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Research paper

Cost risk assessment for renovating old neighborhood of EPC projects in China using SEM-BNT-MEEM method

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Abstract: The transformation of old neighborhood is a significant livelihood project for urban renewal, and promoting the profound transformation of old neighborhood is a significant problem faced by China, while the Engineering Procurement Construction(EPC) model integrates the design, procurement, and construction of the transformation project of old neighborhood, which improves the efficiency and quality of the transformation at the same time, and faces a significant cost risk problem due to the change of fixed lump-sum price contract, so in order to enhance the ability of the general contractor to prevent the cost risk and to improve the transformation project benefits, this study constructs a comprehensive evaluation index system consisting of 19 factors to assess the cost risk in all aspects from environment, technology, management, and economy, which proposes a new type of evaluation method combining structural equation modeling (SEM), blind number theory (BNT), and matter-element extension model (MEEM), and combines with the actual cases of old neighborhood remodeling to arrive at the risk level of the factors and based on the results of the analysis are given to confirm the validity of the model and provides a successful risk assessment tool.

Keywords: renovation of old neighborhood, EPC project, cost risk assessment, general contractor, SEM-BNT-MEEM model

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1. Introduction

Old neighborhood are typically multi-story buildings built in the previous century that are still occupied. However, due to societal advancements and technological progress, they no longer adequately meet people's daily needs. These neighborhood often encounter issues such as outdated building structures, limited building functions, inadequate public facilities, disorganized community environments, and insufficient social services [1]. China's urbanization is progressing, leading to a growing need to renovate old neighborhood. Statistics from the National Bureau of Statistics and the Ministry of Housing and Construction indicate that around 170,000 old neighborhood, housing over 42 million residents, need to be transformed, covering approximately 4 billion square meters of floor area [2]. Due to the robust promotion of national policies, the scope and size of historic neighborhood repair projects are expanding significantly.

The EPC mode integrates design, procurement, and construction into a comprehensive general contracting system, effectively addressing the limitations of traditional construction contracting methods. When applied to old neighborhood renovation projects, the EPC mode enhances project efficiency and ensures centralized and continuous renovation work, maintaining integrity, consistency, and adherence to urban standards [3]. Thus, the contractor is increasingly favoring this contracting approach. The general contractor assumes some of the original owner's responsibilities, which are broader and more challenging. This is compounded by the complex conditions of renovating old neighborhood, historical issues, various interests, uncertainties, and controllable and uncontrollable risks. The cost risk of the EPC fixed-price contract model is especially noticeable [4]. This study is highly significant in identifying and evaluating the cost risk variables of the EPC project for renovating old neighborhood from the viewpoint of the general contractor.

The main objective of this paper is to identify cost risk factors in an old neighborhood renovation EPC project, develop a cost risk assessment index system, propose a new cost risk assessment model of SEM-BNT-MEEM, validate the effectiveness of the index system and assessment model through a specific case study, assess the level of cost risk, and identify core cost risk factors to help the general contractor enhance cost risk control.

2. Literature review

Cost risk studies on renovating old neighborhood mainly focus on urban regeneration, existing building renovation, and community transformation. Femenias P. et al. (2018) analyzed case studies from seven public housing companies and three private housing businesses, determining that cost significantly impacts the rehabilitation of older communities [5]. Zhao et al. (2023) gathered information on energy consumption, building technology, and expenses from 235 certified environmentally friendly homes in the United States. They analyzed the prices of new green construction and rehabilitation projects, discovering that the average cost of renovation projects was 30% less than that of new projects. The average cost was 30% cheaper than new developments [6]. Zhong Yunfeng and colleagues (2021) examined the challenges in cost management encountered by aging metropolitan areas in China about their ongoing rehabilitation. They proposed specific strategies to address these challenges, focusing on controlling material costs and engineering modification costs [7]. Cost management is a significant difficulty for rehabilitation projects in ancient districts. However, the risk assessment for renovation projects in old neighborhood needs more specialized research on cost risk attributes from the perspective of general contractors.

