Research on Performance Evaluation of Full Process Cost Management in Expressway Projects

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Abstract: The research purpose of this article is to optimize the performance evaluation of cost management throughout the entire process of highway projects. Currently, China's highway construction is booming, but cost management is complex and requires the construction of a scientific performance evaluation system to comprehensively supervise and evaluate engineering costs. This article used literature induction method for literature review, followed by expert scoring method to assign scores to indicators, and finally used Analytic Hierarchy Process to determine indicator weights. From the results, this study identified key factors that affect the overall cost management performance of highway projects, and constructed relevant evaluation models and weight hierarchy tables. Therefore, the results of this article are helpful in accurately controlling project costs, evaluating benefits, and optimizing fund management, which is of great significance for improving the level of highway project management and investment return rate.

Keywords: Expressway Project; Full Process Management; Cost Management; Management Performance; Performance Appraisal

1. Introduction

With the vigorous development of the Chinese economy, the construction of highway transportation is increasingly showing its pivotal position. But the cost management of highway projects is not only complex but also extremely crucial. Effective engineering cost management is undoubtedly an indispensable link in ensuring that engineering projects can be completed smoothly according to the predetermined time and quality standards. This article emphasizes that in order to comprehensively improve the efficiency of highway engineering cost management, it is imperative to build a scientific performance evaluation system. This system requires comprehensive supervision and evaluation of engineering costs from the perspective of project owners [1]. With the help of this system, owners can implement cost control and conduct benefit evaluations, thereby timely discovering cost overruns or clearly understanding investment returns, providing strong data support for management decision-making. In order to comprehensively examine every aspect of highway construction, outcome and process indicators should be established step by step, so that existing problems can be identified and corresponding solutions can be taken at the first time [2]. By applying evidence theory methods to evaluate cost management at each stage, it is possible to more accurately grasp the real-time dynamics of cost control and project performance. By systematically summarizing the actual effectiveness of cost management in each link, the management process can be continuously optimized, with the aim of achieving higher quality and efficiency in future highway construction, and making due contributions to China's highway engineering construction.

2. Research Status

2.1 Technical Management Methods for Whole Process Cost Management

The implementation process of cost technology management methods includes: firstly, in the decision-making and design stage of the project, through in-depth market research and accurate cost estimation, determining the overall cost budget of the project. Secondly, during the construction phase, a strategy of real-time monitoring and dynamic adjustment is adopted to ensure that all costs are controlled within the budget range. Finally, during the completion and operation stages of the project, a cost-benefit analysis

and post evaluation are conducted to provide useful references for subsequent projects. In terms of implementation strategy, cost technology management methods emphasize data analysis and comparison, as well as continuous optimization of cost control methods. By introducing advanced cost management systems and information technology, real-time data collection, analysis, and processing can be achieved, thereby improving the accuracy and efficiency of cost control [3]. The cost technology management method has played a crucial role in the proposed closed-loop system. It ensures the accuracy and consistency of information by systematically integrating cost control methods and data. This not only improves the transparency of cost management, but also provides a real-time and comprehensive cost control view for the project team. Through this approach, the project team can promptly identify and solve cost overruns, ensure the smooth progress of the project, and ultimately achieve a comprehensive improvement in the quality and efficiency of highway construction.

2.2 The Impact of a Closed-loop System throughout the Entire Process on the Performance of Cost Management

The introduction of a closed-loop system enables real-time monitoring of various cost indicators in the project process, timely adjustment of management strategies to ensure that the project progresses smoothly according to the established cost budget. At the same time, through the built-in data analysis function of the system, cost data of each stage of the project can be deeply excavated, providing more accurate data support for management decision-making. In practice, the expected results of implementing this system not only include effective control of project costs, but also reflect a significant improvement in project benefits. By monitoring and managing the entire process, various problems during the project progress can be identified and resolved in a timely manner, ensuring timely and high-quality completion of the project, thereby maximizing the overall benefits of the project. The implementation of this system will also bring many benefits, primarily improving the transparency and efficiency of project management, making it more convenient for all parties involved to obtain project information, and strengthening communication and collaboration. Secondly, through the accumulation and analysis of data, project management processes can be continuously optimized to improve the efficiency and quality of future project execution. The successful implementation of this system will lay a solid foundation for the sustainable development of China's highway transportation and promote the progress and prosperity of the entire industry.

