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Research on the Restrictive Factors of Vigorous Promotion of Prefabricated Buildings in Yancheng under the Background of "Double Carbon"

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Abstract: In the field of construction, the promotion of prefabricated buildings has been strongly supported by the state due to its low-carbon, environmental protection and high-efficiency characteristics. The process of design, prefabrication, and installation, is restricted by factors such as unsound policy standards, insufficient technological innovation, lack of professional talents, and high costs, which have led to the slow development of prefabricated buildings in China. The main factors that restrict the development of prefabricated buildings in Yancheng are identified from the researcher's point of view by literature review and questionnaire survey method. The degree of centrality and cause of each constraint has been analyzed by the decision-making laboratory method (DEMATEL), and the interpretation structure method (ISM) was used to build a multi-level hierarchical structure model of constraints, the logical relationship, hierarchical relationship and relative importance of each constraint are clarified. It is concluded that industry policies, imperfect standards and insufficient government publicity are the fundamental reasons to hinder the development of prefabricated buildings in Yancheng. According to the order of the centrality, the main restrictive factors are determined, which benefits the establishment of the homologous counterplan for the vigorous promotion of prefabricated buildings in Yancheng.

Keywords: double carbon; prefabricated building; restrictive factors; DEMATEL; ISM

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1. Introduction

In order to achieve global sustainable development, the Chinese government has proposed to all countries in the world to strive to achieve "carbon peak" before 2030 and "carbon neutrality" before 2060, that is, "double carbon" goal. According to the "China Building Energy Consumption Research Report (2020)" issued by the Energy Conservation Committee of China Building Energy Conservation Association, the total carbon emissions of the whole process of China's construction in 2018 was 4.93 billion tons, accounting for 51.3% of the national carbon emissions. Therefore, whether the construction industry can achieve the "double carbon" goal is crucial to China's sustainable development.

In recent years, the prefabricated building industry are increasingly focused on "carbon peaking and carbon neutrality" in the construction field. Prefabricated building construction not only greatly saves water, energy, steel, wood and other resources, but also reduces construction waste and noise pollution. At the same time, prefabricated building construction can alleviate the shortage of labor force in the construction industry, and realize the transformation of the construction mode from the traditional extensive production and inefficient management to green, assembly, informatization and intelligentization. Therefore, it is particularly urgent to vigorously promote prefabricated buildings. At present, prefabricated buildings have achieved desired results in developed countries such as Europe, Japan, and Singapore, but promoting prefabricated buildings has been restricted to a certain extent in China [1].

Since 2016, the China State Council has issued a series of documents such as "Guiding Opinions on Vigorously Developing Prefabricated Buildings", which put forward the specific goal, which is to have prefabricated buildings account for 30% of new construction within a decade. The document requires that the application of prefabricated buildings should be enlarged with the three major urban agglomerations of Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta as key areas. In 2017, the Ministry of Housing and Urban-Rural Development of China issued three major documents, namely, "The 13th Five-Year Plan for Prefabricated Buildings", "Administrative Measures for Prefabricated Building Demonstration Cities", and "Administrative Measures for Prefabricated Building Industry Bases", indicating that the development of prefabricated buildings has risen to the national strategic level [2]. In 2017, the Jiangsu Provincial Department of Housing and Urban-Rural Development issued the "Jiangsu Construction 2025 Action Outline", which promotes the development of engineering construction methods to the integration direction of the "four modernizations" including refining construction, information technology, green construction and industrialization, and vigorously put a policy into practice in four new construction methods, namely lean construction, digital construction, green construction and prefabricated construction.

The document, namely "Implementation Opinions on Accelerating the Development of Prefabricated Buildings", was released by the Yancheng government in 2017, and pointed out that the development path of government-guided, market-led, industry-driven and enterprise operation by the popularization and application of BIM technology to promote the development of prefabricated building design, production and construction. During the "Thirteenth Five-Year Plan" period, new prefabricated buildings of 3,795,900 square meters were built in Yancheng, and the ratio of prefabricated buildings area to new buildings area increased from 4% in 2018 to 30% in 2020. Six construction industry modernization demonstration bases have been settled in Yancheng, such as Funing Green Intelligent Building Industrial Base, and Jiangsu Shenggong Construction Co., Ltd. (240,000 cubic meters PC components). There are 32 manufacturers of prefabricated building components, such as Jiangsu Qianhe Prefabricated Building Technology Co., Ltd. and Jiangsu Jinmao Construction Group Co., Ltd., whose production covers concrete components, wood components and steel components. Yancheng Pioneer International Hotel project and Yancheng Hope Residential Community project were included in Jiangsu Province prefabricated building demonstration project in 2021. Yancheng government issued the document "Implementation Opinions on Vigorously Promoting the Development of Prefabricated Buildings", which proposed the development goal of prefabricated buildings. Prefabricated buildings should account for more than 35% of initiated construction buildings, and assembled decoration buildings should take a proportion of more than 10% of new housing in 2021. By the end of 2025, prefabricated buildings will reach 50% of initiated construction buildings, and assembled decoration buildings will exceed 30% of delivered housing.

In Yancheng, prefabricated buildings have been gradually promoted, and relevant documents and policies had been launched to stimulate the prefabricated construction market. but there are still constraints on the vigorous development of prefabricated buildings, and problems that need to be deeply studied and solved urgently, for example, the secondary deepening design is not matched with some standards and specifications, and prefabricated buildings are assembled only on "three plates"(prefabricated interior and exterior wall plate, prefabricated stair plate, prefabricated floor plate), The lack of qualified construction professionals and unadvanced operation tools lead to low work efficiency, and it is even difficult to guarantee the installation quality of prefabricated structures. Therefore, the cost of prefabricated construction is not advantageous. At present, prefabricated building is limited to concrete structure, prefabricated steel-concrete composite structure is less, the information level of prefabricated building is not systematized to fail to achieve information management, and so on. The author participated in 30-31# group project construction of Yancheng Institute of Technology dormitory. The designed and produced inner wall plate (Autoclaved Lightweight Concrete (ALC)) does not integrate water and electricity pipelines, which led to slotting ALC to arrange the pipelines. Simple installation equipment, unprofessional construction workers, and inefficient construction make it difficult to guarantee the construction quality of dormitory buildings.

