Development of a risk assessment methodology for the implementation of investment projects of a construction organization

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Abstract. The article considers the risks of implementing an investment project in the construction sector. The purpose of the study is to develop a methodological approach to assessing the risks of implementing investment projects of a construction organization. The object of the study is an investment project of a construction company. The subject of the study is the risks associated with the implementation of the investment project of a construction organization. Research methodology-methods of logical analysis, grouping and comparison, generalization were used. Using the method of expert assessment, an integral indicator of risk assessment is proposed. The main results and conclusions of the study: a risk management algorithm is proposed, a system of external and internal risks for the implementation of investment projects in the construction sector is formed within the algorithm, which allows to identify market and investment risks of the project. A method for assessing the risks of investment projects in the construction sector, based on expert assessment, is proposed. It allows to quantify and rank the impact of risks on the implementation of an investment project of a construction organization, as well as to calculate the integral level of risk for the implementation of investment projects of a construction organization.

1. Introduction

Implementation of investment construction projects is a business with a high level of a risk. In these conditions, the problem of assessing the risks of investment projects and their reduction is enough for construction organizations. The reliability of construction companies is easily disrupted by external and internal factors. Therefore, taking into account the risk factors of a construction organization in the economic assessment of an investment project is an urgent task.

Problems of the theory and practice of assessment of an investment projects are considered in the works of foreign scientists (G. Birman, G. Schmidt, J. Brigham, L. Gapenski, R. Braille, J. Friedman, Nick. Oruduay) and Russian scientists (I.A. Blank, S.A. Vladimirov, N.V. Matveev, E.M. Chetyrkin) In Russia, methodological and theoretical issues of optimizing the risks of investment projects received considerable attention in the works of P.L. Vilenskiy, M.V. Gracheva, A.G. Gryaznova, O.A. Zemlyanskiy, V.N. Livshitsa, M.A. Limitovskiy, N.A. Lysova, A.M. Margolin, I.A. Nikonova, E.R. Orlova, V.M. Rutgaizer S.A. Sirotin, S.A. Smolyaka, T.V. Teplova, M.A. Fedotova, Prodanova N A, Plaskova N S and Khamkhoeva F A [13], Vincent P and Schaaf T [17].
These works mainly deal with risk assessment issues and their impact on indicators of economic efficiency of investment projects.

Methods of risk analysis and management are presented in the works of Gharebaghi G and Omidvari M [8], Vilela M, Olayem G and Petrovski A [16], Kowalski J and Polonski M [11], Zelenakova M, Labant S, Zvijakova L [19], Tengyu B, Xiaopeng D and Bon-Gang H [14], Jelena A M, Jiayuan W, Patrick Z. [10].

Valuation of investment projects and the impact of risks on cost are considered in the works of foreign scientists A. Damodaran, A. Gregory, T. Koller, T. Copeland, B. Myers, K. Mercer, D. Murrini, S. Pratt, P. Samuelson, L. Thomas, D. Fishman, W. Sharp, Philippe V, Schauf T., Kroemer S. [12].

Among domestic researchers who study the pressing problems of risk assessment we can mention the works of such authors as Berval A V and Romanova A I [1], Barikaev E N and Eriashvili N D [2], Korovin E, Smirnova I and Sultygova and etc. [9]. The works of this author cover the problems of accounting and managing production risks in detail and deeply.

The specifics of the risks of investment projects in the construction sector also did not remain without attention of researchers. For example, in work [18] studies on the risks of modular integrated construction are systematized. The authors analyzed research in this area from 1992 to 2019. Analysis reveals that the research publications on risks of modular integrated construction witnessed a steady growth, with considerable progress occurring in the last decade. Existing empirical studies have focused heavily on perceived implementation risks, supply chain risks, schedule risks, investment risks, structural risks, ergonomic risks, and modular integrated construction risk management strategies, which indicate that modular integrated construction is associated with a host of risk events. Research gaps in existing studies are highlighted in this research, and areas for further studies are then proposed.

Dixit S, Sharma K and Singh S. [5] analyzed the key risk factors of construction projects.

In the work of Yu W, Chang H and Cheng S [15] a new method to tackle the duration risks of a construction project is proposed. The authors propose a quantitative model considering the seven risk-levels of activity duration is proposed. Авторский подход к оценке рисков в строительной сфере представлен также в работе Chang H., Yu, W., Cheng, S. et al. [4].

Despite the existing developments of domestic and foreign scientists, existing approaches to assessing the risks of implementing investment projects do not take into account to a large extent the industry features of the functioning of construction enterprises, which is unacceptable from the point of view of studying the nature and essence of risks. Another significant drawback of existing approaches to assessing the risks of implementing investment projects is that most risk assessment methods do not take into account the dynamically changing economic conditions of the modern economy. Moreover, an increase in risk factors requires continuous improvement of the assessment methodology and their management mechanisms.

