Research on the Prefabricated Building Supply Chain and Blockchain's Resiliency Theory

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Abstract: The prefabricated construction business is growing quickly, and maintaining the industry's steady growth depends on strengthening the supply chain. However, as the supply chain for prefabricated buildings grows and external risk factors become more prevalent, there will inevitably be occasional construction delays or even disruptions. Additionally, the operational management of the entire supply chain will become more challenging. The purpose of this project is to investigate how blockchain technology might be used to improve the robustness of supply chains for prefabricated buildings. The fundamentals of blockchain technology and the variables influencing supply chain resilience were thoroughly investigated by employing the literature analysis approach and methodically classifying and evaluating pertinent local and international literature. Taking into consideration the features of supply chains for prefabricated buildings, the study also examined the benefits of blockchain technology in terms of boosting information exchange, optimizing resource allocation, and improving supply chain transparency. The study's findings suggest that applying blockchain technology to prefabricated building supply chains can strengthen their resilience, lower risks associated with them, and increase the effectiveness of collaboration within them. Additionally, a thorough integration of blockchain technology with prefabricated building supply chains will open up new development opportunities for the sector. This paper offers some innovation and useful suggestions for applying blockchain technology to improve the resilience of supply networks for prefabricated buildings. It also gives a theoretical foundation.

Keyword: Blockchain Technology; Prefabricated Buildings; Construction Supply Chain; Supply Chain Resilience; Information Sharing

1 Introduction

Prefabricated structures are a new kind of modern building model that has emerged as the main option for the traditional construction sector looking to reinvent itself thanks to advancements in technology. Prefabricated buildings, as opposed to typical cast-in-place structures, are those whose prefabricated parts are manufactured in a factory and then transported to the construction site for installation and connection. They have the advantages of minimal labor requirements, quick construction, and reduced resource waste. In order to further encourage the rapid growth of prefabricated structures, capacity building in terms of integrated management and flexible supply chains must be strengthened. Significant risks have emerged in the supply chain as a result of the growing number of factors influencing the prefabricated building supply chain's upstream and downstream in recent years. The supply chain's lack of resilience is becoming more and more obvious, and this has a big effect on how long engineering projects can be built on time and how competitively engineering contracting businesses can operate. 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.

Prefabricated building is becoming more and more popular among node firms as a result of engineering projects' richer and more diverse content. The supply chain for prefabricated building is becoming increasingly intricate, encompassing an increasing number of groups and nodes and complicating the numerous information flows throughout the supply chain. Supply chain integration is another unavoidable path for future development,

given the features of blockchain technology and its existing application scenarios. First of all, it can address issues with privacy protection, trust relationships, and information exchange and quality. Furthermore, the implementation of blockchain technology may facilitate the creation of a supply chain traceability authentication system. It is challenging to identify the origin of issues once they arise because of the intricate structure of the supply chain. The implementation of blockchain technology may efficiently combine different supply chain information while tracking and monitoring real-time information exchange, enhancing the chain's overall operating efficiency. Blockchain technology allows different supply chain node firms to establish strong partnership agreements and ensures the quality of shared information in addition to facilitating fast information sharing. As node enterprises in the supply chain develop trusting relationships over time, long-standing issues that the construction industry has criticized—like information asymmetry, mutual deception and concealment, and buck-passing—can be resolved. This improves the supply chain's ability to operate efficiently. Regarding the first, integrating blockchain technology into the construction sector will both broaden its field of use and unavoidably lead to a change in the supply chain management of prefabricated buildings. As a matter of fact, their integration can serve as a solid foundation for the superior advancement of the building sector as a whole. Therefore, by introducing blockchain technology into the practice of prefabricated building supply chain management, possible problems that may arise in the industry in a fiercely competitive market environment can be solved, making the research on the resilience of prefabricated building supply chains more targeted, realistic, and guiding.