2. Literature Review

Factors influencing the promotion of prefabricated buildings are classified into driving factors and restrictive factors. In terms of driving factors, Li et al. analyzed three aspects: direct factors, indirect factors and fundamental factors [3]. The results show that shortening the construction period, saving energy and reducing consumption, improving resource utilization and reducing on-site operations are the main driving factors. Wang et al. used a hybrid model to assess the environmental impact of prefabricated buildings and traditional cast-in-place buildings over the whole life cycle in Japanese construction cases [4]. It was found that the total energy consumption and carbon emissions of 40% assembly buildings downed 7%, and compared to those of traditional cast-in-place buildings. Prefabricated buildings cost less than traditional cast-in-place buildings, reducing the price per square meter by more than 10%. As the assembly rate increases, carbon emissions and costs drop, reaching the bottom when the assembly rate is 60%. Through literature reviews and industry interviews, zhang et al. have identified and discussed the factors reflecting major changes in the current Australian prefabricated construction [5]. These factors include prefabrication industry development, emerging benefits and challenges. The challenges identified from the interviews were grouped into eight fields, involving feasibility, design, manufacturing, transportation, site construction, standardization, skills and knowledge, funding and markets. With the increasing application of prefabricated structures in civil engineering, the seismic performance of prefabricated structures has attracted the wide attention of scholars all over the world. A novel seismic force-resisting system (SFRS) called Floor Isolated Re-entering Modular Construction System (FIRMOCS) has been proposed by Chen et al. for prefabricated modular mass timber (MT) construction [6]. The preliminary results showed that FIRMOC systems significantly reduced the seismic demand on the prefabricated modular MT construction using nonlinear dynamic time-history analysis according to the National Building Code of Canada, thus leading to an improved seismic response. Moreover, modular integrated construction(MiC) is an important process to integrate and assemble prefabricated prefinished modules. Wuni et al. pointed out the critical success factors (CSFs) for implementing MiC projects during the period 1993–2019 [7]. The study result showed that the US, UK, Malaysia, Australia, and Hong Kong are the largest contributors to the MiC CSFs. The further analysis generated 35 CSFs for implementing MiC projects. To improve the performance of the construction industry, design for manufacturing and assembly (DfMA) is introduced into the design of prefabricated buildings in the industrial building system (IBS) and prefabricated buildings, and combined with the parametric design of building information modeling (BIM). The main benefits, hindrances, and upsides of DfMA in the construction industry are discussed [8,9]. The implementation of the DfMA method in prefabricated construction projects is conducive to improving the level of green building activities. As can be seen from "World Green Building Trends 2021", the highest levels of current green building activity are in Australia or New Zealand, Canada and the US. And the highest levels of growth in those doing a majority of green projects are expected in Brazil, Colombia, Canada and Mexico.

Many scholars have different reasons for restricting the development of prefabricated buildings in China. Bian et al. used principal component analysis to identify key factors, including market environment, industrial organization, policies and regulations, talent factors, technical systems, etc. [10]. Based on the willingness of developers, Lu et al. found that high construction costs and low customer perceived value are the main factors restricting the development of prefabricated buildings [11]. Chen et al. pointed out from the perspective of the government that the problems in the implementation of prefabricated building policies included imperfect policy systems, insufficient environmental conditions for policy implementation, and low enthusiasm for policy executors [12]. Chen et al. proposed to increase incentives, improve incentive mechanisms, strengthen standardization, upgrade technical systems, and enhance publicity and education efforts to promote assembly development by building an evolutionary model of "government-developer" and "government-consumer" [13].

Zhai et al. concluded that low supply chain integration, the inability to freeze the design in the early stage, the high cost, and the lack of supportive policies and relevant standards are the main contradictions restricting the development of prefabricated buildings in China [14]. Zhang et al. used fuzzy analytic hierarchy process to analyze the main factors, and the conclusion was that the lack of professional talents and completive industrial chain, and the imperfection of relevant norms and standards restricted the development of China's prefabricated buildings [15]. Based on actual cases, Hong et al. analyzed and found that the main reason for the higher cost of prefabricated buildings in China than traditional buildings is the additional transportation and assembly costs of components [16]. Xue et al. found that little innovation is one major reason to obstruct the promotion of Chinese prefabricated buildings through social network analysis (SNA) and structural equation modeling [17]. Wu et al. studied the development of Chinese prefabricated buildings from the perspective of technology promotion and constructed a model of influencing factors from five aspects, including industry, company, technology, government, and market. The results showed that technology has more influence on prefabricated buildings than cost [18–22]. Lu et al. developed a lean-agile production system for prefabricated housing products based on market demand and production process to achieve a balance between market demand and production capacity [23].

The prefabricated building construction method is similar to automobile production, relying on pre-designed components that are factory-made, specialized, and standardized. The main work on construction sites is to install components, which can cut down the construction period, on-site wet work and formwork, water and electricity consumption, construction waste, and help to protect the environment. Since China's State Council promulgated "Guiding Opinions on Vigorously Developing Prefabricated Buildings" in 2016, and established 48 prefabricated building demonstration cities and 328 industrial demonstration bases [24,25]. the newly-started prefabricated building area in 2021 reached 740 million square meters, accounting for 24.5% of the new building area, and the newly-started prefabricated buildings in key construction areas accounted for 52.1% of the total in China [26].

However, the popularization of prefabricated buildings increases construction costs and lacks supply-side resources and market awareness. Meanwhile, due to government requirements, market development, and environmental protection, most developers are still in passive acceptance and are forced to build prefabricated buildings. Prefabricated building construction is representative of advanced productive forces that can best reflect the advantages of technological progress and industrialization. In China, a package of policies and guidance has been formulated in the stage of exploration and development. Many challenges remain in technology, market, operation, and management that must be addressed for prefabricated building construction to become industrialized.

In recent years, the research on prefabricated buildings is on the rise, and most studies on constraints to the development of prefabricated buildings in China are comprehensive [27,28]. Due to the vast territory of China, the basic conditions and development status of prefabricated buildings in different provinces and cities are different, so specific and quantitative studies are needed. There are few reports on the development status and influencing factors of prefabricated buildings in a certain city in China. The present research is in the stage of theoretical research and qualitative analysis, lacking quantitative analysis and objective data support. Research on the interrelationship and hierarchical relationship of the restrictive factors that affect the promotion of prefabricated buildings is difficult to reflect the deep connection, and very unfavorable to formulate corresponding measures to develop prefabricated buildings.

3. Methodology

This paper takes the prefabricated building construction in Yancheng City, Jiangsu Province as an example. Taking into account the characteristics of geography, humanity, environment and economy, the constraints on the promotion and implementation of prefabricated buildings are sorted out and categorized, a constraint model is created. Factor analysis was carried out by IBM SPSS 22.0 software, and the reliability of the model was verified. The DEMATEL-ISM method was used to analyze the relationship between the influencing factors qualitatively and quantitatively. The main restricting factors were determined and the corresponding countermeasures were put forward.

3.1. Ideas for Extracting and Identifying Restrictive Factors

Using comparative and analytical research methods, many literatures in "CNKI" and "Web of Science" databases on the development and promotion of prefabricated buildings are reviewed, five types of constraints are identified by PEST theory: market, economy, technology, society, and policy.

Based on the analysis of the initial list of restricting factors, the framework table of the restricting factor index system is classified, the amendments based on expert opinions are drawn up, and the revised index system of restricting factors for the promotion and implementation of prefabricated buildings is established.

According to the above index system, questionnaires and statistical regression analysis, the authors identify effective constraints and verify the rationality of the constraint index system.

3.2. DEMATEL-ISM Combined Model Analysis Method

3.2.1. DEMATEL Analysis Steps

(1) Identifying influencing factors Sn.
(2) The numbers 0–4 represent the association between the factors, where the number 0–4 indicates the level of association between the factors from none, low, average, relatively high and high, respectively.
(3) Establishing the initial direct influence matrix.