2.3 Analysis of the Uniqueness of Performance Evaluation Methods for Cost Management throughout the Entire Process of Highway Projects

In the field of highway projects, traditional cost management practices often focus on a single stage or local link, lacking comprehensive and systematic consideration of the entire project cost management process. Compared to this, the performance evaluation method for the entire process cost management proposed in this study demonstrates its unique contribution and advantages [4]. The new system has introduced the concept of full process and closed-loop management, achieving comprehensive monitoring and real-time feedback on various stages of the project from decision-making, design, construction to completion [5]. This systematic management method not only improves the accuracy of cost control, but also effectively reduces the risk of cost overruns. In contrast, traditional methods often only perform cost accounting after project completion, lacking the ability to timely detect and correct cost deviations during the project process. In terms of effectiveness, the new system can objectively measure the results of cost management in each stage of the project by setting clear performance evaluation indicators, thereby timely identifying problems and making improvements [6]. However, traditional methods rely more on empirical judgment and subjective analysis, making it difficult to form a scientific and objective evaluation system. In terms of efficiency, the new system utilizes advanced information technology to achieve real-time data collection, analysis, and processing, greatly improving the efficiency and accuracy of cost management.

However, traditional methods often require manual data organization and calculation, which is not only inefficient but also prone to errors. In terms of feasibility, the new system has strong applicability and flexibility, and can be customized and optimized according to the characteristics and needs of different projects. However, traditional methods are often limited by fixed processes and standards, making it difficult to adapt to complex and ever-changing project environments.

3. Establishment of a Performance Evaluation System for Cost Management throughout the Whole Process of Expressway Construction Projects

In the decision-making stage, use market research data and historical project cost data to conduct preliminary cost estimation and risk assessment. During the design phase, the economic viability of the design scheme is ensured through a detailed bill of quantities and cost estimation data [7]. Entering the construction bidding stage, select the construction unit with the best cost performance ratio based on the bill of quantities and comprehensive unit price data [8]. During the construction phase, real-time monitoring of material costs, labor costs, and machinery usage costs, and timely adjustment of construction plans to control total costs [9]. During the completion stage, the overall cost of the project will be calculated and compared with the budget to evaluate the effectiveness of cost management [10]. Taking a highway project in Yunnan as an example, value engineering analysis was introduced in the design phase. By comparing the cost data of different design schemes, the most cost-effective scheme was selected, achieving significant cost savings before construction. During the construction phase, dynamic cost control methods were adopted, combined with real-time cost data monitoring, to timely adjust the construction plans of some high cost sub projects, further controlling the risk of cost overruns. The specific structure is shown in Figure 1.

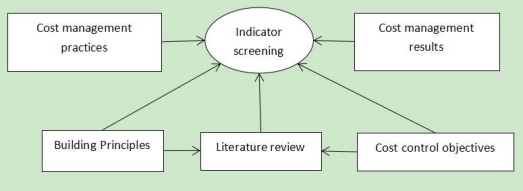

Figure 1. Evaluation Ideas for Cost Management throughout the Entire Process of Highway Construction Projects

Firstly, the decision-making stage of highway construction projects includes planning decisions, investment forecast documents, and financing plans, as shown in Table 1.

The work content of the design phase of highway construction projects includes budget materials, design quality, appropriate estimates, and appropriate budgets, as shown in Table 2.

The work content of the bidding stage of highway construction projects includes the rationality of the engineering project quantity list, the verification of the base bid cost, the standardized bidding process, and the reasonable bidding price, as shown in Table 3 below.

Table 1. Performance Evaluation Indicator Set for Decision Stage

Criterion layer	Indicator layer	evaluating indicator
Performance evaluation indicators for investment decision-making stage	Planning decisions	Is the specifications and standards constructed reasonable
		Is the size of the project or project appropriate
	Investment forecast document	The investment estimate is based on valid information
		Does the budgeting process follow standard procedures
		The ratio of difference between investment estimate and actual
		Evaluate whether the approval of documents complies with relevant regulations
		Is the response to feedback timely
	Fundraising plan	The proportion of capital in total investment
		The proportion of financing expenses to total financing

