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Research on the Drivers of Resilience in the Supply Chain of Assembled Buildings

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Abstract: With China's "double carbon" emission reduction target and the demographic dividend of the construction industry fading out, the construction industry is facing the problem of transformation and upgrading. The development of assembled construction requires a change in the overall supply approach of the construction industry and the introduction of manufacturing supply chain management and resilience management ideas into assembled construction management to solve existing management problems. Supply chain toughness integration is an important means to promote the development of assembled buildings. The current cooperation mechanism of the main bodies of the assembly construction supply chain is not perfect, and the motivation of integration is not clear, resulting in low efficiency of enterprise synergy. In order to improve the efficiency of the supply chain, this paper first identifies the influencing factors and then the driving factors of the supply chain resilience of assembled construction through literature extraction method, and then identifies the key driving factors through questionnaire survey method and expert interview method. This paper addresses the key drivers and determines their relevance by questionnaire survey method.

1. Introduction

1.1. Background of the Selected Topic

At the present stage, China's construction industry is still a traditional industry with labor-intensive and cast-in-place construction as the main method. With the disappearance of the demographic dividend in recent years, the traditional rough construction mode no longer meets the requirements of China's gradual maturation into industrialization. With the "double carbon" emission reduction target and the net inflow rate of construction workers declining year by year, the industrialization of construction has found an opportunity for development. Through a series of encouraging policies issued by the national and local governments, the development of China's construction industrialization has been given a new impetus.

Drawing on the successful development experience of assembled buildings in western countries, China began to advocate the vigorous development of assembled buildings. At the national level, a number of documents, including national standards and industry standards, have been issued one

after another to support the development of China's assembled building industry in all aspects, including design, manufacturing and construction.

With the rapid development of the industry, local governments in China have also responded positively to the national policy by issuing guidelines and supporting measures on the development of assembled buildings, such as the "Opinions of the Provincial Government on Promoting the Reform and Development of the Construction Industry" issued by Jiangsu Province, which explicitly mentions the goal of the province's assembled buildings occupying 30% of the province's new buildings by 2020. On this basis, although relevant policies have been promulgated to support it, the development of China's assembled building industry is still at a preliminary stage, so there is more theoretical research than actual practice [1].

At this stage, there are still many problems in China's assembled buildings, and they cannot compete with traditional cast-in-place buildings in the short term. The high cost of investment has led to the lack of large-scale production, so it is not outstanding in terms of cost advantages [2]; secondly, there is a general lack of certain basic discussion and research in this industry about assembled structures, and there is also a lack of effectiveness and continuity between departments, and the total level of construction management needs to be improved [3]; finally, the current imperfect industrial chain of assembled buildings in China has led to the initial cost of the production enterprises of components higher, and thus the synergy of design, construction and management is not strong [4].

Stable capital flow, information flow and logistics are formed between enterprises through direct or indirect roles, and sound flow of these three aspects, thus ensuring the longevity and stability of the supply chain to achieve its function. In recent years, the research on supply chain management in domestic construction industry mainly focuses on construction supply chain management model, supplier management, logistics management, information management, performance evaluation, risk management, green supply chain, etc. The research content is fragmented and not deep enough [5]. Lean thinking has been introduced in the construction industry for supply chain management, emphasizing the idea of "zero inventory". However, Ruiz-Ben ́ez et.al [6] showed that lean supply chains, which emphasize minimizing inventory, are more vulnerable to uncertainties such as disruptions and failures of major information systems.

Some scholars have found through their research that some manufacturing companies that apply lean thinking still maintain high levels of inventory, i.e., supply chain resilience management coexists with lean management, allowing the supply chain to quickly return to normal or ideal conditions when it is affected to cope with supply chain uncertainty.

1.2. Significance of the Selected Topic

The supply chain resilience of assembled construction is the ability of the supply chain to restore supply in response to risk, which is directly expressed in the form of flexibility, agility, vulnerability and adaptability. Flexibility, the flexibility to make corresponding adjustments when the market or environment changes; agility, the speed to make timely responses when unexpected events occur [7]; vulnerability, the nature of the supply chain to be adversely affected in the event of an unexpected, perturbed situation; and adaptability refers to the ability of the supply chain to adapt and respond to environmental changes through learning. The increase in flexibility, agility, and adaptive capacity all contribute to the resilience of the assembly building supply chain, while increased vulnerability leads to a decrease in resilience. The concept of resilience is borrowed from materials science and refers to the ability of a material to return to its initial shape after deformation [8].