Currently, there is a wealth of research on the factors that influence cost risks in EPC projects, with Adafin J. (2016) identifying factors such as bidding period, local market conditions, project complexity, organization experience, engineering disputes, and design changes as critical influencers of budget overruns. It was highlighted that design issues pose a significant risk in EPC projects [9]. Tang Q.H. et al. (2022) proposed six dimensions of cost risk influencing elements in assembly construction projects under EPC mode: overall design, component manufacture, transportation and stacking, construction and installation, operation and maintenance, and external environment [10]. The cost risk classification methods include project stage division, risk body division, and risk source division. This paper focuses on EPC projects and the cost risk in old neighborhood renovation projects. It identifies cost risk factors from the environment, technology, management, and economic dimensions to enhance the precision of assessment.

Cost risk assessment commonly utilizes the gray clustering technique, fuzzy comprehensive evaluation method, and object element topologically evaluable evaluation method. Hwang B.G. et al. (2015) used the risk criticality index to assess 20 risk factors in a green retrofit project of existing buildings in Singapore, as described in a literature study [11]. Xian L.H. and colleagues (2018) improved the traditional fuzzy inference system's failure mode and impact analysis method to identify the critical risks at each stage of the green retrofit project for existing buildings. They proposed appropriate measures to tackle these significant dangers [12]. Zheng et al. (2019) combined life-cycle cost analysis with monte carlo analysis to provide a methodical way to assess green retrofit choices for current buildings, focusing on economic and risk factors [13]. This research utilizes a structural equation model to provide weights to variables associated with cost risk factors in a refurbishment EPC project for an ancient neighborhood. This methodology rectifies the shortcomings of conventional approaches that fail to account for measurement mistakes. The study uses blind number theory (BNT) to assess the probability of indicators being categorized into various danger levels.

3. Method

3.1. Construction of the indicator system

Several factors influence the cost risk of the old neighborhood transformation EPC project. To ensure the accuracy and scientific validity of the cost risk assessment index system for the old neighborhood transformation, a process is followed to construct the index system, as depicted in Fig. 1.

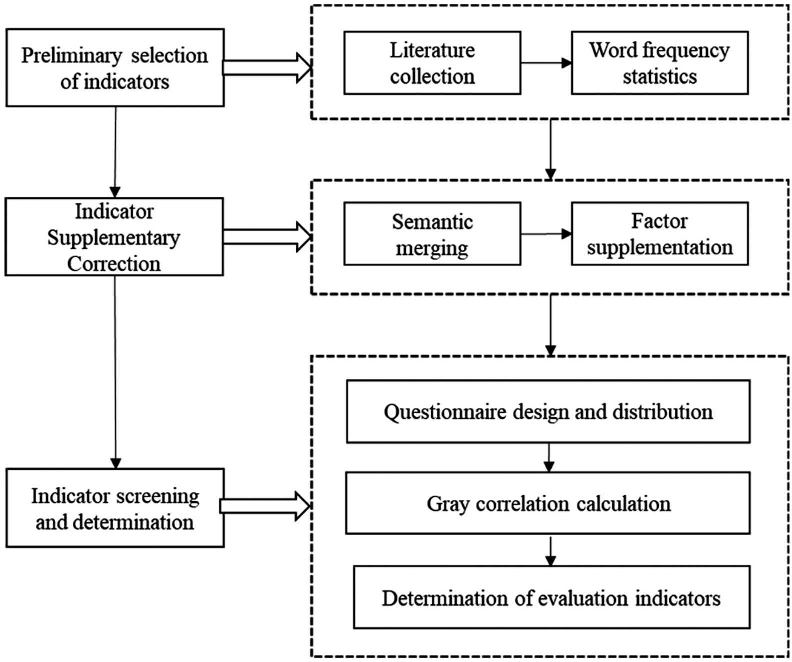


Fig. 1. Construction process of cost risk indicator system for old neighborhood renovation EPC project

3.1.1. Identification of cost risk indicator

The study utilizes China knowledge network and web of science as data sources, with search terms including "cost of renovation projects in old neighborhood", "cost of renovation projects in existing buildings" and "EPC". There is no time restriction for the search, and initially, 135 papers were found. Out of the 135 pieces of literature collected, only 23 were found to be relevant for screening. These 23 pieces were then used to compile a list of risk factors associated with an old neighborhood renovation project. By analyzing keyword frequency, 40 significant cost risk factors were identified. Experts with over five years of experience in old neighborhood renovation projects were invited to conduct interviews. By merging and organizing risk factors with similar meanings, 22 cost risk factors were identified for old neighborhood renovation EPC projects. The results are presented in Table 1.

