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Blockchain-based Research on Supply Chain Finance of Construction Industrialization

LI Wenyue

Master in Digital Technologies for Business

Supervisors:
PhD João Ferreira, Assistant Professor
with Habilitation,
ISCTE – IUL

MSc Daniel Cale, Research Assistant,
ISCTE - IUL

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TECNOLOGIAS
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Resumo

Esta tese analisa primeiro as dificuldades de financiamento do financiamento da cadeia de suprimentos e do modelo de financiamento da cadeia de suprimentos baseado em blockchain e identifica os quatro principais participantes no financiamento da cadeia de suprimentos da industrialização da construção.

Ao analisar os interesses e estratégias de jogo dos quatro principais participantes, busca encontrar os fatores de influência do comportamento de tomada de decisão entre as partes interessadas no financiamento da cadeia de suprimentos da industrialização da construção. Em seguida, explora os fatores que influenciam a interação e o jogo entre as partes interessadas no financiamento da cadeia de suprimentos da construção. Por fim, analisa os desafios enfrentados pelas partes interessadas no financiamento da cadeia de suprimentos da industrialização da construção ao adotar a tecnologia blockchain para financiamento e propõe recomendações para promover o uso do financiamento blockchain entre as partes interessadas no financiamento da cadeia de suprimentos da construção com base nos resultados da análise.

A tese descobriu que o impacto do suporte político sobre as partes interessadas no financiamento da cadeia de suprimentos da construção que adotam o financiamento blockchain tem características em fases. A pressão competitiva e o benefício percebido têm um impacto positivo no comportamento de tomada de decisão das partes interessadas, enquanto o custo percebido tem um impacto negativo. A estrutura hierárquica depende principalmente da proporção de fornecedores de materiais de construção na influência do comportamento de tomada de decisão dos participantes do financiamento da cadeia de suprimentos na adoção do financiamento blockchain.

Palavras-chave:

Industrialização da Construção, Finanças da Cadeia de Suprimentos, Blockchain, Teoria dos Jogos.

Abstract

This project first analyzes the financing difficulties of supply chain finance and the blockchain-based supply chain finance model and identifies the four core participants in the construction industrialization supply chain finance.

By analyzing the interests and game strategies of the four core participants, it seeks to find the influencing factors of decision-making behavior among stakeholders in construction industrialization supply chain finance. Then, it explores the factors influencing the interaction and game among stakeholders in construction supply chain finance. Finally, it analyzes the challenges faced by stakeholders in construction industrialization supply chain finance when adopting blockchain technology for financing and proposes recommendations for promoting the use of blockchain financing among stakeholders in construction supply chain finance based on the analysis results.

The project found that the impact of policy support on stakeholders in construction supply chain finance adopting blockchain financing has phased characteristics. The competitive pressure and perceived benefit have a positive impact on the decision-making behavior of stakeholders, while the perceived cost has a negative impact. The hierarchical structure mainly depends on the proportion of building material suppliers in influencing the decision-making behavior of supply chain finance participants in adopting blockchain financing.

Keywords:

Construction Industrialization, Supply Chain Finance, Blockchain, Game Theory.

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CHAPTER 1

Introduction

1.1 Context

With the acceleration of the global urbanization process, the construction industry is facing unprecedented challenges and opportunities. Traditional construction methods, due to inefficiency, high cost and significant impact on the environment, have been difficult to meet the needs of modern society for the speed and quality of construction. In this context, the industrialization of architecture came into being, marking an important change in the field of modern architecture [1]. By standardizing and serializing the production of building components using factory production technology, this model not only significantly improves the efficiency and quality of construction projects, but also effectively reduces construction costs and environmental impact. The emergence of building industrialization marked a key shift in the modern architectural landscape, characterized by the standardized and serialized manufacturing of building components using factory production techniques. This approach not only greatly improves the efficiency and quality of construction projects, but also plays a vital role in reducing the environmental footprint and overall construction costs. By simplifying the production of prefabricated components, the model addresses the industry's ongoing labor shortage, improves project safety, and enhances sustainability [2-3].

With the industrialization of construction, the complexity of the supply chain is also increasing. In this new production mode, all aspects of raw material procurement, component production, transportation and on-site installation need to be efficiently coordinated, and capital flow management is particularly critical. In this context, Supply Chain Finance (SCF) is particularly important. By providing the necessary liquidity support, SCF helps enterprises in all parts of the supply chain, especially Small and Medium-sized Enterprises (SMEs), to effectively manage their capital needs and ensure the smooth progress of projects. However, traditional SCF methods rely on heavy manual operations and complex document flows, which are not only inefficient, but also prone to errors and fraud [4-5].

