Research Article

Research on Life-Cycle Project Cost Management Based on Random Matrix Weight Algorithm

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The traditional project management in the construction industry has the uniqueness of exclusive customization, the irreversibility of the project, the immobility of the project address, the long-term nature of the project, and the dynamic nature of the project. Based on these characteristics, the complexity and difficulty of project management in the construction industry are determined. Modern engineering is no longer satisfied with the traditional basic needs, but develops in a green, environmental friendly and efficient way. On the one hand, the project is required to meet good use requirements and meet the most basic functional requirements. On the other hand, the project construction process is required to meet the requirements of green environmental protection and ecological harmony. Therefore, the maintenance cost and operation cost corresponding to modern projects have become the key to the sustainable and healthy development of the engineering construction industry. Based on this, this paper will take the construction industry as an example to fully analyze the current situation and existing problems faced by the current project cost management. Through the research on the full life-cycle project cost management mode of the construction industry, the random matrix weight algorithm is creatively introduced, and the adaptive full life-cycle project cost management extended target tracking algorithm is proposed, which cuts the corresponding full life-cycle project cost management model into multiple submodels, and the corresponding management subobjectives are constructed from the submodel, and the expansion status of the corresponding subobjectives is described and analyzed in detail using the inverse distribution description, so as to accurately estimate the effect and target weight coefficient required by the management subobjectives, and finally realize the efficient, reasonable and scientific operation of the construction industry’s whole life-cycle project cost management, so as to maximize economic benefits. An experimental verification is carried out for a specific construction company. The verification results show that the full life-cycle project cost management scheme based on random matrix weight algorithm proposed in this paper has obvious advantages in management efficiency, cost control, process control, and other aspects compared with the traditional management scheme.

1. Introduction

The construction industry will generate a large amount of information at the beginning of the project, and a large number of connections will be generated between the corresponding different engineering information. Therefore, at the beginning of the project, it is necessary to fully consider the overall and partial consideration in the life cycle of the whole project [1–3]. The traditional engineering project management center often has insufficient information, timely communication, and scientific and meticulous project cost management, which leads to the failure of effective transmission of relevant information of engineering projects in the whole life cycle, thus not enabling decision makers to make efficient and scientific decisions in the process of project management, and not conducive to the timely resolution of relevant problems in the process of project development. Based on this, realizing the efficient, reasonable and scientific cost management of the whole life cycle of engineering projects has become the key to the development of modern engineering projects [4–7]. Through reasonable full life-cycle project cost management,
the costs related to project construction, operation, and management can be greatly reduced, the green ecological benefits of construction projects can be further improved, social development and human needs can be met, social benefits can be significantly improved, and the importance of project cost management for engineering projects can be deeply reflected [8, 9]. Based on this, the current conventional construction industry full life-cycle project cost management schemes are diverse, most of which focus on the single purpose of how to improve the construction cost, while ignoring the linkage of other elements in the project cost management [10]. Some research institutions ignore the importance of the management concept cost management, and do a lot of project cost management informatization work, so as to improve the information sharing of the cost management, improve the cost management level, and save resources and meet the requirements for its sustainable development [11, 12].

Traditional project management is often limited to the application of some traditional means and does not have the corresponding scientific theory support. At the same time, the corresponding modern project management is increasingly complex, and the corresponding processes are also increasing. Therefore, the traditional project management has fallen behind the times. As an advanced algorithm concept, the random matrix weight algorithm can decompose the macro-objectives embodied in the whole life cycle and realize the decomposition of objectives by expanding the weighting, which has full advantages in itself. When the random matrix weight algorithm expands and weights the objectives, it will first describe in detail the law of the managed objects changing with time, so as to further determine the phased management objectives set at different time nodes and environment nodes. Based on the corresponding objectives at this stage, the phased objectives are continuously modified through internal deduction and decision-making, so as to achieve the best path to achieve the objectives at the corresponding point stage [13–15]. As for the matrix weight algorithm, it has been developed and used in a large number of scenarios. Its main models focus on single dynamic description model, multidynamic description model, turning model, statistical model, and other models. Based on these models, we can quickly deduce the actual scenarios and results, quickly formulate corresponding solutions based on the deduction results, and conduct weighted state estimation analysis, so as to get the best implementation path [16–18]. In the random matrix weight algorithm, the description process of relevant management projects is relatively important. It needs to establish a random matrix model based on the corresponding project description. The analysis theoretical basis followed in this part mainly comes from the description of inverse distribution and Saudi distribution [19]. Based on the above analysis, how to fully combine the random matrix weight algorithm with the full life-cycle project cost management of the construction industry has become the focus of this paper, which has important value and significance for improving the efficiency of project cost management and meeting the requirements of social development.

