

ANALYSIS ON INFLUENCING FACTOR OF COST CONTROL OF EPC PROJECT BASED ON THE DEMATEL-ISM

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ABSTRACT

The paper selects the influencing factors of EPC project's cost control, analyzes and builds the model of EPC project's cost control from the point of view of system engineering, and utilizes the integrating DEMATEL—ISM method to study the relationships between the influencing factors and their impacts on cost control. It gets the multilevel structure model of the influencing factors of EPC project's cost control. The results show that project construction management level, procurement system, procurement process and standards project content acceptance and project settlement basis are the direct impacting factors of EPC project's cost control. The study provides a reference of EPC project's enterprises to improve project management level, effectively control project cost and achieve project management objectives.

KEYWORDS

EPC Project, Cost Control, Influencing Factors, DEMATEL Method, ISM Method

INTRODUCTION

With the rapid development of Chinese national economy, EPC (Engineering Procurement Construction) projects are widely used in various fields and become a new construction mode of construction project. EPC mode integrates design, construction and procurement. The coordination between various disciplines is strengthened, and the disadvantages of disconnection between design and budget, design and construction are overcome, which is conducive to the realization of the overall goal of the project [1]. But it also brings huge risks to the general contractor, especially in cost control.

At present, many scholars at home and abroad have studied the cost control of EPC project, Zeng Xiang pointed out that project managers need to strengthen cost management in the links of design, construction, acceptance and completion, so as to effectively control the capital investment of the project and ensure the smooth completion of the project [2]. Yuan Yamin elaborated the risks existing in the cost of EPC project. Combined with the current situation of EPC project, she proposed to take effective measures to prevent the cost risk from four aspects [3]. Based on practical cases, Ye Zhaoping and his colleagues put forward the importance of material and equipment procurement cost control, and strictly controlled it from the procurement link, so as to improve the project efficiency [4]. By comparing the EPC project mode with the traditional

contracting mode, Shu Jianping put forward the advantages and disadvantages of the EPC project mode, he also put forward the effective management of EPC project cost from multiple angles, so as to improve the economic benefits of enterprises [5]. On the basis of practical engineering cases, Wu Zhuxu put forward the key points [6] of project cost control under the EPC mode of construction projects, and expounded the specific application in cost control.

With the development of EPC projects in foreign countries increasingly mature, foreign scholars on EPC project research is more and more in-depth. The PCA's Report 1/2016 raised several issues [7]. The most impressive problems mentioned in the 2016 Report were:

(1) Contract changes were being reported in public works contracts in just under 50% of the awarded contracts;

(2) In the total projects analyzed, there was, on average, an increase in contract costs of around 6.75%^[8];

(3) Design alterations and modifications were a recurring pattern, especially in building retrofitting projects;

(4) Modifications occurred especially in architectural designs and water supply and sewage project designs;

(5) Deficiencies in the project design were present in 57% of all projects analyzed;

Jan Pícha, Aleš Tomek, Harry Löwitt put forward that necessary and good contract management [9] plays a good role in promoting the development of EPC; otherwise, it would have a negative impact on all relevant parties--customers, contractors, lenders, governments, etc. Once the management of the contract was not in place, it would have a negative impact on the whole project, which may include delayed schedule, cost overruns, quality, safety and so on. Mary Bajomo, Akinola Ogbeyemi, Wenjun Zhang believed that material procurement management and material transportation logistics [10] played an important role in EPC project construction, and EPC projects often encountered problems such as cost overrun, schedule overrun, material supply delay and production efficiency decline in the management process. To overcome these problems and realize the sustainable development of EPC system, it was necessary to conduct in-depth research on the procurement of building materials. Johnny Kwok Wai Wong, Jackson Kit San Chan, Mesthrige Jayantha Wadu put forward his own views on promoting the better development of architecture. Through questionnaires and interviews with experts, he explored the important role of procurement [11] in the construction industry and put forward some factors affecting procurement. Through the analysis of the potential influencing factors, it was pointed out that how to effectively promote the healthy development of the construction industry by using the procurement link.

Procurement is a key process in construction project management. Paying more attention to procurement is crucial to the sustainable development of construction projects. Rajeev Ruparathna, Kasun Hewage believed that adopting sustainable procurement measures [12] was very necessary in construction projects and played an important role in promoting the development of construction projects. Research showed that government regulations was the main driver for sustainable procurement.

By analyzing real cases and from the perspective of engineering design, Manman Xia, Lemeng Zhao, and Li Zhao found that construction and design could bring potential risks to EPC projects, and strengthening the management of these two links laid a foundation for the realization of project

objectives [13]. For EPC projects in the oil and gas industry, how to help general contractors to effectively manage the cost and schedule of EPC projects, Myung-hun Kim, Eul-bum Lee, and han-suk Choi believed that it was necessary to start at the design stage. Identify the factors that influenced project management during the design phase to help the general contractor reduce risk and achieve the stated objectives [14]. Pan Gong, Ningshuang Zeng, Kunhui Ye and Markus Konig proposed to use 4D BIM technology to solve the problems in the construction and completion acceptance stages of EPC projects. Reduce the impact of various influencing factors on cost and schedule management [15].

