Journal of Civil Engineering and Urban Planning (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/jceup.2025.070111
ISSN 2616-3969 Vol. 7 Num. 1

Risk Factor Analysis of Old Residential Renovation Project Based on ISM-MICMAC

Yang Yu[1,*], Zhu Yali[1], Cui Peng[2]

[1]*School of Engineering Management, Changchun Institute of Technology, Changchun, 130103, Jilin, China*
[2]*Zhongsheng Jushi Construction Co., Ltd, Beijing, 100024, China*
**Corresponding author*

Keywords: Renovation of old residential areas; Risk factor analysis; Fishbone diagram; ISM- MICMAC

Abstract: With the gradual aging of the communities developed in the 1980s and 1990s, and the continuous improvement of people's material and cultural needs, the functions and conditions of the old communities have been difficult to meet the needs. In recent years, the national reconstruction planning policy for old residential areas has gradually emerged. This paper discusses the risks and challenges faced in the reconstruction process of old residential areas, and analyzes the impact of each risk factor on the overall project. Taking the renovation project of an old residential area as an example, from the perspective of the construction unit, based on the theoretical framework of "three controls, three pipes and coordination", this paper uses the fishbone diagram to identify the main risk factors, uses the ISM method to determine the relationship between the factors, and finally makes an in-depth analysis of the risk factors through the MICMAC method, and puts forward corresponding risk countermeasures and strategies.

1. Introduction

There are significant differences between the reconstruction projects of old residential areas and the new projects, which are not only reflected in the management mode of the projects, but also in the different risks and challenges faced by the two types of projects. In contrast, the reconstruction project of old residential area will face the extensive participation of residents, the uncertain hidden engineering quantity, the complex construction environment and other factors, which will lead to the complex social factors and interest relations in the process of management and implementation, thus increasing the uncertainty and risk of the project. As the direct implementor of the project, the contractor bears important responsibilities in the renovation project of old residential areas, but also faces unique risks and challenges.

In recent years, domestic scholars have carried out various studies on the reconstruction projects of old residential areas, and achieved remarkable results in the establishment of risk index system and model analysis. Chen Guangling (2021) carried out risk management research on the reconstruction of old residential areas, and proposed risk identification, evaluation and response strategies for the reconstruction projects of old residential areas, providing a theoretical basis for the risk management of contractors [1]. From the perspective of the whole life cycle of the project, Huo Xiaosen et al. constructed a list of risk factors for the reconstruction project of old residential areas, used C-OWA and gray cluster model to evaluate the risk, and proposed risk management and control according to different risk levels [2]. Meng Min (2023) conducted an in-depth study on the risk management of old residential renovation projects from the perspective of contractors, proposed the monitoring single method to monitor safety and quality risks, and adopted the earned value method to conduct dynamic risk monitoring of cost and progress, providing a new perspective for contractors' risk management in old residential renovation projects [3]. Li Jun (2024) took the reconstruction project of the old residential area in Community J as an example, initially defined the risk factors through document review, expert visits, discussion meetings and other methods, and used WBS-RBS technology to refine and revise the risk index system, providing practical guidance for contractors' risk control in the construction stage [4].

Although scholars have discussed the risk factors of old residential renovation projects from multiple perspectives, the risk analysis methods from the perspective of contractors still need to be further explored. Due to the particularity of the old community reconstruction project itself, contractors face more risks and challenges in the process of project implementation. These challenges are not only reflected in construction technology, but also involve cost control, schedule management, quality control, contract management, information management, safety and environmental management, and organization and coordination. Therefore, it is important to identify and respond to the risk factors of old residential renovation projects, especially for systematic analysis from the perspective of contractors. Based on the management framework of "three control, three management and one coordination", this paper systematically identifies, analyzes and expounds the risk factors and their interrelations through expert interviews, fishbone diagrams, ISM-MICMAC and other methods, so as to provide scientific decision-making support for contractors, help them effectively deal with various risks in the project, and ensure the smooth implementation of the project.

2. Theory and method

"Three control, three management and one coordination" is an important management concept in project management, which is used to ensure the smooth progress and efficient completion of project construction. It mainly includes seven dimensions: cost control, schedule control, quality control, information management, contract management, safety and environmental management, and organization and coordination. The project management of the construction unit is an important part of the project management. The management level of the construction unit directly affects the construction effect of the project. Doing a good job in "three control, three management and one coordination" can greatly improve the project management level [5].