Based on the above analysis and research, this paper will take the construction industry as an example to fully analyze existing problems of the current project cost management. Through the research on the full life-cycle project cost management mode of the construction industry, the random matrix weight algorithm is creatively introduced, and the adaptive full life-cycle project cost management extended target tracking algorithm is proposed, the corresponding full life-cycle project cost management model is cut into several submodels, the corresponding management subobjectives are constructed from the submodels, and the expansion status of the corresponding subobjectives is described and analyzed in detail using the inverse distribution description, so as to accurately estimate the effect and target weight coefficient required by the management subobjectives, and finally realize the efficient, reasonable, and scientific operation of the full life-cycle project cost management of the construction industry to maximize economic benefits. An experimental verification is carried out for a specific construction company. The verification results show that the full life-cycle project cost management scheme based on random matrix weight algorithm proposed in this paper has obvious advantages in management efficiency, cost control, process control, and other aspects compared with the traditional management scheme.

This paper mainly analyzes the current research status of the whole life-cycle project cost management strategy of the construction industry and its corresponding advantages and disadvantages; In the third section of the article, the full life-cycle project cost management scheme based on the random matrix weight algorithm is analyzed and studied in detail, and the specific scheme is given for the random matrix weight algorithm and the full life-cycle project cost management. The fourth section of the article will verify and analyze the whole life-cycle project cost management scheme based on the random matrix weight algorithm proposed in this paper; Finally, it is summarized.

2. Relevant Research and Analysis: Analysis on the Current Situation of the Research on the Full Life-Cycle Project Cost Management of the Construction Industry

The research on the full life-cycle project cost management of the construction industry was first carried out by relevant research institutions in the United States, and then by relevant experts and research institutions in Europe and the United States. American scholars [20] first proposed to apply the concept of full life-cycle cost management to the power industry, study its corresponding procurement costs, improvement costs, disposal costs, and other costs within the scope of the whole project, and directly associate the corresponding costs with the project management cycle. Relevant British research institutions [21] have analyzed the project cost management of highway and bridge and other construction industries based on the full life-cycle project cost. In the process of formulating and implementing the actual scheme, they have introduced the best intervention
algorithm, genetic algorithm, and other advanced algorithms. This scheme has important guiding significance for predicting the project cost and minimizing the cost. At the same time, it also provides valuable experience for subsequent researchers, and the enterprise has greatly broadened the practical application scope of the whole life-cycle project cost management. Research institutions in relevant Asian countries [22–24] have optimized and localized the full life-cycle project cost management according to their own characteristics. Relevant research scholars in Chinese Mainland have introduced BIM Technology into the full life-cycle project cost management, thus establishing an efficient, scientific, and reasonable full life-cycle project cost management scheme for the construction industry production. The whole process of construction and operation and maintenance has further improved the efficiency of project cost management in the whole life cycle; On this basis, relevant research institutions [25–27] further developed and put forward three key contents of full life-cycle project cost management, corresponding to the database of project management within the life cycle of the construction industry. At the same time, cost, cycle, and corresponding discount rate were selected as weighted evaluation index elements, and various analysis models were established by using data mining technology. Finally, hidden valuable data grasp their corresponding laws, so as to complete the comprehensive, scientific and systematic evaluation of the whole life cycle of the construction industry and realize the maximization of benefits. Through the above research and analysis on the research status of the full life-cycle project cost management of the construction industry, it can be found that the current mainstream management schemes are more traditional, and they do not have the self-adaptive adjustment in the management process, which has reached the purpose of the phased optimal scheme. Therefore, the research on a method can realize all links of the full life-cycle project cost management of the construction industry, the management scheme of adaptive adjustment of each time node and environment node has an important significance and value.