Through the analysis, induction and summary of the above research results, it is found that most of the above research contents focus on a certain link, only propose improvement measures for a certain link, do not comprehensively consider the factors affecting EPC project cost control, and lack a set of models and methods that can evaluate and analyze the influencing factors of EPC project cost control. In view of this, the cost control of EPC project will be discussed from the perspective of system engineering, and the influencing factors of cost control will be analyzed by using integrated laboratory decision analysis method (DEMATEL) and interpretative structure model (ISM). It is expected to provide a theoretical basis for EPC project enterprises to reduce engineering costs and improve economic benefits.

The remaining sections of this paper are organized as follows. Section 2 collects the factors that significantly influence the EPC project's cost control. Section 3 applies the DEMATEL-ISM method to the classification and importance analysis of the influencing factors, then obtains the multi-level hierarchical structure model and finally analyses the different levels according to the influencing factors, demonstrating the interrelationships among the influential factors. Based on the result of Section 3, in-depth analysis and effective suggestion on the interrelationships and prioritization of the involved influential factors are provided in Section 4. Finally, in Section 5, the conclusion, limitation and future researches of the study is presented.

SELECT THE INFLUENCING FACTORS OF EPC PROJECT COST CONTROL

Aiming at the problems that the cost amount of EPC project far exceeds the expected cost target and leads to the decline of project economic benefits. Summarize the influencing factors of cost control involved in the existing research [16]. The above influencing factors are tested by questionnaire survey, and experts and scholars with rich experience in the field of EPC project are invited to score. The contents of the questionnaire were evaluated by Likert scale's 5-point system. A total of 145 questionnaires were issued and 122 were recovered. Among them, 110 valid questionnaires were tested by SPSS 24.0 software (IBM SPSS Statistics24.0 is launched in August 2016 by IBM Corporation, which is located in the City of Chicago, the United States) Cronbach's α is equal to 0.854, greater than 0.7, with good reliability, indicating that the data has high reliability. Because the implementation of EPC project is based on the contract signed by both parties. In the process of project implementation, according to the development progress of the project can be divided into design, procurement, construction, completion and other stages, and the cost control of the project mainly involves the above stages, but also need to consider the impact of external environmental factors. Finally, according to the development of the EPC project, it is determined to

identify the influencing factors of EPC project cost control from six dimensions: contract factors, design factors, construction factors, procurement factors, completion acceptance factors and external environmental factors. The sub-factors of each influencing factor are ranked according to the scores of experts and scholars in the questionnaire survey, and the score represents the importance of the factor, as shown in Table 1.

Tab.1 - Influencing Factors and Literature Sources of EPC project's Cost Control

Partition dimension	Influencing Factors(M)
Contract Factors	Formulation of Contract Terms (M_1)
	Contract Bidding Management (M_2)
	Division of Contract Responsibility (M_3)
Design Factors	Selection of Design Unit (M_4)
	Rationality of Design Scheme (M_5)
	Cost Control Consciousness of Design Unit (M_6)
Construction Factors	Selection of Construction Scheme (M_7)
	Project Construction Management Level (M_8)
	Engineering Change and Claim (M_9)
Procurement Factors	Procurement Method (M_{10})
	Procurement System (M_{11})
	Procurement Process and Standards (M_{12})
Completion Acceptance Factors	Acceptance of Changed Data (M_{13})
	Acceptance of Project Contents (M_{14})
	Price Settlement Basis (M_{15})
External Environmental Factors	National Policies and Regulations (M_{16})
	Market Price of Manual Work, Material and Machine (M_{17})
	Development Level of Science and Technology (M_{18})

Construction projects were complex with regard to variety of works, budget, duration, and the number of parties involved^[17]. The use of time, cost, and quality as critical success factors of construction projects for the purpose of construction project performance evaluation have widely been studied by several researchers^[18], however, there was great need to understand these critical success factors with regard to EPC phases of the construction projects and to identify and prioritize the factors that could affect critical success factors of the project in the different stages of EPC and affect project performance^[19].

Contract Factors

(1) Formulation of contract terms

The formulation of contract terms includes the ownership of the project, the delivery time of the project, quality assurance, inspection methods, conformity standards, the treatment of force majeure factors, as well as the procurement method of materials, including the quality, quantity, specifications and price of materials, etc.

(2) Contract bidding management

Bidding is a part of the contract content, but also a very important part of project construction quality and cost control. The specific contents of contract bidding management include separate bidding plans for projects, construction equipment and construction materials. Combined with the actual situation of the project construction to choose public bidding or bid negotiation and other ways to determine the bidding and bidding time, process, in addition to the bidding enterprise construction qualification and enterprise reputation evaluation.

(3) Division of contract responsibility

In EPC mode, the division of contract responsibility should be reflected in the signed contract documents. For example, in the process of project implementation, due to the limitation of construction technology, the design must be changed, and the impact on the project cost should be made clear in the contract, so as to avoid possible conflicts of interest between the contractor and the owner.

