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RESEARCH ARTICLE

Risk assessment of local state-owned enterprise owners' projects

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ABSTRACT

There is a common problem of insufficient application of risk management by local state-owned enterprise owners in the actual project management process. It is of great significance to research and use scientific methods to sort out, monitor, and manage various risks existing in the project, in order to achieve the goal of achieving good economic and social benefits after the project is completed. This article elaborates on the steps and methods of qualitative and quantitative analysis of project risks for local state-owned enterprises. The results indicate that the application of checklist method and expert scoring method can determine the indicator system for risk assessment of projects, and the weight of indicators at each level can be determined using Analytic Hierarchy Process. The project can be evaluated using fuzzy comprehensive evaluation method.

Keywords: local state-owned enterprises; risk assessment; analytic hierarchy process; fuzzy comprehensive evaluation

1. Introduction

At present, the early stage of urban agglomeration construction in China mainly focuses on infrastructure construction and industrial layout. Local governments often establish a local state-owned sole proprietorship platform enterprise to undertake the primary land development and policy oriented infrastructure construction of development zones. The common feature of these enterprises is that they can listen to commands and fight tough battles. Due to the policy orientation and social responsibility of these types of engineering projects, including infrastructure development and industrial layout development, they often have complex and unstable prerequisites, and the project schedule is particularly tight. From the completed projects, it can be seen that a considerable number of projects have rough management, chaotic organization, and lack of systems during the construction process. The owner's management lacks foresight, and there is a lack of monitoring and management of risks. As a result, due to quality issues, a large number of rework is carried out, the construction period is delayed, and costs increase. After the project is completed, it cannot meet the expected requirements, and some are even left idle or demolished, causing significant economic losses to the country and enterprises, as well as adverse effects on local economic development and social stability. The core of project management is risk management, but local state-owned enterprise owners have insufficient understanding of project risk management and insufficient application of risk management in the actual project management process. Therefore, it is necessary to study how to scientifically sort out, monitor and manage various risks in the project, in order to achieve the goal of obtaining good economic and social benefits after the project is completed [1-3].

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The senior talent apartment project of a local state-owned enterprise is a key project in a certain city. The project is positioned as a comprehensive project that provides accommodation, catering, shopping, leisure and other living service facilities for the senior talent group in a certain city. It provides important supporting service guarantees for talent introduction in a certain city and drives the development of the surrounding area. The project covers an area of 25663.48 m^2, with a total construction area of 114284.6 m^2 and a total investment of 1.826 billion yuan. The government injected 540 million yuan of the land auction funds into a local state-owned enterprise senior talent apartment project company in the name of special capital injection. The planning conditions for the land auction clearly stated that after the project is completed, it can only be used as a rental talent apartment. After 2 years, 20% of the residential area can be sold, but it must be approved by the municipal government, and the project must be fully completed and delivered for use within 3 years. The specific economic indicators of the project are shown in **Table 1**.

Table 1. Summary of indicators for senior talent apartment projects of state owned enterprises in a certain region.

	Total land area			25663.48	m^2
	Floor area ratio			3.00	m^2
	Building density			22.00%	m^2 (Including overhead layer)
	Green space ratio			35%	m^2
	Building base area			5639.39	
	Total construction area			114284.60	
	Total building area based on capacity calculation			76965.72	
Among	Underground building area			34338.19	m^2
	Among	Civil air defense building area		3997.56	m^2
		Underground parking building area		29301.87	m^2
		Building area of equipment room		1038.76	m^2
	Above ground building area			79946.41	m^2 (Including overhead layer)
	Among	>150M^2 overhead floor area		2623.56	m^2
Among	Among	Among	<90M2 Apartment Building Area and Its Proportion to Apartment Building Area	53779.29	m^2
				77.89%	m^2
			>90M2 Apartment Building Area and Its Ratio to Apartment Building Area	15265.89	
				22.11%	
		Commercial capacity building area		7359.36	m^2
		Staircase above ground level building surface		55.44	m^2
		Building area of public facilities	Property management building area	229.59	m^2
			Building area of garbage bin	49.88	m^2
			Building area of transformer and distribution room	110.64	m^2
			Building area of fire control center	42.29	m^2
			Building area of high-voltage ring network room	73.34	m^2
	Total parking space			1079	Pieces
Among	Ground parking spaces			0	Pieces
	Underground parking spaces			1079	

Due to the tight schedule, a local state-owned enterprise formed a project team after completing the land auction, and began budget preparation and various bidding work. The local construction supervisory department adopts the principle of "reasonable low price bidding method" to determine the winning bidder.

