An Investigation on the Variables Affecting the Supply Chain's Resilience for Prefabricated Buildings

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Abstract: Prefabricated structures have steadily gained importance in the construction sector as urbanization has accelerated because of its many benefits, which include efficiency, environmental preservation, and energy conservation. The prefabricated construction supply chain has gained prominence despite its complexity, unpredictability, and risk. In the event of an emergency or other disruption, the supply chain's stability and continuity are seriously jeopardized. Improving the resilience of prefabricated building supply chains can help enterprises quickly recover and maintain their stability and sustainable operation through methods such as resource restructuring, strategy optimization, and flexible organization in case of emergencies that may cause drastic changes in the supply chain. Using a thorough collection and arrangement of pertinent domestic and international literature, this article employs the literature analysis method as its primary research approach and methodically reviews the theoretical framework and research progress of the resilience of the prefabricated building supply chain. On this basis, this study examined a number of additional variables that affect supply chain resilience, including logistics capability, production and research and development, adaptability, risk management, and informatization. Targeted optimization strategies and suggestions were also proposed. These accomplishments have a significant impact on improving the supply chains for prefabricated buildings' resilience and the sector's capacity to handle risks. To sum up, this research offers both theoretical backing and useful recommendations for enhancing the robustness of supply chains for prefabricated buildings, thereby contributing to the industry's growth.

Keyword: Prefabricated Buildings; Supply Chain; Resilience Improvement Strategy; Risk Management; Informatization

1. Introduction

In recent years, the production capacity of construction enterprises has generally been enhanced, and the production scale has been growing day by day. As a fundamental pillar industry, the construction industry has played an important role in the stable and healthy development of the national economy [1]. However, the construction industry still maintains a labor-intensive and poorly managed production situation. The advantages of prefabricated buildings, such as effective resource conservation, mechanized working methods, shortened construction time, and reduced emissions of construction waste and pollutants, are in line with the requirements of sustainable development in the construction industry [2]. At the same time, as the content of engineering projects becomes increasingly rich and diversified, the number of node enterprises participating in prefabricated construction is gradually increasing. The complexity of the prefabricated construction supply chain also increases, involving more and more groups and nodes, making various information flows in the entire supply chain more complex [3]. Thus, it's imperative to develop a scientifically sound technique for assessing and analyzing the prefabricated construction supply chain's resilience and raising its current level of resilience.

Professors Rice and Sheffi first suggested the fundamental idea of "Supply Chain Resilience" in 2003 [4]. It was initially described by Professors Christopher and Rutherford in 2004 as a supply chain's capacity to revert to a more ideal or initial state following disruption [5]. Zhang identified the critical elements influencing the supply chain for prefabricated buildings' resilience. The key elements that influence the prefabricated building supply chain's

resilience were identified and their influencing mechanisms investigated in light of Hall's three-dimensional theory and related research findings. This improved the supply chain's resilience [6]. According to Liu, enhancing the supply chains for prefabricated buildings to be more resilient will significantly lower the chance of disruptions and encourage associated businesses to achieve superior operational outcomes [7]. Zhu suggested that the construction industry's entire supply chain must change in order to accommodate the growth of prefabricated buildings. It is possible to swiftly modify the prefabricated building supply mode and address current management issues by incorporating the ideas of resilience management and manufacturing supply chain management into prefabricated building management [8]. In order to build resilient supply chains and encourage enterprises at each node to more effectively leverage their technological and resource advantages, Zhang carried out research on the influencing factors of the resilience of prefabricated building supply chains. This research also encourages node enterprises to form strategic partnerships and enhances the supply chain's overall capacity to prevent and resist risks. In the end, this broadens the body of knowledge regarding resilience management in the supply chain of prefabricated buildings, offering a fresh viewpoint on the subject, new suggestions for raising the supply chain's degree of resilience, and support for the thorough and expeditious development of prefabricated buildings [9].

2. Finding the Elements Affecting the Prefabricated Building Supply Chain's Resilience

The resilience management of prefabricated building supply chain aims to improve its resistance to risk events, its own resilience, and its ability to quickly recover from interruption events [10]. In the field of supply chain risk management, resilience management has emerged as a hotspot for research. It focuses on enhancing the adaptive, self-organizing, and self-learning capabilities that influence the resilience improvement of supply chains for prefabricated buildings as well as the ability of the entire supply chain to quickly reconstruct and recover after disruption events [11]. The dynamic ability of a supply chain network to maintain its essential functions and main structure, as well as to continue with regular operations in the face of unforeseen disruptions, is known as supply chain resilience. It also refers to the network's proactive response to interruptions, which enables it to swiftly return to its pre-disturbance or even improve upon it [12]. This article defines the prefabricated building elastic supply chain as a dynamic closed-loop network structure that is guided by the concepts of sustainable development and elastic supply chain, with reference to pertinent elastic supply chain concepts and the prefabricated building supply chain's operational mechanism. The supply chain network can swiftly return to its ideal or original state after being disrupted during the prefabricated building product construction process, resulting in an efficient supply chain for prefabricated buildings, mutual benefit and win-win outcomes for all parties, and the formation of strategic partnership relationships [13].