The influence relationship between the factors can be shown from the matrix to create the initial direct influence matrix D. D_{ij} represents the degree of influence of S_{i} on S_{j}, $D_{\mathrm{ij}} = 0,1,2,3,4$.

(4) Normalizing the matrix.

The standardization matrix B is obtained by normalizing the direct influence matrix D, as shown in Equation (1).

$$B = \left[b_{ij}\right]_{n\times n} = \frac{1}{\max\limits_{1\le i\le n}\sum\limits_{j=1}^{n} d_{ij}} D \tag{1}$$

(5) Calculating normalized direct influence matrix to obtain the combined influence matrix T, as shown in Equation (2).

$$T = B + B^2 + B^3 + \ldots + B^n = B(I - B)^{-1} = t_{ij} \tag{2}$$

where element matrix $\boldsymbol{I}$ denotes the influence of the factor itself.

(6) Calculating influence degree f_i, affected degree e_i, centrality degree z_i and cause degree y_i for each factor.

Influence degree f_i and affected degree e_i are equal to the sum of each value in row i and column i of combined influence matrix T, respectively. Centrality degree z_i which represents the degree of each factor's importance is the sum of influence degree f_i and affected degree e_i, influence degree f_i minus affected degree e_i is equal tocause degree y_i, The Equations (3)–(6) are as follows.

$$f_i = \sum_{j=1}^{n} t_{ij} (i = 1, 2, \ldots, n) \quad (3)$$

$$e_i = \sum_{j=1}^{n} t_{ji} (i = 1, 2, \ldots, n) \quad (4)$$

$$z_i = f_i + e_i (i = 1, 2, \ldots, n) \quad (5)$$

$$y_i = f_i - e_i (i = 1, 2, \ldots, n) \quad (6)$$

(7) Centrality degree z_i and cause degree y_i of each factor are respectively taken as horizontal and vertical coordinates in the factor-cause-result diagram, and the position of each constraint is marked in the coordinate axis for intuitive analysis of the importance of each constraint.

3.2.2. DEMATEL-ISM Method

After completing step (7) of DEMATEL model analysis, Dematel-ISM model analysis is carried out in the following steps.

(8) Calculating the overall influence matrix H. It is considered that the influence of each factor on itself is to be added, and the influence of the factors themselves can be reflected by the element matrix I, the overall influence matrix H can be obtained according to Equation (7).

$$H = I + T \quad (7)$$

(9) Calculating reachability matrix R according to specific threshold λ.

$$R = \left| r_{ij} \right|_{n \times n}, (i = 1, 2, \ldots, n; j = 1, 2, \ldots, n)$$
$$r_{ij} = \begin{cases} 1, h_{ij} \geq \lambda \\ 0, h_{ij} < \lambda \end{cases} \quad (8)$$

where λ is threshold value, in the process of selecting specific threshold, it is necessary to ensure the appropriate nodes and coordinate with the key nodes obtained by the DEMATEL method.

(10) Analysyzing hierarchical relation.

After solving reachable matrix R in step (9), reachable set *P(Si)* and antecedent set *Q*(Si) can be derived, *P(Si)* is the column set containing 1 in row i of *R*, and *Q(Si)* is rowset containing 1 in column i of *R*. When $P_{si} = P(S_i) \cap Q(S_i), i = 1, 2, \ldots, n$, 1st layer of factors can be obtained, and deleting this layer creates *R1*. In the same way, the *i*th layer of factors can be set up, and so on.

(11) Drawing the hierarchical diagram of constraints.

4. Results

4.1. Identifying the Constraints on the Vigorous Promotion of Prefabricated Buildings

The authors of this paper analyze and summarize the research results of many scholars on the development constraints of prefabricated buildings [3,10,25], 25 factors restricting the development of prefabricated buildings in China were identified, as shown in Table 1. Through a series of questionnaires,10 factors with negligible influence were eliminated from the 25 influence factors, and 15 factors with large influence on the vigorous promotion of prefabricated buildings in China were determined. As can be seen from Table 2, 15 factors are grouped into five categories: market, economy, technology, society, and policy according to the hierarchy and systemicity of constraints themselves and the connotation of the constraints by PEST theory.

Table 1. Yancheng prefabricated building promotion and implementation restriction index system framework.

Serial Number	Restrictive Factors
1	Insufficient motivation for enterprise transformation
2	The inefficiency of cooperation among participants
3	Imperfect supporting industrial chain
4	Traditional habit constraints
5	Insufficient market demand
6	Poor awareness of energy conservation
7	Weak willingness of construction enterprises to transform
8	High construction cost
9	High template cost and low utilization rate
10	Higher component production, installation costs and value-added tax
11	Large upfront investment
12	Lack of information technology application
13	Backward prefabricated building management model
14	Imperfect design standardization and modularization system
15	Lack of innovation
16	Insufficient investment in research and development
17	Insufficient technical support
18	The construction is difficult and the construction level is low
19	Talent shortage
20	low public awareness and purchase willingness
21	low degree of social acceptance
22	Insufficient government propaganda
23	Imperfect industry policy and standard system
24	Insufficient financial support
25	Imperfect industry standard system

Table 2. The revised index system of restrictive factors for the promotion and implementation of Yancheng prefabricated buildings.

Classification	No.	Restrictive Factors
Marketaspect	S1	Insufficient motivation for enterprise transformation
	S2	Imperfect supporting industry chain
	S3	Insufficient market demand
Economic management	S4	High construction cost, low cost performance
	S5	Large upfront investment
	S6	The prefabricated building management model is backward
Technical aspect	S7	Design standardization, modularization, and integrated systems are not perfect
	S8	Prefabricated building production, construction experience and technology are immature
	S9	Insufficient basic research and innovation of prefabricated buildings
Social aspects	S10	Talent shortage
	S11	Low public awareness and willingness to buy
	S12	low degree of social acceptance
Policyaspect	S13	Imperfect industry policy and standard system
	S14	Insufficient financial support
	S15	Insufficient government propaganda

To ascertain the reliability of the factors in Table 2, the authors designed questionnaires to survey senior professionals in the construction industry to collect feedback and form the original data. According to Clonbach reliability test and factor analysis by SPSS 22.0 software, the reliability of the constraint system had been tested.

(1) Questionnaire design and collection

The questionnaire is based on a cumulative scale table, in which the numbers 5, 4, 3, 2 and 1 represent high, relatively high, average, relatively low and low respectively according to the degree of importance from high to low. Please refer to Appendix A.

A total of 110 questionnaires were surveyed, and 102 completed questionnaires were returned. After eliminating 7 questionnaires with incomplete filling and obvious distortion of content, 95 valid questionnaires were actually obtained. Figures 1–3 show the basic statistics of 95 questionnaire.