2. Methods
To assess the risks of implementing investment projects of the company, a number of steps will be required to ensure the scientific validity and methodological sequence of actions and decisions. We have proposed a method for assessing the risks of implementing investment projects of a construction organization, based on calculating the integral level of risk. An expert method of calculation is used by scoring the probability of risk occurrence and the expected value of losses in the implementation of this risk. The main stages of the risk management algorithm for the implementation of investment projects of a construction organization are as follows.

1 Analysis of the external and internal environment. The environment of an investment construction project consists of numerous variables: market conditions, various organizations, global risks, political and legal environment, competitors, suppliers, consumers. Also, during this stage, the data of the project itself are studied and analyzed in detail, including the contract agreement, design and estimate documentation; construction organization project; work execution plan; data on the experience of implementing previous projects, etc.
2. Investment analysis of the project, the calculation of the main indicators of the effectiveness of the investment project. The main performance indicators of the investment project are: Net Present Value (NPV), Internal Rate of Return (IRR), Profitability index (PI), Discounted Payback Period (DPP).

3. Identification of the risks of implementing an investment project. The purpose of this stage is to obtain a description of the risks of implementing an investment construction project.

The risks of construction are considered in detail in the works of researchers. In particular, Dixit S, Sharma K and Singh S. [5] analyzed the key risk factors in construction projects.

We propose to use the classification of risks by the sphere of occurrence. Taking this into account, the following risk groups can be identified:
1. External (market) risks in relation to the project:
   - risk of economic deterioration (R1);
   - risk of depreciation of the national currency (R2);
   - risk of rising inflation (R3);
   - risk of reduced availability and increased cost of borrowed funds to finance investment projects (R4);
   - risk of reducing the solvency of demand for construction products (R5);
   - risk of strengthening legislation in the construction sector (R6).

2. Internal (investment) risks are the risks of the project itself:
   - risk of unscrupulous contractors (R7);
   - risks of location of the construction site (R8);
   - risk of reducing the planned profit for the project (R9);
   - risk of failure to meet construction deadlines (R10);
   - risk of increasing the volume of work and exceeding the project financing budget (R11);
   - risk of lack of necessary technical resources (including construction equipment) (R12);
   - risk of non-compliance with construction decisions (R13);
   - risk of reducing the quality of construction (R14);
   - the risk of violation of construction safety (R15);
   - risk of lack of qualified personnel for the implementation of the construction project (R16).

4. Risk assessment of the implementation of the investment project. To assess the risks of implementing investment projects of a construction organization, we propose to calculate the integral level of risk. The authors' developments reflected in the results of previous studies are taken as the basis [3; 6; 7].

It is proposed to evaluate the integral risk level using an expert calculation method by scoring the probability of occurrence of risk and the expected value of losses in the implementation of this risk.

The sequence of calculation of the integral level of risk for the implementation of an investment project of a construction organization is as follows:

Estimates of the probability of occurrence of the i-th risk are made. Proposed scale for assessing the probability of occurrence of the i-th risk is given in Table 1.

| Type of risk           | Probability of occurrence of risk | Characteristics of probability                                      | Number of points (Pi) |
|------------------------|---------------------------------|---------------------------------------------------------------------|-----------------------|
| Weakly probable        | \(0 < P \leq 0.1\)             | Event can occur in exceptional cases.                               | \(P_i=1\)            |
| Low probable           | \(0.1 < P \leq 0.4\)           | A rare event, but, as known, has already taken place.              | \(P_i=2\)            |
Probable $0.4 < P \leq 0.6$ Sufficient evidence to suggest the possibility of an event. $P_i=3$

Highly probable $0.6 < P \leq 0.9$ Event can occur. $P_i=4$

Almost possible $0.9 < P < 1.0$ Event is expected to happen. $P_i=5$

Estimates of the amount of losses when the $i$-th risk occurs are made:

$W_i=1$ – if possible losses are estimated as minimal;

$W_i=2$ – low;

$W_i=3$ – medium;

$W_i=4$ – high;

$W_i=5$ – maximum.

Then the $i$-th risk index is calculated. The index of the $i$-th risk:

$$R_i = P_i \cdot W_i,$$

where $P_i$ - the probability of occurrence of the $i$-th risk;

$W_i$ – the amount of losses when the $i$-th risk occurs.