Table 2. Performance Evaluation Indicator Set for Design Phase

Criterion layer	Indicator layer	evaluating indicator
design phase	Budget materials	Is complete budget preparation necessary
		Ensure that the depth of budget preparation meets regulations

performance appraisal index		Is the timeliness and compliance of the audit process crucial
		Feedback should be timely and handled accordingly
	Design quality	Comparison, selection, and optimization of design schemes should be carried out
		Need to achieve a certain level of design standardization
		The design should be completed within the limit
	Appropriate estimate	Pricing indicators and expenses should comply with regulations
		The calculation of engineering quantity needs to be correct and error free
		Analysis is needed on the deviation of overestimation in the estimated budget
	Appropriate budget	The calculation and listing of engineering quantities should be accurate and error free
		Reasonable application and conversion of quotas
		The unit price and cost standards need to be accurate

Table 3. Performance Evaluation Index Set for the Bidding Stage

Criterion layer	Indicator layer	evaluating indicator
Performance evaluation indicators during the bidding stage	Rationality of engineering project quantity list	The correctness of list items must be ensured
		Newly added projects should comply with corresponding rules and regulations
		The bill of quantities needs to be formulated strictly in accordance with the specifications
	Benchmark cost verification	Need to verify whether the quantity of the project is accurate and error free
		The accuracy of various expenses is an important link in checking the base bid cost
	Standardized bidding process	The most suitable and effective bidding method should be selected
		The bidding process must comply with relevant rules to ensure compliance
		The effectiveness of evaluation methods is the key to ensuring fairness and impartiality in the bidding process
	Reasonable bidding price	The deviation rate of bidding control price should be within an acceptable range
		The deviation rate of bidding control price review needs to be controlled within a reasonable range
		The proportion of unbalanced quotation sub items should be as low as possible to maintain the overall balance of the quotation

The work content during the construction phase of highway construction projects includes engineering cost recording, budget approval implementation, cost control and fund utilization plan, engineering change management, engineering claim handling, and settlement document production and approval. The specific details are shown in Table 4.

The work content of the completion stage of the highway construction project includes the preparation and circulation of accounting documents, fund investment management, project acceptance, construction safety, and schedule, as shown in Table 5 below:

4. A Performance Evaluation Model for Full Process Cost Management of Expressway Construction Projects Based on Evidence Theory

After visiting and scoring 15 experts in the construction of relevant highways, based on the scoring data, a judgment matrix was obtained using the Analytic Hierarchy Process, and then the hierarchical ranking weights were calculated.

During the decision-making stage, three indicators and their weights were obtained, as shown in Table 6.

During the design phase, four indicators and their weights were obtained, as shown in Table 7.

During the bidding stage, four indicators and their weights were obtained, as shown in Table 8.

During the construction phase, six indicators and their weights were obtained, as shown in Table 9.

Table 4. Performance Evaluation Indicator Set for Construction Stage

Criterion layer	Indicator layer	evaluating indicator
Performance evaluation indicators during the construction phase	Engineering cost records	Ensure the accuracy of measurement and payment records
		Design change records need to be kept complete
		Price adjustment records need to be accurate
		Claim records need to be detailed
	Budget approval implementation	Analyze by comparing contracts with approved budgets
		Reserve fees should be used appropriately
	Cost control and fund utilization plan	The fund utilization plan should be reasonable
		Conduct in-depth analysis of investment deviations
		Control measures need to demonstrate effectiveness
	Engineering Change Management	Engineering change quotation must comply with regulations
		Change calculations should follow relevant regulations
		The deviation rate of the change amount approval should be within an acceptable range
	Engineering claim processing	The claim process should be complete and complete
		Claim fees must comply with relevant regulations
	Settlement document production and permission	Settlement materials must be complete and authentic
		The preparation content needs to be complete and flawless
		The basis for preparation must be valid
		The approval of settlement documents must be reasonable

Table 5. **Performance Evaluation Indicator Set for Completion Stage**

Criterion layer	Indicator layer	evaluating indicator
Completion stage performance appraisal index	Preparation and circulation of accounting documents	The completeness and effectiveness of the detailed content of the final account are reflected in whether it contains all necessary information and is accurate and accurate.
		The proportion of deviations in the final accounting review process involves the processing and interpretation of raw data.
		The accuracy of final accounting data means that there are no errors in both numerical and content aspects.
		The approval process of final accounting documents and the response speed to corresponding issues.
	Fund investment management	The change rate of construction safety engineering costs may affect the overall cost of the project.
		The deviation rate of land acquisition and demolition refers to the difference between actual costs and expected costs.
	Project acceptance, construction safety, and schedule	The quality standards of the project, including materials, processes, and structures.
		Whether the safety regulations during the construction process are followed, including personal protection of employees and proper use of equipment.
		The deviation ratio between the completion time of the project and the plan.