3. Research and Analysis of Full Life-Cycle Project Cost Management Scheme Based on Random Matrix Weight Algorithm

This section mainly analyzes in detail the fusion application of the random matrix weight algorithm used in this paper in the full life-cycle project cost of the construction industry. This paper creatively introduces the random matrix weighting algorithm, proposes an adaptive full life-cycle cost management extended target tracking algorithm, cuts the corresponding full life-cycle engineering cost management model into multiple submodels, constructs the corresponding management subgoals from the submodels, and
uses the inverse distribution description to describe and analyze the extended state of the corresponding subgoals in detail. In order to accurately estimate the effect and target weight coefficient required by the management subgoals, and finally achieve efficient and efficient management, reasonably and scientifically operate the full life-cycle project cost management of the construction industry, so as to maximize economic benefits. Based on the corresponding theoretical knowledge proposed in this paper, this section will also carry out experimental verification and analyze the results, and the corresponding framework diagram of the full life-cycle project cost management scheme based on the random matrix weight algorithm is shown in Figure 1. It can be seen from the figure that the whole life-cycle project cost industry includes the investment cost estimation in the project investment decision-making stage, the design cost estimation in the preliminary design stage, the construction drawing cost estimation in the design stage of the construction drawing, the contract price in the bidding stage of some projects, the settlement price in the construction stage of the construction project, and the final settlement price in the completion acceptance stage. In the above part, the random matrix weight algorithm is introduced to segment, model, and deduce the phased objectives. The corresponding BIM is a digital representation of the physical and functional characteristics of the building facilities and a complete description of the entity and functional characteristics of the project facilities. BIM Technology integrates other relevant physical information, functional requirements, performance requirements, and other parameter information of building facilities on the basis of three-dimensional geometric data model, and realizes information interoperability through open standards. Building information model aims to realize knowledge resource sharing and information sharing in the whole life cycle of buildings. Based on this shared digital model, relevant personnel at all stages of project planning, design, construction, operation and maintenance can obtain the required data. At the same time, based on the deduction of the subobjectives after segmentation, the optimal scheme of project cost management in the whole life cycle of the project is finally obtained. In addition, it can be seen from Figure 1 that the corresponding engineering cost management problems solved in different stages of the whole life cycle of the construction industry (corresponding to the decision-making stage, design stage, implementation stage, completion stage, and operation and maintenance stage in this paper) are different. The main problems solved are as follows: solve the unreasonable and unscientific problems in industry, solve the problem of difficult information sharing and collaborative work in the process of full life-cycle project

Figure 2: Basic framework diagram of operation process of random matrix weight algorithm in the full life-cycle project cost management scheme of the construction industry.
cost management in the construction industry, solve the problem of corresponding man hour cost calculation in the process of project construction, solve the problem of insufficient data update in the process of full life-cycle project cost management in the construction industry, and solve the problem of shallow awareness of refined cost management.

3.1. Analysis and Research of Random Matrix Weight Algorithm. In this section, based on the full life-cycle project cost management scheme of the construction industry, the random matrix weight algorithm is added for phased objective optimization. In this process, the random matrix weight algorithm infiltrates into each stage of the full life-cycle project cost management scheme, namely the corresponding decision-making stage, design stage, implementation stage, completion stage, and operation and maintenance stage. The basic framework of the application of the corresponding random matrix weight algorithm in the full life-cycle project cost management scheme of the construction industry is shown in Figure 2. The operation flow of the algorithm can be seen clearly in Figure 2.