Due to the large scale and tight schedule of the construction project, a state-owned enterprise project company was concerned that the approval time for the planning scheme would be too long, affecting the overall implementation progress of the project. Through planning, the project was decided to be constructed in two phases. The principle of quickly following up on project implementation was adopted, and the project construction was promoted through a phased drawing and bidding model. The specific bidding stage division

plan is shown in **Table 2**. The first phase basement has one floor and adopts a steel structure prefabricated building form, with a total of 11 floors and 134 residential units. The budget investment is 215 million yuan, which will be constructed first. The second phase basement has two floors and adopts a reinforced concrete structure. There are 1043 residential units, with a budget investment of 1.611 billion yuan. It will be constructed in the later stage. At the same time, during the bidding period, due to the increasing environmental protection requirements of the country for enterprises, there is a trend of rising material production costs and building entity production costs.

Table 2. Division of bidding stages for a local state-owned enterprise senior talent apartment project.

Number	Bidding project	Bidding form	Start date	Bid issuance date	Entry date	Remarks
1	Tendering agency	Shake Ball Tender				
2	Cost consulting unit	Public bidding				
3	construction control unit	Public bidding				
4	Preliminary survey unit	Shake Ball Tender				
5	The overall architectural design unit of the project	Open bidding for competition with proposals				
6	Project survey and design unit	Public bidding				
7	Site leveling unit	Shake Ball Tender				
8	Soft foundation treatment unit	Public bidding				
9	Excavation and protection unit of foundation pit	Public bidding				
10	Main engineering general contracting unit	Public bidding				
11	Testing unit	Inviting bids				
12	Monitoring unit	Inviting bids				
13	surveying and mapping danwei or unit	Direct delegation				
14	Lightning protection testing unit	Direct delegation				

2. Identification of risk factors based on the entire life cycle

In order to quickly determine the risks, an expert group was organized and the checklist method was used to identify the risks throughout the entire project process, ultimately obtaining the risk factors of the owner of a talent apartment project in a state-owned enterprise.

2.1. Early stage

The early stage includes the risk of land use change and land delivery delay.

The risk of land use change refers to the risk of changing the land use or overdue development after the land auction is completed, which is mainly caused by the risk of changes in national and local policies. Countries and regions will introduce different policies at different times, which inevitably affect the smooth implementation of engineering projects. Among them, changes in land use have the greatest impact on the owner, which is also an important uncertain factor. If they occur, it will lead to huge losses for the owner.

The risk of delayed land delivery refers to the delay in land delivery after the land use right holder pays the land transfer fee, mainly due to the risk of incomplete demolition and leveling by the land transfer party. For this project, due to the complex ownership relationships of buildings on the site, there is a risk of not being able to complete the demolition on time, ultimately leading to the inability to deliver the land on time.

2.2. Bidding stage

The risks during the bidding stage mainly involve various key provisions of the bidding documents and contracts. The bidding documents are important references for various participating units to participate in construction activities. Due to the limitations of the owner's own technical conditions, or lack of understanding of design, icons, etc., there may be risks of incomplete bidding lists, unclear pricing explanations, significant omissions, and unscientific preparation of bidding schedules.

During the bidding process, the owner may, for their own benefit, contract to the contractor with the lowest quotation, or the contract terms may be unfair and the risk may be infinitely transferred to the bidder. As a whole, each participating unit in the construction project will have a certain impact on the owner. If the contract is formulated unreasonably and accurately, it will inevitably have an impact on the construction of the entire project.

2.3. Design phase

The quality of design work directly determines the final quality of the project. Insufficient scheme argumentation, insufficient research, unreasonable architectural layout, and unsuitable layout are common risks that design often faces. These risks are the biggest risks that homeowners face, directly related to the progress and quality of the project, and may cause significant losses.

