Analysis of Influencing Factors of Prefabricated Building Supply Chain

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Abstract: With the continuous development of the construction industry, prefabricated buildings occupy an important position in China's construction industry due to their short construction period, environmental protection and energy saving advantages, and gradually become the trend of future development. However, the supply chain of prefabricated buildings is affected by many factors in the process of whole process management due to its particularity. This paper establishes an index system of influencing factors of prefabricated building supply chain from seven processes and 24 influencing factors of external market, organization and management, design stage, procurement stage, manufacturing stage, transportation stage and assembly stage of prefabricated building supply chain. The results show that the organization management, assembly stage and transportation stage occupy the main position in the influencing factors of the assembly supply chain.

Keywords: architecture; assembly; supply chain; influencing factors; ahp

1. Introduction

With the continuous development of assembly buildings, the competition in the construction market is more intense. The content involved in assembly buildings is higher than that of traditional buildings, and the internal relations are more complex and close. At the beginning, the enterprise improved the design, transportation and assembly of the assembly. Nowadays, enterprises are more inclined to cooperate with each other through the ' horizontal integration ' and ' vertical integration ' of the assembly as a whole, and the cooperation of people, materials and machines to complete the complex tasks of each link. The integrated management theory system of supply chain is gradually applied to the prefabricated building, which can be used as a series tool to connect all aspects of the assembly into a network system, so that the construction enterprises are more closely linked, the management between enterprises is more efficient, and the construction process is more smooth. The connection realizes the rational allocation of resources, reduces costs, and improves market competitiveness and share. Through the five aspects of design, production, transportation, management and society, the influencing factors of assembly building cost are summarized. Using DEMATEL for quantitative analysis, it is found that reducing cost and improving competitiveness should be considered from the aspects of technology maturity, prefabrication rate, component splitting and component transportation efficienc [1]. Using DEMATEL to calculate the importance level of the external construction environment characteristics, the technical characteristics of the project itself, the organization and management of the project personnel and the causal relationship between each other, and put forward measures and suggestions to reduce the cost of prefabricated buildings [2]. Based on the cloud matter-element theory, the sustainability and risk early warning of the assembly supply chain are studied respectively [3]. The green contribution evaluation index is proposed to measure the environmental impact of the activities of all parties in the green supply chain of prefabricated buildings [4]. Based on the grounded theory, the index system of influencing factors of prefabricated building flexible supply chain is constructed. On this basis, the weight of each impact index is determined and the key factors are identified [5]. Identify risk factors from the perspective of stakeholders and the whole life cycle; then, a risk analysis model based on social network analysis (SNA) is constructed to study the risk factors and their interactions in the green supply chain of prefabricated buildings [6]. It is found that the research field of prefabricated buildings mainly covers five research topics: the connotation and development status of prefabricated buildings, development environment, project life cycle management, organization management and sustainability research [7]. The research adopts the overall bibliometric method, combined with qualitative (systematic literature review) and quantitative (bibliometric analysis) methods to evaluate the research status of prefabricated building risks (PCRs) and identify literature trends. Different from previous PCR studies, our study utilized the quantitative analysis ability of Bibliometrix R-tools [8]. Low-frequency cyclic loading tests were carried out to study the mechanical properties of stair end joints under in-plane and out-of-plane low-frequency cyclic loading [9]. Based on the existing research, the 13 influencing factors of IS in PBSC were comprehensively analyzed from the perspective of information ecology theory [10].

2. Influencing Factors and AHP Model Construction

Analytic Hierarchy Process (AHP) was proposed by American operations research expert T.L.Saaty in the 1970 s. It is a ' system analysis + operations research '

method. It can solve the hierarchical structure decision-making problem composed of ' scheme layer + factor layer + target layer ' through qualitative analysis and quantitative analysis. It mathematicalizes the thinking process of decision-making, so as to solve complex decision-making problems with multi-criteria or unstructured characteristics, and provides a simple decision-making method. Scholars apply AHP or improved AHP to many fields such as enterprise credit rating, enterprise management, talent prediction, economic management planning, etc., and make a comprehensive and systematic evaluation of related issues more objectively.

2.1 Influencing Factors and Index System Construction

Based on the investigation and research on the influencing factors in the relevant literature, this paper conducts relevant research on the construction market according to the characteristics of the assembly supply chain. Finally, the influencing factors of the assembly construction supply chain are quantitatively compared from seven aspects: external market, organization management, design risk, procurement stage, manufacturing stage, transportation stage and assembly stage. In order to find out the main influencing factors affecting the assembly construction supply chain, relevant improvements are made in order to improve the resilience of the whole life cycle supply chain of the assembly building, reduce the construction cost, shorten the construction period, and promote the vigorous development of the assembly building.