Inquiry The influencing factor of the toughness of the supply chain of prefabricated buildings should first determine the recognition method of influencing factors, and then determine the research perspective. According to the definition, the supply chain toughness reflects the ability to maintain the supply chain when it is subject to internal and external risks or the ability to increase anti –risk [14]. The reference part of the research literature of research scholars in the tough or elastic field is first identified from the side of the side and outside risks from the side, and then identified and analyzed the targeted factors of toughness. The product of prefabricated buildings and the supply chain is the essence of the prefabricated supply chain, so the supply chain's toughness and influencing factors should be taken into account when evaluating the two components of the supply chain: prefabricated buildings and the supply chain itself. First, the pertinent subjects of "supply chain toughness" and "prefabricated building supply chain" were obtained from databases, China Zhiwang, Web of Science, etc., and 63 documents in total were returned. The quantity of scribbled documents indicates that both domestic and foreign researchers have not done as much research on the

supply chain of prefabricated structures as they have, and the majority of the research on their toughness has only recently been conducted. According to the current status of prefabricated buildings, the risk identification of the supply chain of prefabricated buildings, and the analysis of the analysis of the effects of toughness, analyze the retrieved literature, this study extracts key influencing factors from effective references, and the identified prefabricated building supply factors of chain toughness are influencing, and the literature analysis method screens indicators that affect the toughness of the chain of prefabricated buildings to form five dimensions of logistics capabilities, production and research and development, adaptability, risk management, and informatization. Divide the 17 second -level indicators in the lower detail. The identified prefabricated building supply chain tough indicators include: basic operating capacity, logistics flexible, logistics information integration capabilities, number of suppliers of parts of product components, new product design capabilities, corporate innovation capabilities, product products, product products, products Standardization, prefabricated parts and material reduction, manufacturing capacity, outsourcing quantity, risk response capacity, emergency incentive mechanism, resource and process reconstruction capacity, risk tolerance ability, information sharing level, information communication mechanism, and information system visualization [15].

This study's analysis of the literature revealed that experts think that variables like risk response capability, degree of information sharing, and redundancy of prefabricated parts and materials, which significantly affect the resilience of prefabricated building supply chains, can be gauged by how frequently they are brought up. The level of information sharing is related to almost all key influencing factors, and the supply chain involves the exchange of information flow between enterprises at different nodes. The quality and speed of information transmission play a crucial role in the overall stability of the supply chain. According to information management theory, as a complex system network, the supply chain relies on information communication as the foundation of operation [16]. It assures the supply chain's resilience to hazards and not only assesses each company's efficiency within it, but also the competitiveness of the chain as a whole. Increasing the degree of informatization helps make the supply chain more visible, which increases its resilience. The accuracy and timeliness of information transmission increase with increasing levels of informatization, and different supply chain firms respond more quickly. The notion of rapid reaction in supply chain management places a strong emphasis on timeliness. To increase the supply chain's adaptability, businesses need to strengthen their capacity to react swiftly to market changes. On the one hand, it suggests that different participating units may be influenced by the degree of information sharing to improve the resilience of prefabricated building supply chains from multiple angles; On the other hand, it also indicates that the current level of information sharing still has certain limitations. The redundancy of prefabricated components and materials is the fundamental influencing factor at the bottom level, directly or indirectly affecting the remaining 16 factors. This is closely related to the essential characteristics of "component factory production and reduced on-site operations" in prefabricated buildings, and is the primary influencing factor that needs to be paid attention to in the resilience management of the supply chain of prefabricated buildings [17]. Moreover, risk management can encourage collaboration and cooperation between all supply chain participants. Maintaining the effective functioning of the prefabricated construction supply chain requires collaboration and coordination amongst its numerous partners (suppliers, manufacturers, logistics firms, etc.) [18]. Through risk management, trust and communication among all parties can be strengthened, cooperation can be promoted, and various challenges in the supply chain can be addressed together. Firstly, to ensure prompt detection and treatment of potential risks, businesses can set up effective risk management systems, such as risk identification, assessment, early warning, and reaction mechanisms. Secondly, all parties involved in the supply chain must be better able to recognize and assess risks, as well as be ready to respond to them, which can only be achieved through professional talent introduction and training. By strengthening risk management awareness,