The fishbone diagram, also known as Ishikawa diagram, was proposed by the Japanese management master Mr. Ishikawa Kaoru in 1953. As an analytical method for exploring the "root cause" of problems and looking at the essence through phenomena, it is also known as the causal diagram. Since the drawn analysis diagram looks like a fish with bones and spines, it is named the fishbone diagram [6]. The risk factors in the reconstruction projects of old residential areas can be systematically and systematically identified through the fishbone diagram. Based on the management framework of "three control, three management and one coordination", this paper uses the fishbone diagram method to identify the main risk factors in the reconstruction project of old residential area, and provides the basis for the subsequent risk analysis.

ISM-MICMAC is an Interpretative Structural Modeling Method. ISM method for short) and Matriced Impacts Croises Multidimensional Analysis (MICMAC method for short) [7].

The ISM method is used to analyze the hierarchical relationships of elements in complex systems. First, the adjacency matrix A is constructed, where aij=1 indicates that factor i has a direct impact on factor j, otherwise aij=0. Then, by adding the adjacency matrix A and the identity matrix I, the matrix $\mathbf{M = (A+I)^{\lambda+1}}$ is obtained, where k is A power, until the matrix converges, that is, $\mathbf{M = (A+I)^{\lambda+1} = (A+I)^{\lambda} \neq (A+I)^{\lambda-1}}$, and the final matrix M is the reachable matrix. It is used to analyze the hierarchical relationship between factors [8-9].

MICMAC method analyzes the cross influence among factors, constructs the cross influence matrix, calculates the driving force and dependence of factors, and classifies them into driving factors, dependent factors, associated factors, adjustment factors and autonomous factors [10].

3. Identification and classification of risk factors

Based on the engineering project management principle of "three control, three management and one coordination", this paper uses the fish bone diagram to identify the risk factors of the old community reconstruction project, and divides the risk factors into seven dimensions: cost control, quality control, schedule control, contract management, information management, safety and environmental management and organization and coordination. On this basis, further risk factors identification is carried out from the perspective of the construction party. Based on the opinions of front-line project managers and experts, 20 risk factors in 7 dimensions are identified, and the specific risk identification factors are as follows (see Figure 1 for details).

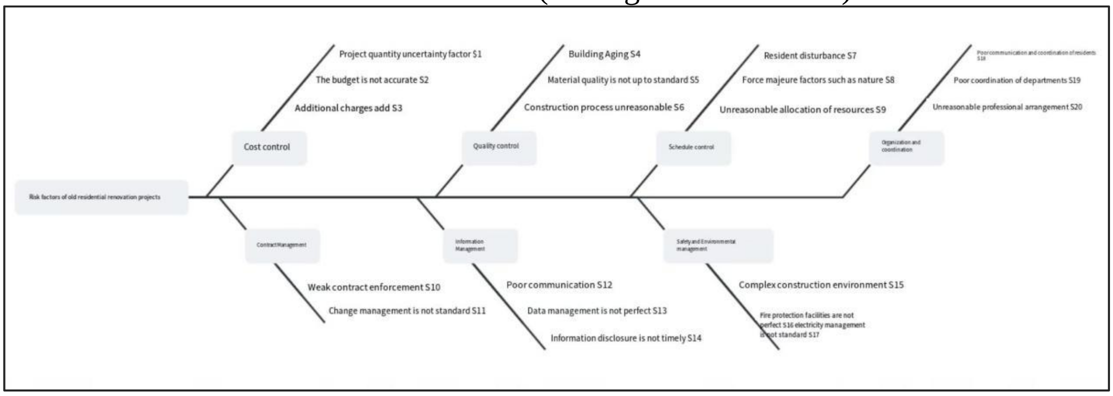

Figure 1 Fishbone diagram of risk factors of old residential renovation projects

4. Construction of ISM model and factor hierarchy analysis

In the above research, 20 risk factors have been identified and numbered for each factor. The reachability matrix M is obtained by adding the adjacency matrix A and the identity matrix I. If the matrix M satisfies $\mathbf{M = (A+I)^{\lambda+1} = (A+I)^{\lambda} \neq (A+I)^{\lambda-1}}$, the reachability matrix M of matrix A is obtained, as shown in Table 1.

Table 1 Reachability matrix M

SI/J	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	1	1	1	0	1	1	0	0	0	0	0	0	0	1	1	0	1	0	0
5	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0

9	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
11	1	1	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
14	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0
15	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
16	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
17	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
18	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
19	0	0	1	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	1	0
20	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1

According to the data in Table 1, this paper uses the ISM module of SPSSAU software to perform systematic calculation and obtains the table of reachable set, advanced set and their intersection (see Table 2 for details), the hierarchical decomposition table of old community reconstruction project (see Table 3 for details) and the schematic diagram of hierarchical relationship of old community reconstruction project (see Figure 2 for details).