Therefore, the industrialization of modern buildings has put forward higher requirements for SCF, that is, it must be more efficient, transparent and safe. The integration of Blockchain Technology (BT) offers the possibility to solve these problems by automating transactions and record keeping, reducing the need for manual operations and reducing the risk of error and fraud, thereby improving the quality and efficiency of financial services throughout the supply chain.

The integration of BT offers a transformative solution by automating and securing the flow of financial transactions and information within the SCF system. The decentralization and transparency of blockchain not only simplifies operations, but also improves reliability, making SCFS more resistant to fraud while providing faster and more cost-effective financial services. This integration is expected to optimize the entire supply chain ecosystem in building industrialization, ensuring the timely and efficient allocation of resources, thereby supporting the overall goals of modern building practices [6-8].

1.2 Motivation

With the continuous growth of global building demand, traditional building methods have been difficult to meet the multiple requirements of efficiency, cost control and environmental protection. Through its advantages of standardized production and rapid assembly, building industrialization presents a feasible path to solve the challenges of modern architecture. However, in achieving this transformation, the efficient management of capital flows has become one of the central challenges. In this context, it is critical to improve the efficiency, transparency and security of SCF. Traditional SCF model has many limitations, including tedious manual processing process and file management, which seriously affect the fund efficiency and security of the project.

The main motivation for this project is to explore how BT can revolutionize the traditional SCF model by optimizing fund flow management, reducing the risk of fraud, and improving responsiveness and financial transparency throughout the construction supply chain through its distributed ledger and smart contract technology. Through an in-depth analysis of the application of blockchain in construction SCF, this project aims to provide an innovative financial solution that promotes the modernization of the construction industry to meet the growing market demand and increasing environmental challenges.

1.3 Objective

The main objective of this project is to explore the application of BT in building industrial SCF, focusing on reducing implementation costs and simplifying technical complexity through technological innovation, thereby enabling SMEs to more easily access and utilize the benefits of blockchain. This project emphasizes improving the integrated efficiency of capital flow, logistics, and information flow through BT, driving the modernization and digital transformation of the construction industry.

The project evaluates the specific role of BT in enhancing construction supply chain management,

including increasing transaction transparency, reducing operational costs, and improving data security. Through a real-world case study, it verifies how BT provides solutions for real-time capital liquidity management, whole-process tracking of commodities, and the immutable guarantee of transaction records.

Furthermore, the project explores the potential of BT in reducing credit and operational risk, particularly in helping SMEs overcome financing barriers and strengthen the foundation of trust throughout the supply chain. By analyzing the latest advancements in blockchain, such as sharding technology and cross-chain technology, it proposes solutions to address scalability and sustainability challenges in existing first- and second-generation blockchain technologies.

1.4 Structure of the project

In the project, first explore the historical development and current applications of construction industrialization, SCF and BT. This initial discussion laid the foundation that provided comprehensive background information to help understand the complexities and potential of integrating BT into construction SCF.

Next, the research methods are elaborated. In this section, the methodology used to study how to integrate BT into construction SCF is introduced. This include analyze empirical data to assess the effects, challenges, and benefits of blockchain applications in this context. In the following chapters, the research findings are presented. These results are discussed in the context of current industry practices to highlight the practical impact and potential of BT. This discussion aims to provide valuable insights to industry stakeholders to help them use BT to enhance the efficiency, transparency and security of construction SCF.

At the end of the project, the findings are summarized, the limitations of the project are discussed, and the direction of future research is proposed. This section is critical to framing the next step in the academic and practical exploration of blockchain in construction SCF, providing a path for further investigation and implementation.

CHAPTER 2

Literature review

2.1 Backdrop

Globally, the construction industry has been one of the key industries driving economic growth. However, this industry also faces inefficiencies, high costs and time delays [9]. Construction industrialization as a solution aims to improve the efficiency and quality of construction projects and reduce costs through prefabricated components and rapid on-site assembly. With the spread of construction industrialization, the supply chain associated with it has become complex, involving a number of suppliers and subcontractors, posing a great challenge to supply chain management. SCF has thus become a key tool to ensure the stable operation of the supply chain, playing a crucial role in capital flow management and credit risk control [10]. With the rapid development of information technology, especially the rise of BT, it provides a new solution strategy for SCF in construction industrialization. BT provides a transparent, reliable and efficient data management platform with its unique decentralized characteristics. This technology not only optimizes the transaction process and reduces intermediary costs, but also enhances the security and non-tamperability of data, which is extremely important for multi-party construction projects, as Figures 2.1 and 2.2 show.