2 Blockchain Technology's Applicability in the Building Industry

Blockchain technology was proposed by Satoshi Nakamoto in a white paper on Bitcoin in 2008. In December 2015, Nasdaq was the first to launch the Linq Securities Trading Platform, which was the first platform to be implemented through blockchain technology. Blockchain technology can achieve distributed, encrypted, and secure recording of digital transactions. It is the underlying technology of Bitcoin and other cryptocurrencies. Blockchain is predicted to completely transform computing across a range of domains, particularly those where privacy is essential and centralization is out of place. The construction industry's digitization, intelligence, and information transformation necessitate a constant adoption of new information theory and technology. However, the level of informatization in the construction industry is very low, with only 0.1% of the total output value invested in informatization, and only higher than agriculture in all industries. The construction business is not as advanced in applying blockchain technology as other industries like manufacturing and services. Blockchain technology and the construction sector together have the potential to significantly increase the degree of digitization and have a significant impact.

In order to maximize the potential of the present construction sector, Wang initially suggested the pairing of blockchain technology and construction project management. He talked about three different kinds of blockchain applications, taking into account the difficulties faced by construction companies: applications related to notarization, which reduce the time needed to verify the authenticity of building documents; applications related to transactions, which encourage automated procurement and payment; and applications related to suppliers, which improve transparency and traceability in the construction supply chain. Additionally, three blockchain-supporting user scenarios—contract management, supply chain management, and equipment leasing—were described [1]. Seven future application scenarios, including smart energy, smart cities and the sharing economy, smart government, smart homes, smart transportation, BIM and construction management, business models, and organizational structures, were ultimately identified by Jennifer et al. after conducting a thorough literature review. They presented a four-dimensional technology, policy, process, and society socio-technical framework to examine the advantages and disadvantages of implementing blockchain in the building sector [2]. Blockchain technology can create passports for buildings to store high-quality

long-term data throughout the lifecycle, guaranteeing that all data users can track data owners at any point in time to manage compliance and legal issues. Ganter believes that the entire lifecycle of a building is constantly updated and stored. New business models or scopes are possible for designers or other service providers. The possibility of using new information technologies to improve document traceability and accessibility of building and lifecycle related information using current techniques [3]. According to Perera et al., blockchain has significant development potential in the building sector. Blockchain, a decentralized technology that can achieve information transparency without requiring trust guarantees from third-party institutions, can be combined with emerging technologies like artificial intelligence, BIM, and the Internet of Things to revolutionize the way the construction industry operates. By conducting a thorough literature review and use case analysis, it is demonstrated that blockchain technology is more than just a passing fad in the construction sector; rather, it is a real example of disruptive next-generation technology that has the potential to propel the sector into the forefront of the fourth industrial revolution. According to Dakhli et al., blockchain reduces transaction costs by doing away with the need for middlemen to build trust—a requirement for the proper implementation of protocols. Second, case studies were used to examine the possible cost savings that real estate organizations could realize by utilizing blockchain. The findings indicate that, with a standard deviation of 1.26%, the possible cost savings of blockchain technology account for 8.3% of the entire cost of residential building. We have recognized the dangers and ways that blockchain technology can enhance the entire design and building process. We have also located areas where blockchain technology may be used in the future in the construction industry.

Chinese scholars mainly conduct research on the application of blockchain technology in the construction field based on the characteristics of blockchain (multi-party mutual trust, open ledger, immutability, traceability), aiming to unlock more applicable scenarios in the construction industry and make up for the technological shortage in the industry. It can improve the digitalization level of the construction industry, inject fresh energy into the industry, improve efficiency, reduce risks, and promote the healthy and rapid development of the construction industry.

For the first time, Zhou suggested using blockchain technology to handle building projects. Based on a thorough examination of several reform initiatives in the construction sector and the underlying circumstances, he thinks that integrating blockchain technology into the sector can help to open up new avenues for engineering management development. We also explored the future prospects of combining blockchain technology with the construction industry: in open bidding, utilizing the characteristics of blockchain to ensure the decentralization, transparency, authenticity, and immutability of bidding information; Applying blockchain technology to the management of construction contracts strengthens the process of contract management, and owners can use smart contracts to monitor project quality and risks [4].