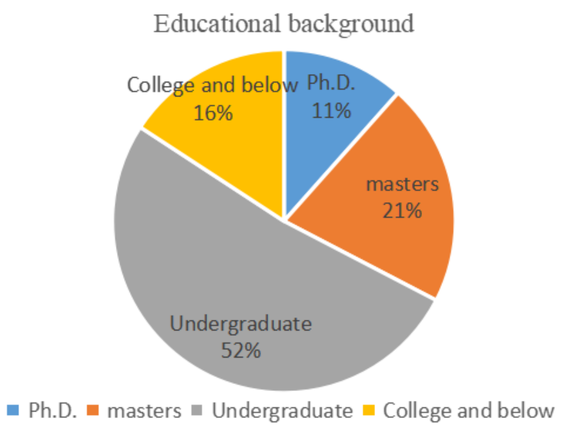

Figure 1. Educational background of interviewees.

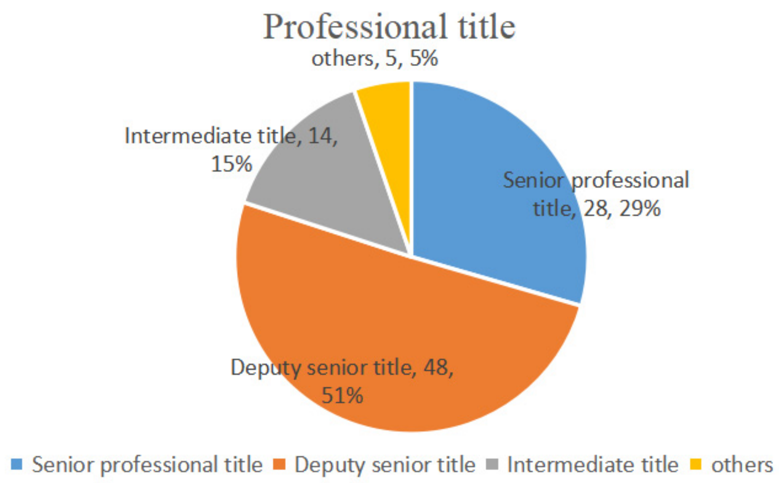

Figure 2. Professional title of interviewees.

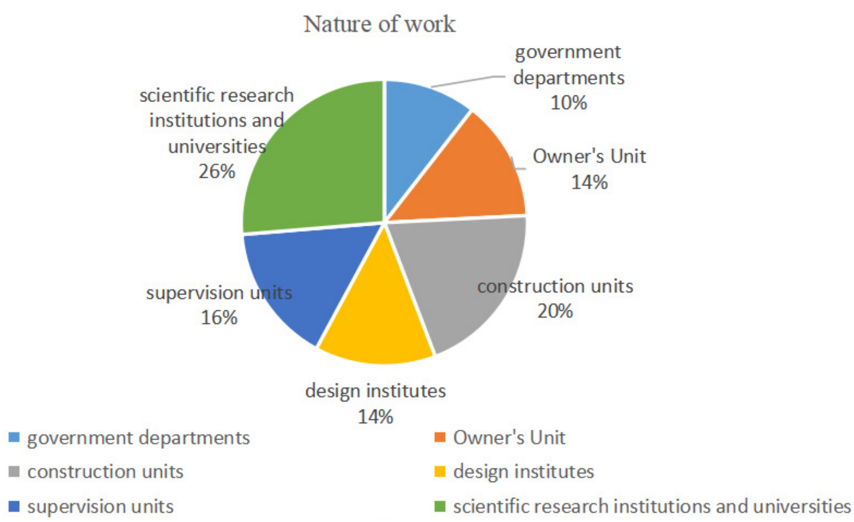

Figure 3. Work nature of interviewees.

(2) Reliability Analysis.

Reliability refers to the consistency and reliability of test results. In this reliability analysis, Cronbach's coefficient α was used to test the reliability of the questionnaire. The statistical significance of Cronbach's coefficient is shown in Table 3.

Table 3. Statistical significance of Cronbach's coefficient α.

Cronbach's Coefficient α	Statistical Significance
$\alpha < 0.6$	Insufficient reliability, unacceptable
$0.6 \leq \alpha < 0.7$	Acceptable reliability
$0.7 \leq \alpha < 0.8$	Certain reliability
$0.8 \leq \alpha < 0.9$	Relatively high reliability
$\alpha \geq 0.9$	High reliability

Using SPSS 22.0 software to analyze the reliability of the data, the following results are obtained.

Tables 4 and 5 show that all 95 questionnaires are valid, the Cronbach's coefficient $\boldsymbol{\alpha}$ is 0.784, and the reliability of the survey data meets the requirements.

Table 4. Case Processing Summary.

		Number of Cases	%
Cases	Valid	95	100
	Exclusion[a]	0.0	0.0
	Total	95	100

Table 5. Reliability statistics.

Cronbach's Coefficient α	Cronbach's Coefficient α Based on Normalization Terms	Number of Items
0.782	0.769	15

(3) Component analysis.

Component analysis involves to group variables with common characteristics into a single factor by dimensionality reduction method, to reduce the number of variables, and to test hypotheses about relationships between variables. Before using SPSS 22.0 for component analysis, it is necessary to test the matching degree of the data by KMO and Bartlett sphericity test methods. The results are shown in Table 6.

Table 6. KMO and Bartlett test.

KMO Sampling Suitability Quantity		0.784
Bartlett's test for sphericity	Approximate chi-square	1107.234
	degrees of freedom	105
	Significance	0.000

It can be seen from Table 6 that the KMO value of the questionnaire is 0.784, which is suitable for Component analysis. The Bartlett sphericity test value is 1107.234, and $p = 0$, indicating that the results meet the significance standard to do factor analysis with common components in the matrix. Factor analysis was then performed to obtain the total variance in Table 7.

Table 7. Total Variance.

No.	Initial Eigenvalue			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total/%	Percentage Variance/%	Sum/%	Total/%	Percentage Variance/%	Sum/%	Total/%	Percentage Variance/%	Sum/%
1	5.999	39.996	39.996	5.999	39.996	39.996	4.930	32.869	5.999
2	2.784	18.560	58.556	2.784	18.560	58.556	2.347	15.646	2.784
3	1.365	9.100	67.655	1.365	9.100	67.655	2.199	14.661	1.365
4	1.184	7.895	75.551	1.184	7.895	75.551	1.599	10.663	1.184
5	0.883	5.887	81.438	0.883	5.887	81.438	1.140	7.599	0.883
6	0.774	5.161	86.600						
7	0.654	4.358	90.958						

According to Table 7, there are five components whose total initial eigenvalues are higher than 0.8, and their cumulative contribution rate is greater than 60%, which shows that 15 factors can be well converged into 5 common components. That is, the restrictive factors of Yancheng prefabricated buildings can be categorized into five aspects including market, economic management, technology, society, and policy.

