



Methods for Cost Forecasting at the Project Planning Stage

Alberto Zamatteo Gerosa

Freelance Engineer, Project Director Valledaghi (Trento) – Italy

ABSTRACT

This article explores various methods of cost forecasting at the project planning stage, which is crucial for ensuring the financial stability of projects. It emphasizes that the accuracy of calculations at this stage impacts the project outcome, as errors in estimates lead to overspending and delays in implementation. Several factors are considered when selecting a forecasting method: project specifics, data availability, and the degree of uncertainty.

The aim of the work is to examine existing cost forecasting methods, including both traditional and new approaches. Expert methods such as analogy-based estimation, the Delphi method, and statistical methods like regression analysis and time series analysis are discussed. The paper also covers methods utilizing neural networks and classification algorithms. Practical examples are provided to illustrate their effectiveness.

The methodology includes a theoretical analysis of articles available in the public domain on the internet. The results show that combining different methods, such as statistical models and expert assessments, improves the accuracy of forecasts. Additionally, the application of machine learning methods accelerates the calculation process and reduces the influence of subjective factors.

The findings will be useful for project managers, financial specialists, and theorists involved in the development of forecasting methods in project management.

Keywords: cost forecasting, forecasting methods, project planning, expert methods, machine learning, risk management, statistical methods.

INTRODUCTION

Cost forecasting during the project planning stage is a critical task in project management. This is due to the fact that accurately defining the budget in the early stages helps reduce resource overspending and ensures that tasks are completed within the established time frame. The correctness of calculations is a necessary condition for achieving the set goals.

As projects develop and both external and internal factors change, the requirements for forecasting methods increase. Traditional approaches, such as expert evaluations and analogical reasoning, are still used but do not always provide the required accuracy. Modern methods, including statistical analysis and computational models, offer a high level of reliability in forecasts. However, implementing these methods involves challenges, such as issues with data quality, the complexity of using the results, and the need for integration into existing project management systems.

The relevance of the article lies in the need to reassess existing approaches to cost forecasting and find effective methods for applying them in various fields. The aim of the paper is to examine existing cost forecasting methods, including both traditional and new approaches.

MATERIALS AND METHODS

Cost forecasting during the project planning stage plays a crucial role in project management as it enables resource allocation, risk assessment, and financial stability throughout the project's lifecycle. In scientific papers authored by Pan Y. and Zhang L. [3, 7], the process of integrating building information modeling with digital twins is discussed to improve accuracy in construction project cost estimation. These methods allow for tracking progress, collecting data, and subsequently analyzing it, which helps to adjust the budget in a timely manner during project execution. Baduge S. K. et al. [5] discuss existing machine learning approaches for cost estimation in the construction industry, which are tied to the "Construction 4.0" concept. These methods increase the accuracy of forecasts while improving project management. However, their implementation requires infrastructure upgrades and specialist training, resulting in additional costs.

The scientific work of Rush C. and Roy R. [1] examines cost estimation processes in concurrent engineering during new product development. These approaches improve the accuracy of forecasts at various stages of the lifecycle, provided that multiple processes are executed simultaneously.

Thesing T., Feldmann C., and Burchardt M. [2] explore the application of various methodologies such as Agile and Waterfall. Within the Agile framework, forecasts are revisited as the project progresses, making the process more adaptable. In contrast, the Waterfall method locks the cost estimation structure at the initial stage, limiting opportunities for adjustments.

In the work of Kasprowicz T., Starczyk-Kołbyk A., and Wójcik R. R. [4], a net present value (NPV) estimation method is presented, which helps account for uncertainties inherent in large construction projects. This approach allows for forecasting cost fluctuations and assessing the financial viability of projects.

Thota M. K. et al. [6] describe the use of machine learning for risk assessment in software development. While these studies are not directly related to cost forecasting in construction projects, their findings are valuable for risk evaluation in engineering projects, which impacts the forecasting process.