Table 1. A simple longtable example

First level indicator	Second level indicators	Literature sources
Environmental risk	Changes in laws and regulations	[14, 15, 17, 19, 22]
	Imperfect transformation standards	[16, 17, 21]
	Low willingness and cooperation of residents to remodel	[19, 22]
	Force majeure events	[16, 21, 22]
Technological risk	Insufficient site investigation	[14, 17, 20, 21]
	Unreasonable remodeling design scheme	[18, 19, 21]
	Insufficient capacity and experience of designers	[19, 20, 22]
	Inadequate construction organization design	[18, 21]
	Immature application of remodeling technology	[15, 18, 19]
	Insufficient synergy between trades	[16, 20]
Management risk	Inadequate cost management mechanism	[17, 19]
	Inadequate supplier selection and management	[18, 19, 22]
	Unreasonable procurement plan arrangement	[16, 20]
	On-site construction safety hazards	[16, 22]
	Poor organizational coordination and communication	[15, 19, 21]
	Unclear definition of contractual rights and responsibilities	[18, 19, 22]
	Difficulty in transportation of materials and equipment	[17, 20, 21]
Economic risk	Untimely government financial allocation	[18, 19]
	Fluctuating prices of materials and machinery	[14, 18, 21]
	Inflation	[14, 20, 22]
	Interest rate changes	[17, 19]
	Engineering changes and claims	[14, 15, 17, 19, 20]

3.1.2. Development of index system

Following the selection principle of the gray correlation analysis method, indicators with correlation values below 0.5 were eliminated [23]. This process resulted in 19 evaluation indicators and the establishment of an assessment index system for cost risks in the rehabilitation of old neighborhood EPC projects (refer to Fig. 2).

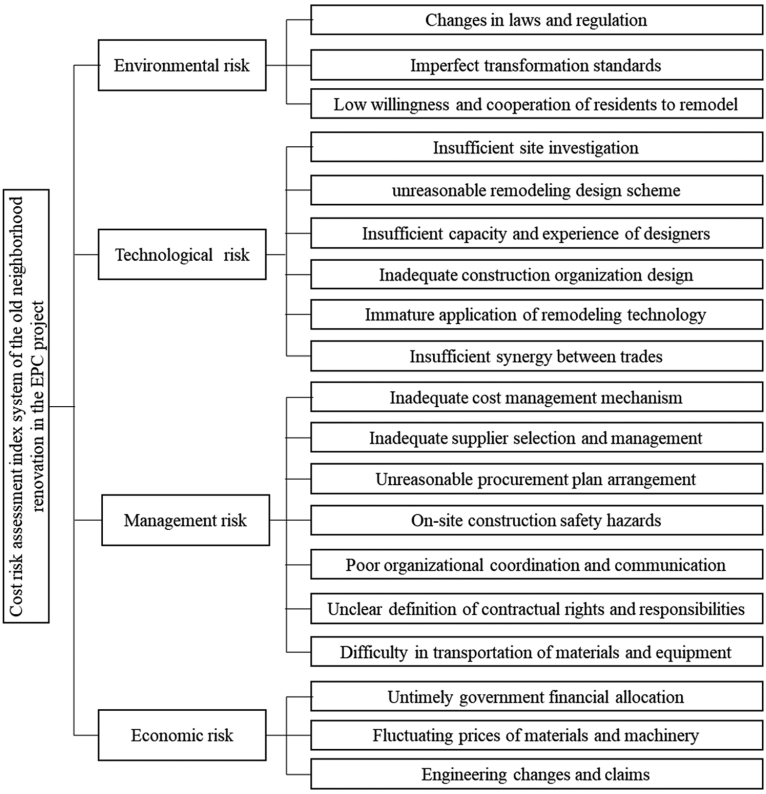


Fig. 2. Cost risk indicator system for old neighborhoods renovation in EPC project