Although the above-mentioned scholars or institutions have studied the supply chain emergency

response capability and supply chain risk factors from different aspects, none of them understands the impact factors and structure of resilient supply chain in response to emergencies from the perspective of "consensus"[9]. It is because of the inadequacy of the traditional management model of assembly construction and its difference from the manufacturing and traditional construction industries that its supply chain resilience management is more important.

This paper integrates the lean management ideas used in the traditional construction supply chain and the resilience evaluation methods in the manufacturing supply chain to the study of the resilience of the assembly building supply chain, uses the literature analysis method and the explanatory structure model to identify the key factors influencing the resilience of the assembly building supply chain and their interrelationships, and proposes the assembly building supply chain resilience improvement strategies from the perspective of the assembly building supply chain as a whole and from the perspective of each participating unit in the whole life cycle. The study proposes strategies to improve the resilience of the assembly building supply chain from the perspective of the whole assembly building supply chain and from the perspective of each participating unit in the whole life cycle.

2. Research Status

2.1. Status of Research on Assembled Buildings

As the birthplace of prefabricated buildings in Europe, the industrialization of construction emerged early in Europe, and a large number of residences were built in Europe and Japan through industrialized construction to meet the needs of social development. The remarkable characteristic of green and sustainable construction industrialization is in line with the sustainable development strategy of developed countries, and assembled buildings have been developed rapidly in many developed countries. The development of assembled buildings in foreign countries includes three stages: the initial stage, the development stage and the mature stage. In the initial stage, the main focus is on the establishment of an industrialized production system; in the development stage, the main focus is on improving the quality and diversity of building products; and in the maturity stage, the main focus is on the research and development of green buildings as well as resource-recycling homes.

China also started to take the road of construction industrialization in the 1950s due to the influence of foreign construction industry development. Until the early 1980s, the application of prefabricated components developed faster, and prefabricated components such as large-slab buildings and block buildings emerged. In the early 1990s, although the government attached higher importance to the development of industrialized construction, the development of China's assembled buildings encountered a low tide due to economic level limitations and technical quality aspects. In the late 1990s, China's rapid economic development, the productivity of the construction industry The "Opinions on Promoting the Modernization of Residential Industry and Improving the Quality of Residential Housing" issued in 1999 pointed out the need to promote the modernization of residential industry and improve the quality of residential housing. after 2010, with the continuous change of people's consumption concept, people's requirements for the quality of construction as well as energy saving and environmental protection have been increasing, and the construction industry must undergo From 2016 to 2020, the country began to frequently introduce relevant policies, and China's assembly-type construction entered a period of great development. Under the background of sustainable development, the construction industry gradually changes to the direction of high-quality and sustainable development, and the research on the development of assembled buildings has a certain necessity. At present, experts and scholars are increasingly mature in their research on assembled buildings in terms of quality, cost, duration and construction

risks, and certain achievements have been made in the development of assembled buildings.

2.2. Research Status of Construction Supply Chain

At present, the domestic exploration and research on the supply chain of assembled construction is relatively short. The traditional construction supply chain, which is mainly researched by combining relevant research literature and the characteristics of assembled construction to study the concept of assembled construction supply chain, can be described as, with the assembled construction project as the core, the relevant parties involved in the whole life cycle of the project are closely linked through the three forms of capital flow, information flow and logistics A complete functional mesh structure. It includes the planning, design, manufacturing, procurement, transportation, assembly and delivery of each stage of the assembled building, and is a complex system composed of many participants such as developers, designers, constructors and component manufacturers. Innovative thinking according to the current development and needs of the construction industry. First of all, the project management department and relevant personnel should fully understand the importance of project management, go deep into the process of project development and be familiar with the overall management process. The problems encountered in the work should be carefully analyzed and solution measures should be proposed in time, and the accountability system for each link should be implemented. There are fewer studies dedicated to collaborative supply chain management of assembled buildings, and the mechanism of collaborative supply chain management of assembled buildings is not perfect, resulting in low efficiency of collaborative supply chain management [10].