The random matrix weight algorithm mainly focuses on the prediction and analysis of each stage in the process cost management process. At the same time, it needs to model and deduce based on the prediction and analysis, so as to obtain the optimal strategy of the subobjectives corresponding to each stage, and finally complete the optimal strategy of the system level scheme. The corresponding algorithm process is as follows.

Step 1: carry out periodic state prediction analysis for the policy stage, design stage, implementation stage, completion stage, and operation and maintenance stage in the full life-cycle project cost management scheme of the construction industry. The corresponding analysis model is set as the Gaussian distribution model. The calculation formula of the corresponding periodic analysis model is shown in formula (1), in which the corresponding $F_k$ is the one-dimensional state transition model of the periodic target, the corresponding $I$ represents the identity matrix of $n$ dimension, and the corresponding $d$ represents the number of dimensions of observable phased objectives:

$$F_k = W_{n-1} + (I_{n-1} \otimes X_{n-1}) * F_{n-1}. \quad (1)$$

Based on the calculation formula of the above phased analysis model, the weighted posterior probability calculation method of the corresponding phased management state at different times is obtained. The corresponding calculation is formula (2). Based on this, the prediction probability calculation formula of the corresponding phased state is formula (3), and the mathematical symbols in the corresponding formula are consistent with those in formula (1):
Based on formula (2) and the description in formula (3), assuming that the final control objective of the construction industry’s full life-cycle project cost management scheme remains unchanged, the weighted status of the corresponding adjacent phased objectives can be considered to be approximately equal, and the corresponding equivalent calculation formula is shown as follows:

\[
F(M_{n-1} | M_{n-1}, A^{n-1}) = N(M_{n-1}: M_{n-1}, P_{n-1} \oplus X_{n-1}),
\]

(2)

\[
F(M_n | M_n, A^n) = N(M_n: M_n, P_{n-1} \oplus X_n).
\]

(3)

The calculation formula of the corresponding weighted likelihood function is the key. At this time, the corresponding weighted likelihood calculation function is shown in formula (5). In the corresponding formula, \(w\) represents the Weissard distribution, \(M\) represents the degree of freedom index, and \(V\) represents the corresponding scale index. The corresponding \(Z\) represents the scattering matrix.

\[
F(A_n | n_k, X_k) = N(M_n: M_{n-1}, P_{n-1} \oplus X_n)
\]

\[
* \frac{W_{n-1}^{\text{opposite}}}{(W_{n-1} - 2* (b + 1))}
\]

(5)

Step 2: real-time update the phased situation of construction cost management in the whole life cycle of the construction industry, and at the same time, real-time update the corresponding weighted information. The calculation of the corresponding weighted likelihood function is the key. At this time, the corresponding weighted likelihood calculation function is shown in formula (6). The calculation formula of the scattering matrix in the corresponding formula (5) is shown in the following formula:

\[
F = (F_n^1 - F_n) \ast (F_n^1 - F_n)^T + (F_n^2 - F_n)^T + \ldots (F_n^i - F_n) \ast (F_n^j - F_n)^T.
\]

(6)
Step 3: phased strategy state output of the construction industry’s full life-cycle project cost management scheme. At this time, the probability distribution of the corresponding hypothetical scenario is the phased target state is Gaussian distribution. At this time, the corresponding state output expression formula is shown as follows:
\[ F_k = \text{diag}(y^{n-1} \cdot y^{n-2}) \ast R(\phi) \ast R^T(\phi), \]  
\[ F_{k-1} = E(A_{k-1} | Z_{k-1}) = \frac{W_n^{n-1}}{W_n^{n-1} - 2 \ast (b + 1)} \]  

Step 4: setting of adaptive parameters. The adaptive parameters to be processed here include the adaptive parameters of the stage target expansion state and the corresponding noise parameters. The adaptive parameter setting formula of the corresponding stage target expansion state is shown in formula (8), where the corresponding matrix A is set as a positive definite matrix parameter, and the corresponding adaptive noise parameter setting formula is shown in formula (9). Here, it is assumed that the noise parameter model weights of the corresponding adjacent stages are approximately equal. Based on the addition of adaptive parameters, the random matrix weighting algorithm can be adjusted adaptively, so as to optimize the phased objectives, deduce the phased objectives, and finally obtain the optimal strategy for the phased project cost process.