4.2. DEMATEL-ISM Model Calculation

4.2.1. Establishing Direct Influence Matrix

According to model calculation requirements, 10 practitioners who have been engaged in the field of prefabricated construction for more than 15 years are invited to fill out the questionnaires on the relationship between the constraints. The statistical results of interviewed experts from different organizations are 2 from the construction owner unit, 2 from the design institute, 2 from the engineering consulting corporation, 2 from the construction enterprise and 2 from scientific research institutions. Based on profound experience over the years and the high professional quality of practitioners, they judged the mutual relations among the factors restricting the development of Yancheng prefabricated buildings in the questionnaires and scored a scale of (0,1,2,3,4) referring to Appendix B. To ensure the objectivity and accuracy of the scoring, the scoring of each item is averaged, then the direct influence matrix is constructed as shown in Table 8.

Table 8. Direct influence matrix.

Factor	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
S1	0	3	3	2	0	1	2	2	2	0	1	4	0	0	0
S2	0	0	0	2	0	0	2	0	0	0	2	2	0	0	0
S3	4	3	0	0	0	0	0	0	0	2	3	3	1	0	0
S4	2	0	3	0	0	0	0	0	0	0	3	4	0	0	0
S5	2	0	0	3	0	2	0	3	3	0	1	1	1	0	0
S6	0	0	0	3	0	0	0	3	3	0	1	2	0	0	0
S7	2	2	3	3	0	1	0	0	0	0	3	3	0	0	0
S8	1	0	0	4	0	0	0	0	0	0	3	0	0	0	0
S9	1	1	2	2	2	4	2	3	0	0	0	0	3	0	0
S10	2	1	4	0	0	0	0	0	0	0	0	4	0	0	0
S11	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
S12	1	1	2	2	2	2	2	2	2	4	3	0	0	0	0
S13	3	3	1	1	1	2	2	2	2	4	1	3	0	0	0
S14	2	1	1	3	4	1	1	1	1	2	1	3	0	0	0
S15	2	3	1	3	0	4	3	4	4	0	1	2	0	0	0

4.2.2. Create Comprehensive Influence Matrix

(1) Creating a normalized direct influence matrix.

According to the established direct influence matrix and Equation (1) calculation rules, the normalized direct influence matrix B is obtained as shown in Table 9.

Table 9. Normalized direct influence matrix.

Factor	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
S1	0.000	0.111	0.111	0.074	0.000	0.037	0.074	0.074	0.074	0.000	0.037	0.148	0.000	0.000	0.000
S2	0.000	0.000	0.000	0.074	0.000	0.000	0.074	0.000	0.000	0.000	0.074	0.074	0.000	0.000	0.000
S3	0.148	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.074	0.111	0.111	0.037	0.000	0.000
S4	0.074	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.148	0.000	0.000	0.000
S5	0.074	0.000	0.000	0.111	0.000	0.074	0.000	0.111	0.111	0.000	0.037	0.037	0.037	0.000	0.000
S6	0.000	0.000	0.000	0.111	0.000	0.000	0.000	0.111	0.111	0.000	0.037	0.074	0.000	0.000	0.000
S7	0.074	0.074	0.111	0.111	0.000	0.037	0.000	0.000	0.000	0.000	0.111	0.111	0.000	0.000	0.000
S8	0.037	0.000	0.000	0.148	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.000	0.000	0.000	0.000
S9	0.037	0.037	0.074	0.074	0.074	0.148	0.074	0.111	0.000	0.000	0.000	0.000	0.111	0.000	0.000
S10	0.074	0.037	0.148	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.148	0.000	0.000	0.000
S11	0.111	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
S12	0.037	0.037	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.148	0.111	0.000	0.000	0.000	0.000
S13	0.111	0.111	0.037	0.037	0.037	0.074	0.074	0.074	0.074	0.148	0.037	0.111	0.000	0.000	0.000
S14	0.074	0.037	0.037	0.111	0.148	0.037	0.037	0.037	0.037	0.074	0.037	0.111	0.000	0.000	0.000
S15	0.074	0.111	0.037	0.111	0.000	0.148	0.111	0.148	0.148	0.000	0.037	0.074	0.000	0.000	0.000

(2) Factor comprehensive influence matrix

According to Equation (2), calculate the matrix *I-B* first, then deduce the inverse of the matrix *I-B*, and finally obtain comprehensive influence matrix *T*, which is the matrix *B* multiplied by matrix *I-B*, as shown in Table 10.

Table 10. Comprehensive influence matrix.

Factor	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
S1	0.094	0.187	0.190	0.168	0.028	0.084	0.124	0.126	0.114	0.055	0.155	0.253	0.021	0.000	0.000
S2	0.042	0.035	0.039	0.105	0.010	0.017	0.090	0.017	0.015	0.021	0.120	0.118	0.004	0.000	0.000
S3	0.215	0.186	0.074	0.068	0.020	0.036	0.051	0.045	0.041	0.117	0.186	0.207	0.045	0.000	0.000
S4	0.140	0.068	0.161	0.048	0.019	0.029	0.034	0.036	0.032	0.045	0.178	0.213	0.010	0.000	0.000
S5	0.141	0.057	0.069	0.193	0.022	0.118	0.039	0.167	0.151	0.032	0.120	0.123	0.057	0.000	0.000
S6	0.054	0.038	0.051	0.169	0.020	0.035	0.027	0.147	0.132	0.025	0.102	0.127	0.017	0.000	0.000
S7	0.156	0.149	0.178	0.173	0.019	0.068	0.042	0.042	0.037	0.046	0.203	0.209	0.011	0.000	0.000
S8	0.075	0.032	0.034	0.165	0.004	0.009	0.012	0.012	0.011	0.010	0.147	0.046	0.003	0.000	0.000
S9	0.131	0.111	0.147	0.181	0.092	0.191	0.115	0.177	0.060	0.048	0.111	0.122	0.127	0.000	0.000
S10	0.136	0.098	0.200	0.051	0.019	0.030	0.037	0.036	0.033	0.049	0.075	0.221	0.012	0.000	0.000
S11	0.126	0.136	0.025	0.030	0.004	0.011	0.024	0.016	0.014	0.008	0.031	0.041	0.003	0.000	0.000
S12	0.144	0.122	0.168	0.169	0.093	0.119	0.114	0.133	0.120	0.183	0.213	0.129	0.023	0.000	0.000
S13	0.216	0.205	0.153	0.157	0.067	0.133	0.136	0.148	0.133	0.201	0.163	0.258	0.023	0.000	0.000
S14	0.173	0.113	0.133	0.213	0.174	0.093	0.085	0.109	0.099	0.122	0.149	0.235	0.022	0.000	0.000
S15	0.180	0.201	0.144	0.252	0.032	0.212	0.173	0.230	0.207	0.047	0.181	0.215	0.029	0.000	0.000

(3) Influence factor strength

According to Equations (3)–(6), the influence degree, affected degree, centrality degree and cause degree of each constraint factor are calculated, as shown in Table 11.

(4) Centrality degree and cause degree distribution

According to the obtained centrality degree and cause degree, the scatter distribution diagram of each factor can be drawn, as shown in Figure 4. The attributes and importance of each factor can be analyzed more clearly and intuitively according to the position of each factor in Figure 4.