2.1.1 External market

The influencing factors of the external market include four aspects: market demand fluctuation, consumption concept change, price fluctuation of human resources and machinery, and bad climate influence.

2.1.2. Organizational management

The influencing factors of the organizational management stage include the lack of experience and ability of managers, the unreasonable distribution of benefits, and the unreasonable process connection.

2.1.3. Design phase

The influencing factors of the design stage include three aspects: design specification change, design change and design maturity.

2.1.4. Purchase phase:

The influencing factors of the procurement stage include four aspects: procurement cost, inventory cost, punctuality of delivery, and number of suppliers.

2.1.5. Manufacturing stage

The influencing factors of the manufacturing stage include three aspects: construction quality, manufacturing technology capability and mechanical failure.

2.1.6. Transport phase

The influencing factors of the transportation stage include four aspects: construction of transportation process damage, rationality of transportation planning, auxiliary equipment, and supplier address selection.

2.1.7. Assembly stage

The influencing factors of the assembly stage include four aspects: construction period control, safety accident, assembly technology maturity and mechanical coordination. To sum up, the influencing factors of seven categories and twenty-four kinds of prefabricated building supply chain are summarized, as shown in Table 1.

Table 1. Indicator system

first grade indexes	numbering	second index	Indicator description
B1 External market	C1	Fluctuation of market demand	The influence of external demand on the number of assemblies
	C2	Change of consumption concept	The impact of emerging building materials on existing prefabricated buildings
	C3	People, materials, machine price fluctuations	The impact of price changes on the total cost of the cost
	C4	Harsh environmental impact	Rain, snow, cold and other climates
B2 Organizational management	C5	The ability experience level of management personnel	Prefabricated building related personnel, process to make reasonable arrangements
	C6	Rationality of benefit distribution	Rationality of interest distribution among all parties involved
	C7	Rationality of process connection	Arrange the construction sequence reasonably.
B3 Design stage	C8	Standard specification changes	Standard Specification for Design and Construction Units
	C9	Design changes	Changes in drawings due to external causes
	C10	Design Maturity	The overall design level of drawings depends on the operation level.
B4 Purchase phas	C11	Procurement cost	Procurement of building materials and labor, machinery hire lease costs
	C12	Inventory costs	The cost of excess material storage
	C13	delivery accuracy	Can the goods be delivered on time during the contract period
	C14	building material quality	Construction of quality standards for production
	C15	Number of suppliers	Suppliers of building materials
B5 Manufacturing stage	C16	Building quality	Suppliers even if the manufacturing level
	C17	manufacturing level	Ability of the equipment to maintain normal operation
	C18	mechanical equivalent of light failure	Build the integrity in the process of transportation
B6 Transportation stage	C19	Rationality of transportation planning	Construction of transportation route planning
	C20	auxiliary equipment	Equipped with lifting facilities related to transportation process
	C21	construction period control	The construction unit on-site construction time control
B7 Assembly stage	C22	Qualified rate of assembly construction quality	The quality standard degree of the construction unit after assembly
	C23	Assembly technology maturity	On-site assembly construction level of construction unit
	C24	Mechanical fit	Construction of mechanical preparation and cooperation during assembly

2.2 Build Model to Calculate Weight

According to the relevant influencing factors obtained above, the evaluation index system of influencing factors of prefabricated building supply chain is established. The influencing factors of the prefabricated building supply chain established in this paper include the target layer, the criterion layer and the scheme layer. The target layer is used to determine the subject of the research object and the purpose of the research. The criterion layer is generally composed of multiple levels, which are intermediate links. The scheme layer is usually decision-making and measures.

3. AHP Weight Calculation Steps

(1) Expert scoring method. Relevant experts of prefabricated buildings, relevant personnel of suppliers, relevant personnel of construction parties and relevant personnel of supervision parties are invited to score and assign values to indicators at all levels according to the 1-9 scale method. Each indicator is compared in pairs, and the judgment matrix A ~ B is constructed as the judgment matrix of the first-level indicator. B1 ~ (C1 ~ C4), B2 ~ (C5 ~ C7), B3 ~ (C8 ~ C10), B4 ~ (C11 ~ C15), B5 ~ (C16 ~ C18), b6 ~ (C19 ~ C21) and B7 ~ (C22 ~ C24) are the second-level index judgment matrix.

