Research on Risk Management of Prefabricated Construction Supply Chain Based on Immune Principle

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Abstract. The structure of the prefabricated construction supply chain is becoming more and more complex, and the related risks of the prefabricated construction supply chain are becoming more and more prominent. Therefore, it is necessary to strengthen the supply chain risk management of the prefabricated construction enterprise. Firstly, starting from the concept and mechanism of biological immunization, combined with the risk analysis of the prefabricated construction supply chain, the similarity between the risk management of the prefabricated construction supply chain and the biological immune system is discussed, and a risk management model based on the immune principle is established. Further, the corresponding recommendations for risk prevention of prefabricated construction node enterprises are also proposed, which provides new ideas for enterprise risk management activities.

1. Introduction
On the premise of guaranteeing industrial balance, prefabricated construction can improve the efficiency of capital use, optimize the structure of existing industrial chain and improve the environmental pollution of construction by shortening the construction period and reducing the labor cost, etc. [1]. Its own manufacturing characteristics also provide a link for defining the complete functional network chain structure of prefabricated construction. Pieces. As an important part of the construction industry chain, supply chain has high application value by sorting out the logistics, capital flow and information flow involved, optimizing the supply-demand relationship between node enterprises, and reducing the risk of high construction cost brought by prefabricated construction itself from multiple dimensions. Koskela first applied the supply chain management mode of manufacturing industry in the construction field in 1990s, which marked the establishment of the rudiment of the supply chain management mode of construction [2].

The immune system is a robust, complex and parallel adaptive system [3]. These characteristics are very similar to risk management. Both systems must maintain internal stability in a constantly changing external environment. The immune principle can be combined with risk control in dealing with crisis situations and screening different schemes, so as to guide risk management according to immune principle.

Through the existing research, it is found that scholars at home and abroad have made some achievements in the study of risk management of construction supply chain, but there are few studies on assembly construction supply chain, and the existing supply chain risk management rarely combines with bio-immune theory, so as to provide risk management measures for node enterprises. In order to reduce the chain reaction of risk factors caused by the business relationship between supply chain node enterprises and fundamentally reduce risk losses, this paper draws lessons from the theoretical results of bio-immunity research, analyses the similar mechanisms of immune principle and risk management,
and establishes a risk management model based on immune principle. Furthermore, the paper puts forward relevant suggestions on enterprise risk prevention, which provides a new way of thinking for enterprise risk management activities.

2. Biological Immune Theory

The immune system is an important system of immune response and immune function. It consists of immune organs, immune cells and immune molecules. The immune system has the function of identifying and eliminating antigenic foreign bodies and coordinating with other systems of the body. It can maintain the stability of the internal environment and physiological balance of the body together [4]. The immune system plays an important role in the complex and changeable natural environment in which organisms can carry out normal life activities. The mechanism of action of the immune system is shown in Figure 1.

![Figure 1. Mechanism of immune system action](image)

The immune response of the immune system to pathogens and other foreign bodies can be divided into two types: innate immune response and adaptive immune response. These two immune systems are interrelated and constitute the human defense system. When pathogens invade the body, the innate immune system is the first defense, which can defend against a variety of pathogens. If the pathogen breaks through the first line of defense, the adaptive immune system recognizes and eliminates the pathogen. Adaptive immunity is the specific active response of organism under the stimulation of antigen to obtain or passive immunization with immune vaccine [5].

The immune system of organism can recognize self-cells and non-self-cells from a large number of cells, thus realizing the function of eliminating disidents and protecting the integrity of the organism. The reason why the immune system has high defensive ability is that it has highly evolved intelligent functions such as immune protection, immune surveillance, immune defense, immune memory and so on [6]. Therefore, we can draw lessons from the functions of immune protection, immune surveillance, immune defense and immune memory of biological immune system to establish a risk management model based on immune principle, thus providing a new and effective way of thinking and method for risk management of prefabricated construction supply chain.