establishing sound risk management systems, improving the risk identification and evaluation capabilities of all parties, and strengthening cooperation and coordination, the resilience of the prefabricated building supply chain can be further improved, promoting its stable and efficient operation. Goods are exchanged and transferred between supply chain enterprises through logistics transportation. Considering the special quality and volume of sand and gravel raw materials and prefabricated components, which have the characteristics of large carrying capacity and cross regional transportation, they are highly susceptible to risks such as changes in market supply and demand, adverse weather, and congested road conditions both inside and outside the supply chain during transportation [19]. The precision of following assembly and construction processes will be immediately impacted by any damage to PC component quality during shipping, particularly. This highlights the need of basic operational capabilities in ensuring supply chain continuity. In addition, based on the principles of synchronous operation and rapid response in the supply chain, emphasizing the timeliness of goods, timely integration of logistics information can improve the efficiency of logistics information transmission, enhance the visibility of the supply chain, ensure the timeliness of logistics, and help prevent or respond to uncertain fluctuations in the supply chain [20]. The robustness of supply chains for prefabricated buildings is thus greatly influenced by logistics capacity. This result is also a reflection of the current problems of high initial investment, low standardization of components, high costs, and supply delays in component production enterprises. Manufacturers of components can strengthen the robustness of supply chains for prefabricated buildings by streamlining production procedures, enhancing component quality, and standardizing components.

3. Strategies for Enhancing the Resilience of Prefabricated Building Supply Chain

First, the creation of an information sharing platform can improve communication and information sharing while enabling real-time tracking of production, shipping, and on-site assembly. It successfully manages each participant's management process and enhances the supply chain management process's visibility, safety, and transparency. Sexuality helps each participant to strengthen their management decision -making and strategic models. Every supply chain node enterprise should investigate the application research of cutting-edge IT in supply chain management, fully utilize the benefits of this technology, enhance platforms for information exchange, and enhance the system of communication between organizations. The continuous update of the information exchange platform will also effectively improve the efficiency of communication efficiency, help to detect the risk interrupt point in time in time and quickly adopt emergency measures to improve the tough level of the supply chain. Effectively enhancing the chain's level of toughness through cooperative partnerships can save needless costs at every stage of the prefabricated building process.

Second, the appropriate transportation scheme and route of scientific planning will be designed and loaded according to the characteristics of the prefabricated components, and the appropriate transportation tools are selected, and the component production plants that are closer or suitable for transportation are given priority. Optimize the spatial layout of the construction site, reserve the appropriate warehousing area and inventory distribution, make full use of the vehicle transportation space and on -site warehousing space to ensure the demand for multiple points to be delivered to reduce the occurrence of interrupt events.

Third, improve the high connection among supply chain participants, establish comprehensive risk management, and fortify the capacity to prevent and control risks. There will be numerous severe repercussions following risk incidents, including component damage and delivery delays. All supply chain linkages should be addressed through comprehensive risk management to increase the supply chain's overall toughness and resilience to risks. By developing risk prevention and control plans, creating a risk growth system, and enforcing risk management rules and regulations to identify risks, their causes, and the steps involved in risk treatment, node enterprises can enhance their risk prevention and management capabilities.

Fourth, increase adaptability and the redundancy level of node enterprises. From the transportation of raw materials to the final product, the production process entails a very intricate structure. Numerous elements need to be taken into account, such as time, money, company strategy, etc. To guarantee the timely, accurate, and high-quality material delivery, we must first thoroughly take into account the material's quality requirements and supply cycle in the material supply link. To prevent cost waste, an appropriate strategic allocation for excess capacity or inventory must be carried out concurrently.

4. Conclusions

This article examines the variables that have shaped the growth of prefabricated buildings in China from the standpoint of a robust supply chain, which is crucial for advancing the prefabricated building industry. The theories of resilience, supply chain management, and supply chain theory form the foundation of this investigation. The identification method of influencing elements in literature research is used to develop the final list of factors impacting the resilience of prefabricated construction supply chains and to suggest hypotheses based on this, starting from the viewpoints of risk management and resilience. Enhancing the supply chain's resilience for prefabricated buildings is crucial to preventing and lessening the effects of unforeseen events as well as guaranteeing the timely completion of prefabricated building construction projects. Research on the prefabricated building supply chain has been done by numerous academics in the present, but little of it integrates resilience theory with the prefabricated building supply chain. In order to encourage the growth of prefabricated structures, this article outlines the major influencing elements on the resilience of prefabricated building supply chains and offers recommendations and remedies for enhancing that resilience. The following are the primary research conclusions:

Prior to using a literature research approach to screen and identify 5 key indicators and 17 secondary indicators that affect the resilience of the prefabricated building supply chain, the pertinent concepts of resilience in the prefabricated building supply chain were specified. A total of 16 secondary indicators were summarized and summarized in five dimensions: logistics capability, production and research and development, adaptability, risk management, and informatization, providing data support for proposing strategies to enhance resilience in the future.

Then, it first made clear the variables that affect how robust the prefabricated construction supply chain is, as well as how these variables relate to one another. The consequences of many factors have been demonstrated in detail, and solutions to strengthen the supply chain's resilience have been suggested. Establish an information sharing platform to improve the information exchange system; scientific planning appropriate transportation solutions and routes to reduce the occurrence of interrupt events; strengthen risk prevention and control capabilities, implement comprehensive risk management; raise the node enterprises' degree of redundancy and allocate extra capacity in a responsible manner.

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