Table 11. Strength of each constraint factor.

Factor	Influence Degree f_i	Affected Degree e_i	Centrality Degree z_i	Cause Degree y_i
S1	1.598	2.022	3.620	−0.424
S2	0.633	1.738	2.371	−1.105
S3	1.292	1.766	3.057	−0.474
S4	1.015	2.143	3.158	−1.128
S5	1.290	0.624	1.914	0.666
S6	0.944	1.186	2.129	−0.242
S7	1.331	1.102	2.433	0.228
S8	0.558	1.441	1.999	−0.883
S9	1.612	1.197	2.809	0.415
S10	0.997	1.009	2.005	−0.012
S11	0.470	2.134	2.604	−1.664
S12	1.730	2.518	4.248	−0.788
S13	1.994	0.407	2.400	1.587
S14	1.719	0.000	1.719	1.719
S15	2.104	0.000	2.104	2.104

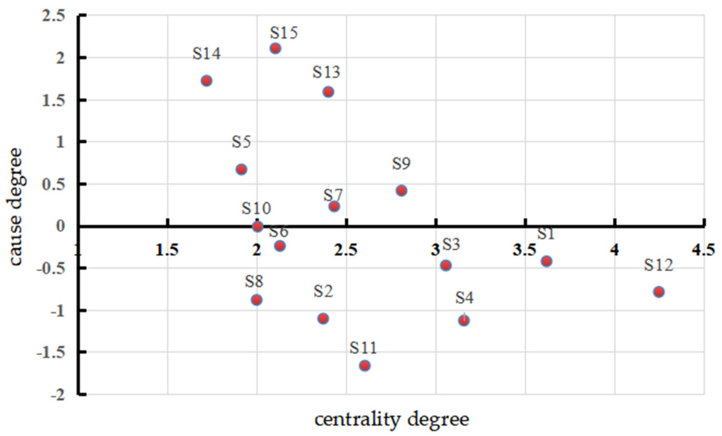

Figure 4. The distribution of centrality degree and cause degree of each factor.

4.2.3. Establishment of Reachability Matrix

The commonality between DEMATEL and ISM determines that the reachability matrix can be obtained from the comprehensive influence matrix. First, it is necessary to set up an appropriate threshold λ to simplify the structure of the system and parttition system layer. After several trial calculations, the final optimal value of λ is 0.16, which can optimize the system hierarchy. The reachability matrix $\boldsymbol{R}$ can be calculated by Equations (7) and (8), as shown in Table 12.

Table 12. Reachability matrix *R*.

Facto	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
S1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0
S2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
S3	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0
S4	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0
S5	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0
S6	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
S7	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0
S8	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
S9	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0
S10	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
S11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
S12	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0
S13	1	1	0	0	0	0	0	0	0	1	1	1	1	0	0
S14	1	0	0	1	1	0	0	0	0	0	0	1	0	1	0
S15	1	1	0	1	0	1	1	1	1	0	1	1	0	0	1

4.2.4. Developing the Multi-Layer Hierarchical Model

After forming reachability matrix R, the components included in each level are obtained in turn according to step (10), as shown in Table 13. In this way, Table 14 can also be obtained.The hierarchical diagram of constraints at all levels is shown in Figure 5.

Table 13. Reachable set R and preceding set Q and their intersection A.

Factor	Reachable Set R	Preceding Set Q	Intersection set $A = R \cap Q$
S1	1, 2, 3, 4, 10, 11, 12	1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15	1, 3, 4, 10, 12
S2	2	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15	2
S3	1, 2, 3, 4, 10, 11, 12	1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15	1, 3, 4, 10, 12
S4	1, 2, 3, 4, 10, 11, 12	1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15	1, 3, 4, 10, 12
S5	1, 2, 3, 4, 5, 8, 10, 11, 12	5, 14	5
S6	1, 2, 3, 4, 6, 10, 11, 12	6, 9, 15	6
S7	1, 2, 3, 4, 7, 10, 11, 12	7, 15	7
S8	1, 2, 3, 4, 8, 10, 11, 12	5, 8, 9, 14, 15	8
S9	1, 2, 3, 4, 6, 8, 9, 10, 11, 12	9, 15	9
S10	1, 2, 3, 4, 10, 11, 12	1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15	1, 3, 4, 10, 12
S11	11	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	11
S12	1, 2, 3, 4, 10, 11, 12	1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15	1, 3, 4, 10, 12
S13	1, 2, 3, 4, 10, 11, 12, 13	13	13
S14	1, 2, 3, 4, 5, 8, 10, 11, 12, 14	14	14
S15	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 15	15	15

Note: Numbers represent a certain element, for example, 2 represents the second factor.

Table 14. Hierarchical Decomposition.

Level	Factor
Layer 1 (Top)	S2-Imperfect supporting industry chain, S11-Low public awareness and willingness to buy
Layer 2	S1-Insufficient motivation for enterprise transformation, S3-insufficient market demand, S4-High construction cost and low cost performance, S10-lack of talent-rich professionals, S12-low degree of social acceptance
Layer 3	S6- Backward prefabricated building management mode, S7-The low system of design standardizationmodularization, and integration, S8-Immature construction experience, S13-Imperfect industry policy and standard system
Layer4	S5-Large upfront investment, S9-Insufficient basic research and innovation of prefabricated buildings
Layer5 (bottom)	S14-Insufficient financial support, S15-Insufficient government propaganda

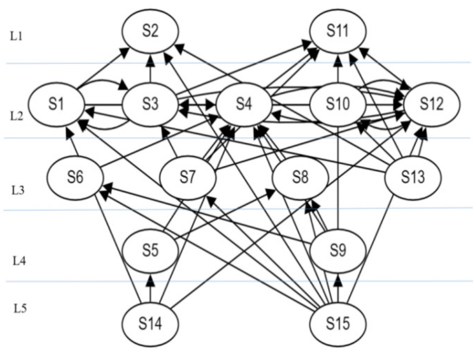

Figure 5. Multi-layer hierarchical diagram of restrictive factors for the promotion and implementation of Yancheng prefabricated buildings.

5. Discussion

5.1. DEMATEL Analysis Results

(1) Influence degree Analysis

The larger the influence degree value of a factor is, the more the factor influences other factors. Compared to the value of influence degree, the top five factors are S15, S13, S12, S14, and S9, as shown in Table 15.

Table 15. Ranking listof influence degree.

Sort	Factor	Influence Degree
1	S15	2.104
2	S13	1.994
3	S12	1.730
4	S14	1.719
5	S9	1.612
6	S1	1.598
7	S7	1.331
8	S3	1.292
9	S5	1.290
10	S4	1.015
11	S10	0.997
12	S6	0.944
13	S2	0.633
14	S8	0.558
15	S11	0.470

(2) Affected degree analysis

The higher the affected degree value of a factor is, the greater the factor is constrained by other factors. As can be seen from Table 16, the top five most affected factors are S12 (insufficient market demand), S4 (insufficient enthusiasm for enterprise transformation), S11 (low public awareness and willingness to buy), and S1 (high construction cost and low-cost performance), S3 (low social acceptance).