Design Factors

(1) Selection of design unit

Selection of design units is an important step in the design stage, which mainly determines the selection method, bidding process and evaluation standards of design units. Meanwhile, it also needs to inspect the qualification of design units, their familiarity with EPC project fields and their concept of design projects. Design units are selected based on the above factors.

(2) Rationality of design scheme

The rationality of the design scheme should be combined with the actual situation of the project, comprehensively considering the scale, construction intention, function, use and other factors of the project, and should also consider the total investment of the project, under the premise of safety, rationality and economy, to ensure that the design scheme meets the requirements of the project.

(3) Cost control consciousness of design unit

The consciousness of unit cost control is mainly reflected in the quota design of the project. Quota design includes the following aspects: first, the rationality of professional allocation, construction drawing design and budget synchronous, technology and economy combined to meet the requirements of the project; Second, the implementation of reward and punishment measures to strengthen the cost control consciousness of designers.

Construction Factors

(1) Selection of construction scheme

According to the structural characteristics of the project, the project scale and other factors, the construction content can be decomposed into the main civil engineering, decoration engineering,

power supply and distribution engineering. Construction scheme is for a specific construction content of the construction planning to achieve the construction goal, the selection of construction scheme needs to consider the construction process, construction section division, construction sequence arrangement, construction process and other factors, so as to determine the best construction scheme.

(2) Project construction management level

The construction management level of EPC projects is mainly reflected in the following aspects: First, control the extent of the project progress and rational allocation and use of funds. Second, to establish the project manager responsibility system as the core of the management system, organization and launch enterprise management, project management, project operation layer and other levels actively participate in the construction project management activities, to achieve the whole process of all-round management. Third, according to the development of the general construction scheme, construction method for construction, reasonable arrangement of construction strength, machinery and deployment. The use and maintenance of all kinds of equipment and maintenance responsibility gradually clear, implement to people, reduce the wear and tear of equipment improper operation.

(3) Engineering change and claim

Engineering change and claim is a common phenomenon in the construction stage. Engineering change is mainly reflected in two aspects, one is design change, the design is unreasonable or there is conflict with the construction process need to be changed, the other is the owner temporarily change the intention of the project, change the current project design. The claim is due to the external environment, drawing changes and other factors, the contractor requires the Owner to compensate in terms of economy and time limit.

Procurement Factors

(1) Procurement method

Scientific and reasonable procurement methods can effectively reduce the cost input of EPC project materials procurement. Currently, there are mainly the following procurement methods. The first is bidding procurement, which is generally used in some EPC projects that need to purchase a large number of construction materials and equipment. The second is to adopt the way of inquiring price procurement. Inquiring price procurement refers to inquiring about the price of materials and equipment required by the project from the supplier, comparing these quotations with several suppliers, and finally selecting a supplier with the most reasonable price and relatively good quality to sign the contract. The third is direct procurement, which is usually used only in the case of designated suppliers or special materials and equipment. The specific procurement method needs to be combined with the actual situation of the project.

(2) Procurement system

The procurement system includes formulating standardized procurement procedures and

standards and assigning procurement responsibilities for equipment and materials to departments and individuals. Procurement system requires every link, every post to do a good job of coordination, clear division of labor, and materials and equipment in and out of storage management.

(3) Procurement process and standards

Procurement process and standards include the following aspects, the first is the formulation of the procurement plan, according to the construction process and characteristics of the procurement plan to determine the content, the correct grasp of the quantity and quality of material procurement; The second is to compare the price of materials given by different suppliers, including the quality of materials, the price of materials, purchase concessions and transportation costs.

Completion Acceptance Factors

(1) Acceptance of changed data

The acceptance of changed data mainly includes the following aspects: first, the acceptance of the contents of the modification documents and the signature of each participant; the second is the acceptance of the drawings of the changed parts, and the third is the inspection of the field record of the number of manual work, material and machine consumed when the change occurs; the fourth is related to the demolition of completed projects, acceptance of recyclable equipment and materials record form.

(2) Acceptance of project contents

The acceptance of the project content is mainly to examine and accept the location, elevation and axis of the building to meet the design requirements. Check the data of foundation engineering, structural engineering and other engineering, and also need to check the equipment installation engineering, process equipment installation engineering, check whether the specification, model and quantity of equipment meet the design requirements.

(3) Price settlement basis

Price settlement basis shall be based on contract terms, national pricing specifications, construction contracts, as-built drawings and materials, quantities confirmed by both parties, additional (less) project price confirmed by both parties, claims confirmed by both parties, on-site visa matters and price, bidding documents and other evidence.

External Environmental Factors

(1) National policies and regulations

National policies and regulations play an important role in promoting the healthy and orderly development of EPC projects. National policies and regulations include a series of policies issued to promote the implementation of EPC projects, such as preferential policies for EPC general contractors, qualification requirements of general contractors, responsibilities of general contractors, and responsibilities and obligations of participating units

(2) Market price of manual work, material and machine

The market price of manual work, material and machine is easily affected by the external environment, which directly affects the project cost. The market price of manual work, material and machine includes the market price of manual work, the market price of materials and the market price of machine. The market price of manual work refers to the cost of construction workers and auxiliary production workers. The market price of manual work, material includes cement, steel, sand and other building materials. The market price of machine mainly refers to the use fee of machinery and the rental fee paid by the leased machinery.