Next, the risk level is determined and the risks are ranked according to the degree of their acceptability for the construction organization. The risk level characterizes the degree of its acceptance for the construction organization performing the contract, and shows the place of each risk in the queue for processing. Based on the value of the risk index, we can determine the level of the $i$-th risk. Three levels of risk are suggested:

$1 \leq R_i \leq 4$ – acceptable risk;

$5 \leq R_i \leq 10$ – justified risk;

$12 \leq R_i \leq 25$ – unacceptable risk.

Далее рассчитывается интегральный уровень риска при реализации инвестиционного проекта:

$$IR = \frac{\sum_{i=1}^{n} R_i}{n \cdot 25},$$

where $R_i$ - the $i$-th risk index;

$n$ - the number of risks;

25 - maximum risk index score on a 5-point scale, taking into account the probability of loss $(5*5=25)$.

Next, the risk level is determined in accordance with the rating scale. The proposed scale for assessing the integral level of risk in the implementation of an investment project of a construction organization is shown in table 2.

| IR      | Risk               | Risk level      |
|---------|--------------------|-----------------|
| 0.04 ≤IR≤ 0.19 | Ignored risk      | Acceptable risk |
| 0.20 ≤IR≤ 0.39 | Insignificant risk | Justified risk  |
| 0.40 ≤IR≤ 0.59 | Moderate risk     | Justified risk  |
| 0.60 ≤IR≤ 0.79 | Significant risk  | Unacceptable risk |
| 0.80 ≤IR≤ 1.00 | Critical risk     | Unacceptable risk |
The integral level of risk, expressed as a percentage, is the possible amount of loss when risks occur. Thus, the losses of the construction organization during the manifestation of risks will amount to:

\[ S_{IR} = S \times IR \]  

(3)

where S - the cost of construction work.

Based on the results of calculations, management decisions on risks are developed and made.

In accordance with the proposed risk management algorithm for the implementation of investment projects of a construction organization.

5 Processing of investment project implementation risks. The goal of this stage is to reduce the risk impact to an acceptable level.

Currently, in the practice of risk management there are four main ways of their processing: 1) risk mitigation; 2) risk acceptance; 3) risk deviation; and 4) risk transfer. It is recommended to choose the method of processing and managing risk in the following order: acceptance, mitigation, transfer, deviation, for justified risk-mitigation, transfer, acceptance and deviation, for unacceptable risk-mitigation, deviation, transfer, acceptance. To assess the effectiveness of the measures taken, the indicators of the relevant risks are compared before and after the implementation of the risk management program. In this case, the costs of implementing the proposed solutions should be taken into account. An effective solution is considered if the cost of implementing it does not exceed the possible damage.

6 Control and monitoring of the risks of implementing the investment project.

To take into account the impact of risks on indicators of economic efficiency of an investment project of a construction organization, it is proposed to introduce risk into the discount rate, i.e. use the method of adjusting the discount rate. The method for adjusting for the risk of the discount coefficient is as follows:

- the risk-free rate of return Emin is set - the minimum real rate of return (risk-free rate, this is the coupon-free yield of government securities);
- the forecast inflation rate is set;
- the risk premium is determined.

The b-method (beta method) was used to move from the integral risk level to the risk premium. The general standards for the b-coefficient value are shown in table 3.

| b-coefficient | Security dynamics                      |
|---------------|----------------------------------------|
| 0             | The income from the security does not depend on the risk (risk-free security – Treasury bill) |
| 0,5           | A security reacts at half its value to changes in the risk of securities |
| 1,0           | A security fully reacts to a change in the securities market (medium risk) |
| 2,0           | A security reacts doubly to changes in the securities market |

The formula for moving from the integral risk level to the risk premium included in the discount rate calculation is as follows:

\[ r = 2^*IR, \]  

(3)

where IR - the integral level of risk, fraction of units;

2 - maximum risk level (beta coefficient).

Discount rate E:

\[ E = Emin + I + r, \]  

(4)

Where E is the discount rate;

Emin - the minimum real rate of return (risk-free rate, this is the coupon-free yield of government securities);

I - the rate of inflation;

r - the risk premium.

3. Results
The proposed approach was tested on the example of an investment project for the construction of a multifunctional hotel complex. An expert assessment of the probability of risks and the amount of losses is given in table 4.

