск потери или хищения векселя |

**Table 3.** Risk portfolio of promissory notes.

| Risk portfolio (includes foreign currency) | Operations                                                                 |
|------------------------------------------|---------------------------------------------------------------------------|
| Exchange rate risk                       | Buying an asset for resale: hard currencies, soft currencies. (Tod, tom, spot), securities, precious metals, forward contracts. The open foreign exchange position on assets and liabilities not related to the conduct of speculative operations |
| Interest rate risk                       | Transactions with assets and liabilities that are sensitive to changes in interest rates (interest-bearing assets and liabilities that do not match in terms of maturity). Transactions with different frequency of interest payment or receipt of other types of income and expenses |
| Counterparty risk (credit risk)          | Interbank credit. Calculations (operations on counter payments, or pre-payment). Pre-settlement risk (the risk of the counterparty’s refusal to conduct the transaction, which will lead to exchange rate or currency risk). The issuance of the guarantee (the risk of the object of guarantee). Credit under guarantee (the risk of the guarantor). Purchase of promissory notes (risk of the promissory note issuer) |
| Liquidity risk                           | Exceeding the maturity of assets over the maturity of liabilities |
| Operational risk                         | Risk of loss of funds as a result of deficiencies in arranging the bank work |

The cost of the “portfolio” is determined by the amount of cash receipts for all customers included in the portfolio and is determined by the formula (1):

\[ C = \sum_{i=1}^{n} N^{\text{rev}_i} \]  

where \( C \) – the portfolio cost;

\( N^{\text{rev}_i} \) - the amount of revenue received by the \( i \)-th customer for the time period under review.
Revenue for a particular customer is distributed unevenly throughout the year. As a result, there is a “risk of suboptimal order portfolio”, which is understood as uneven cash receipts over time.

All calculations for quantitative risk assessment and optimization of the order portfolio were made using the G. Markowitz model. Despite the fact that the Markowitz model was proposed more than 60 years ago, it is still widely used by investors. A survey of 229 European portfolio managers, each with between €5 billion and €100 billion under management, found that half of those surveyed use the Markowitz optimal portfolio model when deciding whether to form an investment portfolio [20]

The value of the order portfolio is a random variable and is numerically characterized by the average monthly receipt ($N$) and the standard deviation ($\sigma_p$) calculated using formulas (2) and (3), respectively:

$$N = N^{\text{mono}}/n,$$

where $N^{\text{mono}}$ - amount of receipts of the $i$-th customer;

$n$ – number of months.

$$\sigma_p^2 = \sum_{i=1}^{k} W_i^2 S_i^2 + \sum_{i=1}^{k} \sum_{j=1}^{b} W_i W_j \text{cov}_{ij},$$

where $S_i^2$ - standard deviation of the $i$-th customer’s receipts;

$W_i$ - $i$-th client’s share in the order portfolio;

$W_j$ - $j$-th client’s share in the order portfolio;

$\text{cov}_{ij}$ - covariance between receipts for $i$-th and $j$-th clients.

4. Discussion

In the context of railway transport reform, the problem of ensuring the sustainable functioning of the industry and neutralizing emerging risk situations is very relevant. This problem is fully manifested in the construction of transport facilities, which makes it necessary to identify risks and develop the most effective methods of managing them.

The proposed matrix form of comparison of the identified types of risk and processes occurring in each subsystem of construction management of a transport facility allows formulating more reasonable recommendations for reducing the impact of risks on the stability of the construction production process.

5. Summary

To determine the integral point assessment of the potential customer’s insolvency risk, it is proposed to use the coefficient method, which allows determining the criterion that characterizes their solvency based on an express assessment of the financial condition of customers, and justify recommendations for concluding contracts with them for the construction of a transport facility.

