Risk Assessment of Knowledge Transfer in Green Building Based on ISM-MICMAC

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Abstract. Green buildings have made a significant contribution to low-carbon and energy-saving. However, green construction projects will face greater risks than traditional construction projects due to their high cost and complex technology. Having important information or knowledge can help the project organization to stifle the risk at the source. This paper intends to improve the efficiency and effectiveness of knowledge transfer by studying the risk assessment in the process of knowledge transfer between project organizations, thereby helping to reduce the risk of green building projects. This paper first explores the influencing factors of knowledge transfer and the interrelationship between the influencing factors by analyzing the existing literature; then uses ISM method and the MICMAC analysis method, to sort out the order and hierarchy of the influencing factors in knowledge transfer, and analyze at the same time their forces of driving and dependences. Then author proposes countermeasures to the risk of knowledge transfer between project organizations. The results show that the two types of risks, low network connection strength and lack of transfer mechanisms, have a greater impact on knowledge transfer, but they are easy to manage. Therefore, construction project managers should identify these factors first and take certain measures to avoid these risks.

1. Introduction
In the current era of knowledge economy, knowledge management has become the key to the long-term development of enterprises' core strategies. Any organization or enterprise must improve the level of knowledge management to cope with the rapid changes in the competitive environment [1]. Knowledge transfer is a very important part of knowledge management, which refers to the exchange of knowledge between the transmitting party and the receiving party. Through knowledge transfer, companies can master the required knowledge, reduce waste of resources, reduce costs, and improve their own innovation capabilities, thereby enhancing their core competitiveness and promoting the sound development of the company.

Many scholars have done a lot of research on engineering construction knowledge transfer. In terms of influencing factors of knowledge transfer: Guo Jienan's study found that the leadership of project managers is the key factor influencing knowledge transfer [2]. Ren Xu analyzed the similarity of projects through research and analysis to promote communication between projects, increase the willingness to transfer, and then have a positive effect on the effectiveness of knowledge transfer; at the same time, the application of information technology can promote communication and compensate for geographical distance to knowledge transfer [3]. Sun Jian believes that the temporary nature of the
project will not affect the knowledge transfer of construction engineering, but the urgency of the project has a beneficial effect on the knowledge transfer, and the adjustment of the relationship between the transfer subjects has no obvious impact on the knowledge transfer [4]. In terms of knowledge transfer risk: Zhai Yunkai roughly summarizes the risks according to the stage of occurrence as the ability and collaboration risk of the knowledge transfer subject in the pre-intermediate stage, the risk of knowledge damage during the transfer process, and the intellectual property risk in the mid-late stage. The ability of the main body of knowledge transfer and the risk of collaboration at the stage have a greater impact [5]. Li Baizhou and Xu Guangyu divided knowledge transfer risk into three categories: knowledge characteristic risk, knowledge transfer collaboration risk, and knowledge transfer subject risk, and concluded that reducing knowledge characteristic risk is the basis, reducing collaboration risk is the key, and reducing subject risk is a guarantee [6].

At the same time, this article also conducts a lot of research on study methods. Dai Hongmei and Qin Ying used ISM combined with the MICMAC method to study the factors restricting the promotion of prefabricated concrete buildings and their correlation, and derive the control model and the mutual influence of the restrictive factors [7]. Zheng Mengya used the DEMATEL method to determine the key risk factors in the application of BIM in construction engineering costs, and used ISM to analyze the internal logical relationships of many elements [8]. Scholars such as Roma believe that the research of influencing factors is similar to the decision analysis of complex problems with multiple criteria and multiple goals. For problems that are difficult to quantify and complex research objects, common methods in the field of systems engineering science and decision-making can be used for reference. For example, ISM can help to explore the multi-level hierarchical structure of complex systems [9]. Zhou Wei used ISM to clarify the hierarchical structure of the influencing factors [10].