Table 2 Reachable sets and antecedent sets and their intersection table

	The reachable set R	The prior set Q	The intersection A=R∩Q
S1	1,2,3,13	1,2,3,4,11	1,2,3
S2	1,2,11	1,2,3,4,11	1,2,11
S3	1,2,3	1,3,4,5,7,8,9,11,15,19,20	1,3
S4	1,2,3,4,6,7,15,16,18	4,16,17	16,4
S5	3,5	5	5
S6	6	4,6,8	6
S7	3,7	4,7,14,18	7
S8	3,6,8	8,12	8
S9	3,9	9,19,20	9
S10	10,11	10,11	10,11
S11	1,2,3,10,11,13	2,10,11,19	10,2,11
S12	8,12,14	12,19	12
S13	13	1,11,13,19	13
S14	7,14,18	12,14	14
S15	3,15	4,15	15
S16	4,16	4,16	16,4
S17	4,17	17	17
S18	7,18	4,14,18	18
S19	3,9,11,12,13,19	19	19
S20	3,9,20	20	20

Table 3 Hierarchical decomposition table of old residential renovation projects

Level of hierarchy	The elements
Floor 1 (top floor)	S2,S6,S10,S13,S16
Level 2	S1,S3
Level 3	S5,S7,S8,S9,S11,S15
Level 4	S18,S20
Level 5	S4,S14
Level 6	S12,S17
Floor 7 (bottom floor)	S19

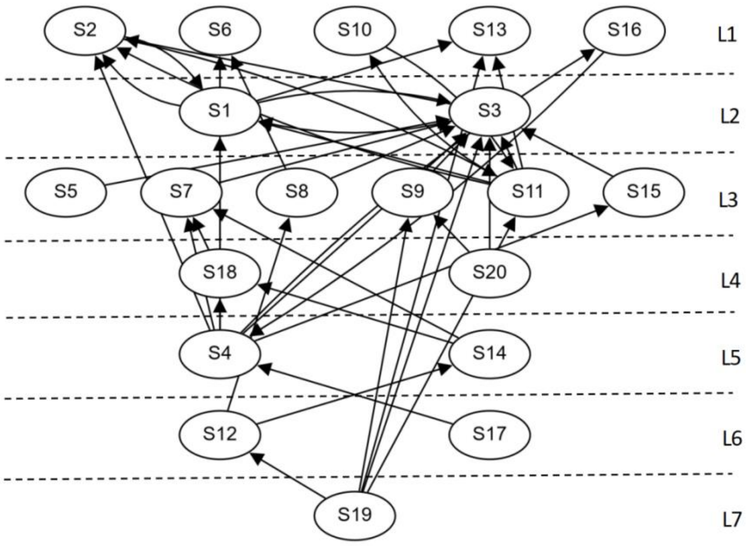

Figure 2 Schematic diagram of the hierarchical relationship of old community reconstruction projects

According to the above data, this paper divides the seven hierarchical factors in the hierarchical decomposition table of the old residential area reconstruction project into three aspects for analysis: top, middle and deep influencing factors.

Top-level influencing factors: it is the most directly influential factor in the reconstruction project of old residential area, including the following five factors: S2 - inaccurate budget, S6 - unreasonable construction technology, S10 - weak contract execution, S13 - imperfect data management, S16 - imperfect fire facilities.

Top-level factors are the basic conditions for project implementation, which have a direct impact on the project.If these factors cannot be reasonably controlled, the project will face major challenges in cost, schedule, quality, contract and safety. Therefore, in the early stage of the project, it is necessary to give priority to fully control the top-level factors, and ensure a solid foundation for the reconstruction project of old residential areas through accurate budget, reasonable construction process design, perfect contract management process and data management system, and fire protection facilities, so as to reduce the potential risk transmission to the middle and bottom layers.

Middle-level influencing factors: Middle-level factors involve all aspects of project management, mainly play the role of connecting the past and the next, and need to be continuously monitored during project implementation, including the following 8 factors: S1 - Uncertain factors of engineering quantity, S3 - Additional cost increase, S5 - substandard material quality, S7 - residents' interference, S8 - force majeure factors such as nature, S9 - Unreasonable resource allocation, S11 - non-standard change management, S15 - Complex construction environment.

