Management of the investment and construction project cost under conditions of risk and uncertainty

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Abstract. The solution to the problem of managing the cost of an investment and construction project under conditions of risk and uncertainty is presented in the issue. The external and internal factors of project risks are analyzed. The concept of uncertainty is characterized as a property of the external and internal environment of the project, which underlies the occurrence of risks. Additional prerequisites for the emergence of risks, both objective and subjective, are considered. An authors' model for managing the cost of an investment and construction project based on a process approach has been developed based on the above mentioned prerequisites. The content of the stages of the project cost management model has been determined. The possibility of managing the cost of the project through the analysis of budget spending has been investigated. In the course of the study, a comparison was made between the work schedule in accordance with the basic project plan and the actual work schedule with deviations from the project plan. Unfavorable deviations of the baseline indicators of the project were revealed, both in terms of work execution time and in the cost of work performed. It has been proved that the adverse impact of risk factors on the overall performance of the project, expressed by indicators of investment efficiency, is reduced as a result of the application of the process model for managing the cost of an investment and construction project.

1 Introduction

Management of the investment and construction project cost is a complex of actions. The deviation of the actual costs from the planned level occurs as a result of the influence of risk factors due to the uncertainty of the environment. The deviation of the actual costs from the planned level can be considered as a result of the influence of risk factors, the nature of which is due to such a property of the environment as uncertainty. "Uncertainty" is understood by the authors as environmental conditions with a low degree of predictability of events. Also an important prerequisite for the occurrence of risks, along with uncertainty, is the limited resources of the project.

Uncertainty in the external environment of the project is enhanced by the presence of uncertainty in the internal environment of the project caused by the increase in the number of participants involved in the construction project. Investors, customers, developers, contractors and subcontractors have to be named among the key participants in the construction project. Participants are represented by both legal entities and individuals, endowed with their own functions. At the same time, the functional diagram of the construction project implementation continues to change. The designated prerequisites determine the objective and subjective nature of the risks, which are based on factors of both a subjective nature and those that do not depend on the behavior of individual project participants. Among the risk factors external and internal (project) ones can be highlighted [1].

External risk factors are due to the uncertainty of the macroenvironment. They include legislative, political, economic and social factors. Significant factors of legislative risks include the adoption of laws related to the regulation of investment and construction activities, sources of attracting investments, tax payments, forms of placing orders for construction, updating regulatory documents [2]. Political risk factors are associated with government policy, as well as with the political structure of society, which can lead to a change in the general course of economic development and influence the adoption of laws that stimulate or hinder the development of the construction business. The main economic risk factors include the following ones: increased inflation, falling investment demand, deterioration of the financial and credit mechanism, changes in lending conditions and interest rates, late payment for work performed, delays in project approval, improper coordination between the customer and project implementers, changes in the contract documentation, incorrect insurance operations, damage to production assets, untimely deliveries of construction materials and equipment, changes in market prices for resources. Social risk factors include the human factor, which can

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be the cause of possible failures of erected structures, accidents and fires during the entire construction period [3].

Internal risk factors are directly related to the implementation of the project at the construction site, they include organizational, technological, environmental and climatic ones. These risks are the higher, the lower the requirements for the qualifications of production personnel, the timing and quality of construction are. Organizational risks include irrational organization of the construction site, unclear planning of the production cycle, failure to meet the delivery schedules of material, technical and labor resources, lack of a quality control system for construction work and as-built documentation.

The most common technological risk factors that are associated with a lack of geological and geodetic surveys, inaccuracy of initial data and standards used in calculating production parameters and economic indicators, such as: completeness of the list and volume of work planned to be performed, the amount of material and technical resources, productive innovative technologies, effective building materials and structures, volume and structure of capital investments. Environmental risk factors can manifest themselves in the form of excessive noise and vibration effects on the territory of the construction site, unacceptable sedimentation of the foundation of the structure, flooding of the building area, the development of landslide processes and landslides, wind loads, precipitation in the form of rain and snow.

All the factors listed above interact and complement each other.

The impact of external factors that create the likelihood of adverse consequences caused by the impact of the macroenvironment is indirect and manifests itself through a change in the project parameters. Thus, the dominant factors in terms of influence on the cost of the project are internal risk factors for which the analysis is carried out, and decisions are made to clarify the technical, time and cost indicators of the project. .

2 Methods of research

Based on the process approach to project management, the authors have analyzed the implementation of the project in stages [4]:

1. Identification – revealing project indicators for which deviations from the planned parameters were observed. Responsible executives notify project managers of deviations using previously established written or electronic forms. The notifications record the nature of the deviations, give a brief assessment of the reasons and provide general data (date, location, type of work, etc.). In order to ensure the implementation of the change management process, notifications should be classified by source (for example, supply chain, production and technical department, estimate department, accounting department, etc.) and recorded in journals.