3.2. Evaluation based on SEM-BNT-MEEM

3.2.1. Structural equation modeling

Structural equation modeling (SEM) is a statistical technique that combines factor analysis and path analysis to examine the relationships among multiple variables. It can account for measurement errors and estimate their magnitude, addressing the limitations of conventional methods [24]. Due to its objectivity and reliability, the structural equation model is selected to estimate the weights of the indicators for the cost risk affecting elements of the old neighborhood renovation EPC project, and the normalized route coefficients for each observed variable are inserted into Eq. 3.1. Next, the route coefficients of each cost risk evaluation indicator are standardized to calculate the indicator weights.

$$W_i = \frac{\lambda_i}{\sum_{i=1}^{4} \lambda_i} \tag{3.1}$$

3.2.2. Theory of blind numbers

With the various cognitive levels of experts and the inherent ambiguity of the cost risk assessment process, the notion of "expert credibility" is presented and evaluated based on years of experience, degree, and professional title [25]. Table 2 displays the precise assessment criteria for expert credibility.

Table 2. Criteria for evaluating the reliability of specialists

Item	Classification	Reliability	Item	Classification	Reliability	Item	Classification	Reliability
title	senior	[8, 10]	seniority	> 15	[8, 10]	Degree	PhD	[8, 10]
	Intermediate	[4, 7]		5~15	[4, 7]		Master's	[6, 7]
	Junior	[1, 3]		< 5	[1, 3]		Bachelor's	[3, 5]

If the credibility of expert group member I_i is β_i, then the total credibility of the experts in the group is:

$$\theta_i = \beta_i / \sum\nolimits_{m=1}^{n} \beta_m \tag{3.2}$$

β_i represents the credibility of the ith expert, whereas θ_i represents the combined credibility of the ith expert. Experts are asked to use intervals to assign indicator values to qualitative indicators. The scoring intervals are re-divided, and the credibility of the newly divided intervals is recalculated, taking into account the experts' entire credibility. Create the blind number matrix D based on credibility.

$$D = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \cdots & \gamma_{1n} \\ \gamma_{21} & \gamma_{22} & \cdots & \gamma_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \gamma_{k1} & \gamma_{k2} & \cdots & \gamma_{kn} \end{bmatrix} \tag{3.3}$$

γ_{kn} represents the probability that the n-th indicator's value is inside the k-th interval.

According to the cost risk grading standard and interval credibility of the old neighborhood restoration EPC project, determine the insertion points $a_1, a_1, \ldots, a_n$, then calculate the comprehensive assessment score of the index. The formula for calculating the comprehensive score is as follows:

$$v_i = \sum_{j=1}^{n} \gamma_{ij} a_i \tag{3.4}$$

3.2.3. Construct matter-element extension model

1. Constructing the object element matrix
   Evaluation object R is the cost risk of the old neighborhood renovation EPC project, c refers to evaluation indicators of cost risk, v represents the score of the evaluation indicator.

$$R = \begin{bmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & c_3 & v_3 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \tag{3.5}$$

2. Constructing the classical and joint domains
   The cost risk of the old neighborhood renovation EPC project is classified into j levels, and the classical and joint domain object matrix expressions are 3.6 and 3.7, respectively:

$$R_j = \begin{bmatrix} & c_1 & V_{j1} \\ & c_2 & V_{j2} \\ N_j & c_3 & V_{j3} \\ & \vdots & \vdots \\ & c_n & V_{jn} \end{bmatrix} = \begin{bmatrix} & c_1 & (a_{j1}, b_{j1}) \\ & c_2 & (a_{j2}, b_{j2}) \\ N_j & c_3 & (a_{j3}, b_{j3}) \\ & \vdots & \vdots \\ & c_n & (a_{jn}, b_{jn}) \end{bmatrix} \tag{3.6}$$