It should be emphasized that economic methods of risk management give a chance not only to maintain a stable position of the industry, but also to create certain prerequisites for economic development. Moreover, we will proceed from the fact that both builders and customers of the transport construction sector now understand this

6. References

[1] Yuan T, Xiang P, Li H, Zhang L 2020 Identification of the main risks for international rail construction projects based on the effects of cost-estimating risks Journal of Cleaner Production 274 122904

[2] Shen L Y, Wu G W C, Ng C S K 2001 Risk assessment for construction joint ventures in China Journal of Construction Engineering and Management ASCE 127(1) 76-81
Loosemore M, Lim B T H, Ling F Y Y, Zeng H Y 2018 A comparison of corporate social responsibility practices in the Singapore, Australia and New Zealand construction industries Journal of Cleaner Production 190 149-159

Austin P, Groenhart L 2020 Improving public transport infrastructure in Auckland: Who will benefit? 2018 Joint Asia-Pacific Network for Housing Research and Australasian Housing Researchers Conference APNHR and AHRC 2018 - Proceedings 296-305

Atampugre G, Larbi M, Ojo T K, Liu G 2020 Transport system and climate change risks: Potential adaptation constraints and opportunities in Ghana Transactions on Transport Sciences 11(1) 65-81

Liu J, Zhao X., Yan P 2016 Risk Paths in International Construction Projects: Case Study from Chinese Contractors Journal of Construction Engineering and Management 142(6) 05016002

Zhang R, Xing J, Ye K, Lu W, Shan Y 2019 Synchronicity of global construction cost indexes Engineering Construction and Architectural Management 26(3) 367-385

Andrić J M, Wang J, Zou P X W, Zhang J 2019 Fuzzy Logic–Based Method for Risk Assessment of Belt and Road Infrastructure Projects Journal of Construction Engineering and Management 145(12) 04019082

Bhargava A, Labi S, Chen S, Saeed T U, Sinha K C 2017 Predicting Cost Escalation Pathways and Deviation Severities of Infrastructure Projects Using Risk-Based Econometric Models and Monte Carlo Simulation Computer-Aided Civil and Infrastructure Engineering 32 620-640

Saenz C, Brown H 2018 The disclosure of anticorruption aspects in companies of the construction sector: Main companies worldwide and in Latin America Journal of Cleaner Production 196 259-272

Owusu E K, Chan A P C, Hosseini M R 2020 Impacts of anti-corruption barriers on the efficacy of anti-corruption measures in infrastructure projects: Implications for sustainable development Journal of Cleaner Production 246 119078

Lingard H, Warmerdam A, Shooshtarian S 2019 Getting the balance right: Regulating occupational health and safety planning and coordination in the Australian construction industry Engineering, Construction and Architectural Management 26 (4) 599-617

Spiridonov E S, Dukhovny G S, Suprun E V 2015 Economic efficiency of cimulation of construction technology and organization Bulletin of BSTU named after V G Shukhov 6 281-286

Li H, Zhang X, Ng S T, Skitmore M 2018 Quantifying stakeholder influence in decision/evaluations relating to sustainable construction in China – A Delphi approach Journal of Cleaner Production 173 160-170

Hendiani S, Bagherpour M 2019 Developing an integrated index to assess social sustainability in construction industry using fuzzy logic Journal of Cleaner Production 230 647-662

Dikmen I, Birgonul MT, Anac C, Tah J H M, Aouad G 2008 Learning from risks: A tool for post-project risk assessment Automation in Construction 18(1) 42-50

Lee K P, Lee H S, Park M, Kim D Y 2017 Management-Reserve Estimation for International Construction Projects Based on Risk-Informed k-NN Journal of Management in Engineering 33(4) 04017002

Wu C, Chen C, Jiang R, Wu P, Xu B, Wang J 2019 Understanding laborers’ behavioral diversities in multinational construction projects using integrated simulation approach Engineering, Construction and Architectural Management 26(9) 2120-2146

Ribas J R, Arce M E, Sohler F A, Suárez-García A 2019 Multi-criteria risk assessment: Case study of a large hydroelectric project Journal of Cleaner Production 227 237-247

Amenc N, Goltz F, Lioui A 2011 Practitioner portfolio construction and performance measurement: Evidence from Europe Financial Analysts Journal 67(3) 39-50
[21] Glagolev S N, Bukhonova S M, Chikina E D 2020 Implementing Lean Production Management System (LPMS) in the Practice of Russian Organizations Materials Science and Engineering 753(7) 072019

Acknowledgments
This work was realized in the framework of the Program of flagship university development on the base of the Belgorod State Technological University named after V G Shukhov, using equipment of High Technology Center at BSTU named after V G Shukhov.