2. Analysis of deviations – determining the trend of the deviation is performed in order to assess whether the deviations are random or repeatable, and whether they are acceptable. A trend is a non-random deviation of the actual parameters of the project's performance from the planned indicators. In most cases, trends are the result of changes in market prices for material and labor resources. If a deviation is unacceptable, then an analysis of its content and probable causes is carried out, and then options for corrective actions are developed to eliminate these causes. Corrective actions are the solution of tasks to overcome deviations from the planned parameters of the project. Most often, an unfavorable deviation trend indicates that the project's performance in the future will also be unsatisfactory, so corrective actions are taken. At the same time, if deviations within the budget are the result of randomness and there are no total deviations in the analysis period, this does not mean that the project's performance will be satisfactory in the future. In other words, if the positive outcomes of the interim analysis are due to chance, then this also requires corrective action.

3. The processing of data on trends and random deviations (using logs) is carried out by the responsible executors (value engineers) and consists in the development of proposals for corrective actions and changes to the project baseline. The decision-making on these changes is made by the project management. As a result of the implementation of corrective actions, the project budget is updated.

The main goal of project cost management is the timely adjustment of its base plan to minimize the identified non-random and unfavorable deviations in cost and to ensure the effectiveness of investments [5].

3 Experimental part

The process model for managing the cost of an investment and construction project is shown in Fig. 1.

This model contains the following stages: planning, identification, performance evaluation, analysis, processing [6].

At the planning stage, the project budget and work schedule are drawn up. Below is the Schedule of work on the arrangement of the zero cycle of the industrial building construction at an estimated cost of 10 million rubles with the duration of the work - 43 days (Fig. 2).

In the course of the implementation of the project plan (before the start of work on the installation of the basement overlap), deviations in the fulfillment of the baseline indicators of the project were revealed. At the identification stage, deviations in the execution schedule for certain types of construction work presented in table 2 were determined.

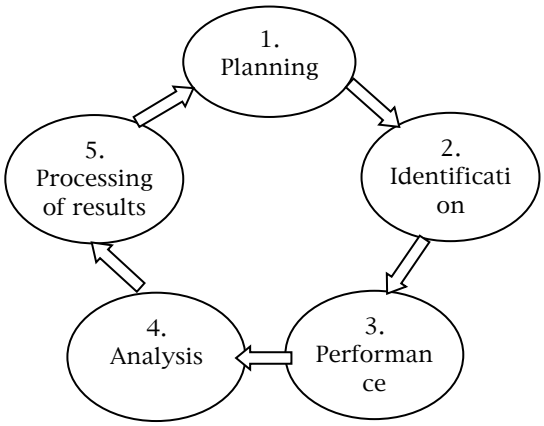

Fig. 1. The process model for managing the cost of an investment and construction project.

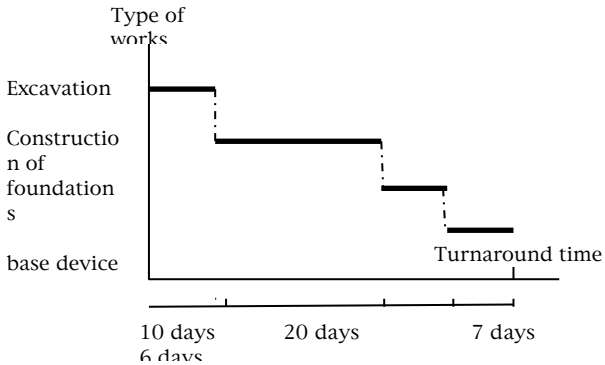

Fig. 2. Work schedule in accordance with the project baseline.

Also, at the planning stage, the list and the value of the baseline indicators of the project for the implementation of the zero cycle of work on the construction of an industrial building were determined (Table 1).

Table 1. Baseline project parameters

Types of work	Period of completion according to the schedule (days)	Cost of work according to the estimate (million rubles)
1. Excavation	10	2
2. Construction of foundations	20	4
3. Base device	7	1
4. Base overlap device	6	3
Total	43	10

Table 2. Fulfillment of the baseline schedule

Types of work	Compliance with the plan
1. Excavation	According to the plan
2. Construction of foundations	Deviation
3. Base device	Deviation
4. Base overlap device	Planned in accordance with the project schedule

Thus, it is planned to carry out work on the arrangement of the basement overlap in accordance with the updated project execution schedule (Fig. 3).