   N_j represents the risk level of each indicator of the cost risk assessment of the renovation of old neighborhood, N_p represents the total risk level of the cost risk assessment of the renovation of old neighborhood, c_i represents the cost risk indicator, V_{ji} represents the range of the ith cost risk indicator under different levels, and V_{pi} represents the total range of values of the ith cost risk indicator.

$$R_p = \begin{bmatrix} & c_1 & V_{p1} \\ & c_2 & V_{p2} \\ N_p & c_3 & V_{p3} \\ & \vdots & \vdots \\ & c_n & V_{pn} \end{bmatrix} = \begin{bmatrix} & c_1 & (a_{p1}, b_{p1}) \\ & c_2 & (a_{p2}, b_{p2}) \\ N_p & c_3 & (a_{p3}, b_{p3}) \\ & \vdots & \vdots \\ & c_n & (a_{pn}, b_{pn}) \end{bmatrix} \tag{3.7}$$

3. Determination of elements to be evaluated
   Making the cost risk assessment indexes of the old neighborhood renovation EPC project a matter element. The evaluation matter element is expressed as $R = (Ncv)$.
4. Calculation index correlation degree
   A mathematical formula expresses the correlation function of the table set, and the expression of the correlation function:

$$K_j(v_i) = \begin{cases} \dfrac{-\rho(v_i, V_{ji})}{|V_{ji}|}, & v_i \in V_{ji} \\ \dfrac{\rho(v_i, V_{ji})}{\rho(v_i, V_{pi}) - \rho(v_i, V_{ji})}, & v_i \notin V_{ji} \end{cases} \tag{3.8}$$

   The correlation of each indicator is represented by $K_i(v_j)$, $\rho(v_i, v_{ji})$, $\rho(v_i, v_{ji})$ respectively, represent the distance from the finite intervals v_{ji} and v_{pi}.

5. Determine the cost risk level
   Integrate index weights and correlation degrees to calculate risk levels. The formula is as follows:

$$K_j(q) = \sum_{i=1}^{n} w_i K_j(v_i) \tag{3.9}$$

   $K_j(q)$ represents the comprehensive correlation degree, and w_i is the indicator weight. According to the principle of maximum relevance, the final cost risk level of the project can be determined as K_j, the specific formula is as follows:

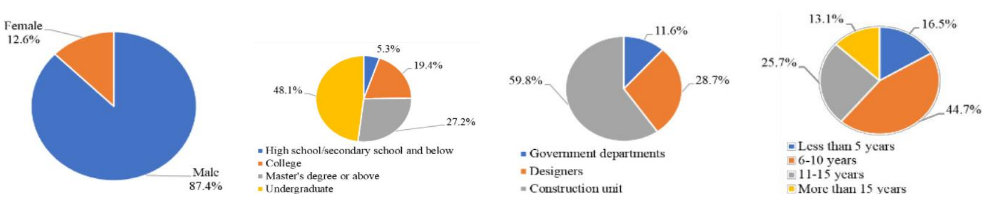
$$K_j = \max K_j(q) \tag{3.10}$$

4. Result and discussion

4.1. Data acquisition and analysis

The questionnaire for the old neighborhood transformation of the EPC project cost risk influencing factors design is broken into two parts: one for collecting basic information about the investigator and the other for assessing the importance of cost risk influencing variables. The investigators are involved in construction engineering field-related activity to ensure the data's veracity. The questionnaire was constructed using the Likert 5-level scale method. In this method, "1" signifies a minimal impact of the indicator, "2" signifies a small impact, and "3" signifies a general impact. The scale ranges from 1 to 5, with 1 and 2 indicating minimal impact, 3 indicating moderate impact, and 4 and 5 indicating substantial influence. 250 surveys were disseminated online and offline, and 225 were returned. 206 questionnaires were considered legitimate after excluding those with evident answer patterns and short response times. The characteristics of the interviewees are displayed in Fig. 3.

Reliability and validity tests were conducted to assess the construction of indicators and questions and the accuracy of the data. The KMO test, Bartlett's spherical test, and Cronbach's α value were used. The overall Cronbach's α for cost risk was 0.920, and the KMO test value was 0.902 ($p < 0.001$). All four latent variables had Cronbach's α coefficients above 0.7, indicating high questionnaire data credibility and reasonable question design. Factor loading coefficients were ≥ 0.5, latent variables had explanatory rates > 50%, KMO values were > 0.7, and the significance index was 0.000, passing the validity test.