Table 16. Ranking list of affected degree.

Sort	Factor	Affected Degree
1	S12	2.518
2	S4	2.143
3	S11	2.134
4	S1	2.022
5	S3	1.766
6	S2	1.738
7	S8	1.441
8	S9	1.197
9	S6	1.186
10	S7	1.102
11	S10	1.009
12	S5	0.624
13	S13	0.407
14	S14	0.000
15	S15	0.000

(3) Centrality degree Analysis

It can be concluded from Table 17, the larger the centrality degree is the closer the relationship between this factor and other factors in the system. In Table 17, the top five factors with centrality values from large to small are S12, S1, S4, S3 and S9. S12 with the largest value of centrality degree is the most important factor, which closely relates to other constraints in the entire system.

Table 17. Ranking list and weight of the centrality degree.

Sort	Factor	Centrality Degree	Weight
1	S12	4.248	0.110
2	S1	3.620	0.094
3	S4	3.158	0.082
4	S3	3.057	0.079
5	S9	2.809	0.073
6	S11	2.604	0.068
7	S7	2.433	0.063
8	S13	2.400	0.062
9	S2	2.371	0.061
10	S6	2.129	0.055
11	S15	2.104	0.054
12	S10	2.005	0.052
13	S8	1.999	0.052
14	S5	1.914	0.050
15	S14	1.719	0.045

(4) Cause degree Analysis

The larger the value of the degree of cause, the greater the influence this element has on other elements in the system. The reason degree sorting table is shown in Table 18. It can be seen from the table that the top five causes are: S15, S14, S13, S5, and S9. Among them, S15 (Insufficient publicity by the government) has the highest degree of reason, indicating that the insufficient publicity of policies and regulations by the government in terms of prefabricated buildings has the greatest impact on other factors in the entire restrictive factor system.

Table 18. Ranking list of cause degree.

Sort	Factor	Cause Degree
1	S15	2.104
2	S14	1.719
3	S13	1.587
4	S5	0.666
5	S9	0.415
6	S7	0.228
7	S10	−0.012
8	S6	−0.242
9	S1	−0.424
10	S3	−0.474
11	S12	−0.788
12	S8	−0.883
13	S2	−1.105
14	S4	−1.128
15	S11	−1.664

The factors with high centrality are more closely related to other factors in the system and have greater influence, which are used as the basis to screen these important factors. According to the value of cause degree to rank 15 factors in Table 18, the top five factors are A15, S14, S13, S5 and S9, which should be paid attention to develop Yancheng prefabricated buildings.

The factor with a high affected degree is defined as the resulting factor, which is easily affected by other factors in the system during the development of prefabricated buildings. In the process of formulating measures, it is concluded from Figure 4 that it is necessary to take targeted measures for these factors.

Yancheng is a relatively underdeveloped city in Jiangsu Province, the Yancheng government has limited financial resources for the development of prefabricated buildings every year. Although the policies and documents have been formulated and promulgated to vigorously promote prefabricated buildings, the publicity of the policies only remains within the construction industry. Due to the lack of effective research and innovation system, the public generally believes that the structure of prefabricated buildings is unsafe, which restricts the promotion of Yancheng. From the perspective of long-term development, increasing financial investment, improving research & innovation, and strengthening public awareness and acceptance, all of which are the basis for vigorously promoting Yancheng prefabricated buildings.

5.2. ISM Analysis Results

Figure 5 shows the multi-layer hierarchical relation obtained by the ISM method, then an important conclusion can be drawn that the constraint factor system of Yancheng prefabricated buildings is a five-layer hierarchical structure, and the hierarchy of the constraint factors is from simple to complex and from top to bottom.

The first layer of factors is the superficial restrictive factor, also known as the cause of proximity, including imperfect supporting industrial chain, low public awareness and low purchase willingness. In terms of the imperfection of the industrial chain, it is mainly reflected in the insufficient design capabilities, as well as the insufficient number and production capacity of component manufacturers. It is mainly reflected that the public with low awareness and willingness hardly initiate buying prefabricated houses and believing that the structure is safe. These factors are the direct reasons for the vigorous promotion of Yancheng prefabricated buildings.

The second to fourth layers belong to the middle-level constraints, also known as transition causes, including insufficient enthusiasm for enterprise transformation, insufficient market demand, high construction costs, low-cost performance, lack of talents, low social recognition, backward manufacturing management mode, unsound design standardization, modularization, and integrated systems, insufficient construction experience, imperfect industry policy and standard system, the relatively large initial investment, and the insufficient basic research and innovation. While these factors which belong to the middle part of the internal influence path of the system directly or indirectly affect surface factors, and are also affected by bottom constraint factors. In Yancheng, the cost and construction period of prefabricated buildings are higher than those of cast-in-place buildings, and the integrated design of various specialties has not been truly achieved. There is a lack of professional technicians and skilled installation workers. The on-site management mode still relies on traditional methods and lacks an intelligence management platform, etc. The factors that cause these problems are involved in market, economy, technology, society, and policy, with a wide distribution and a large number.

The fifth layer of factors belongs to the bottom constraints, also known as essential causes, including insufficient financial support and insufficient government publicity. The bottom-level constraints are the most complicated factors affecting the promotion of prefabricated buildings in Yancheng, and they have a relatively large impact on other factors. The scope of action is mainly the middle-level constraints, and the mechanism of action is direct or indirect. The two constraints included in the bottom-level constraints are factors at the policy level, so it is crucial to promote prefabricated buildings in Yancheng. Therefore, the Yancheng government needs to increase financial support, especially in terms of basic innovation and market cultivation, and strengthen publicity efforts. so that good policies can take root and improve public awareness and willingness to buy prefabricated houses. If the attention of the government, the inclination of policies and the investment of various resources, the underlying constraints will have been improved, it has a positive impact on the middle and surface constraints, and thus the healthy development of prefabricated buildings will be greatly gone on.

From the above, the following points are obtained:

(1) In the DEMATEL method, the reasons for the high centrality include insufficient basic research and innovation of prefabricated buildings, imperfect industry policies and standard systems, insufficient government publicity, lack of talents, and relatively low initial investment in scientific research. Large and insufficient financial support. These factors are likely to affect other factors in the system and play a greater role in the system. However, low social recognition, high construction cost and low-cost performance, low public awareness and purchase willingness are the primary result factors with high centrality, which are easily affected by other factors in the system.
(2) In the ISM method, Imperfect supporting industry chain, low public awareness and low willingness to purchase are superficial factors that directly affect the promotion and implementation of prefabricated buildings in Yancheng. Insufficient financial support and insufficient government publicity, as the underlying factors of the hierarchical structure, are the fundamental factors affecting the development of prefabricated buildings in Yancheng. They restrict the transitional factors and surface influencing factors within the system directly or indirectly. The problems must be solved with the promotion of prefabricated buildings in Yancheng.