(3) Development level of science and technology

The development level of science and technology includes the use of new building materials, new construction technology and the use of information technology, such as BIM technology and procurement management system. The application of BIM technology in the construction stage can effectively manage the construction process and reduce the impact of various influencing factors on cost and schedule management. Procurement management system to the procurement stage of the whole process of supervision and management, reduce procurement links caused by the increase in project costs.

BUILDING THE INFLUENCING FACTOR MODEL OF EPC PROJECT COST CONTROL BASED ON DEMATEL-ISM

Based on the above selected influencing factors of EPC project cost control, this paper uses DEMATEL method to analyze the importance of the above EPC project cost control factors. On this basis, the hierarchical structure model of the influencing factors of EPC project cost control is constructed by using ISM model, the hierarchical relationship between various influencing factors is analyzed. The process of model analysis and construction is as follows:

Establish the Direct Influence Matrix

Record the influencing factors of EPC project cost control as $M=\{M_1, M_2, \dots, M_{18}\}$, The relationship between M_i ($i=1, 2, \dots, 18$) and M_j ($j=1, 2, \dots, 18$) is expressed as b_{ij} , Use 0, 1, 2 and 3 to represent the influence intensity of factor M_i on M_j . It means:

$$b_{ij} = \begin{cases} 0 & \text{no impact} \\ 1 & \text{weak impact} \\ 2 & \text{medium impact} \\ 3 & \text{strong impact} \end{cases} \quad (1)$$

The direct influence matrix A of influencing factors of EPC project cost control can be obtained:

$$A = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1j} \\ b_{21} & b_{22} & \cdots & b_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ b_{i1} & b_{i2} & \vdots & b_{ij} \end{bmatrix} \quad (2)$$

An expert discussion group is established according to the 18 influencing factors in Table 1. The members of the group include 12 from the building unit, 10 from the general contractor, 12 from the design unit, 10 from the construction unit, 10 from the procurement department and 11 teachers studying EPC projects in colleges and universities. From the perspective of achieving EPC project management objectives, the relationship between the influencing factors of EPC project cost control is discussed and finally an agreement is reached, so as to establish a direct matrix A of the influencing factors of EPC project cost control. $A = (b_{ij})_{18 \times 18}$ is shown as below:

$$A = \begin{bmatrix} 0 & 1 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 0 & 0 & 0 & 0 & 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 3 & 2 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 3 & 2 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 3 & 0 & 0 & 0 & 0 & 0 & 2 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 3 \\ 0 & 0 & 0 & 0 & 0 & 0 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 2 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \quad (3)$$

Establish the Comprehensive Influence Matrix

The planning impact matrix is obtained by normalizing the above direct impact matrix, the calculation formula is as follows:

$$N = \left(\frac{b_{ij}}{\text{Max var}} \right)_{18 \times 18} \quad (4)$$

Among them, $\text{Max var} = \max \left(\sum_{j=1}^{18} b_{ij} \right)$

Based on the standard influence matrix, the comprehensive influence matrix of the influencing

factors of EPC project cost control is obtained by using the following calculation formula T ,

$T = (t_{ij})_{18 \times 18}$, the matrix is shown below:

$$T = N(I - N)^{-1} \tag{5}$$

Among them matrix I is identity matrix.

$$T = \begin{bmatrix} 0 & 0.13 & 0.38 & 0 & 0 & 0 & 0 & 0.06 & 0.17 & 0 & 0 & 0 & 0.01 & 0.05 & 0.08 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.09 & 0.25 & 0 & 0 & 0 & 0.06 & 0.12 & 0.45 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.14 & 0.38 & 0 & 0 & 0 & 0.01 & 0.1 & 0.06 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.47 & 0.25 & 0.18 & 0.3 & 0.3 & 0 & 0 & 0 & 0.02 & 0.1 & 0.18 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.38 & 0.53 & 0.38 & 0 & 0 & 0 & 0.01 & 0.1 & 0.06 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.38 & 0 & 0.14 & 0.2 & 0.14 & 0 & 0 & 0 & 0 & 0.04 & 0.02 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.38 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.38 & 0 & 0 & 0 & 0 & 0.02 & 0.27 & 0.17 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.03 & 0 & 0 & 0 & 0.25 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.06 & 0.13 & 0 & 0 & 0.13 & 0 & 0.03 & 0.02 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.13 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.05 & 0.05 & 0.4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.02 & 0.02 & 0.13 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.13 & 0.13 & 0.07 & 0 & 0 & 0 \\ 0.39 & 0.05 & 0.15 & 0 & 0 & 0 & 0.15 & 0.08 & 0.07 & 0 & 0 & 0 & 0 & 0.02 & 0.03 & 0.05 & 0.39 & 0 \\ 0.05 & 0.01 & 0.02 & 0 & 0 & 0 & 0.39 & 0.15 & 0.01 & 0 & 0 & 0 & 0 & 0 & 0 & 0.13 & 0.05 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.25 & 0 & 0 & 0 & 0 & 0.15 & 0.02 & 0.18 & 0 & 0 & 0 \end{bmatrix} \tag{6}$$