3. Risk Analysis of Prefabricated Construction Supply Chain

The supply chain management of prefabricated construction enterprises is a kind of project management based on engineering projects, standardization of design, factories of manufacture, integration of construction prefabricated, decoration and management informatization, and sharing of project information, in order to achieve the optimal completion effect of the project and win-win results of the participants. All participants (general contractors, owners, suppliers, manufacturing and construction subcontractors, etc.) collaborative and integrated management model [7]. Emphasis is laid on the integrated management of all departments and external participants in the core enterprise in the supply chain. Through the realization of information sharing and the establishment of strategic partnership, the
efficiency of the enterprise can be improved and the purpose of rapid response to market changes can be achieved.

Supply chain risk management can be divided into four stages: risk identification, risk assessment, risk control and risk management feedback [8]. Taking the supply chain risk management of prefabricated housing construction as an example, the risk analysis is carried out. The supply chain risk of assembled housing has the characteristics of systematicness, dynamics and complexity [9]. According to the general classification principle of risk factors, combined with the previous research results and the characteristics of the operation structure of the prefabricated housing supply chain, it is divided into two parts: internal risk and external risk. The external risk factors of the supply chain of assembled housing are mainly related to the environment, including natural risk, political risk, economic risk, market risk, fluctuation risk of owner's demand and immature risk of industrial chain. In a word, the supply chain changes badly during the whole life cycle of the prefabricated housing construction, and the risk factors related to the external environment can be attributed to external risks. Internal risk mainly refers to the risk on the chain, which is usually caused by the blockage of information channels or uncoordinated cooperation among enterprises in the supply chain.

4. Project Risk Management Based on Immune Principle

4.1. Principles of Biological Immunity and Risk Management

It is reasonable to use immune system for risk management research. Firstly, when the immune system is invaded by outsiders, self and non-self identification will be carried out, and then the antigens will be tolerated, rejected or eliminated according to the results of identification. In the face of complex risk events, on the one hand, the management system must have sufficient stability and sustainability, on the other hand, after risk identification, the system will adopt different risk responses according to different analysis results to minimize losses and optimize the overall objectives of the project. For example, the way of accepting, mitigating, transferring or avoiding negative risks. Secondly, when the immune system is stimulated by the same antigen again, the memory cells will be activated for recognition and processing, and when the antigen mutates, the immune system will re-regulate the production of new memory cells. In risk management, the corresponding management departments establish and update risk registers and risk databases to provide strong support for dealing with similar risk factors in risk management. In addition, maintaining an appropriate number of antibodies immune regulation mechanism without external invasion is in line with the fact that even in the absence of risk, we should strengthen the supervision of risk sources, internal and external conditions of the project and other elements to ensure the smooth development of the project. In addition, the immune system continues to provide fast and stable feedback to external objects, similar to the continuous updating and feedback of information as the project progresses in risk management. Finally, the stable autoimmune tolerance and immune regulation of the immune system correspond to the stable construction of the whole project environment through risk management in the project. The corresponding relationship between immune system and risk management is shown in table 1.

| Immune system          | Risk management                      |
|------------------------|--------------------------------------|
| Immune organ           | Risk management department           |
| Antigen                | Risk event                           |
| Antibody, B cell       | Risk management measures             |
| Antigen and antibody affinity | Risk measure assessment         |
| Crossover              | Risk management measures change      |
| Autotolerance          | Risk register assessment             |
| Memory cell            | Risk case library                    |
4.2. Risk Management Model Based on Immune System

Enterprise is the basic unit of building supply chain, and the close business cooperation among enterprises in supply chain leads to a strong correlation between their operational risks [10]. The supply chain risk management model based on immune theory has strong environmental adaptability and evolutionary learning ability, and can effectively enhance the risk resistance of supply chain. The risk management model of prefabricated construction supply chain based on immune principle is shown in figure 2.

In this process, "immune identification" is the first step of supply chain risk management activities. In this stage, enterprises should make two judgments in turn: first, to judge whether the current suspected risk events belong to the risk events which are different from the normal activities of enterprises and may cause losses to enterprises. If the threat of suspected risk events to enterprises can be ruled out, immunization activities can be directly taken. Successful, follow-up work can be operated according to the normal workflow of the enterprise. When a suspected risk event is identified as a risk event, it is necessary to further determine whether the risk event has been recognized by the enterprise. If the risk is a known risk event, it can be directly entered into the next disposal activities according to past experience. If the risk is an unknown risk event, it must be further analyzed and studied to achieve the purpose of identification. It should be pointed out that the basis for judging suspected risk events in immune recognition activities comes from the "risk event feature database" of enterprises. The "Risk Event Characteristic Database" established by enterprises is a detailed record of the risk events they have known and dealt with in the past.