(a) Gender ratio (b) Education level (c) Work unit (d) Service years

Fig. 3. (a) Gender ratio, (b) Education level, (c) Work unit, (d) Service years

Table 3. Reliability and validity tests

Independent variable	**Cronbach's α**	**KMO**	**Bartlett test**	
			Approximat Chi-square	**Degree of Freedom**
Environmental risks	0.815	0.703	168.61	0.000
Technological risks	0.904	0.905	567.608	0.000
Management risks	0.919	0.930	861.117	0.000
Economic risks	0.866	0.724	249.108	0.000

4.2. Indicator weight calculation

The reliable data was imported into AMOS 24.0 software. First-order and second-order structural equation models were fitted using maximum likelihood estimation. Fitness tests were conducted on the indicators, and the model was adjusted based on the test results. The final standardized path coefficients were determined and presented in Fig. 4.

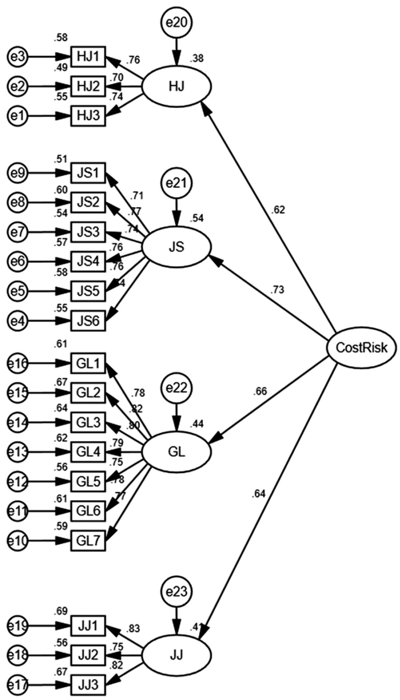


Fig. 4. Displays the fit of a second-order structural equation model.

The path coefficients of the indicators in the same tier were normalized to calculate the weights of the indicators, as detailed in Table 4.

Table 4. The weights derived from equation 4.12 are displayed in

First level indicators	**Weight**	**Second level indicators**	**Weight**	**Comprehensive weight**
Environmental risk (HJ)	0.2336	Changes in laws and regulations (HJ1)	0.3460	0.0811
		Inadequate remodeling standards (HJ2)	0.3175	0.0745
		Low willingness and cooperation of residents to remodel (HJ3)	0.3365	0.0789
Technological risk (JS)	0.2766	Insufficient site investigation (JS1)	0.1589	0.0440
		Unreasonable remodeling design scheme (JS2)	0.1725	0.0477
		Insufficient ability and experience of designers (JS3)	0.1644	0.0455
		Inadequate construction organization design (JS4)	0.1687	0.0467
		Mature application of remodeling technology (JS5)	0.1700	0.0470
		Inadequate synergy between trades (JS6)	0.1656	0.0458
Management risk (GL)	0.2490	Inadequate cost management mechanism (GL1)	0.1421	0.0354
		Inadequate supplier selection and management (GL2)	0.1494	0.0372
		Unreasonable procurement plan arrangement (GL2)	0.1455	0.0362
		On-site construction safety hazards (GL3)	0.1439	0.0358
		Poor organizational coordination and communication (GL4)	0.1366	0.0340
		Unclear definition of contract rights and responsibilities (GL6)	0.1423	0.0354
		Difficulty in transportation of materials and equipment (GL7)	0.1403	0.0349
Economic risk (JJ)	0.2408	Untimely government financial allocation (JJ1)	0.3470	0.0836
		Fluctuation price of materials and machinery (JJ2)	0.3128	0.0753
		Engineering changes and claims (JJ3)	0.3403	0.0819

4.3. Comprehensive evaluation

The evaluation will focus on the cost risk level of the old neighborhood rehabilitation project, using established standards from the cost risk research literature. The cost risk level of the large-scale old neighborhood renovation EPC project is categorized into five levels: I, II, III, IV, V, corresponding to "low risk", "lower risk", "medium risk", "higher risk", and "high risk". The scoring range is from 0 to 100, with a higher score indicating a higher risk level. The scale spans from 0 to 100, where higher scores indicate lower risk levels. The classical domain and section of the domain object element matrix are denoted as RI, RII, RIII, RIV, RV, and Rp, based on the risk level of the division of the domain interval using formulas 3.3 and 3.4, with each object element range corresponding to a specific risk level (refer to Table 5).