Calculate the influence degree, affected degree, center degree and cause degree

Add the values of the influencing factors in each row of the above comprehensive influence matrix T to obtain the comprehensive influence value, as is influence degree D_i . The affected degree C_i is obtained by adding the values of the influencing factors in each column of the comprehensive influence matrix T . The sum of the influence degree and the affected degree of the influencing factor i is the center degree F_i of the influencing factor, and the difference between the them, is the cause degree R_i . The specific formula is as follows:

$$D_i = \sum_{j=1}^{18} t_{ij} \quad (i = 1, 2, 3, \dots, 18) \tag{7}$$

$$C_i = \sum_{j=1}^{18} t_{ji} \quad (i = 1, 2, 3, \dots, 18) \tag{8}$$

$$F_i = D_i + C_i \quad (i = 1, 2, 3, \dots, 18) \tag{9}$$

$$R_i = D_i - C_i \quad (i = 1, 2, 3, \dots, 18) \tag{10}$$

The above formula is used to calculate the influence degree, affected degree, center degree and cause degree of each influencing factor of EPC project cost control. The results are shown in Table 2.

Tab.2 - Influence Degree, Affected Degree, Center Degree, Cause Degree of Influencing Factors of EPC Project's Cost Control

influence factor	influence degree D_i	affected degree C_i	Center degree F_i	Cause degree R_i
M_1	0.88	0.44	1.32	0.44
M_2	0.97	0.18	1.15	0.79
M_3	0.69	0.54	1.23	0.15
M_4	1.80	0	1.80	1.80
M_5	1.46	0.84	2.30	0.62
M_6	0.92	0.25	1.17	0.67
M_7	0.38	1.23	1.61	-0.86
M_8	0	2.78	2.78	-2.78
M_9	0.83	1.82	2.65	-0.99
M_{10}	0.28	0	0.28	0.28
M_{11}	0.37	0	0.37	0.37
M_{12}	0.13	0.38	0.51	-0.26
M_{13}	0.50	0.48	0.98	0.02
M_{14}	0.17	1.06	1.23	-0.89
M_{15}	0.33	1.87	2.20	-1.54
M_{16}	1.38	0.18	1.56	1.20
M_{17}	0.81	0.44	1.25	0.37
M_{18}	0.60	0	0.60	0.60

Center degree indicates the importance of each influencing factor. The greater the value of center degree, the greater the role of this factor in the index system. According to the center degree value in the above table, draw the importance curve of influencing factors of EPC project cost control, as shown in Figure 1 below.

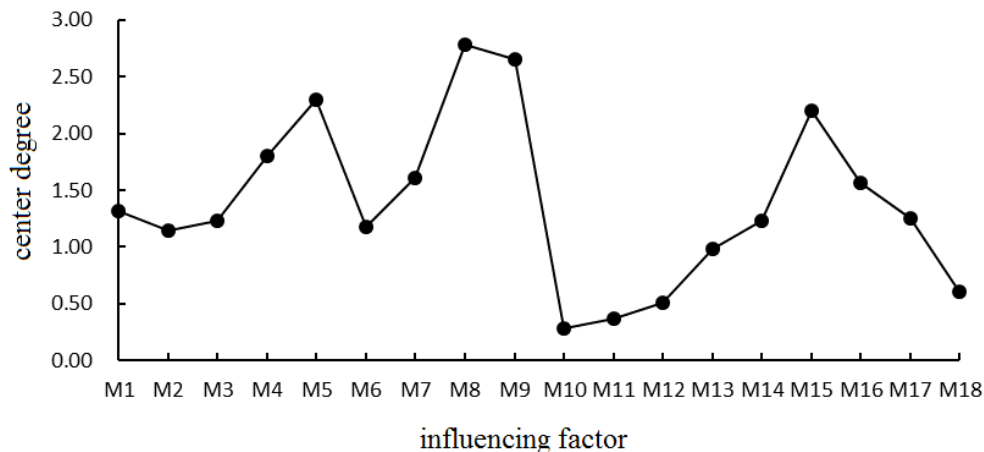


Fig.1-Curve of center degree of influencing factors of EPC project's cost control

It can be seen from Figure 1 that the factor that has a great impact on the cost control of EPC project is the project construction management level M_8 , engineering change and claim M_9 , rationality of design scheme M_5 , price settlement basis M_{15} ; secondly, the selection of design unit M_4 , the selection of construction scheme M_7 , national policies and regulations M_{16} , the formulation of contract terms M_1 , the market price of human resources, materials and machines M_{17} , the division of contract responsibility M_3 , the acceptance of project content M_{14} , the cost control awareness of design unit M_6 , and the contract bidding management M_2 ; finally, the acceptance M_{13} of the changed data, the level of scientific and Technological Development M_{18} , the procurement process and standard M_{12} , the procurement system M_{11} , and the procurement method M_{10} .