Yang employs a highly integrated smart construction platform technology, utilizing data, artificial intelligence, and construction technology as means, and a project information portal as a shared platform. He develops an intelligent environment for project construction and operation based on the full project lifecycle. He efficiently oversees the whole project process through information integration, management optimization, and technology innovation. It can change the channels and methods of information exchange to improve the quality of information exchange; Implement full lifecycle management of construction projects and improve project information traceability; Raise the degree of digitization in the building sector and offer assistance in the development of smart cities; Crack the pain points of performance in traditional engineering projects and achieve "penetration management" throughout the entire process of engineering projects. Jiang designed and constructed a digital property blockchain platform in the construction field based on the characteristics of blockchain technology, providing guarantees for the confirmation, protection, and operation of digital property rights. In the event of property rights disputes, it can

provide strong evidence to judicial institutions. In order to jointly promote the landing and application of blockchain in the construction industry and the industry's healthy and rapid development, analyze the viability of applying blockchain to the protection of digital property rights in the construction industry, introduce application attempts and specific system implementations of blockchain in the construction industry [5].

3 Research Status on the Resilience of Prefabricated Building Supply Chain

The goal of prefabricated building supply chain resilience management is to increase the chain's resilience, resistance to risk events, and speed of recovery from interruptions. 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 skills 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 occur.

Professor Sheffi and Professor Rice proposed the basic concept of "Supply Chain Resilience" as early as 2003. In 2004, Professor Christopher and Rutherford first defined it as the ability of a supply chain to recover to its original or more ideal state after being disrupted [6]. Shuai proposed that in supply chain management, simply emphasizing low cost and high efficiency can easily make the supply chain system fragile, lacking resilience, and even disorderly. A quantitative measurement method for reference material mechanical stress relaxation time based on the theory of biological cell toughness is proposed, which helps to quantitatively study supply chain toughness. The purpose of introducing resilience into the supply chain of prefabricated buildings is to prepare enterprises in the supply chain to face potential risks of future or ongoing work [7]. Zhang discovered that whereas 9-level elements like interruption reaction time and interruption emergency plan are passive outcome factors, 10 s-level factors like interruption risk prediction and supply chain information sharing level are active causative factors. The strongest influence on the resilience of prefabricated construction supply chains among the secondary elements is interruption response time, whereas component design universality has the least effect on this resilience. Primary elements including evolutionary potential, effectiveness, and adaptability have a decreasing effect throughout time [8]. Predictive ability, absorption potential, adaptability, intrinsic resilience, and growth ability are the five main resilience aspects that Liu identified as critical supply chain resilience indicators in prefabricated building projects. Furthermore, there is diversity in the supply chain's resilience for prefabricated construction projects when there are major changes. Risk awareness, logistical support level, collaboration intensity, supply chain restructuring capacity, and management strategic decision-making skill are the most sensitive secondary factors among all subsystems [9].

Zhu presents research findings that indicate the key influencing factors can be categorized into three levels and six levels: component manufacturing-based bottom level fundamental influencing factors, middle level indirect influencing factors, and top level direct influencing factors. Resilience can be directly increased by increasing the degree of information sharing between design units and supply chains as well as the logistics companies' transportation capacity. However, enhancing resilience solely from a construction or manufacturing perspective is challenging to accomplish quickly [10]. Wang believes that prefabricated building supply chains face enormous risks, and whether the supply chain can recover in a timely manner in response to risks depends on the level of resilience. The model calculation results indicate that improving the degree of information sharing can effectively compensate for the negative impact of adverse weather conditions; When making decisions to improve resilience, emphasis should be placed on procurement, transportation, and assembly processes; Enhancing communication between design, manufacturing, and transportation links can enhance supply chain resilience; Focusing on employee factors can significantly promote the improvement of supply chain resilience[11]. According to Ma, there are major risks associated with the rise in upstream and downstream disturbance factors in the supply

chain for prefabricated buildings, and the issue of inadequate supply chain resilience is becoming more and more apparent. Project supply chains' degree of resilience can be successfully raised using a reasonable supply chain resilience evaluation. By combining the vector angle cosine method with G1 and C-OWA operators based on game theory, a resilience assessment model was created, offering fresh suggestions for enhancing the supply chain's resilience and accelerating the development of prefabricated buildings [12].