6. Conclusions and Suggestions

Under the background of the "double carbon target" proposed by China, the development of the construction industry is towards green, low carbon, environmental protection and energy saving. The vigorous development of prefabricated buildings is in line with china's sustainable development strategy. Yancheng in China, as an area for the promotion of prefabricated construction, has made some achievements in the development of the prefabricated construction industry, but there are still many unfavorable factors for its development. Through a series of studies in this paper, the index system of restricting factors affecting the development of the prefabricated construction industry is proposed and modified. the authors analyze the main restrictive factors of the prefabricated construction industry in Yancheng through the DEMATEL-ISM method and find out the key restrictive factors of vigorously promoting the prefabricated construction industry. It provides certain precision-oriented policies for promoting the development of prefabricated buildings in Yancheng. The main conclusions are as follows:

(1) Through literature review, it is concluded that prefabricated buildings are being gradually promoted around the world due to their low carbon, high efficiency, energy saving, green, and environmental protection. Among them, the United States, Canada, Australia and other countries have relatively high development levels by new methods of DfMA. The relatively rapid and high-quality development of the industrial chain in design, production and installation has been an important reference for the promotion of prefabricated buildings in China.
(2) Establishing the index system of restrictive factors of prefabricated buildings in Yancheng. Firstly, 25 restrictive factors of prefabricated buildings are preliminarily summarized and sorted out through literature analysis, and the general framework of the restrictive factor index system for the promotion and implementation of prefabricated buildings in Yancheng is initially formed. Then, through the form of asking for expert opinions and drawing on the experience of experts, the restrictive factors are revised to form an index system of restrictive factors for the promotion and imple-

mentation of prefabricated buildings in Yancheng. To ensure that the index system is reasonable and reliable, a large number of questionnaires are designed and issued to collect relevant data, and the reliability and validity analysis and factor analysis of the questionnaires are carried out to verify the scientificity of the index system of restrictive factors for the promotion and implementation of prefabricated buildings in Yancheng. Finally, the index system of restrictive factors for the promotion and implementation of prefabricated buildings in Yancheng is determined to be composed of 15 major restrictive factors in five aspects: market, economy, technology, society and policy.

(3) Analyzing the main constraints of prefabricated buildings in Yancheng. Based on the application of the DEMATEL method, we analyze the logical relationship and influence degree among the restrictive factors, and find out the cause factors and result factors in the constraint index system.; On the basis of the DEMATEL comprehensive matrix, ISM is used to establish an reachability matrix, and a hierarchical model including surface-level influencing factors, middle-level transition factors and bottom-level influencing factors is constructed, and the comprehensive level of each restrictive factor in the system is obtained. The key restrictive factors for the vigorous promotion of prefabricated buildings in Yancheng have been identified.

Based on the current situation of the development of prefabricated buildings in Yancheng, according to the research results: In terms of policies, regulations and standard systems, the government needs to continue to supplement and improve the system of policies and regulations related to prefabricated buildings, improve the implementability of various policies and standards, and strengthen the implementation of policies and standards.; In terms of government financial support, the Yancheng government needs to strengthen financial support and guarantee measures, and further refine and formulate specific incentive measures; In terms of government publicity, it is necessary to strengthen the exposure and promotion of major media, increase the enthusiasm of enterprise transformation and improve public awareness; In terms of technology and innovation, enterprises are encouraged to set up research and development institutions, focusing on the research and development of standardized design and construction technologies for prefabricated buildings.It is necessary to gradually promote the DfMA design method; In terms of personnel training, the government should encourage the cultivation of professional talents in colleges and universities in Yancheng, and strengthen the training of talents combining production, education and research; In terms of market cultivation, the government should focus on developing prefabricated construction industrial bases and parks, cultivate market production entities, and improve the industrial chain.

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Appendix A

Questionnaire on the Importance of Restricting Factors for the Promotion and Implementation of Prefabricated Buildings in Yancheng

Dear experts:

I am from the research group of Yancheng Institute of Technology "Promotion and Application of Prefabricated Buildings in Yancheng under the Background of 'Double Carbon'". I am doing a questionnaire on "Restricting Factors in the Promotion and Implementation of Prefabricated Buildings in Yancheng". We need to conduct a survey on these factors Importance evaluation (scored in the form of numbers 1–5, numbers 5, 4, 3, 2, and 1 represent high, relatively high, general, relatively low, and low according to the degree of importance from high to low). thank you for your support!

Educational background: ☐Ph.D. ☐masters ☐Undergraduate ☐College and below

Professional title: ☐Senior professional title ☐Deputy senior title ☐Intermediate title ☐others

Nature of work: ☐government departments ☐Owner's Unit☐construction units ☐design institutes ☐supervision units ☐scientific research institutions and universities

Table A1. Survey Questionnaire on the Importance of Restricting Factors for the Promotion and Implementation of Prefabricated Buildings in Yancheng.

Restrictive Factors		Degree of Importance				
		High	Relatively High	Average	Relatively Low	Low
		5	4	3	2	1
marketaspect	insufficient motivation for enterprise transformation					
	imperfect supporting industry chain					
	insufficient market demand					
economic management	high construction cost, low cost performance					
	large upfront investment					
	the prefabricated building management model is backward					
technical aspect	design standardization, modularization, and integrated systems are not perfect					
	Prefabricated building production, construction experience and technology are immature					
	Insufficient basic research and innovation of prefabricated buildings					
social aspects	talent shortage					
	low public awareness and willingness to buy					
	low degree of social acceptance					
Policyaspect	imperfect industry policy and standard system					
	insufficient financial support					
	insufficient government propaganda					

Appendix B

Questionnaire on the influence relationship of restrictive factors in the vigorous promotion and implementation of prefabricated buildings in Yancheng

Dear Expert:

I am from the research group of Yancheng Institute of Technology "Promotion and Application of Prefabricated Buildings in Yancheng under the Background of 'Double Carbon'". Evaluation of the influence relationship among them (the influence of row elements on column elements is scored in the form of numbers 0–4, and the numbers 0, 1, 2, 3, and 4 represent no influence, low influence, average impact, relatively high impact, high impact, respectively, ignore the impact on itself). thank you for your support.

Table A2. Questionnaire for the Influencing Relationship of Restricting Factors in Vigorously Promoting and Implementing Prefabricated Buildings in Yancheng.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**
S1															
S2															
S3															
S4															
S5															
S6															
S7															
S8															
S9															
S10															
S11															
S12															
S13															
S14															
S15															

Note: S1-insufficient motivation for enterprise transformation; S2-imperfect supporting industry chain; S3-insufficient market demand; S4-high construction cost, low cost performance; S5-large upfront investment; S6-the prefabricated building management model is backward; S7-design standardization, modularization, and integrated systems are not perfect; S8-prefabricated building production, construction experience and technology are immature; S9-insufficient basic research and innovation of prefabricated buildings; S10-talent shortage; S11-low public awareness and willingness to buy; S12-low degree of social acceptance; S13-imperfect industry policy and standard system; S14-insufficient financial support; S15-insufficient government propaganda.

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