The cause degree of the influencing factor is greater than 0. The greater the value, the greater the impact of the factor on other factors. It is the cause index in the system, if the cause degree is less than 0, the more obvious the value is, the smaller the impact of this factor on other factors is. It is the result index in the system. According to the cause degree value in Table 2, it draws the cause and effect diagram of the influencing factors of EPC project cost control, as shown in Figure 2 below.

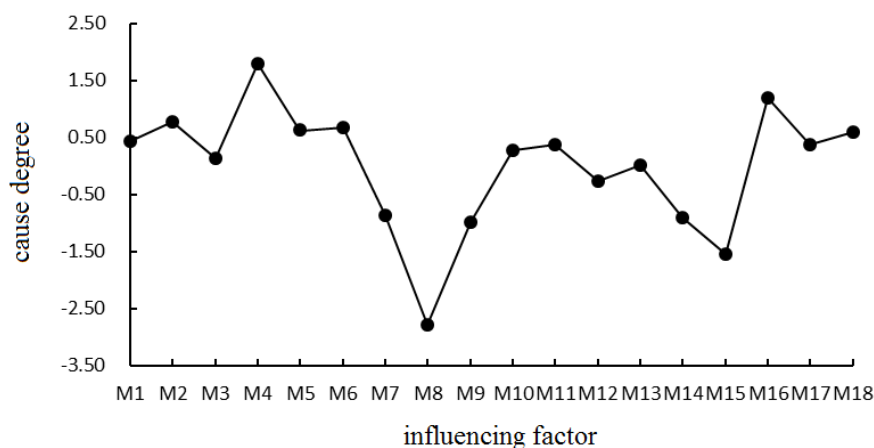


Fig.2-Curve of cause degree of influencing factors of EPC project's cost control

As can be seen from Figure 2, the designer selection M_4 , national policies and regulations M_{16} , contract bidding management M_2 , the designer's cost control awareness M_6 , the rationality of the

design scheme M_5 , the project construction management level M_8 , the formulation of contract terms M_1 , the procurement system M_{11} , the market price of human resources M_{17} , the procurement method M_{10} , the division of contract responsibilities M_3 , Acceptance M_{13} of changed data is the cause index in the influencing factor system of EPC project cost control; Project construction management level M_8 , price settlement basis M_{15} , engineering change and claim M_9 , project content acceptance M_{14} , construction scheme selection M_7 , procurement process and standard M_{12} , those influencing factors are the result indicators in the EPC project cost control influencing factor system.

Establish Reachability Matrix

In the comprehensive influence matrix, due to the lack of consideration of the influence of influencing factors on itself, the following formula needs to be used to obtain the overall influence matrix P of the system, the formula is as follows:

$$P = I + T \quad (11)$$

Among them matrix I is identity matrix.

Set the threshold value λ according to the system impact matrix, by setting the threshold λ , The system can be simplified by eliminating the factors that have little impact on the system[20]. The value of threshold λ will have a great impact on the relationship between influencing factors. If the value is too large, the system structure is relatively simple, it is difficult to measure the relationship between factors, and if the value is too small, the system structure is relatively complex, and the relationship between factors will become complex. In order to obtain the optimal system structure, The values of the threshold λ used in this paper are set to 0.05, 0.1, 0.15 and 0.2 respectively, which are compared and analyzed for many times, and the node degree of each influencing factor under different thresholds is calculated, as is shown in Figure 3. According to the principles[21] of moderate node degree and nodes with large node degree fall in the key node domain determined by DEMATEL method. It is more appropriate when the value of λ is 0.15. The reachability matrix S of influencing factors of EPC project cost control can be obtained according to the following formula.

$$a_{ij} = \begin{cases} 0, & a_{ij} < \lambda \\ 1, & a_{ij} \geq \lambda \end{cases} \quad (i = 1, 2, 3, \dots, 18; j = 1, 2, 3, \dots, 18) \quad (12)$$

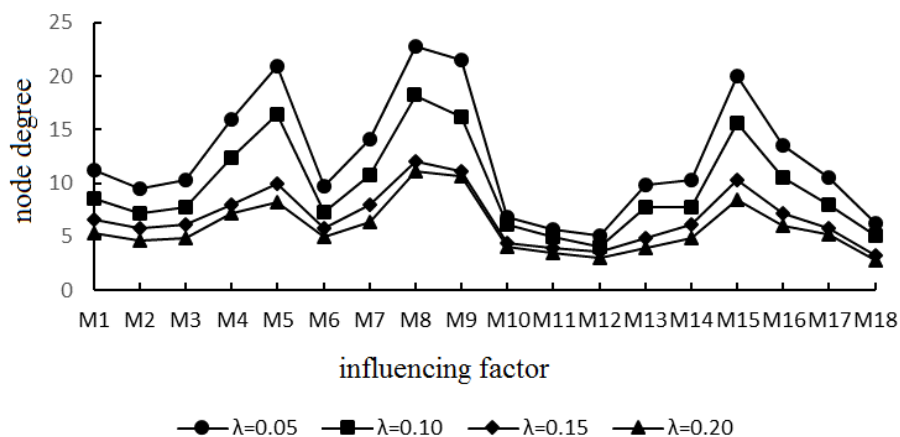


Fig.3 - node degree diagram of influencing factors under different thresholds

$$S = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (13)$$

Establish Multi-layer Hierarchical Structure Model of Influencing Factors

The reachable set $H(M_i)$, antecedent set $K(M_i)$ and common set $N(M_i)$ of influencing factors of EPC project cost control is determined by reachability matrix S , as is shown in Table 3 below. Among them, reachable set $H(M_i)$ is a set of all the influencing factors that can be reached by the influencing factors in the reachability matrix, antecedent set $K(M_i)$ represents the set of all influencing factors that can be reached in the reachability matrix, the common set $N(M_i)$ is the intersection of reachable set and antecedent set.

