Risk Assessment of Prefabricated Buildings Based on Factor Analysis via SPSS: The Case of Qinghai Province

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Abstract—Compared with traditional buildings, prefabricated buildings have significant advantages in protecting the environment, saving resources, and saving labor, and are regarded as the key to the transformation and upgrading of the construction industry. However, the development of prefabricated buildings in Qinghai Province is relatively backward, and there are many risk factors that hinder development. This research takes Qinghai Province as the research object and constructs a risk list containing 25 factors. Then, based on the principle of reducing the dimensionality of factor analysis, SPSS software is used for data processing and comprehensive analysis and evaluation of related indicators. Finally, it is concluded that the key risk factors of prefabricated buildings in Qinghai Province are divided into five categories: market risk, management risk, economic risk, policy risk and technical risk. The research results can provide suggestions for the Qinghai Provincial Government to formulate more effective prefabricated construction industry development policies.

Keywords— Prefabricated Building; Risk Identification; Factor Analysis

1 Introduction

With the rapid urbanization process and economic development of developing countries, it is estimated that by 2050, the urban population of developing countries will reach 2.538 billion [1], which also means that urban development is still facing large-scale housing construction. In developing countries, the construction industry is still dominated by traditional cast-in-place construction methods, and there are many problems such as low labor productivity and high resource and energy consumption. Therefore, it is urgent to change the production mode of the construction industry.

Compared with traditional buildings, prefabricated buildings have significant advantages in protecting the environment, saving resources, and saving labor, and are regarded as the key to the transformation and upgrading of the construction industry [2]. In December 2021, the department of Housing and Urban-Rural Development of Qinghai Province issued a notice on the "Implementation Opinions on Promoting the Coordinated Development of Intelligent Construction and New Building Industrialization" [3], requiring that by 2025, the assembly rate in Xining and Haidong cities should reach more than 20%.

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During the "Thirteenth Five-Year Plan" period, Qinghai Province has accumulated a total of 1,557,900 square meters of newly constructed prefabricated buildings [4]. Although the supporting role of the construction industry in Qinghai Province as a pillar industry is becoming more and more obvious, the assembly rate of the province in the past five years is still less than 10%, which shows that the development of prefabricated buildings in Qinghai Province is relatively slow.

In recent years, in order to control the risk factors of prefabricated construction projects to the greatest extent, effectively improve the level of risk management, reduce project losses, and promote the development of prefabricated buildings, many scholars are keen on the field of construction project risk management research. Luo [5] and Blismas [6] both pay attention to the risk of the prefabricated building supply chain, while Arif [7] and Li [8] pay more attention to the risk factors of the cost and schedule of the prefabricated building. In addition, Lee [9] conducted research on cost risk factors in the life cycle.

The changes in construction methods make prefabricated construction projects face more risks than traditional construction projects, especially in Qinghai Province and similar underdeveloped plateau areas.

Based on literature analysis, this research combines expert interviews and questionnaire surveys to screen out a list of risk factors for prefabricated buildings in Qinghai Province. Then, factor analysis is used to identify and analyze key risk factors, so as to put forward effective development suggestions.

2 Data Sources

2.1 Risk Factors Identification

Screen the documents related to prefabricated buildings in the core collection of Web of Science and CNKI. In Web of Science, advanced search and grouping were carried out with the subject terms "prefabricated construction", "prefabricated building", "prefabricated part", "precast unit" and "risk", and finally 65 valid documents were screened out. In CNKI, advanced search is adopted, and subject search is carried out with the same keywords. The documents were manually inspected one by one, and conference, information, book documents and documents with low relevance were eliminated, and finally 35 valid documents were obtained.

Analyzing the selected 100 documents, identifying 40 risk factors that affect the development of prefabricated buildings, which can be used as the initial list of risk factors for the development of prefabricated buildings in Qinghai Province. The data sources are shown in Table 1.

Table 1. Data sources

Keyword	Period	Type	Source	Result
prefabricated construction prefabricated building	2018 ~2020	Article or Review	Web of Science	65

prefabricated part precast unit risk		CNKI	35

2.2 Risk Factors Determination

A combination of expert interviews and questionnaire surveys was used to assess the appropriateness and rationality of the 40 risk factors initially identified. During the investigation, structured interviews were conducted with the managers, design, construction, and component production leaders of the only two prefabricated component manufacturers in Qinghai Province. A total of 8 questionnaires were distributed, and the questionnaires were evaluated using the Richter 5-point scale method.

According to the survey results, factors that have less impact and are inconsistent with the development status of Qinghai Province are eliminated. At the same time, adding factors that were not identified in the previous literature, combining factors with similar meanings, and finally getting a list of 25 risk factors as shown in Table 2.