At present, there are gaps in the research on risk assessment of knowledge transfer, and the ISM and MICMAC methods are suitable for modeling the relationship structure and interaction between various elements, and have obvious advantages for risk research and analysis of complex scenarios in the field of engineering construction. Therefore, this paper uses ISM combined with MICMAC method to study the risk in the process of knowledge transfer among engineering cooperative companies.

2. Research methods and risk factor identification

2.1. Research methods
This paper investigates a large number of literatures, finds the 14 most representative factors affecting engineering construction knowledge transfer, and identifies the relationship between the factors. Because there are many influencing factors and complex relationships in the process of knowledge transfer, the effect of knowledge transfer has great uncertainty. In order to further analyze the risks in the knowledge transfer process, it is first necessary to sort out the complex relationships between the influencing factors. Therefore, author selects the ISM method to analyze the restrictive relationships between risk factors, and at the same time, the MICMAC method is used to classify the driving forces and dependencies of risk factors. Finally, the improvement plan for the effect of knowledge transfer is studied from the relationship of mutual influence and restriction.
2.2. Risk factor identification

| relationship (the front items affect the latters) | Authors | Literature source | Specific explanation |
|--------------------------------------------------|---------|-------------------|---------------------|
| Temporary nature of the engineering project, trust (A1, A4) | Jian Sun, Xu Ren, Chimay J. Anumba | Analysis of knowledge-transfer mechanisms in construction project cooperation networks | No effect. China's unique interpersonal communication culture has formed unique cooperation practices. People who have worked together before and have a foundation of trust between each other tend to be chosen. Therefore, the temporary nature of engineering project has little impact on the trust between members [4]. |
| Temporary nature of the engineering project, network connection strength (A1, A3) | Jian Sun, Xu Ren, Chimay J. Anumba | Analysis of knowledge-transfer mechanisms in construction project cooperation networks | No effect. China's unique interpersonal communication culture has formed a cooperative network, which makes the cooperative relationship between members long-term. When the project is completed, although the organization will be dissolved, the cooperative relationship between the members will be retained and passed on. Therefore, the temporary nature of the project has nothing to do with the strength of the cooperation network [4]. |
| The urgency of the project, Network connection strength (A2, A3) | Jian Sun, Xu Ren, Chimay J. Anumba | Analysis of knowledge-transfer mechanisms in construction project cooperation networks | Negative effects. When the project schedule is urgent, the frequency of regular project meetings and coordination meetings will increase, and the frequency of communication between participants will increase significantly [4]. |
| The urgency of the project, provider willingness (A2, A5) | Jian Sun, Xu Ren, Chimay J. Anumba | Analysis of knowledge-transfer mechanisms in construction project cooperation networks | Negative effects. The profit of knowledge transfer is difficult to quantify. The knowledge providers, that is, the owners of knowledge, often lack the motivation to share knowledge. In the case of urgent project schedules, they lack the energy to share their experience and knowledge, especially tacit knowledge [4]. |
| The urgency of the project, receiver willingness (A2, A6) | Jian Sun, Xu Ren, Chimay J. Anumba | Analysis of knowledge-transfer mechanisms in construction project cooperation networks | Positive effect. The role of knowledge recipients is a knowledge-seeking organization or enterprise. In an emergency, the willingness of knowledge-seeking enterprises to learn advanced experience and skills will be stronger [4]. |
| Similarity of projects, network connection strength (A7, A3) | Xu Ren, Darr and Kurtzberg, Lewis et al. | Knowledge transfer between projects within project-based organizations: the project nature perspective | Positive effect. In order to solve similar problems and avoid similar mistakes, the project team is more likely to discuss and exchange experiences frequently. Due to the similarity of projects, communication barriers between projects are reduced, making communication between teams easier [3]. |