Table 6. Performance Evaluation Weight Results in the Decision-Making Stage

Criterion layer	weight	Indicator layer	weight	coding	weight
Decision stage X1	zero point two two one	Planning Decision X11	zero point zero seven one	X111	zero point zero three seven
				X112	zero point zero three four
		Investment Forecast	zero point zero eight	X121	zero point zero one seven

		Document X12	nine	X122	zero point zero one nine
				X123	zero point zero two four
				X124	zero point zero one six
				X125	zero point zero one three
		Fundraising Plan X13	zero point zero six one	X131	zero point zero two eight
				X132	zero point zero three three

Table 7. Performance Evaluation Weight Results during the Design Phase

Criterion layer	weight	Indicator layer	weight	coding	weight
Design phase X2	zero point two zero four	Budget material X21	zero point zero four one	X211	zero point zero one one
				X212	zero point zero one three
				X213	zero point zero zero eight
				X214	zero point zero zero nine
		Design Quality X22	zero point zero five one	X221	zero point zero one eight
				X222	zero point zero one six
				X223	zero point zero one seven
		Appropriately estimated X23	zero point zero five nine	X231	zero point zero two five
				X232	zero point zero three four
		Appropriate budget X24	zero point zero five three	X241	zero point zero one seven
				X242	zero point zero two one
				X243	zero point zero one five

Table 8. Performance Evaluation Weight Results during the Bidding Stage

Criterion layer	weight	Indicator layer	weight	coding	weight
Bidding stage X3	zero point one nine zero	Rationality of engineering project quantity list X31	zero point zero four five	X311	zero point zero one six
				X312	zero point zero one five
				X313	zero point zero one four
		Benchmark cost verification X32	zero point zero three three	X321	zero point zero one five
				X322	zero point zero one eight
		Standardized bidding process X33	zero point zero five eight	X331	zero point zero one seven
				X332	zero point zero one three
				X333	zero point zero two eight
		Reasonable bidding price X34	zero point zero five four	X341	zero point zero two one
				X341	zero point zero one five
				X342	zero point zero one eight

During the completion stage, three indicators were obtained, as shown in Table 10:

From this, a complete weight hierarchy table can be obtained in this article. Firstly, the weight indicators and element content for the preparation and circulation of accounting documents are considered as the main influencing dimension X51 for the performance evaluation of cost management throughout the entire process of highway projects. This may be because the preparation and circulation of accounting documents can directly affect the cost of the project, including the accuracy of budget preparation, budget implementation, and accuracy of final accounts. These factors directly affect the cost control of the project and the accuracy of the final accounting results. Project acceptance, construction safety, and schedule are considered as the main influencing dimensions of the performance evaluation of cost management throughout the entire process of highway projects. This may be because project acceptance, construction safety, and the rationality of the schedule are crucial for cost and schedule control of the project. The qualification of engineering acceptance, control of construction safety, and accuracy of construction period all directly affect the progress of the project and the execution of the budget. Planned decision-making is considered as the main influencing dimension of the performance evaluation of cost management throughout the entire process of highway

projects. This may be because the rationality and accuracy of planning decisions have a significant impact on the cost and performance of the project. Good planning decisions can ensure that the project budget is fully optimized and controlled, while balancing the risks and benefits of the project. The investment forecast document is considered as the main influencing dimension X12 for the performance evaluation of cost management throughout the entire process of highway projects. This may be because the accuracy and rationality of investment forecast documents play an important role in cost control and benefit evaluation of projects. An accurate investment forecast document can provide a basis for the project's funding requirements and cost budget, thereby ensuring the accuracy of project funding and cost control. The financing plan is considered as the main influencing dimension X13 for the performance evaluation of cost management throughout the entire process of highway projects. This may be because the rationality and feasibility of the financing plan have a significant impact on the financing cost and fund utilization efficiency of the project. A good financing plan can provide a stable source of funds and reasonable interest costs, thereby reducing the financing costs of the project and improving the return on investment of the project.