Table 2. List of risk factors of prefabricated buildings in Qinghai Province

Code	Risk Factors
R1	market demand fluctuation
R2	Underestimate cost
R3	Difficulties in financing
R4	Low communication efficiency between partners
R5	Low level of decision-making
R6	Policy changes
R7	Imperfect regulations and standards
R8	Lack of financial support policies
R9	Complex or inefficient approval procedures
R10	Low level of information technology
R11	Design changes frequently
R12	Lack of standardized design system
R13	Lack of skilled labor
R14	Identification mark of the prefabricated component is not clear
R15	Poor quality of prefabricated components
R16	Transportation damage of prefabricated components
R17	Lack of management experience
R18	key technology of prefabricated construction is immature
R19	Unreasonable storage of prefabricated components
R20	Installation error of prefabricated components
R21	Delayed payment
R22	Difficult to recycle resources
R23	Lack of reasonable and scientific maintenance

R24	Low social acceptance
R25	Imperfect supervision mechanism

2.3 Survey Design

Based on the list of risk factors in Table 2, the Richter 5-point scale was used to make a questionnaire to collect relevant data, and to study the weight of each risk influencing factor. The questionnaire is distributed in two ways: paper questionnaire and electronic questionnaire. A total of 142 questionnaires were distributed, of which 114 were valid questionnaires, and the effective response rate was 80.28%. Meet the requirements of the questionnaire data research, the basic information of the interviewee is shown in Table 3.

Table 3. Basic information of the interviewee

Category		Quantity	Proportion
Department	Government	12	10.53%
	Developer	22	19.30%
	Contractor	32	28.07%
	Designer	14	12.28%
	Manufacturer	13	11.40%
	Researcher	11	9.65%
	Other	10	8.77%
Development prospect evaluation	Optimistic	86	75.44%
	Pessimistic	28	24.56%

3 Factor Analysis

Factor analysis is a method of grouping reasonably based on the correlation of the original data variables and classifying the variables with higher correlation into one category. The purpose is to use the least common factor to reflect all the original data, and not omit the original data [10].

3.1 Suitability Test

Before using factor analysis to process the original data, Cronbach's coefficient (Cronbach α) was used to test the reliability, and the KMO and Bartlett sphere test were used to test the structural validity of the data. SPPS software was used for data analysis, and the results showed that $\alpha=0.871>0.8$, KMO=0.788, sig.=0.00<0.05 (Table 4 and Table 5). The results show that the reliability of the original data is very high, and there is a certain correlation between the variables, so the original variables are suitable for factor analysis.

Table 4. Reliability statistics

Cronbach's Alpha	Standardized Cronbach's Alpha	Items
0.871	0.871	25

Table 5. KMO and Bartlett's test

Kaiser–Meyer–Olkin measure of sampling adequacy		0.788
Bartlett's Test of Sphericity	Approx. Chi-Square	906.608
	df	300
	Sig.	0

3.2 Extract Eigenvectors and Eigenvalues

The factor analysis method usually takes the factor whose characteristic value is greater than 1 as the common factor [11]. The total variance interpretation table calculated with SPPS software shows that the initial eigenvalues of the first 5 factors total greater than 1, and the total contribution rate is 74.371% (Table 6). It shows that the original variables can converge well to these 5 common factors, thus reducing the 25-dimensionality to the 5-dimensionality.

Table 6. Total variance explained by factor

Component	Initial Eigenvalue			Rotation Sums of Squared Loadings		
	Total	Variance %	Accumulation %	Total	Variance %	Accumulation %
1	6.612	26.447	26.447	6.612	26.447	26.447
2	1.828	22.311	48.758	1.828	22.311	48.758
3	1.568	11.272	60.030	1.568	11.272	60.030
4	1.485	8.941	68.971	1.485	8.941	68.971
5	1.350	5.400	74.371	1.350	5.400	74.371
6	0.906	3.623	77.994			
…	…	…	…			
25	0.182	0.726	100			

3.3 Extract Common Factors

In order to improve the loading degree of 25 variables to each common factor, the maximum variance method is used to perform factor rotation [12]. The analysis results are shown in Table 7. The variables corresponding to the common factors are selected according to the selection principle, and the variables that meet the requirements are shown in bold in Table 7.

Table 7. Rotation component matrix

Code	Component				
	A1	A2	A3	A4	A5
R1	**0.772**	0.098	-0.063	0.289	-0.006
R2	0.063	-0.021	**0.653**	0.079	0.159
R3	0.036	0.011	0.009	0.179	0.038
R4	0.339	**0.671**	0.107	0.164	0.076
R5	0.213	**0.758**	0.219	0.476	0.169
R6	-0.004	0.138	0.079	**0.764**	-0.03
R7	**0.604**	0.051	0.577	0.106	-0.027
R8	0.151	0.099	-0.006	**0.801**	0.113
R9	0.255	-0.136	0.215	**0.745**	0.475
R10	0.584	0.396	0.177	0.014	**0.653**
R11	0.185	0.206	0.282	-0.125	**0.782**
R12	0.049	0.042	0.016	0.202	0.223
R13	0.203	0.186	0.499	0.008	-0.145
R14	-0.096	0.374	0.564	0.119	0.093
R15	0.184	0.308	0.483	0.033	0.247
R16	0.056	-0.139	0.206	0.091	0.189
R17	0.037	**0.804**	0.146	0.15	0.028
R18	0.332	0.05	0.194	-0.012	0.205
R19	-0.008	0.36	-0.223	-0.07	**0.751**
R20	0.096	-0.019	0.021	0.018	0.599
R21	0.076	0.118	-0.03	0.061	-0.039
R22	0.177	0.267	**0.617**	0.202	0.294
R23	-0.047	0.112	0.008	0.133	**0.692**
R24	0.557	0.3	0.306	0.363	0.089
R25	**0.777**	0.434	-0.017	0.321	0.131