At the same time, the design phase is not only the responsibility of the design unit, but also involves planning, drawing review and other units, which may pose risks such as long approval time for planning schemes and long drawing review time. If these risks occur, they will have a significant impact on the project timeline.

2.4. Construction acceptance stage

During the construction phase, if the owner neglects or fails to manage the construction party properly, it may lead to more design changes, resulting in total investment exceeding the estimated budget or incomplete and untrue completion data, affecting project acceptance. These risks increase project costs on the one hand, and on the other hand, they will affect construction progress together with policy changes.

For local state-owned enterprises, social benefits are more important, and engineering quality is the first lifeline of a project. Generally speaking, the likelihood of quality defects affecting engineering safety is very low, but the probability of many small quality problems occurring is much higher. These small problems and minor defects require a lot of manpower and material resources for maintenance, and can also have a negative impact on the reputation of the owner.

2.5. Settlement transfer stage

The risk of settlement transfer comes from both administrative audit risk and unclear project transfer responsibilities. All of these may cause certain hidden dangers and lead to risks.

3. Construction of risk assessment index system for local state owned enterprise owners projects

Project risk assessment includes two aspects, namely qualitative and quantitative analysis of the project, which provides a theoretical and data basis for subsequent risk response [1-4]. Qualitative and quantitative analysis of project risks is not simply a logical relationship before and after. In some cases, the process of quantitative risk analysis has already qualitatively analyzed risks simultaneously, so there is no need to repeat the work of qualitative risk analysis. The local state-owned enterprise owner is the management integrator of

project construction, which involves a large number of suppliers and a complex supply chain. It is at the top of the "pyramid food chain" of project construction, and the risks it faces are also very complex and difficult to identify and control.

The construction of indicator system is a prerequisite for conducting risk assessment. This article uses expert survey method to divide risk factors into two indicator levels. The construction of indicator system is a prerequisite for conducting risk assessment. In this chapter, expert survey method is used to divide risk factors into two indicator levels. The specific indicator system is shown in **Table 3** [5-8].

Table 3. Risk evaluation index system for owners of a talent apartment project.

Risk assessment index system P for the owner	Pre risk P1	After the land auction is completed, changing the land use or overdue development P11
		After the land use right holder pays the land transfer fee, the land cannot be delivered for a long time P12
	Bidding and tendering Risk P2	The bidding list is incomplete, the pricing explanation is unclear, and there are significant omissions P21
		Unscientific preparation of bidding schedule P22
		Risk of bidder winning bid at low price P23
		Unfair contract terms and unlimited transfer of risk to bidders P24
	Design Risk P3	Insufficient scheme argumentation and insufficient research depth P31
		The layout of the building plan is unreasonable, and the unit type is not suitable for P32
		The approval time for the planning scheme is too long P33
		Excessive review time P34
	Construction acceptance risk P4	There are many design changes, resulting in total investment exceeding the estimated P41
		Policy changes have led to an increase in construction costs, affecting construction progress P42
		Product quality unqualified P43
		Incomplete and untrue completion data, affecting project acceptance P44
	Settlement transfer risk P5	Administrative Audit Risk P51
		Unclear project handover responsibilities and rights P52

4. Determination of weights for risk assessment indicators

To conduct a risk assessment on the owner, it is necessary to first determine the weight of each indicator, and the accuracy of the results will directly affect whether the evaluation structure is scientific and reliable. Based on existing research, the following steps can be taken to determine the weight of evaluation indicators: (1) Determine the relationship between the various elements of the indicator system and construct a comparative judgment matrix. (2) Calculate relative weights and perform consistency checks. (3) Calculate the weights of each layer's indicators relative to the total indicators, sort them, and then determine the weights of each evaluation indicator.

Below, each step will be described separately.

4.1. Construction of judgment matrix and consistency testing

After applying the expert scoring method and conducting consistency testing, the importance of each indicator can be evaluated based on its importance.

When constructing a judgment matrix, specific numbers are used to represent the relative importance of one indicator relative to another indicator [9,10].

This article uses the eigenvalue method to calculate, and for talent apartment projects, the matrix order n is taken as 5.

Firstly, score the primary indicators, construct a judgment matrix, and conduct consistency testing. The final results are shown in **Table 4**.