Furthermore, the source [8], hosted on the website www.fastercapital.com, provides practical examples of companies using cost forecasting methods during project planning stages.

Thus, the analysis of scientific works shows that various methods are employed for cost forecasting during the planning stage, ranging from traditional tools to digital technologies such as building information modeling and digital twins. However, there are still unresolved issues in this field. One of them concerns the integration of various technologies and methods within a single project. This issue is particularly relevant for small and medium-sized projects, where resources for implementing new solutions are limited.

The methodology of this work includes theoretical study and testing of methods through examples from the construction industry and information technologies.

RESULTS AND DISCUSSION

The accuracy of the initial budget estimate directly impacts the success of project implementation, including adherence to deadlines, efficient resource use, and goal achievement. Cost forecasting methods can be categorized based on various characteristics such as the project specifics, the complexity of the tasks, and the accuracy of the initial data [3,7]. Below, in Figure 1, the classification of cost forecasting methods is illustrated.

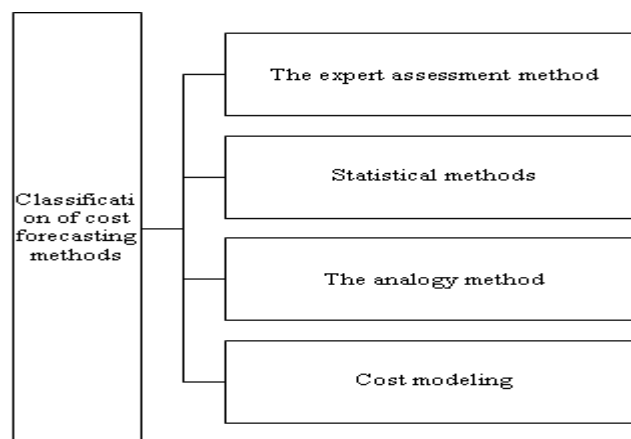


Fig. 1. Classification of cost forecasting methods [3,5,7]

The expert judgment method is used when project information is limited, such as in the early stages of a project, where actual data is still unavailable. Experts help identify risks that cannot be accounted for by standard methods and determine characteristics that are difficult to predict.

In the Delphi method, controlled surveys allow gathering different expert opinions, which helps form an objective picture. This approach works effectively in situations of uncertainty when the project may require adjustments.

When the project relies on historical data or when an analysis of similar cases is possible, statistical methods are used. Linear and nonlinear regression models, as well as time series analysis, provide tools for analyzing costs based on available information.

The least squares method helps identify relationships between variables, which are then used to make forecasts. This method is effective for stable costs, where values do not fluctuate. In projects involving rapid changes or the implementation of new technologies, its use is limited. For accurate analysis, a multidimensional approach is applied, which considers several factors simultaneously. Increasing the number of variables increases the likelihood of errors, especially when their interactions are difficult to model [1,5].

The analogy method is applied in areas where costs and processes can be compared with previously completed projects. In the construction sector, it is important to correctly select reference projects that share similar characteristics with the current one. A key factor is considering changes in market conditions, legislative norms, or technologies that could affect the accuracy of calculations.

Cost modeling, in turn, is based on the use of mathematical models that take into account various factors. This approach allows for both quantitative and qualitative assessments considering multiple possible scenarios. Such a method helps predict future expenses and the risks that arise during implementation.

Sensitivity analysis is used to identify the factors that have the greatest impact on final costs. Scenario analysis helps model the consequences of changes in conditions, and the Monte Carlo method estimates the probability of different outcomes using random variables.

These methods are effective in the later stages of planning, when data has been collected to create substantiated scenarios. However, their application requires accurate initial data, its analysis, and interrelationships. Classification algorithms are used during the planning phase to determine the cost category of a project based on its characteristics. A project can be assigned to a specific type, such as construction, software development, or research, and classified by complexity. Factors such as team size, deadlines, resource needs, and risks are considered during classification. Each cost category is associated with a range of possible expenses, allowing for more accurate forecasting based on prior experience.