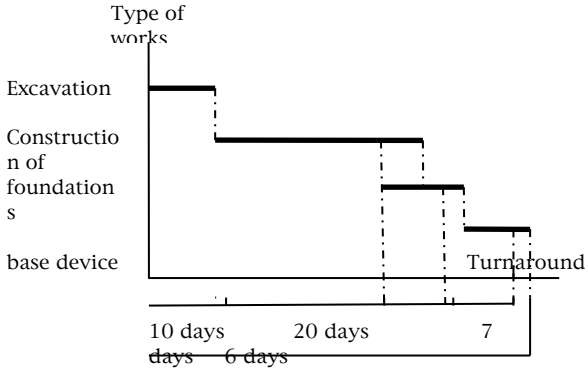

Fig. 3. Actual schedule with deviations from the project plan.

The effectiveness of the execution of an investment and construction project is determined by the level of compliance of the quantitative and qualitative indicators of the construction object with design solutions. Efficiency is expressed in comparing the actual indicator of construction costs and the value of planned costs to obtain the present state of the object.

$$Effectiveness = \frac{\text{Re}\,sult_{fact}}{Indicator_{planned}} \quad (1)$$

The effectiveness of project execution depends on the effectiveness of management and can be measured using three main parameters: time, quality and cost.

In general, the effectiveness of the project is assessed by comparing the actual schedule of its implementation with the budget. It is convenient to use the earned value method for this comparison. To use this method, the following conditions must be met:

- availability of the project schedule and budget;
- the use of the same accounting structure for both planned and actual construction costs (cost of resources);
- periodic fixation of indicators of the execution of the schedule and construction budget;
- constant quality control of the construction result.

Evaluation of the project execution effectiveness based on the assessment of the earned volume of work showed that with these deviations, the estimated cost of the zero cycle upon completion of the project will increase from 10 million rubles up to 11.5 million rubles. At the same time, the project execution time will increase - from 43 days to 45 days. The index of project implementation will be equal to 0.87. Thus, the probability of a decrease in the effectiveness of the project is stated [7].

At the analysis stage, we determine the reasons for deviations in the planned indicators of work on the construction of foundations and the basement, which may be associated with changes in the schedule of execution, the amount of work and cost. In a specific

case, the study of these factors revealed the following reasons for deviations.

Failure to complete work on the construction of foundations on schedule and overstatement of their cost (by 0.8 million rubles) was due to the occurrence of additional unforeseen work associated with force majeure circumstances of a natural nature, which led to changes in the timing of the work. Table 3 shows the data of deviations in terms of work performance.

Table 3. Deviations in terms of the work schedule.

Types of work	Terms of work (days)		Deviation (days)	Type of deviation
	Plan	Fact		
Construction of foundations	20	23	+3	Unfavorable
Base arrangement	7	5	–2	Favorable
Total	27	28	+1	Unfavorable

Table 4 shows the data on the indicators of deviations in the cost of work.

Table 4. Indicators of deviation in the cost of work.

Types of work	Deviation in the cost of work (mln rub)	
	Unfavorable	Favorable
Construction of foundations	+0,8	– 0,4
Base arrangement	+0,2	no
Total	+1,0	–0,4

As a result of the analysis of deviations, it was revealed that the deviation of the planned time for performing work on the construction of foundations and the basement is unfavorable (an increase in the construction time by one day). The cumulative deviation of the planned cost of these types of work in the direction of increase amounted to 0.6 million rubles, which is also unfavorable. Thus, there is a general trend of unfavorable deviations from the baseline, which increases the likelihood of a decrease in project performance.

After determining the nature and causes of deviations, this information is processed and a corrective action plan is developed, which are applied at the next stage of the zero cycle work. Changes are made to the schedule of subsequent work, taking into account three identified deviation factors: unforeseen types of work, exceeding the construction time and an increase in the cost of the zero cycle of work.

3 Conclusion

1. Implementation of an investment and construction project is associated with the likelihood of the impact of various risk factors, the prerequisites of which are both the uncertainty of the external environment of the project and shortcomings in the organization of activities within the framework of the project itself.

2. Exposure to risk factors can cause adverse impacts on the cost of the project, which are of a recurring nature, which will subsequently negatively affect the effectiveness of the project.

3. The process model of project cost management makes it possible to identify deviations in the basic parameters of the project at the early stages of its implementation, to determine their nature and to update the budget and schedule of subsequent work, taking into account the negative trend of the identified risk factors.

4. Application of a process model for managing the cost of an investment and construction project reduces the adverse impact of risk factors on the overall performance of the project, expressed in terms of investment efficiency.

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