Table 4. First level indicator judgment matrix.

P	P1	P2	P3	P4	P5	Wi	AWi
P1	1	1/3	1/5	1/8	1/4	0.042	0.218
P2	3	1	1/3	1/5	1/2	0.095	0.477
P3	5	3	1	1/2	2	0.255	1.291
P4	8	5	2	1	3	0.449	2.249
P5	4	2	1/2	1/3	1	0.157	0.794

By calculation, it can be concluded that:

λ_{max} =5.06, C. I. =0.011, R. I. =1.119, C. R. =0.010<0.1

It can be seen that it has passed the consistency test, and the importance order of each indicator is:

Construction acceptance risk P4>Design risk P3>Settlement transfer risk P5>Bidding risk P2>Preliminary risk P1.

After the consistency of the first level indicators is met, 16 indicators will be evaluated using the above method

Construct a judgment matrix for secondary indicators and verify their consistency.

Construct a judgment matrix for each secondary indicator under risk P1 in the early stage, and the final results are shown in **Table 5**.

Table 5. Matrix for judging secondary risk indicators in the early stage.

P1	P11	P12	Wi
P11	1	1/2	0.333
P12	2	1	0.666

Due to the fact that there are only two secondary indicators under risk P1 in the early stage, the importance relationship between the two is simple and does not require consistency testing. The importance ranking of each secondary indicator is:

After the land use right holder pays the land transfer fee, the land cannot be delivered for a long time P12>After the land auction is completed, the land use is changed or the development is delayed P11.

Construct a judgment matrix for each secondary indicator under bidding risk P2, and the final results are shown in **Table 6**.

Table 6. Evaluation matrix for secondary indicators of bidding risk.

P2	P21	P22	P23	P24	Wi	AWi
P21	1	1/2	1/5	1/3	0.088	0.354
P22	2	1	1/3	1/2	0.157	0.630
P23	5	3	1	2	0.483	1.983
P24	3	2	1/2	1	0.272	1.090

By calculation, it can be concluded that:

λ_{max} =4.015, C. I. =0.005, R. I. =0.90, C. R. =0.054<0.1

It can be seen that it has passed the consistency test, and the importance order of each indicator is:

Risk of bidder winning bid at low price P23>Unfair contract terms, unlimited risk transfer to bidders P24>Incomplete bidding list, unclear pricing instructions, and significant omissions P21>Unscientific preparation of bidding schedule P22.

Construct a judgment matrix for each secondary indicator under design risk P3, and the final results are shown in **Table 7**.

Table 7. Design risk secondary indicator judgment matrix.

P3	P31	P32	P33	P34	Wi	AWi
P31	1	1/2	1/3	1/5	0.089	0.359
P32	2	1	1	1/3	0.189	0.763
P33	3	1	1	1/2	0.232	0.934
P34	5	3	2	1	0.490	1.970

By calculation, it can be concluded that:

λ_{max} =4.025, C I. =0.008, R I. =0.90, C R. =0.092<0.1

It can be seen that it has passed the consistency test, and the importance order of each indicator is:

Long review time for drawings P34>Long approval time for planning schemes P33>Unreasonable layout of building schemes and unsuitable layout P32>Insufficient scheme argumentation and insufficient research P31.

Construct a judgment matrix for each secondary indicator under construction acceptance P4, and the final results are shown in **Table 8**.

Table 8. Construction acceptance secondary index judgment matrix.

P4	P41	P42	P43	P44	Wi	AWi
P41	1	1/2	1/3	1/3	0.072	0.290
P42	2	1	1/5	1/2	0.123	0.493
P43	7	5	1	3	0.587	2.359
P44	3	2	1/3	1	0.218	0.880

By calculation, it can be concluded that:

λ_{max} =4.019, C I. =0.006, R I. =0.90, C R. =0.071<0.1

It can be seen that it has passed the consistency test, and the importance order of each indicator is:

Poor product quality P43>Incomplete and untrue completion data, affecting project acceptance P44>Multiple design changes, resulting in total investment exceeding estimated budget P41>Policy changes, leading to increased construction costs and affecting construction progress P42.

Construct a judgment matrix for each secondary indicator under settlement transfer P5, and the final results are shown in **Table 9**.