Tab.3: Reachable set, antecedent set and common set of influencing factors of EPC project cost control

M_i	$H(M_i)$	$K(M_i)$	$N(M_i)$
1	1、3	1、16	1
2	2、9、15	2	2
3	3、9、	1、3	3
4	4、5	4	4
5	5、7、8、9	4、5、6	5
6	5、6	4、6	6
7	7、8	5、7、17	7
8	8	5、7、8、9、18	8
9	8、9、14	2、3、5、9	9
10	10、12	10	10
11	11	11	11
12	12	10、12	12
13	13、15	13	13
14	14	9、14	14
15	15	2、13、15	15
16	1、16、17	16	16
17	7、17	16、17	17
18	8、18	18	18

The method of level division is to extract levels according to the condition of $H(M_i) = N(M_i)$, as is shown in Table 3, when $i=8、11、12、14、15$, $H(M_i) = N(M_i)$, this is expressed as the top level of the system and the highest element set of influencing factors of EPC project cost control, it is $L_1 = \{M_8、M_{11}、M_{12}、M_{14}、M_{15}\}$. At this time, $M_8、M_{11}、M_{12}、M_{14}、M_{15}$ will be deleted from the reachability matrix, on this basis, the highest-level feature set in the reachability matrix will be found again. And so on, finally it gets $L_3 = \{M_2、M_3、M_5、M_{17}\}$, $L_4 = \{M_1、M_4、M_6\}$, $L_5 = \{M_{16}\}$. Therefore, the levels of factors affecting EPC project cost control are divided into five levels, as it means L_1, L_2, L_3, L_4, L_5 . It establishes a hierarchical structure model of influencing factors of EPC project cost control, as shown in Figure 4.

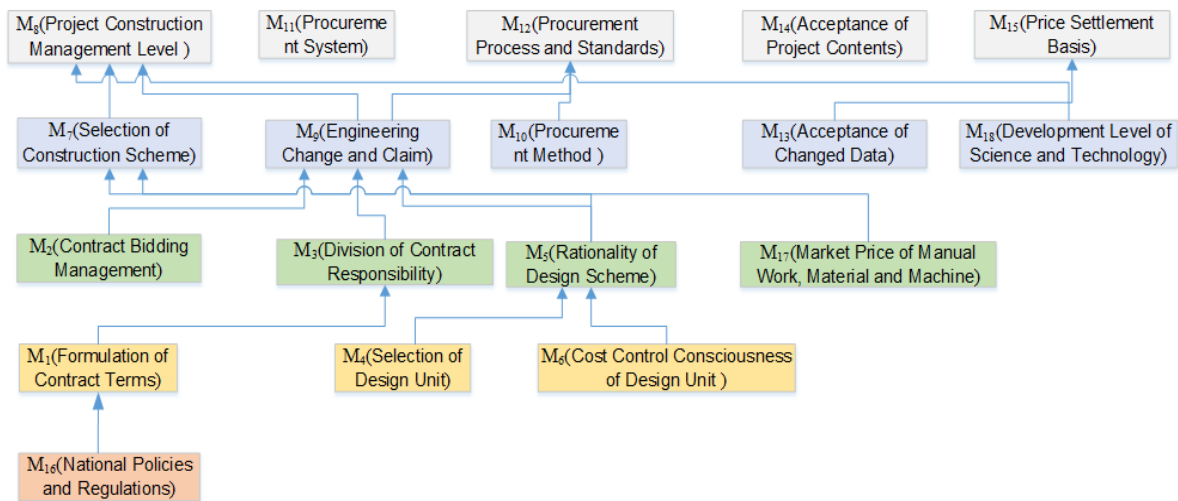


Fig.4-Hierarchical structure model of influencing factors of EPC project cost control

ANALYSIS AND SUGGESTIONS ON HIERARCHICAL STRUCTURE MODEL OF INFLUENCING FACTORS OF EPC PROJECT COST CONTROL

Direct influencing factors of EPC project cost control

According to the above hierarchical structure model diagram, the direct factors affecting the cost control of EPC project are project construction management level M_8 , procurement system M_{11} , procurement process and standard M_{12} , project content acceptance M_{14} and price settlement basis M_{15} . Good project construction management can reasonably arrange the use of labor, materials and machinery, ensure the smooth implementation of EPC project and avoid engineering changes caused by improper construction. On the basis of paying attention to the project construction management level, it can avoid increasing the procurement cost by establishing a sound procurement system and improving the procurement process and standards. In the completion acceptance stage of EPC project, the acceptance of project content needs to check whether the project meets the needs of Party A and is consistent with the design drawings to ensure the smooth progress of acceptance. By checking the engineering change, design change, material change and other problems in the process of project construction, all parties involved in the construction of EPC project need to determine the basis of price settlement according to the specific situation, so as to ensure the interests of all parties involved.