Table 9. Weight Results of Performance Evaluation during Construction Stage

Criterion layer	weight	Indicator layer	weight	coding	weight
Construction phase X4	zero point two zero one	Engineering cost record X41	zero point zero four two	X411	zero point zero one three
				X412	zero point zero one zero
				X413	zero point zero one one
				X414	zero point zero zero eight
		Budget Approval Implementation X42	zero point zero three nine	X421	zero point zero two one
				X422	zero point zero one eight
		Cost Control and Fund Utilization Plan X43	zero point zero three five	X431	zero point zero one zero
				X432	zero point zero one four
				X433	zero point zero one one
		Engineering Change Management X44	zero point zero three five	X441	zero point zero zero nine
				X442	zero point zero one one
				X443	zero point zero one five
		Engineering claim processing X45	zero point zero two four	X451	zero point zero one three
				X452	zero point zero one one
		Settlement Document Production and Allowing X46	zero point zero two six	X461	zero point zero zero six
				X462	zero point zero zero eight
				X463	zero point zero zero seven
				X464	zero point zero zero five

Table 10. Weight Results of Performance Evaluation during Completion Stage

Criterion layer	weight	Indicator layer	weight	coding	weight
Completion stage X5	zero point one eight four	Preparation and circulation of accounting documents X51	zero point zero seven nine	X511	zero point zero two five
				X512	zero point zero three three
				X513	zero point zero two one
		Fund Investment Management X52	zero point zero four one	X521	zero point zero two two
				X522	zero point zero one nine
		Project acceptance, construction safety and schedule X53	zero point zero six four	X531	zero point zero two five
				X532	zero point zero two one
				X533	zero point zero one eight

For the main secondary influencing factors, the rationality of construction standards X111 and the rationality of construction scale X112 are considered as the main influencing dimensions. This may be because the rationality of construction standards and the scientificity of construction scale have a significant impact on the investment returns and cost-effectiveness of the project. Reasonable construction standards and scale can ensure the quality and efficiency of the project, reduce investment risks and cost waste. The financing cost ratio X132 is considered a secondary influencing factor, which may be

because the high or low financing cost ratio directly affects the funding cost and financing efficiency of the project. Low financing cost ratio can reduce the financing cost of a project, improve its profitability and investment return rate. The analysis of estimated deviation X232 and the deviation rate between final accounts and budgets X512 are considered as secondary influencing factors. This may be because the analysis of estimated deviations and the deviation rate between final accounts and budgets play an important role in cost control and benefit evaluation of projects. Accurate analysis of budget deviation and final accounting deviation rate can provide cost control information for projects, thereby guiding project management and decision-making.

In summary, based on the given Analytic Hierarchy Process weight table, this article can conclude that the reasons for the weight of these results are based on their impact and importance on the overall cost management performance of highway projects. These weight indicators and element contents reflect the attention and importance placed on cost control, benefit evaluation, and fund management in the performance evaluation of the entire process.

5. Conclusions

This study successfully constructed a comprehensive weight hierarchy table by analyzing multiple dimensions of cost management performance throughout the entire process of highway projects. The results show that the preparation and circulation of accounting documents, project acceptance, construction safety, schedule, planning decisions, investment forecast documents, and financing plans have a significant impact on cost management performance evaluation. Among them, the accuracy and circulation of accounting documents directly affect the accuracy of project cost control and final accounting, while project acceptance, construction safety, and the rationality of the schedule are crucial to the progress and budget execution of the project. In addition, the rationality and accuracy of planning decisions, the accuracy of investment forecast documents, and the feasibility of fundraising plans all have a profound impact on the overall performance of the project. Among the secondary influencing factors, the rationality of construction standards and the scientificity of construction scale have been proven to play a crucial role in the investment returns and cost-effectiveness of the project. At the same time, the financing cost rate directly affects the funding cost and financing efficiency of the project, while the analysis of estimated deviations and the final accounting and budget deviation rate provide important references for cost control and benefit evaluation of the project.

Overall, this study reveals the key influencing factors of cost management performance throughout the entire process of highway projects. It not only provides strong theoretical basis for project management and decision-making, but also emphasizes the core position of cost control, benefit evaluation, and fund management in project management. This research achievement has important practical significance for improving the management level and investment return rate of highway projects.

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