In the process of project implementation, the middle-level influencing factors mainly involve the uncertainty of engineering quantity, the substandard quality of materials, the non-standard change management, the unreasonable allocation of resources and the influence brought by the external environment. For these influencing factors, managers should start from the reality of the project, flexibly respond to various possible changes, and ensure the smooth progress of the project and effectively reduce the risk of project interruption or rework by establishing a standardized change management mechanism, reasonable resource allocation and carrying out sufficient communication with residents.

Deep influencing factors: Deep factors are located at the bottom of risk management, usually belonging to outcome risks, and are comprehensively affected by upper-level factors, including the following seven factors: S4 -Aging buildings, S12 -Poor information transmission, S14 -untimely information disclosure, S17 -non-standard power consumption management, S18 -poor communication and coordination among residents, S19 -poor coordination among departments. S20 - Unreasonable professional arrangements.

The bottom factor is the risk result of long-term accumulation, often the product of multiple upper and middle factors. The underlying factors affect the cooperation between departments, reasonable task arrangement, timely and effective project information transmission, residents' communication and cooperation, safe power consumption management and other key indicators. To effectively control the underlying risks, the project management team needs to optimize the construction process, ensure the smooth and timely disclosure of information, eliminate the hidden dangers of building safety, and improve the level of power consumption management with the support of the top-level and middle-level factors. Meanwhile, through active communication with the residents and community collaboration, the satisfaction of the residents and the successful completion of the project were guaranteed.

5. MICMAC driving type and dependency analysis

According to the data in Table 1, the driving force and dependence of the risk factors of the old residential area reconstruction project can be calculated, and the calculation results are drawn into MICMAC four-quadrant diagram (see Figure 3 for details). Taking the arithmetic mean of driving force and dependence as the dividing line of the quadrant, taking the driving force as the horizontal axis and the dependence as the vertical axis, and their mean value as the dividing line, the coordinate system is established, and the influencing factors are divided into the following four quadrants: autonomous cluster, dependent cluster, associated cluster and independent cluster.

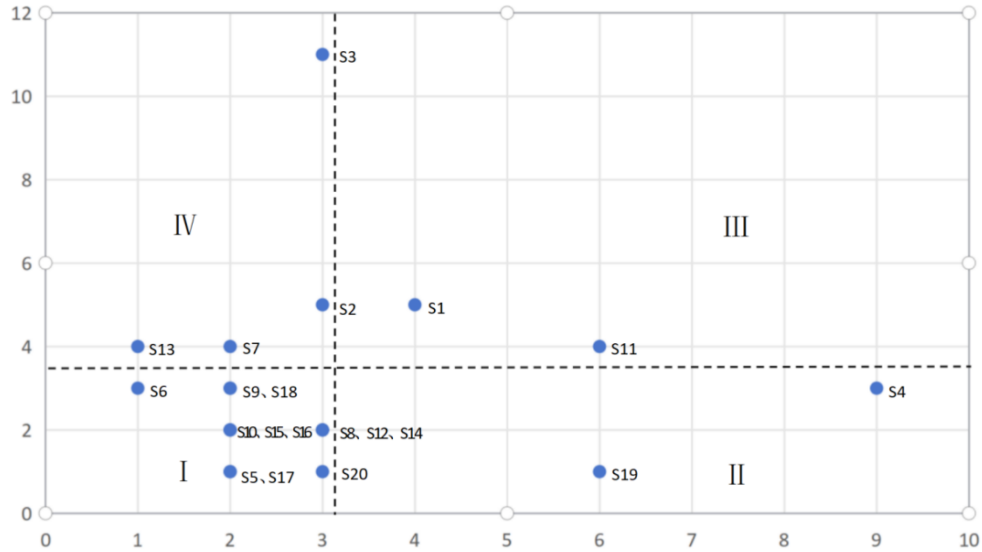

Figure 3 Driving force of risk factors of old residential renovation projects-dependence

According to the driving force dependence diagram of risk factors of old residential area reconstruction project based on MICMAC matrix results, each risk factor can be divided into four categories:

1) Independent zone (I quadrant) : such factors have low driving force and dependence, limited scope of influence, and are less affected by other factors in the system. In this figure, 12 factors such as S5, S6, S8, S9, S10, S12, S14, S15, S16, S17, S18, and S20 fall into this category and can be considered as secondary factors.

2) Connection zone (Quadrant II) : this type of factor has a high driving force but low dependence, and has a strong impact on other factors. In the figure, 2 factors such as S4 and S19 fall in this region, indicating that they have a significant impact on the rest of the system and are key drivers that need to be focused on management.