**Table 4.** Expert assessment of the significance of the risks of implementing the construction of a multifunctional hotel complex

| Risk | Pi | Wi | Ri | Risk | Pi | Wi | Ri |
|------|----|----|----|------|----|----|----|
| R1   | 3  | 3  | 9  | R9   | 3  | 5  | 15 |
| R2   | 3  | 1  | 3  | R10  | 4  | 3  | 12 |
| R3   | 3  | 3  | 9  | R11  | 4  | 5  | 20 |
| R4   | 3  | 3  | 9  | R12  | 2  | 3  | 6  |
| R5   | 4  | 4  | 16 | R13  | 2  | 5  | 10 |
| R6   | 4  | 4  | 16 | R14  | 3  | 3  | 9  |
| R7   | 3  | 3  | 9  | R15  | 3  | 3  | 9  |
| R8   | 2  | 2  | 4  | R16  | 3  | 3  | 9  |

The integral risk level of the project is equal to:

\[
IR = \frac{\sum_{i=1}^{n} R_i}{n \times 25} = \frac{165}{16 \times 25} = \frac{165}{400} = 0.4125
\]

In accordance with the risk assessment scale, the project is characterized by moderate risk. The risk premium included in the calculation of the discount rate for this risk value will be:

\[
r = 2 \times 0.4125 = 0.825.
\]

The discount rate will be:

\[
E = Emin + I + r = 6.55 + 3.4 + 0.825 = 10.78\%.
\]

Risks fall within the acceptable risk zone: R2, R8.

Risks fall into the zone of justified risk: R1, R3, R4, R7, R12, R14, R15, R16.

Risks fall into the zone of unacceptable risk: R5, R6, R9, R10, R1.

To transfer risks to the acceptable zone, it is necessary to minimize them. Risk minimization will be achieved by performing a number of measures for each risk separately. The risk index after these measures will be estimated at 84 points. The integral risk level of the project after the events will be 0.21. The risk premium included in the discount rate calculation for this risk value will be 0.42.

The discount rate will be:

\[
E = Emin + I + r = 6.55 + 3.4 + 0.42 = 10.37\%.
\]

A comparison of how the project indicators will change without taking into account and taking into account the minimization of risks is given in table 5.

**Table 5.** Comparison of project indicators

| Indicator          | Excluding risk management measures | Taking into account risk management measures |
|--------------------|------------------------------------|---------------------------------------------|
| IR                 | 0,4125                             | 0,2100                                      |
| r, %               | 0,825                              | 0,420                                       |
| E, %               | 10,78                              | 10,370                                      |
| NPV, thousand rubles | 317 578                           | 332 305                                     |
| IRR, %             | 14,2                               | 14,7                                        |
| PI                 | 2,30                               | 2,36                                        |
| DPP, years         | 5,34                               | 5,29                                        |

Thus, risk assessment and accounting can significantly improve the indicators of efficiency of
construction projects. Using the proposed approach to assessing and accounting for risks in construction projects can encourage investors to take measures to reduce them.

4. Conclusion

1 Risk management algorithm has been developed that can be used to manage the risks of a real investment project, both at the stage of its design, and to serve as a basis for further development of management decisions made during the implementation of the project.

2 The classification of risks for the implementation of investment projects of a construction organization by the sphere of occurrence has been developed. With this in mind, the following risk groups are identified: external (market) risks in relation to the project and internal (investment) risks, i.e. the risks of the project itself.

3 A methodology has been developed for assessing the risks of implementing investment projects of a construction organization, based on the calculation of the integral risk level using an expert calculation method by scoring the probability of occurrence of risk and the expected value of losses in the realization of this risk. It is recommended to choose the method of processing and managing risk in the framework of the proposed method in the following order: acceptance, mitigation, transfer, deviation; for justified risk-mitigation, transfer, acceptance and deviation; for unacceptable risk-mitigation, deviation, transfer, acceptance.

4 A method of correction to the risk of the discount coefficient which is taken into account when calculating the effectiveness of an investment project is proposed. At the same time, it is proposed to use the b-method (beta method) to move from the integral risk level to the risk premium in investment projects included in the discount rate calculation.

5 Expert assessment of the probability of risk occurrence and magnitudes of losses have shown that the greatest influence on the effectiveness of the investment project construction of a multifunctional hotel complex have the following risks: the risk of increasing the scope of work and an excess of the project financing budget, risk of reduction of solvency of demand for construction products; the risk of increased legislation in the sphere of construction (related to escrow accounts); the risk of reduction in the planned profit on the project; the risk of a delay in construction; the risk of non-compliance with construction decisions.

6 Measures for transferring risks to an acceptable risk zone were proposed. By implementing the proposed measures, it is possible to prevent or reduce the probability of a risky event occurring as a result of the implementation of the investment project for the construction of a multifunctional hotel complex. According to the results of the calculations, the project risks will be reduced by almost 50%, the net present value of the project will increase by 14.7 million rubles or 4.6%, the internal rate of return will increase by 0.42 percentage points, amounting to 14.7%.

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