4 Research Status of Blockchain Technology and Prefabricated Building Supply Chain

Zhang discovered that blockchain technology offers a workable way to modify the centralized storage style and associated problems of conventional traceability systems. Based on this, Zhang Z suggests a blockchain-based prefabricated component quality traceability system framework. The system framework can successfully accomplish the objectives of decentralization, openness, immutability, and efficient traceability. It does this by embracing a hybrid blockchain architecture and dual storage mode, defining three types of smart contracts, and developing an interactive and effective traceability query method [13]. In order to address real-world problems including automatic information sharing, information traceability, and transparency in prefabricated supply chains, Wang developed the BIMF-PSC model. through participants exchanging knowledge; Control over scheduling in real time; enhancing information traceability in the supply chain management of prefabricated components [14].

Liu, based on the characteristics of prefabricated building construction, addressed the problems of unclear information owners, low transparency, insecure storage, and regulatory difficulties in the supply chain. An information flow model for the supply chain of prefabricated buildings was built using the features of blockchain technology, and the use of blockchain in information flow was examined. The use of blockchain technology in the prefabricated building supply chain can not only speed up information updates and interactions between all parties, foster greater trust among them, streamline work procedures, lower construction costs, but also generate fresh concepts for the supply chain's optimization management [15]. In order to thoroughly investigate the mechanism by which blockchain technology affects the performance of the supply chain for prefabricated buildings, Xia uses prefabricated buildings as the research object, combines the features of blockchain technology, takes into account the dual chain integration of blockchain and supply chain, and introduces trust relationship as an intermediary variable. The prefabricated building supply chain can benefit from the application of blockchain technology, but the indirect effects on performance outweigh the direct ones because blockchain technology primarily depends on the intermediary role that trust relationships play [16]. Xia conducts a SWOT analysis of blockchain technology in supply chain management by combining the features of blockchain with the drawbacks of the existing prefabricated building supply chain management. This may lead to a better comprehension of the ways in which blockchain technology can be implemented to demonstrate its worth in the supply chain. In the meanwhile, prefabricated construction supply chain management issues can be resolved by utilizing the benefits of dual chain integration between blockchain and supply chain [17]. According to Xiao, information tampering and collection issues are common in the prefabricated building supply chain when there is information sharing. The challenge of information sharing in the supply chain for prefabricated buildings has a new answer with the introduction of blockchain technology. By utilizing blockchain technology, data integrity and authenticity can be guaranteed before to uploading, as well as the impossibility of information being altered once it has been posted.

5. Conclusions

This study produced a number of ground-breaking and useful research findings by utilizing a literature analysis to investigate the connection between blockchain technology and the theoretical underpinnings of resilience in supply chains for prefabricated buildings.

First off, this study shows how blockchain technology has a great deal of potential for strengthening the supply chains for prefabricated buildings. By building a supply

chain information platform based on blockchain technology, real-time sharing and traceability of information in each link of the supply chain can be achieved, effectively improving the transparency and collaborative efficiency of the supply chain. This not only lowers supply chain risks but also ensures the network's continuity and stability by swiftly adjusting supply chain tactics in the event of an emergency. Second, a thorough examination of the particular use of blockchain technology in the supply chain for prefabricated buildings was carried out in this study. The prefabricated building business can become more competitive overall by using blockchain technology to optimize resource allocation, improve production efficiency, and lower operational costs. This study also discovered that the adoption of blockchain technology will support the modernization and transformation of the prefabricated building sector toward intelligence and digitalization. Lastly, there is a great deal of theoretical and practical significance to this study. It not only adds to the theoretical framework of supply chain management, but it also offers a theoretical justification for the real-world use of blockchain technology to strengthen the supply chains for prefabricated buildings. Future application opportunities for blockchain technology to increase the robustness of supply chains for prefabricated buildings will be even more numerous as it continues to evolve and improve.

To sum up, our research has established a strong theoretical framework for the integration of blockchain technology with the robustness of supply chains for prefabricated buildings. Our is a critical advance that will foster industry growth and improve supply chain resilience.

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