3) Dependence zone (Quadrant III) : These factors have low driving force, but high dependence and are greatly affected by other factors in the system. In this analysis, two factors, including S1 and S11, belong to the dependence zone, indicating that the status of these factors depends on the changes of other factors.

4) Dual zone (Quadrant IV) : Such factors have high driving force and dependence, are the core factors of the system, and have a decisive impact on the overall behavior of the system. Four factors, including S2, S3, S7 and S13, belong to this region and are the key factors that need to be controlled preferentially.

6. Conclusions

Based on the theoretical framework of "three control, three management and one coordination", combined with the fishbone diagram, ISM and MICMAC methods, this study systematically analyzed the risk factors and the relationship among the factors of the old residential area reconstruction project from the perspective of contractors, and drew the following conclusions:

1) Hierarchy of risk factors: With the help of ISM model, the risk factors of the project are carefully divided into 7 levels. Among them, the top-level factors (such as inaccurate budget S2, unreasonable construction technology S6, etc.) have the greatest impact on the project and are the key factors for the priority control of the project. For the middle-level factors (such as uncertain engineering quantity S1, residents' interference S7, etc.), continuous and close monitoring should be carried out during the implementation of the project. Deep factors (such as poor department coordination S19, poor information transmission S12, etc.) are the resulting risks accumulated over a long period of time, which need to be alleviated by optimizing the management process and strengthening communication and collaboration.

2) Driving force and dependence of risk factors: Through MICMAC analysis, risk factors are clearly divided into independent zone, connected zone, dependent zone and dual zone. In these areas, dual zone factors (such as inaccurate budget S2, additional cost increase S3, etc.) have high driving force and high dependence, which are the core risks of the system and need to be controlled in the process of project management. The connected zone factors such as aging buildings S4, poor departmental coordination S19, etc., have a significant impact on other factors and are the focus of project management.

3) Risk management from the perspective of contractors: from the perspective of contractors, combined with the theoretical framework of "three control, three management and one coordination", a series of targeted risk management strategies are put forward. By strengthening the identification of hidden engineering quantity, improving the budget level, making detailed schedule plan, improving the construction technology level, improving contract management, strengthening communication with residents and community cooperation and other measures, contractors can effectively deal with all kinds of risks in the project and ensure the smooth implementation of the project.

This paper combines the fishbone diagram, ISM-MICMAC method and the theoretical framework of "three control, three management and one coordination" for the first time, and systematically analyzes the risk factors and their interrelations of old residential renovation projects from the perspective of contractors, making up for the shortcomings of the existing research. The risk factor system and coping strategies proposed in this study provide practical and reasonable theoretical reference and decision-making basis for contractors, which is of great significance to improve the success rate and sustainable development ability of old residential renovation projects.

References

[1] Chen Guangling.. Research on risk management of Old Community Reconstruction Project [D]. South China University of Technology, 2021

[2] Huo Xiaosen, Xue Hao, Jiao Liudan. Risk management of retrofit project in old residential areas under green development [J]. Energy & Buildings, 2023: null.

[3] Meng Min.. Research on Risk Management of contractors in Old Community Reconstruction Project [D]. Tianjin University of Technology, 2023

[4] Li Jun.. Research on Risk management in Construction Stage of Reconstruction Project of Old Residential Area in J Community [D]. Jiangxi University of Finance and Economics, 2024

[5] Wang Liangcheng, Chen Xiaohu.. "Three control, three Management and One Coordination" of construction units [J]. Shanxi Architecture, 2017, (12): 233-235.

[6] Dong Qingli, Xu Wenbin, Xu Wenting.. Fire accident analysis of shopping mall based on fishbone diagram [J]. Anhui Architecture, 2020, (11): 100-102.

[7] Xu, S., Xiong, M. & Zhang, C. Influencing factors of green construction based on ISM-MICMAC and AHP [J]. Journal of Fujian University of Engineering, 2021, 19(03): 261-267.

[8] Zhou Xianhua, Pan Hongting, Shen Yunfei.. Risk factors evaluation of underground comprehensive pipe corridor PPP model: based on ISM-MICMAC model [J]. Friends of Accounting, 2017, (13): 59-64.

[9] Li Mingzhu, Wang Wendong, Zhang Zhichao.. Research on construction Risk factors based on ISM and MICMAC [J]. Journal of Safety and Environment, 2022, (01): 22-28.

[10] Bai J., Fan Y. Long. Research on Influencing factors and Strategies of EPC Project Bidding based on ISM-MICMAC [J]. Construction Economics, 2023, 44(S2): 78-84.