Table 9. Matrix for judging secondary indicators of settlement transfer risk.

P5	P51	P52	Wi
P51	1	2	0.666
P52	1/2	1	0.333

Due to the fact that there are only two secondary indicators under risk P1 in the early stage, the importance relationship between the two is simple and does not require consistency testing. The importance ranking of each secondary indicator is: Administrative audit risk P51, unclear transfer of responsibilities and rights for leap projects P52.

4.2. Determine the weights of each evaluation indicator

Based on the above calculated primary indicators and the weights of each secondary indicator, they can be summarized together to calculate the composite weights of each secondary indicator, as shown in Table 10.

From **Table 10**, it can be seen that among the various risk indicators faced by the owner, the construction acceptance risk P4 has the greatest impact, accounting for 0.449%, while the early risk impact is relatively small, accounting for only 0.042%; From the composite weight of the secondary indicators, the impact of product quality nonconformity P43 is significant, accounting for 0.264%. The bidding list is incomplete, the pricing explanation is unclear, and there are significant omissions. P21 has a relatively small impact, accounting for only 0.008%.

Table 10. Risk assessment index system for owners of a talent apartment project.

Primary indicators	Weight of primary indicators	Secondary indicators	Secondary indicator weight	Composite weight of secondary indicators
Pre risk P1	0.042	After the land auction is completed, changing the land use or overdue development P11	0.333	0.0140
		After the land use right holder pays the land transfer fee, the land cannot be delivered for a long time P12	0.666	0.0280
Bidding and tendering Risk P2	0.095	The bidding list is incomplete, the pricing explanation is unclear, and there are significant omissions P21	0.088	0.0084
		Unscientific preparation of bidding schedule P22	0.157	0.0149
		Risk of bidder winning bid at low price P23	0.483	0.0459
		Unfair contract terms and unlimited transfer of risk to bidders P24	0.272	0.0258
Design Risk P3	0.255	Insufficient scheme argumentation and insufficient research depth P31	0.089	0.0227
		The layout of the building plan is unreasonable, and the unit type is not suitable for P32	0.189	0.0482
		The approval time for the planning scheme is too long P33	0.232	0.0592
			0.490	0.1250

		Excessive review time P34		
Construction acceptance risk P4	0.449	There are many design changes, resulting in total investment exceeding the estimated P41	0.072	0.0323
		Policy changes have led to an increase in construction costs, affecting construction progress P42	0.123	0.0552
		Product quality unqualified P43	0.587	0.2636
		Incomplete and untrue completion data, affecting project acceptance P44	0.218	0.0979
Settlement transfer risk P5	0.157	Administrative Audit Risk P51	0.666	0.1046
		Unclear project handover responsibilities and rights P52	0.333	0.0523

5. Fuzzy comprehensive evaluation of risks for property owners

5.1. Project risk assessment level

Referring to the relevant provisions of the Construction Project Management Specification, combined with the characteristics of the local state-owned enterprise owner project, and based on the risk level classification criteria, when evaluating the risk of the talent apartment owner, the risk is divided into five levels: low risk V1, low risk V2, general risk V3, high risk V4, and high risk V5. The corresponding scores for each level are shown in **Table 11**.

Table 11. Risk assessment level score table.

Evaluation level	Low risk	Lower risk	General risk	Higher risk	High risk
Score	[10 30)	[30 50)	[50 70)	[70 90)	[90 100)

5.2. Fuzzy comprehensive evaluation matrix for secondary indicators

By inviting experts from the owner, design, construction, supervision, and user units, the fuzzy comprehensive evaluation matrix for the second level risk indicators of the talent apartment project owner was determined using the expert scoring method. The results are shown in **Table 12**. According to the risk levels of each secondary indicator in **Table 12**, the fuzzy comprehensive evaluation matrix of the secondary indicators under each primary indicator can be summarized:

Table 12. Risk assessment index system for owners of a talent apartment project.