(2) Calculate the weight of each level index, calculate the maximum eigenvalue of each judgment matrix and the corresponding eigenvector, and use the consistency index, random consistency index and consistency ratio for consistency test. The formula of consistency test is

$$CR = CI / RI \tag{1}$$

In the formula, CR represents the consistency ratio. When n $\geqslant$ 3, CR < 0.1, it meets the consistency condition. Otherwise, the judgment matrix should be corrected until the consistency condition is met. CI is the consistency index, and the calculation formula is:

$$CI = (\lambda_{\max} - n)/(n-1) \tag{2}$$

λ max-- the maximum eigenvalue;

n--number of factors;

The hierarchical total ranking of all elements is carried out, and the consistency test of the hierarchical total ranking is carried out. The test formula is:

$$CR = \frac{\sum_{j=1}^{m} a_j CI_j}{\sum_{j=1}^{m} a_j RI_j} \tag{3}$$

If the consistency test is passed, the normalized feature vector is the weight; if it does not pass, it is necessary to reconstruct the judgment matrix and repeat the consistency test steps, as shown in Table 2.

Table 2. Comprehensive weight of influencing factors of prefabricated building supply chain

first grade indexes	First-level weight	second index	second-degree weight	Indicator description	ahp weight
External market	0.0419	C1	0.6028	Fluctuation of market demand	0.0252
		C2	0.1099	Change of consumption concept	0.0046
		C3	0.2353	People, materials, machine price fluctuations	0.0098
		C4	0.052	Harsh environmental impact	0.0022
Organizational management	0.3238	C5	0.738	The ability experience level of management personnel	0.2389
		C6	0.0944	Rationality of benefit distribution	0.0306
		C7	0.1676	Rationality of process connection	0.0543
Design stage	0.0981	C8	0.1373	Standard specification changes	0.0135
		C9	0.2395	Design changes	0.0235
		C10	0.6232	Design Maturity	0.0611
Purchase phase	0.0548	C11	0.4045	Procurement cost	0.0222
		C12	0.1034	Inventory costs	0.0057
		C13	0.1557	delivery accuracy	0.0085
		C14	0.2652	building material quality	0.0145
		C15	0.0712	Number of suppliers	0.0039
Manufacturing stage	0.1338	C16	0.5907	Building quality	0.079
		C17	0.3338	manufacturing level	0.0447
		C18	0.0755	mechanical equivalent of light failure	0.0101
Transportation stage	0.1167	C19	0.7014	Rationality of transportation planning	0.0818
		C20	0.0853	auxiliary equipment	0.01
		C21	0.2132	construction period control	0.0249
Assembly stage	0.2316	C22	0.2648	Qualified rate of assembly construction quality	0.0612
		C23	0.6555	Assembly technology maturity	0.1514
		C24	0.0796	Mechanical fit	0.0184

4. Conclusions and Measures

This paper evaluates the influencing factors of prefabricated building supply chain, establishes a more comprehensive index system of influencing factors of prefabricated building supply chain, and systematically and comprehensively reflects the relevant influencing factors of prefabricated building supply chain risk. According to the data analysis, the organizational management stage has the highest influencing factors in the entire assembly supply chain, followed by the assembly stage, manufacturing stage, transportation stage, design stage, procurement stage, and external market. Therefore, the following suggestions are put forward:

(1) Developers should do relevant research on the market of prefabricated buildings before construction, control the risk management of the supply chain in advance, and reduce the possibility of risk occurrence. Understand the weak points of the prefabricated building supply chain, sub-control of different influencing factors, formulate different standards for different influencing factors, and formulate accurate response plans for different risks.

(2) In the construction and installation stage of the prefabricated building, the key parts, key and difficult points, quality, and operation points should be described in detail, and the relevant personnel should be fully explained to ensure that there is no error and low loss. Carry out relevant training and learning for workers, continuously improve the work, and shorten the construction period on the premise of ensuring quality.

(3)Do a good job of linking up and down. Because the construction of prefabricated buildings is relatively large and complex, it is very important to do a good job of communication between different types of work, understand the construction of 'where to go ', and provide accurate and effective transmission solutions.

(4) In the whole life cycle of prefabricated buildings, it is necessary to organize front-line grassroots employees and supply chain participants to learn relevant knowledge of the supply chain, promote the full participation of the supply chain in prefabricated buildings, and make the supply chain run through the whole process of installing a prefabricated building.

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