Classification helps assess the likelihood of overruns or budget failures, categorizing projects as "high" or "low" risk based on factors such as supply instability, development difficulties, or economic conditions. The use of classifiers enables the implementation of warning systems that alert to potential problems, allowing for timely adjustments and budget optimization.

Neural networks, in turn, can increase the accuracy of cost forecasting by analyzing data from previous projects, such as time, resources, costs, and other parameters. These algorithms detect patterns and relationships that are difficult to identify using traditional methods. Neural networks are capable of adapting to changes in project conditions, adjusting forecasts as new data becomes available. This, in turn, allows for more accurate estimates of future expenses and risks, improving planning and management processes.

Cost forecasting methods vary depending on the project's stage, the available information, and the level of detail in the forecast. At each stage, approaches should be adapted to the current conditions and available data [3,4,6]. The main elements of implementing cost forecasting methods will be described in Figure 2.

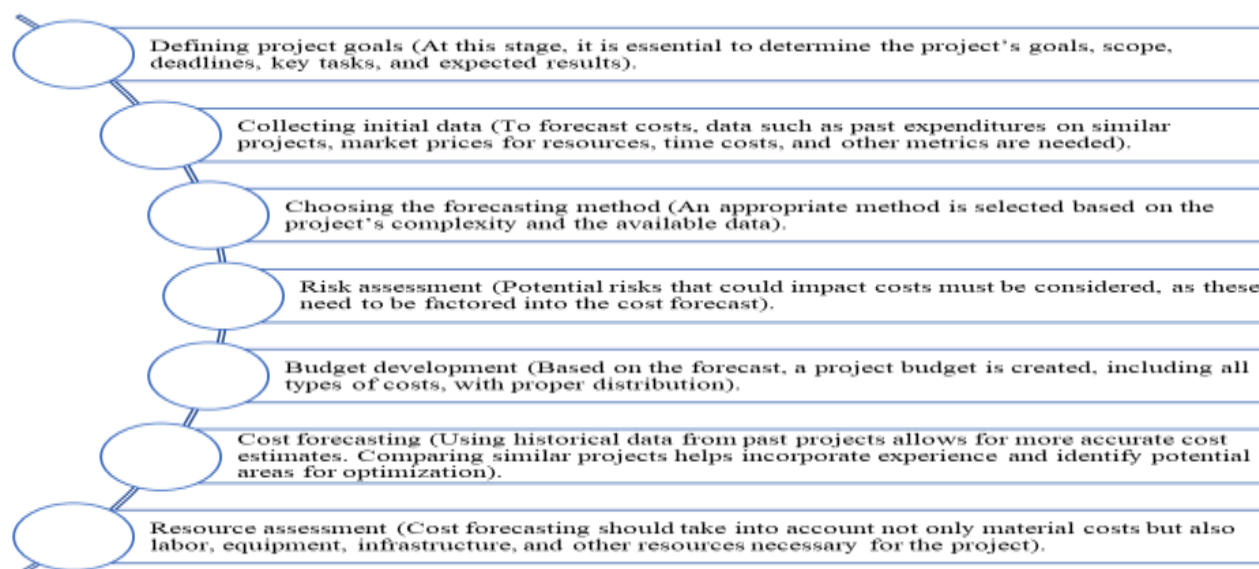


Fig.2. The main elements of the implementation of cost forecasting methods (compiled by the author)

At the initial stage of design, when information is limited, expert estimation and analogy methods become essential. These approaches help form an initial understanding of expenses and make conclusions about the scale and feasibility of the project. Forecasts made at this stage contain errors, but they serve as the foundation for decision-making that determines the project's further development.

As the project becomes clearer and information about resource expenses becomes available, the use of statistical methods and modeling increases. This allows for narrowing the range of potential deviations and performing risk analysis to identify vulnerable points in the project.