Indirect Influencing Factors of EPC Project Cost Control

(1) The second level influencing factors are the selection of construction scheme M_7 , engineering change and claim M_9 , procurement method M_{10} , acceptance of changed data M_{13} , and scientific and technological development level M_{18} . Through the in-depth study of the design drawings, selecting a reasonable construction scheme can ensure the smooth progress of each link in the construction. At the same time, we also need to pay attention to engineering changes and claims. On the one hand, we should effectively record the contents of changes and claims and

retain effective documents. On the other hand, we should do a good job in the management of changes and claims to reduce the impact of engineering changes and claims on project implementation. Scientific and reasonable procurement methods can effectively reduce the procurement costs of EPC project equipment and materials, select the most suitable way for the project benefit objectives, and improve the cost performance of purchased equipment and materials. By checking the validity and authenticity of visa, change and claim documents, the probability of disputes in completion acceptance can be effectively controlled. The advanced scientific and technological level can effectively promote the in-depth development of EPC project, especially the promotion and application of BIM technology, which provides strong scientific and technological support for the future development of EPC project.

(2) The third level influencing factors are contract bidding management M2, contract responsibility division M3, rationality of design scheme M5 and market price of manual works, materials and machines M17. Through the review of the bidding documents, the key information involved, such as construction standards, project scale, technical requirements, etc., shall be deeply studied, so as to ensure the accuracy of the bidding documents. If the responsibilities or obligations of Party A and the general contractor cannot be clearly specified during the formulation of the contract, it will lead to a conflict of interest. Therefore, clarifying the division of contract responsibilities can protect the interests of both parties of the EPC project. The rationality of the design scheme directly affects whether the subsequent construction links can be carried out smoothly. The design unit and the construction party shall participate in the strict review and optimization of the design drawings to improve the rationality, integrity and scientific of the design scheme. Combined with the development status of market and regional economy, master the market price fluctuation of talents and machines, and evaluate the expected economic benefits of the project to avoid unnecessary waste in the process of cost control.

(3) The fourth level influencing factors are the formulation of contract terms M1, the selection of design units M4 and the awareness of cost control M6. In terms formulation, the general contractor of the project needs to carefully review the contract terms, reasonably foresee the potential risks, and establish a perfect contract review process. The selection of EPC project design unit shall be based on the principle of paying equal attention to technology and economy, so as to avoid the consequences of high project cost caused by only paying attention to technology and not paying attention to economy. At the same time, it is also necessary to constantly strengthen the cost control awareness of the design unit, so as to make the project design economical and meet the needs of the project.

Fundamental Influencing Factors of EPC Project Cost Control

Based on the above analysis, national policies and regulations M16 is the fundamental factor affecting the cost control of EPC project. Therefore, in order to effectively reduce the cost of EPC projects, the state needs to introduce a series of policies and measures to ensure the continuous improvement and promotion of EPC projects. On the one hand, the government can give preferential treatment to EPC projects in terms of finance and taxation and create more relaxed financing conditions and environment. On the other hand, the government can focus on supporting representative enterprises to drive the rapid development of EPC mode, In addition, more EPC

professionals will be trained through industry training to make the development of EPC project more standardized, standardized and sustainable, so as to realize the benign development of EPC project.

CONCLUSION

Combined with the relevant literature on EPC project cost control, this paper summarizes and analyzes the influencing factors, and puts forward 18 factors affecting EPC project cost control from six dimensions: contract factors, design factors, construction factors, procurement factors, completion acceptance factors and external environmental factors. The decision laboratory analysis method (DEMATEL) is used to calculate the centrality and cause degree of each influencing factor, and classify them. On this basis, the interpretative structure model (ISM) is used to study the relationship between each influencing factor, and a multi-layer hierarchical structure model of the influencing factors of EPC project cost control is established, so as to improve the economic benefits and provide theoretical basis for reducing project construction cost.

The research in this paper also has some limitations. As EPC projects are widely used in various fields, there will be more and more factors affecting the cost control of EPC projects. The number of influencing factors of EPC project cost control identified in this paper is still present, and the implicit influencing factors, such as the reputation and communication ability of both parties, are not taken into account. Although the analytical method in the paper is scientific, it relies to some extent on people's experience, and the accuracy of the analytical conclusions is mainly determined by the factors selected and the number and quality of the experts consulted. The subsequent study can complete the analysis of the cost control of EPC projects by comparing quantitative data with qualitative results to make the analysis conclusions more convincing.

ACKNOWLEDGEMENTS

Special thanks to National Social Science Foundation of the Ministry of Education of China, I would like to thank Northeast Petroleum University and Chengde Petroleum College for their support.

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