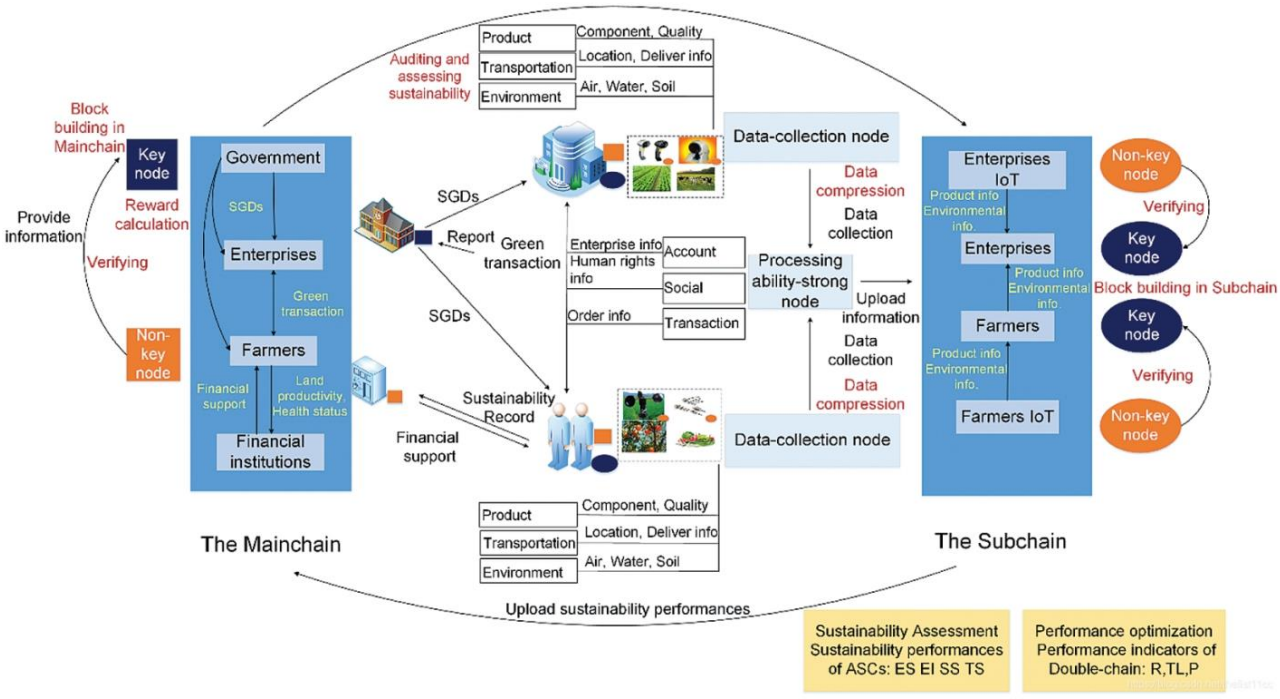


Figure 2.1 The engineering architecture of blockchain [11]