Table 5. Description of cost risk levels and object dollar ranges

Risk level	**Risk status description**	**Section**	**Classical Domain**
I	Target costs were not exceeded by actual expenses, and no further control measures were needed.	(0, 100)	(0,20)
II	little variation between goal and actual costs, necessitating a reaction plan based on common hazards		(20, 40)
III	Large deviation of actual cost from target cost, need to take active and reliable preventive measures		(40, 60)
IV	Extremely high real cost variance from goal cost, necessitating quick control measures		(60, 80)
V	Serious deviation of actual costs from target costs, requiring mandatory measures to control them		(80, 100)

Invite 5 experts (including 2 university professors with rich professional theoretical knowledge and long-term related research, 3 experts with the title of intermediate engineer or above, and experts with experience in old neighborhood renovation projects) to form an expert assessment team, score the indicators according to the scoring standard, and based on the theory of the blind number, assign different credibility to the different experts (See Table 6).

Table 6. Fundamental details and reliability of experts

Number	**Professional title**	**Seniority**	**Academic qualifications**	**Credibility**	**Comprehensive credibility**
Z1	professor	7	PhD	0.850	0.198
Z2	professor	20	PhD	0.875	0.203
Z3	senior engineer	12	MD	0.900	0.209
Z4	Middle Engineer	8	MD	0.850	0.198
Z5	Middle Engineer	5	MD	0.825	0.192

The second-level indicator correlation calculation was performed using Formula (3.7), and the results are presented in Table 7. Based on public opinion, use Table 8 to determine the complete correlation and grade association.

Table 7. Second level indicators indicator relevance values and risk levels

Second level indicators	**Indicator Correlation**					**Risk level**
	I	**II**	**III**	**IV**	**V**	
HJ1	0.0027	–0.0027	–0.3351	–0.5013	–0.6011	I
HJ2	–0.1675	0.2472	–0.1654	–0.3741	–0.4993	II
HJ3	–0.3536	–0.1921	0.0773	–0.0669	–0.2760	III
JS1	–0.2367	0.0361	–0.0337	–0.2753	–0.4202	II
JS2	–0.4484	–0.3105	–0.0807	0.0962	–0.2156	IV
JS3	–0.2456	0.01195	–0.0117	–0.2588	–0.4070	II
JS4	–0.3375	–0.1719	0.1042	–0.0862	–0.2838	III
JS5	–0.3605	–0.2006	0.0658	–0.0582	–0.2725	III
JS6	–0.2115	0.1084	–0.0891	–0.3168	–0.4534	II
GL1	–0.2975	–0.1191	0.1563	–0.1328	–0.3062	III
GL2	–0.3399	–0.1749	0.1001	–0.0834	–0.2826	III
GL3	–0.1885	0.1786	–0.1316	–0.3487	–0.4790	II
GL4	–0.2317	0.0500	–0.0454	–0.2841	–0.4273	II
GL5	–0.1654	0.2473	–0.1685	–0.3764	–0.5011	II
GL6	–0.1593	0.2338	–0.1775	–0.3831	–0.5065	II
GL7	–0.2322	0.0487	–0.0443	–0.2833	–0.4266	II
JJ1	–0.1660	0.2485	–0.1677	–0.3758	–0.5006	II
JJ2	–0.1139	0.1475	–0.2350	–0.4263	–0.5410	II
JJ3	–0.2923	–0.1069	0.1359	–0.1481	–0.3185	III

From Table 7 and 8, the comprehensive assessment places it in risk level II, signifying an acceptable medium-low risk level. The general contractor demonstrates a proficient level of cost risk management for the project overall; however, precautions should still be taken to prevent the risk from escalating to a higher level. Environmental, management, and economic risks fall within Level II, aligning with the project's overall risk level.