Secondary indicators	Risk level				
	Low risk	Lower risk	General risk	Higher risk	High risk
After the land auction is completed, changing the land use or overdue development P11	0.6	0.3	0.1	0	0
After the land use right holder pays the land transfer fee, the land cannot be delivered for a long time P12	0.5	0.3	0.2	0	0
The bidding list is incomplete, the pricing explanation is unclear, and there are significant omissions P21	0.3	0.5	0.2	0	0
Unscientific preparation of bidding schedule P22	0.4	0.4	0.2	0	0
Risk of bidder winning bid at low price P23	0.3	0.3	0.4	0	0
Unfair contract terms and unlimited transfer of risk to bidders P24	0.4	0.3	0.3	0	0
Insufficient scheme argumentation and insufficient research depth P31	0.2	0.5	0.2	0.1	0
The layout of the building plan is unreasonable, and the unit type is not suitable for P32	0.1	0.5	0.4	0	0
The approval time for the planning scheme is too long P33	0.2	0.4	0.3	0.1	0

Excessive review time P34	0.1	0.3	0.4	0.2	0
There are many design changes, resulting in total investment exceeding the estimated P41	0.2	0.2	0.4	0.2	0
Policy changes have led to an increase in construction costs, affecting construction progress P42	0.3	0.5	0.2	0	0
Product quality unqualified P43	0.1	0.2	0.4	0.3	0
Incomplete and untrue completion data, affecting project acceptance P44	0.2	0.3	0.3	0.2	0
Administrative Audit Risk P51	0.4	0.4	0.2	0	0
Unclear project handover responsibilities and rights P52	0.3	0.5	0.2	0	0

Preliminary risk fuzzy comprehensive evaluation matrix R1:

$$R1=\begin{bmatrix}0.6 & 0.3 & 0.1 & 0 & 0\\ 0.5 & 0.3 & 0.2 & 0 & 0\end{bmatrix}$$

Fuzzy comprehensive evaluation matrix R2 for bidding risks:

$$R2=\begin{bmatrix}0.3 & 0.5 & 0.2 & 0 & 0\\ 0.4 & 0.4 & 0.2 & 0 & 0\\ 0.3 & 0.3 & 0.4 & 0 & 0\\ 0.4 & 0.3 & 0.3 & 0 & 0\end{bmatrix}$$

Design risk fuzzy comprehensive evaluation matrix R3:

$$R3=\begin{bmatrix}0.2 & 0.5 & 0.2 & 0.1 & 0\\ 0.1 & 0.5 & 0.4 & 0.0 & 0\\ 0.2 & 0.4 & 0.3 & 0.1 & 0\\ 0.1 & 0.3 & 0.4 & 0.2 & 0\end{bmatrix}$$

Fuzzy comprehensive evaluation matrix R4 for construction acceptance risk:

$$R4=\begin{bmatrix}0.2 & 0.2 & 0.4 & 0.2 & 0\\ 0.3 & 0.5 & 0.2 & 0.0 & 0\\ 0.1 & 0.2 & 0.4 & 0.3 & 0\\ 0.2 & 0.3 & 0.3 & 0.2 & 0\end{bmatrix}$$

Fuzzy comprehensive evaluation matrix R5 for settlement transfer risk:

$$R5=\begin{bmatrix}0.4 & 0.4 & 0.2 & 0 & 0\\ 0.3 & 0.5 & 0.2 & 0 & 0\end{bmatrix}$$

5.3. Fuzzy comprehensive evaluation matrix for secondary indicators

According to the theory of fuzzy comprehensive evaluation, the risk of five primary indicators can be quantified using the formula S=W × R. In the calculation process, each risk level can be taken as [11,12]:

$$V=[V1 \quad V2 \quad V3 \quad V4 \quad V5]=[20 \quad 40 \quad 60 \quad 80 \quad 95]$$

Ultimately, it can be concluded that:

Fuzzy comprehensive evaluation of early risk:

$$S1=W1\times R1=[0.533 \quad 0.300 \quad 0.167 \quad 0 \quad 0]$$

Quantified:

$$D1=S1\times V^{T}=32.634$$

Fuzzy comprehensive evaluation of bidding risks:

$$S2 = W2 \times R2 = [0.343 \quad 0.333 \quad 0.324 \quad 0 \quad 0]$$

Quantified:

$$D2 = S2 \times V^T = 39.618$$

Fuzzy comprehensive evaluation of design risks:

$$S3 = W3 \times R3 = [0.132 \quad 0.379 \quad 0.359 \quad 0.130 \quad 0]$$

Quantified:

$$D3 = S3 \times V^T = 49.742$$

Fuzzy comprehensive evaluation of construction acceptance risk:

$$S4 = W4 \times R4 = [0.154 \quad 0.259 \quad 0.354 \quad 0.234 \quad 0]$$

Quantified:

$$D4 = S4 \times V^T = 53.364$$

Fuzzy comprehensive evaluation of settlement transfer risk:

$$S5 = W5 \times R5 = [0.366 \quad 0.433 \quad 0.200 \quad 0 \quad 0]$$

Quantified:

$$D5 = S5 \times V^T = 36.630$$

By summarizing the above results, the evaluation results of each level of risk indicator for the owner can be obtained, as shown in **Table 13**.

Table 13. Evaluation results of level 1 risk indicators.

Level 1 risk indicators	Early stage risk	Risk of bidding and tendering	Design risk	Construction acceptance risk	Settlement transfer risk
Risk assessment value	32.63	39.62	49.74	53.64	36.63
Risk level	Lower risk	Lower risk	Lower risk	General risk	Lower risk

From the above evaluation results, it can be seen that among these five primary indicators, the construction acceptance risk evaluation value is 53.6+4, which belongs to general risk. The evaluation values of the other four indicators are all within the range of [30 50], which belongs to a lower risk level. Therefore, special attention needs to be paid to the risks during the construction acceptance stage.

5.4. Calculation of fuzzy comprehensive evaluation results

Through comprehensive evaluation of indicators at all levels, the fuzzy comprehensive evaluation matrix R of the owner can be determined:

$$R = \begin{bmatrix} 0.533 & 0.300 & 0.167 & 0.000 & 0 \\ 0.343 & 0.333 & 0.324 & 0.000 & 0 \\ 0.132 & 0.379 & 0.359 & 0.130 & 0 \\ 0.154 & 0.259 & 0.354 & 0.234 & 0 \\ 0.366 & 0.433 & 0.200 & 0.000 & 0 \end{bmatrix}$$

Subsequently, it can be concluded that:

$$S = W \times R = [0.215 \quad 0.325 \quad 0.320 \quad 0.138 \quad 0]$$

Quantified:

$$D = S \times V^T = 47.549$$

It can be seen that the project as a whole belongs to a low-risk level.

5.5. Analysis of evaluation results

The fuzzy comprehensive evaluation result of this talent apartment is 47.549, located within the range of [30 50) in the risk level score table, with a risk level of low risk. In addition, the probability of low risk occurring in this project is 0.215, the probability of low risk occurring is 0.379, the probability of general risk occurring is 0.320, and the probability of high risk occurring is only 0.138. It can be seen that the probability of occurrence of general and below is as high as 0.862. Therefore, the overall risk level of this project is not high, and the engineering construction is feasible.

According to the comprehensive evaluation results of the first level indicator risk factors mentioned above, the quantified risk value in the early stage is 32.63, and the quantified settlement transfer value is 36.63. The risk level is relatively low, belonging to a lower risk level. The quantified values of bidding risk and design risk are 39.62 and 49.74, respectively, which are also classified as low risk levels, but the degree of risk is higher than that of the early stage risk and settlement transfer risk. The highest quantified value of construction acceptance risk is 53.64, and the risk level belongs to general risk. For the owner, special attention should be paid to the risk of construction acceptance, which is related to the characteristics of local state-owned enterprises. Once quality problems occur, local state-owned enterprises need to spend a lot of manpower and material resources to repair, so ensuring construction quality is very important.

6. Conclusion

This chapter takes a state-owned enterprise talent apartment project in a certain area as an example to comprehensively apply and elaborate on the construction of the owner's project risk evaluation indicator system, determination of indicator weights, and risk evaluation. The risk assessment index system of the project was determined using the checklist method and expert scoring method. The weights of indicators at each level were determined using the Analytic Hierarchy Process, and the project was evaluated using the Fuzzy Comprehensive Evaluation method. The overall risk of this project belongs to a lower risk level, and the project construction is feasible. The construction acceptance risk is the most quantified risk.

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