3.2. Construction of Full Life-Cycle Project Cost Management Scheme Based on Random Matrix Weight Algorithm. The implementation schemes of each stage of the full life-cycle project cost management scheme and the introduction of the random matrix weight algorithm are shown in Figure 3.

In the corresponding investment decision-making stage, based on the random matrix weight algorithm, the corresponding important elements of the stage, such as construction standards, construction scale, construction location, technology and equipment, are weighted, and they are taken as the influencing factors of the investment decision-making stage, so as to realize the reasonable...
determination and effective control of the project cost in this stage. Through the analysis and research on the important elements in the investment stage, we can quickly and accurately estimate and determine the price of the project to be invested and constructed. At this stage, through the introduction of random matrix weight algorithm, the corresponding quantities are internalized into a specific database model. The appraisers conduct quantitative analysis and comparison through the weight parameter model. At the same time, based on the corresponding BIM information and other software means, they quickly and accurately estimate the project cost based on the quantities.

At the stage of architectural engineering design, it is necessary to focus on the project cost estimation. At this stage, the building itself needs to be deeply considered in the random matrix weight algorithm. The unified treatment of the cost borne by the building structure and the corresponding professional equipment can reduce the design errors in this stage through the weighted deduction of random matrix. At the same time, it can help the appraisers to obtain accurate quantities and combine the cost estimation in the investment decision-making stage, so as to weave a more accurate construction drawing budget.

In the bidding stage, the situation of each bidding unit can be quantified based on the random matrix weight algorithm. By quantifying the engineering model provided by each unit, the quantities reflected by the bidding unit can be quickly obtained. At the same time, the management work in the bidding stage can be effectively completed by combining the list of relevant specific projects given by each unit. At this stage, the effective introduction of the random matrix weight algorithm can effectively avoid the omission of the top of the list and the wrong calculation of quantities, so as to make the bidding work more reasonable, scientific, fair and just.

In the construction stage, it is necessary to introduce the random matrix weight algorithm in the engineering drawing review meeting, project construction organization optimization, project cost management, project cost settlement, and the corresponding dynamic cost analysis for quantitative analysis in the corresponding construction stage. At the corresponding engineering drawing review meeting level, the corresponding design drawing review indicators are weighted and quantified to obtain the comprehensive score of the corresponding drawings, so as to make the process of drawing review more scientific and the corresponding review results more fair.

**Figure 6:** Comparison curve of cost utilization rate of full life-cycle cost management.
At the corresponding project construction organization optimization level, it is necessary to carry out engineering quantitative analysis on the corresponding construction organization process through the random matrix weight algorithm. In this project, it is necessary to deal with the progress plan prepared in combination with the specific construction scheme and actual conditions. Through this way, the reasonable engineering resource planning is finally realized, so that the capital, manpower, equipment, and other resources can flow efficiently. At the corresponding level of project cost management, the project can be handled by BIM technology. The introduction of BIM model enables all participants to view the corresponding information in real-time on the platform, so as to make the project cost management more fair and reduce the cost caused by disputes. At the level of corresponding project cost settlement and corresponding dynamic cost analysis, the random matrix weight algorithm is also introduced for processing and analysis, the corresponding indicators are quantified, and the real-time view of each unit is realized through BIM technology, so as to further reduce the time cost, improve the settlement speed of project funds, and improve the efficiency of payment and settlement.

In the corresponding completion acceptance stage, this part first quantifies and assigns the corresponding weight proportion to each index to be accepted based on the random matrix weight algorithm, and then quantifies and inputs the corresponding various data into the database based on BIM technology. In this way, the changes in the whole life cycle of the project and the records in the whole process of iteration can be realized, so as to make the project more complete and continuous.