| Network connection strength, willingness of provider and receiver (A3, A4/A5/A6) | Jian Sun, Xu Ren, Morgan, Hunt | Analysis of knowledge-transfer mechanisms in construction project cooperation networks | Positive effect. The more intersections exist between companies, the more opportunities they will have to learn technology and management knowledge, which will help to increase mutual trust and willingness to share knowledge [4]. |
| Trust, willingness of provider and receiver (A4, A5/A6) | Jian Sun, Xu Ren, Naoum, Szulanski et al. | Analysis of knowledge-transfer mechanisms in construction project cooperation networks | Positive effect. Trust makes knowledge recipients believe that the source of the knowledge imparted to them is reliable, and they do not worry about exposing their weaknesses to other participants in the process of acquiring knowledge. Knowledge providers will also be more willing to provide knowledge to trusted organizations [4]. |
|---|---|---|---|
| Knowledge distance, receiver willingness (A8, A6) | Jian Sun, Xu Ren, Shengyue Hao | Research on the Influencing Factors of Knowledge Transfer in the Project Cooperation Network | Positive effect. Through the study of cross-border knowledge, one can expand one's own knowledge field and combine cross-border knowledge with one's own knowledge to realize knowledge innovation. Therefore, in the face of diverse knowledge resources, companies often have a higher willingness to transfer knowledge [11]. |
| Network connection strength, tacit knowledge (A3, A13) | Chunhao Li, Xiongying Niu, Lyttinen, Rydberg | A Commentary on the Influencing Factors of Knowledge Transfer of International Expatriates | Positive effect. Increasing the way and frequency of communication, such as team activities, job rotation, etc., to enhance the strength of the cooperation network, can increase the opportunity to obtain tacit knowledge [12]. |
| Transfer mechanism, willingness of provider and receiver (A14, A5/A6) | Helai Zhou | Analysis of the Causes of Knowledge Stickiness and Exploration of Governance Measures | Positive effect. By establishing an incentive mechanism or a shared cultural mechanism between cooperative organizations, a good transfer atmosphere is formed, which can improve the motivation or willingness of the knowledge provider or receiver [13]. |
| Ability of provider and receiver, tacit knowledge (A9/A10, A13) | Helai Zhou | Analysis of the Causes of Knowledge Stickiness and Exploration of Governance Measures | Positive effect. The stronger the transformation and transfer ability of the knowledge provider, the less sticky knowledge will be formed, and the easier it is to acquire tacit knowledge. If the knowledge-providing receiver has stronger ability of recognition, reception, and application, it will be easier to identify and acquire tacit knowledge [13]. |
| Tacit knowledge, trust (A13, A4) | Helai Zhou | Analysis of the Causes of Knowledge Stickiness and Exploration of Governance Measures | Negative effects. Some knowledge is inherently invisible, difficult to express and easy to express or be misunderstood, causing dissatisfaction with the recipient and reducing trust between both parties [13]. |
| Application of Information Technology, network connection strength and trust (A12, A3/A4) | Xu Ren, Lihua Liang, Karlsen, Gottschalk, Mansour, Wiewiora | Knowledge Transfer Between Projects within Projects-based Organizations: the Project nature perspective | Positive effect. The emergence of IT technology has made it easier to save or restore knowledge, reduce the cost of communication, increase the transfer speed and channels, and enhance the strength of network connections. On the other hand, it also enhances the intimacy of members and enhances mutual trust [3]. |
| Application of Information Technology, physical distance (A12, A11) | Chunhao Li, Xiongying Niu, Lyttinen, Rydberg | A Commentary on the Influencing Factors of Knowledge Transfer of International Expatriates | Negative effects. Many communication channels can be established through IT technology, such as face-to-face communication through informal networks, so as to reduce the physical distance [12]. |
Physical distance, Network connection strength, trust and tacit knowledge (A11, A3/A4/A13)

Chunhao Li, Xiongying Niu, Lyttinen, Rydberg

A Commentary on the Influencing Factors of Knowledge Transfer of International Expatriates

Negative effects. If the physical distance is smaller, the frequency of face-to-face will be greater, which will increase the frequency of communication, increase the strength and intimacy of the network connection, and thereby increase trust. And it is easier to make tacit knowledge explicit, so that it is easier to obtain tacit knowledge [12].