Table 8. First level indicators indicator relevance values and risk levels

First level indicator	**Indicator Correlation**					**Risk level**
	I	**II**	**III**	**IV**	**V**	
HJ	–0.0402	0.0030	–0.0334	–0.0738	–0.1078	II
JS	–0.0854	–0.0252	–0.0020	–0.0405	–0.0941	III
GL	–0.0577	0.0159	–0.0107	–0.0669	–0.1039	II
JJ	–0.0464	0.0231	–0.0206	–0.0756	–0.1087	II
synthesis	–0.0585	0.0033	–0.0160	–0.0633	–0.1032	II

However, the indicators for residents' willingness to renovate and cooperate, supplier selection and management, inadequate cost management mechanism, engineering changes, and claims exceed the project's overall risk level. Technical risk is classified as grade III, indicating a medium level of risk. Analysis of single indicator correlation reveals that the quality of retrofit design scheme, construction organization design, and application of retrofit technology show the strongest correlation with grade III technical risk, surpassing the project's overall risk level.

4.4. Discussion

The structural equation model can effectively analyze the role of the relationship between the various assessment indicators of the cost risk of the old neighborhood renovation EPC project, and the error is taken into account in the parameter estimation, which effectively overcomes the drawbacks of the entropy weighting method and other traditional methods [12], and makes the calculation of the weights more objective. The cost risk of the old neighborhood renovation EPC project is affected by the complexity of multiple indicators in multiple dimensions, and most of them are qualitative indicators, which are difficult to be quantified. Combining the blind number theory and the material element topology method, giving the experts a certain degree of credibility, and letting the experts determine the scoring intervals of the assessment indicators, and then determining the scoring values of the assessment indicators through calculations, which can make the assessment process and the results of the assessment more objective.

In the renovation projects of old neighborhood, technical risk is considered to be the most important cost risk factor, and this conclusion is consistent with the results of previous studies [9]. However, residents' willingness to retrofit and cooperation are also important factors affecting project costs with relatively high risk ratings, but this has often not been given enough attention in previous studies. In view of this, considering the influence of traditional Chinese culture, when implementing the renovation of old neighborhood, we should do a good job of the residents' ideological work and life security to ensure the smooth implementation of the renovation project.

5. Conclusions

This paper takes the cost risk of the old neighborhood renovation EPC project as the research object, from the perspective of the general contractor, this paper proposes a comprehensive risk evaluation model based on the existing research at home and abroad, in order to provide suggestions for the cost risk management of the general contractor to carry out the similar old neighborhood renovation project in the future, and the main conclusions are as follows:

1. This paper identifies and constructs a cost risk evaluation system for large-scale old district renovation EPC projects through literature analysis, expert surveys, and grey relational degree analysis. The system includes 19 indexes across four dimensions: environmental risk, technological risk, management risk, and economic risk. This system assists general contractors in identifying and predicting potential cost risks and implementing appropriate preventive measures.
2. A cost risk assessment model called sem-bnt-meem is developed by integrating constitutive equation modeling, blind numbers theory, and material element topology theory. This model enhances the conventional approach of using average values with interval numbers by capturing the vagueness and unpredictability of qualitative evaluations. The applicability of the model is verified through actual cases, which provides a new assessment method for the cost risk of old neighborhood renovation projects.
3. The EPC project for the rehabilitation of W's old neighborhood in C city has a computed overall cost risk level of II, indicating a medium-low risk level that accurately reflects the project's real scenario. The technical risk level is categorized as III, whereas the environmental, managerial, and economic risk levels are categorized as II. An extensive examination of the secondary indicators reveals seven key risk indicators: quality risk of retrofit design scheme, construction organization design risk, retrofit technology application risk, residents' willingness to be retrofitted and cooperation risk, suppliers' selection and management risk, insufficient cost management mechanism risk, and engineering changes and claim risk.

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