During the implementation stage, cost forecasting transitions from a prediction tool to a control mechanism. Adaptive planning methods must be used, allowing for budget adjustments when external or internal conditions change. Models that account for risks and changes contribute to effective cost management in real-time [2,4,6,7].

Practical examples of companies using cost forecasting methods during the planning stage will now be considered. For example, the construction of the famous Sydney Opera House serves as an example of successful cost estimation. Initially estimated at 7 million Australian dollars, the final cost rose to 102 million Australian dollars due to changes in the design, engineering issues, and unforeseen circumstances. This highlights the importance of accounting for potential risks and uncertainties during the evaluation process. The Burj Khalifa, the tallest building in the world, is another significant example. Despite its complexity, the project was completed within budget due to careful cost estimation. By using modeling methods, conducting thorough risk assessments, and involving experienced professionals, the project team was able to accurately estimate costs and ensure the successful completion of the project.

In terms of Agile methods, such as Scrum and Kanban, they have gained popularity in software development due to their flexibility and iterative approach. By breaking projects into small, manageable stages, Agile teams are able to provide accurate cost estimates. The production of the Tesla Model 3 electric car, aimed at the mass market, also faced challenges in cost estimation. The ambitious goals, technological advancements, and supply chain complexities made accurate cost estimation crucial to its success [8].

Table 1 below describes the different methods used in the cost forecasting process during the project planning stage.

Table 1. Methods used in the cost forecasting process at the project planning stage (compiled by the author).

Method	Features	Disadvantages	Ways to Eliminate Disadvantages	Implementation Features	Future Trends
Expert Evaluation Method	- Applied when data is limited or the project has unique characteristics.	- Possibility of errors due to human factors.	- Application of statistical methods to evaluate errors.	- Requires experienced specialists.	- Development of machine learning systems to improve forecasting accuracy.
Analogy Method (Comparative Analysis)	- Comparison of costs with similar projects.	- Limited analogies for unique projects.	- Conducting additional analysis of differences between projects.	- Requires data on previous projects.	- Development of databases and platforms for sharing project data.
Parametric Modeling Method	- Cost estimation using mathematical models and statistical data. - Applicable to standard projects.	- Requires large data volumes for building accurate models. - Not suitable for non-standard projects.	- Development of statistical models using data. - Integration with machine learning systems.	- Requires specialized knowledge in mathematical modeling. - Requires data collection and analysis.	- Implementation of artificial intelligence and machine learning algorithms to create accurate and adaptive models.
Three-Point Method	- Allows for consideration of uncertainties.	- Estimation may be too broad or inaccurate.	- Requires precise data input for estimating the probable scenario. - Application of analytical methods to refine probabilistic	- Requires regular review of estimates during project execution.	- Application of neural network approaches to create probabilistic distributions.

			estimates.		
Detailed Calculation Method	- Development of budgets considering all costs.	- Preparation time and estimation accuracy depend on the completeness of information.	- Use of software for automation of calculations.	- Requires implementation of tools to account for all factors.	- Automation of calculations using artificial intelligence and cloud technologies.

Cost forecasting is a necessary process that requires expertise and the ability to respond quickly to changes. In this context, various methods are used: expert assessments, statistical analysis, modeling, and sensitivity analysis. These approaches allow for accurate forecasting and risk minimization. Modern technologies open new horizons for improving forecasting tools, enhancing their accuracy.

CONCLUSION

Traditional methods, such as expert assessments and the analogy method, are used in situations with limited information or during early project development stages. However, the accuracy of these methods depends on the level of expertise of the specialists and the influence of subjective factors. Statistical methods and machine learning algorithms improve forecast accuracy, but they require quality, extensive data and specialized knowledge. In projects with a high degree of uncertainty, where traditional methods may prove ineffective, the relevance of machine learning becomes evident.

Thus, an effective approach to cost forecasting is a combination of various methods, taking into account the project's characteristics and available data. The success of the chosen approach depends on multiple factors, such as the scale of the project, the availability of information, and the level of uncertainty in the external environment.

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