![Risk Management Flow Chart Based on Immune Principle](imageURL)

Figure 2. Risk Management Flow Chart Based on Immune Principle
The next stage of immune response is the specific process of risk management. For the risk events that have been identified by immunization, the corresponding risk disposal strategies stored in the "risk event feature database" can be directly invoked at this stage to deal with the risk events. The results of immune response directly determine the success or failure of risk event processing. The results produced in this stage should be recorded in the "risk characteristics database" for enterprise members to learn and memorize, as well as the need for reference in the next risk identification work [11].

The process of storing the relevant information of risk processing results into the "risk event feature database" is the "immune memory" stage. The significance of this stage is to update the original database with new risk information, and to expand the capacity of the database with the increase of the types and quantity of risks dealt with by enterprises over time, so as to provide more sample support for the follow-up risk identification work. At the same time, after the completion of the immune response, the disposal process and effect were timely collated and summarized. The work of immune learning mainly involves two activities: one is to learn about unknown risk events in the process of immune response; the other is to organize and summarize the disposal process and effect of immune response in time after completion of immune response.

Based on the above activities, enterprises have the ability to resist risks effectively. Accordingly, we can also use the idea of immunology to describe the ability of enterprise risk management system.

5. Conclusion
Risk management model based on immune principle is a complex system. Enterprises need to make full use of existing information and experience to manage the supply of existing assembly building, and deal with risks quickly and efficiently. Therefore, based on the current situation of risk management, the following suggestions are put forward.

First, improve the level of enterprise risk management technology. Assembled construction supply chain involves many enterprises and its structure is complex. Full-time risk immunization department should be established to collect and study internal and external information for enterprises, exercise surveillance function, and enhance the ability of resisting risks and self-correcting [12]. Interim committees can also be set up. When important internal and external events occur in enterprises, members of the interim committees will participate in information communication, action coordination and solution formulation. Second, establish a perfect supplier management system. There are many kinds of raw materials and parts purchased in the assembly construction industry, involving many and miscellaneous suppliers. Establishing a perfect supply chain management system is conducive to improving the ability of the whole supply chain and reducing the risk of the supply chain.

References
[1] Liu Kangning, Zhang Shoujian, Su Yikun. A review of the field of fabricated building management [J]. Journal of Civil Engineering and Management, 2018, 35 (06): 163-170+177.
[2] Koskela L. Application of the new production philosophy to construction[J]. Physics Letters B, 1992 (2) : 182-184.
[3] Yuan Gang. Study on Artificial Immune System and Its Algorithm[J]. Software Guide, 2013, 12(02):35-37.
[4] Chen Shuzeng, Yang Wei, Qiu Danyi, editor. Pathogen Biology and Immunology, 2nd ed. Wuhan: Huazhong University of Science and Technology Press, 2015.08: Page 9
[5] Wang Xingqiong, Chen Weizheng. Organizational Health: Concepts, Features and Dimensions[J]. Advances in Psychological Science, 2008(02):321-327.
[6] Zhang Jianguang. Research on the Operation Mechanism of Enterprise Immune System [D]. Wuhan University of Technology, 2012.
[7] Liu Tangliang. Research on Supply Chain Risk Management of Prefabricated Building Enterprises [D]. Chongqing University, 2016.
[8] Cheng Guoping, Sheng Gangbing. The Construction and System Exploration of Supply Chain Risk Management Model[J]. Consumer Guide, 2009(06):114-115.
[9] Li Wei. Research on Risk Management of Prefabricated Residential Supply Chain [D]. Qingdao Technological University, 2018.

[10] Ru Baofeng. Simulation study of supply chain risk management based on artificial immune [D]. Xiamen University, 2014.

[11] Wang Nan. Research on the relationship between enterprise risk management elements and risk management performance from the perspective of immunization [D]. Jilin University, 2015.

[12] Lü Ping, Wang Yihua. Study on Tissue Immunity Behavior and Mechanism [J]. Journal of Management, 2009, 6(05): 607-614.