In the corresponding operation and maintenance stage, it occupies most of the time in the whole life-cycle project cost management process of the construction industry. In this process, it needs to continuously maintain a large number of building equipment, structures, and infrastructure. In this process, each maintenance element needs to be quantified through the random matrix weight algorithm, and the comprehensive score is obtained through the weight. The score can be used to quickly judge whether the maintenance element needs maintenance and the degree of maintenance. Input all the data in this process into the BIM system for processing, so as to realize the dynamic connection of cost management in each stage of the project, so as to control the total cost of the project in the last link, improve the corresponding investment benefits, and realize the value-added of the project.
4. Analysis of Results

The simulation verification analysis is carried out based on a construction project. The flowchart of the corresponding cost management scheme is shown in Figure 4. Based on this flowchart, a comparative verification analysis is made with the traditional cost management scheme.

Based on the above scheme, the cost control rate, cost utilization rate, project operation efficiency, and corresponding project profit rate of the whole life-cycle cost management are simulated and analyzed. There are four corresponding comparative analysis indicators in the practice part, and the corresponding contents are as follows: the cost control rate of life-cycle cost management mainly reflects the cost control of the management scheme; cost utilization rate of life-cycle cost management mainly reflects the cost utilization of the scheme; operation efficiency of life-cycle cost management project mainly reflects the operation efficiency of the scheme; and profit margin of full life-cycle cost management mainly reflects the profit of the project.

At the cost control rate level of the corresponding full life-cycle cost management, the corresponding cost control rate comparison curve of each stage is shown in Figure 5. From the figure, it can be clearly seen that the full life-cycle project cost management scheme based on random matrix weight proposed in this paper has advantages in each management stage; the cost control rate is the best in the corresponding construction stage, compared with the traditional project cost control, it has been optimized by about 31%.

At the level of corresponding full life-cycle project cost management cost utilization rate, the corresponding comparison curve is shown in Figure 6. The full life-cycle project cost management scheme based on random matrix weight proposed in this paper reflects certain advantages in each management stage, and this advantage is positively related to the corresponding advantages of cost control rate. The higher the corresponding cost control rate, the higher the corresponding cost utilization rate.

In Figure 7, the algorithm proposed in this paper has obvious advantages in cost control and corresponding cost utilization, which greatly improves the operation efficiency of the whole project. The corresponding relationship also shows a positive relationship, benefiting from the advantages of the above two indicators. Compared with the traditional mode, the efficiency of the management scheme proposed in this paper is about 15% higher than that of the traditional mode.

![Figure 8: Profit margin comparison curve of full life-cycle cost management.](image-url)
At the level of corresponding project profit rate, the corresponding comparison curve is shown in Figure 8. It can be clearly seen from the figure that the project cost management scheme proposed in this paper has obvious profit advantages, which benefits from the advantages of cost control and overall project operation efficiency.

5. Conclusion

This paper mainly analyzes the current research status of the whole life-cycle project cost management in the construction industry and summarizes the related problems. In order to further optimize the full life-cycle project cost management scheme, taking the construction industry as an example, this paper fully analyzes the current situation and existing problems of the current project cost management. Through the research on the full life-cycle project cost management mode of the construction industry, the random matrix weight algorithm is creatively introduced, and the adaptive full life-cycle project cost management extended target tracking algorithm is proposed, the corresponding full life-cycle project cost management model is cut into several submodels, the corresponding management subobjectives are constructed from the submodels, and the expansion status of the corresponding subobjectives is described and analyzed in detail by using the inverse distribution description, so as to accurately estimate the effect and target weight coefficient required for the management subobjectives, and finally realize the efficient, reasonable, and scientific operation to maximize economic benefits. An experimental verification is carried out for a specific construction company. The verification results show that the full life-cycle project cost management scheme based on random matrix weight algorithm proposed in this paper has obvious advantages in management efficiency, cost control, process control, and other aspects compared with the traditional management scheme. In the follow-up research, this paper will focus on the cost control problem in the full life-cycle project management scheme, try to ensure the management quality and efficiency at the same time, minimize the management cost, and maximize the utilization of resources.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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