Willingness of provider and receiver, tacit knowledge and network connection strength (A5/A6, A13/A3)

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Positive effect. When both parties have a high transfer motivation, that is, when the willingness is strong, the knowledge provider will try to transfer its own knowledge. Similarly, the receiver will try to learn to receive, which increases the frequency of communication and makes tacit knowledge explicit, improving the receiving effect of tacit knowledge [14].

3. Model building

Author obtains the relationship matrix of each factor which is showed in Figure 1 through Table 1, and the value of (Ai, Aj) in the matrix indicates whether Ai has a direct influence on Aj. If the value is 1, it means Ai has a direct influence on Aj, otherwise it is 0.

Figure 1 shows that (A3, A5) and (A3, A6) have a strong connection, that is, there is a direct influence between A3 and A5, and A3 and A6. In these two strong relations, one factor should be deleted in each relation, so A3 and A6 are selected here to get the reduced reachable matrix, which can be seen in Figure 2.

|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Driving force |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Dependence 1 2 10 11 10 11 2 1 1 1 3 2 13 1

Figure 1. Reachable matrix.
In the reduced reachable matrix, the number of elements "1" in each row is the number of the factors affected by the factor in this row. Arrange them from less to more, and recombine them into a new matrix. Then decompose the unit matrix of the largest order in turn from the upper left corner to the lower right corner, and add boxes (each box represents a level), then get Figure 3.

It can be seen that the 14 elements in the system can be divided into 6 levels according to the degree of influence from shallow to deep: A1, A8, and A9 are the first level, A4 is the second level, and A3, A5, A6, and A10 are the third level, A13 is the fourth level, A2, A7, A11, and A14 are the fifth level, and A12 is the sixth level. Among them, A12 is IT technology, but in the contemporary information technology era, the IT technology of all enterprises can meet the needs of knowledge transfer, so it is used as a control variable to obtain a hierarchical diagram. It is showed in Figure 4.
Figure 4. ISM structure of factors.

Figure 5 can be obtained, which classifies the relevance of 14 influencing factors, and evaluates the driving force and dependence of risk factors in the knowledge transfer process.

4. Conclusion
This paper sorts out 14 types of risks, which are temporary, urgent, low network connection strength, low network dependency, weak willingness of the provider, weak willingness of the recipient, low project similarity, large knowledge distance, insufficient provider's ability, insufficient recipient's ability, large physical distance, poor application of information technology, invisible knowledge and lack of knowledge transfer mechanism.

The research’s results show that, first, although the factor of network connection strength is located in the middle layer of ISM, it belongs to the linkage group which has a large driving force and high
dependence. Large driving force means that if the network connection strength is low, it will affect many other factors and bring more risks to the system. High dependence means that if the network connection strength is low, the risk that affects it has not been effectively controlled, and further effective measures are needed. Therefore, the risk of low network connection strength should be focused on.

Second, the network dependence and the willingness of the provider and receiver are located in the middle layer of the ISM and belong to the dependent group, which means that these factors are affected and restricted by many other factors and limit the influence of surface factors on knowledge transfer. Once these three risks occur, it indicates that there may be many other risks in the system, which need to be managed and controlled in time.

Third, the risks in the autonomous group are not easily affected by other risks and should be improved from the factors themselves. The project has inherent risks such as temporary, urgency, and low similarity, and cannot be improved. At the same time, risks such as insufficient capabilities of the provider and receiver, large physical distance, and large knowledge distance cannot be effectively controlled in a short time. And there is a lack of transfer mechanism or the risk factor of imperfect mechanism can be avoided through effective measures. Therefore, we should focus on the assessment, management and control of the risk of the transfer mechanism.

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