To sum up, construction supply chain is a system engineering involving multiple dimensions and layers, and it is an integrated management idea and method for multiple objectives. The research of experts and scholars on construction supply chain has gradually formed a system, but the current relevant research is still relatively small and installed lack of sufficient theoretical support.

3. Identification and Screening of Driving Factors

3.1. Identification of Driving Factors

Firstly, the literature analysis method was used to collect 21 papers related to the supply chain and supply chain resilience of assembled buildings from databases such as China Knowledge Network and Web of Science, and 6 primary indicators and 21 secondary indicators of supply chain resilience were screened and identified from the literature. Based on the literature analysis method, only 12 journal papers, master's theses and conference papers were searched from China Knowledge Network under the title of "assembly building supply chain"; only 26 journal papers and conference papers were searched. From the number of documents retrieved, it can be seen that scholars at home and abroad have conducted relatively little research on the supply chain of assembled buildings, and the research on its tenacity is even less, and is still in its initial stage.

3.2. Screening of Key Influencing Drivers of the Resilience of the Assembled Building Supply Chain

Based on the current issues of assembled buildings, risk identification of assembled building supply chain, and analysis of resilience influencing factors as the focus, the retrieved literature was analyzed and 21 valid references were screened out. Since assembled buildings integrate design, production, review, transportation, construction, and maintenance, they are subject to numerous influencing factors in the promotion process, and the different influencing factors are also

interconnected and constrained with each other. This study extracts key influencing factors from valid references and further subdivides the identified key driving factors into 21 secondary indicators using all parties in the supply chain as primary indicators. The identified resilience drivers of the assembly building supply chain.

4. Analysis of Results and Suggestions

The top-level direct influence factors are the most direct manifestation of the resilience of the assembly building supply chain. For example, an increase in the degree of component redundancy and transportation redundancy can directly enhance the supply chain resilience.

Secondly, except for the supervisory unit level, each participating unit has an influence factor that can characterize the resilience of the assembly building supply chain, and these influences can be used to visually judge the resilience from the perspective of different participating units. Of particular note is the correlation between two direct top-level influences, crisis awareness and professional and labor training, suggesting that crisis awareness in assembly construction management can facilitate the improvement of professional skills and capabilities of relevant operators and managers to cope with supply chain risks.

Finally the influence of top-level influencing factors on resilience is often cascaded through the influence of intermediate and bottom-level factors, acting in synergy with intermediate and bottom-level influencing factors.

It is the primary influence factor that needs to be focused on for the resilience management of the assembly building supply chain. This result is also a reflection of the high initial investment, low standardization of components, high cost and delay in supply of component manufacturers at this stage in China. Component manufacturers can improve the supply chain resilience of assembled buildings by simplifying the production process and improving the quality and standardization of components.

5. Conclusion

At this stage, relevant research is still in its infancy, and the study of its influencing factors has not yet formed a system, which to a certain extent limits the development of assembled buildings. In order to explore the driving factors, this paper identifies and screens out 15 key influencing factors through literature analysis and expert interviews, analyzes their interrelationships, constructs a structure diagram, and clarifies the logical relationships among the key influencing factors. The fundamental factor is "component manufacturing", the direct factors are "redundancy of components" and "redundancy of transportation", and the indirect factors are "information the indirect factors are "information sharing", "construction technology", etc. This paper analyzes the internal logic of the key influencing factors from a qualitative perspective, which has significant theoretical and practical significance: first, from the perspective of the assembly construction supply chain, the crisis awareness of enterprises can promote the relevant operators and managers to improve their professional skills and levels to cope with supply chain risks; second, the design and logistics of assembly construction are independent and specialized, so from the perspective of design and logistics that enhancing the resilience of the assembly building supply chain is the most effective and direct strategy; third, it reveals the core place of construction units and component manufacturers in the assembly building supply chain.

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