3.4 Common Factor Correlation Test

The extracted common factors should reflect a certain information of the evaluation target from different angles and levels, that is, there should be no correlation between the factors [13]. From the component score covariance matrix in Table 8, it can be seen that the matrix is equivalent to the identity matrix, indicating that there is no correlation between the five factors, and they represent different evaluation dimensions.

Table 8. Component score covariance matrix

Component	1	2	3	4	5
1	1.000	0.000	0.000	0.000	0.000
2	0.000	1.000	0.000	0.000	0.000
3	0.000	0.000	1.000	0.000	0.000
4	0.000	0.000	0.000	1.000	0.000
5	0.000	0.000	0.000	0.000	1.000

3.5 Common Factor Explanation

According to Table 7, the common factors are sorted and named, and then the key influencing factor indicators are obtained. The specific analysis is as follows:

In A1, the indexes with larger load coefficients are ranked as R25, R1 and R7 (the variance contribution rate is 26.447%), which corresponds to imperfect supervision mechanism (0.777), market demand fluctuation (0.772), and imperfect regulations and standards (0.604). The indicators mainly reflect the risks that may be encountered in the development process of prefabricated buildings from the perspective of market regulation, so they are named as Market Risk Factors.

In A2, the indexes with larger load coefficients are ranked as R17, R5 and R4 (the variance contribution rate is 22.311%), which corresponds to lack of management experience (0.804), low level of decision-making (0.758), and low communication efficiency between partners (0.671). The indicators mainly reflect the impact of management on the development of prefabricated buildings, so they are named as Management Risk Factors.

In A3, the indexes with larger load coefficients are ranked as R2 and R22 (the variance contribution rate is 11.272%), which corresponds to underestimate cost (0.653) and difficult to recycle resources (0.617). The index mainly reflects the capital risk of the prefabricated construction project, so it is named as Economic Risk Factor.

In A4, the indexes with larger load coefficients are ranked R8, R6 and R9 (the variance contribution rate is 8.941%), which corresponds to the lack of financial support policies (0.801), policy changes (0.764), and Complex or inefficient approval procedures (0.745). The indicators reflect the impact of government policies on the development of prefabricated buildings, so they are named as Policy Risk Factors.

In A5, the indexes with the largest load factors are ranked R11, R19, R23 and R10 (the variance contribution rate is 5.4%), which corresponds to design changes frequently (0.782), unreasonable storage of prefabricated components (0.751), lack of reasonable and scientific maintenance (0.692), and low level of information technology (0.653). The indicator mainly describes the technology-based risk, so it is named as the Technical Risk Factor.

According to analysis, market risk, management risk, economic risk, policy risk, and technical risk can more comprehensively reflect the basic information of the original 25 variables. These five risk categories are the key risks for the development of prefabricated buildings in Qinghai Province.

4 Development Strategy

4.1 Market Risk

The Provincial Government of Qinghai need to use macro-control measures to intervene in the construction market. It can solve the production and operation problems of land purchase and plant location selection for the prefabricated construction related enterprises stationed in

Qinghai Province. Appropriate preferential policies can be implemented for consumer loans and interest rates to increase market demand to promote development.

4.2 Management Risk

All stakeholders should reflect on their own management model and management system. Abandoning complicated management concepts, streamlining unnecessary management personnel in various departments, and introducing a more concise and efficient management model is the focus of current management reform.

4.3 Economic Risk

The Provincial Government of Qinghai should improve incentive policies and promote the introduction of policies on unit price subsidies and tax reductions and exemptions to reduce economic costs.

4.4 Policy Risk

Based on policy optimization, the Provincial Government of Qinghai should learn from the development experience of other regions. It is necessary to focus on the goals and approaches of the development of prefabricated buildings, and then carry out detailed planning to accelerate development.

4.5 Technical Risk

All stakeholders should conduct in-depth research on key technology systems, innovate special technologies, and introduce high-end equipment. In addition, train experienced operators to improve design and production efficiency and improve construction quality.

5 Conclusions

Although prefabricated buildings are considered to be an effective way to solve the problem of building sustainability, the development in Qinghai Province is still in its infancy and faces many obstacles.

This study mainly uses factor analysis to analyze and study 25 risk factors involved in prefabricated buildings in Qinghai Province. Five types of key risks that hinder the development of prefabricated buildings in Qinghai Province have been identified, including market risks, management risks, economic risks, policy risks and technical risks.

In addition, in response to the above key risk factors, suggestions for the development of prefabricated buildings in Qinghai Province are put forward. The research results provide a reference for Qinghai Province to formulate effective development strategies for prefabricated buildings.

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