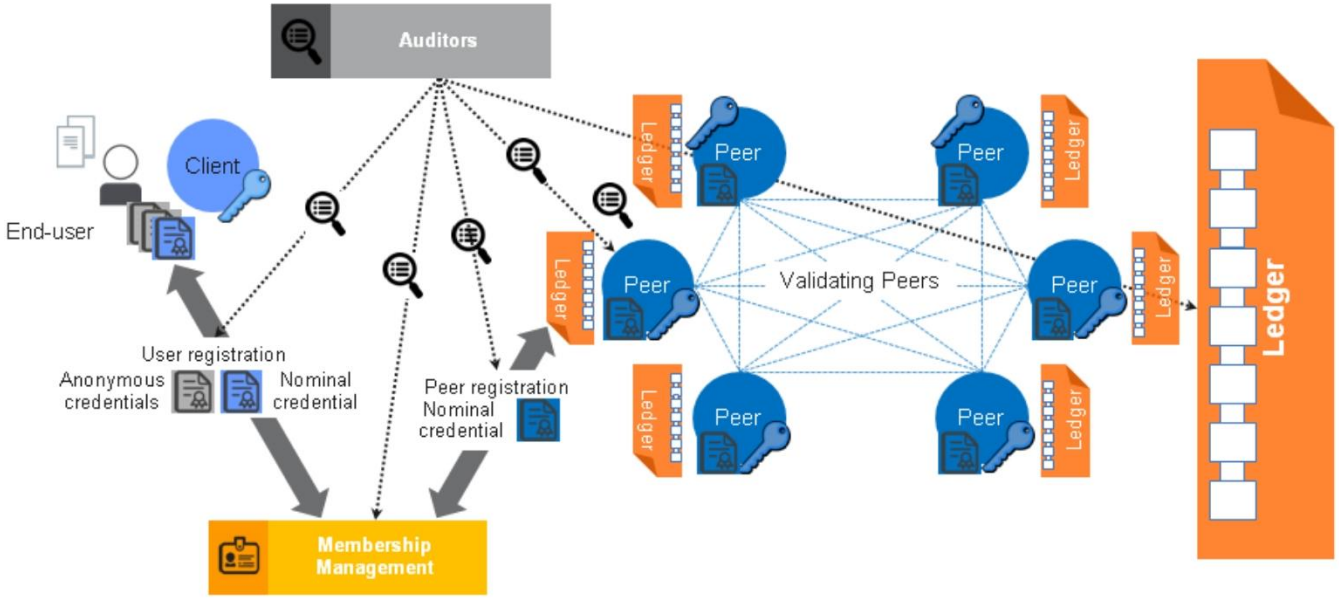


Figure 2.2 The engineering architecture of blockchain of membership management [12]

However, despite the many potential advantages offered by blockchain, its application in the field of industrialized construction SCF is still in its infancy. Most of the existing research focuses on the application of BT in other industries, such as financial services, supply chain management, and healthcare, etc., and there is a lack of systematic research and in-depth technical discussions on SCF issues specific to construction industrialization. In addition, how to deal with the issues of privacy protection, high cost and legal regulatory uncertainty of BT are also key issues that need to be addressed in current research.

This chapter aims to provide an in-depth discussion of the current status and challenges of SCF for industrialized construction, assess the application potential of BT, and identify the problems and research gaps through a literature review and relevant theoretical analysis. This project provides the theoretical foundation and technical guidance for the subsequent chapters to support more specific experimental design and solution development.

2.2 Related work

In related study, Kouhizadeh et al. [13] explored how BT can transform global supply chain management, especially in terms of transparency and efficiency. They argued that the decentralized audit trajectory provided by blockchain reduces mistrust and time delays in supply chains and is particularly effective in multi-layer supply chain structures. They concluded that BT can significantly improve supply chain transparency, reduce fraud, and improve overall efficiency.

Larsson et al. [14] focused on the creation of the digital currency, Bitcoin, but their concepts of decentralized networks and cryptographic security provided the theoretical foundation for subsequent blockchain applications. Their research demonstrated that without the need for a central authority how data consistency and security can be maintained through network consensus mechanisms.

Lee et al. [15] concentrated on the application of blockchain in ensuring sustainability and compliance in the supply chain of construction materials. They noted that by utilizing blockchain to document the origin and handling of construction materials, it is possible to effectively track the environmental impacts of the materials and to ensure compliance with the standards of sustainable construction. Their conclusions emphasized that BT not only improves data traceability but also enhances regulatory compliance.

Xue et al. [16] uncovered how BT could play a role in reducing transaction costs and increasing liquidity. Their theory is that blockchain can optimize SCF processes by eliminating intermediaries and automating contract execution. It concluded that the implementation of this technology, especially in the capital-intensive construction industry, can significantly speed up the flow of funds in projects and reduce the cost of capital.

On the application of BT in the industrialized construction supply chain, Li et al. [17] identified how blockchain can optimize the management and distribution of project funds. Their theory is based on the observation that in construction projects, lagging disbursement of funds often leads to project delays or even failure. They explored the potential of BT to automate payments and enhance the transparency of funding flows. In their study, blockchain smart contracts are used to automate and conditionalize payment management. This means that once a supply chain node meets a preset condition (e.g., material delivery verification or project progress is met), the corresponding payment is automatically released, which significantly reduces manual intervention and associated time delays. In addition, this mechanism reduces the legal costs associated with payment disputes.

Liu et al. [18] also noted that while BT offers significant efficiency gains, it faces number of technical and managerial challenges in its full implementation, such as demand-side and supply-side acceptance of the technology, system scalability, and compatibility with existing financial systems. They concluded that despite the challenges, BT holds great promise for application in industrialized construction SCF, especially in improving the efficiency of capital use and reducing transaction costs. It provided an empirical basis for understanding the application of blockchain in actual construction SCF, demonstrated the specific advantages and challenges faced by the technology, and offered an important future research and practice reference. These insights are particularly valuable for decision makers who are exploring the integration of BT into more complex industrial supply chain systems.

Fang et al. [19] discovered the data privacy risks of blockchain application in the construction supply chain. They proposed a blockchain-based encrypted storage solution to protect the privacy of

sensitive data while maintaining data transparency among supply chain parties. Their theory is based on the recognition of the challenges of publicity in existing blockchains. They believed that by introducing layered encryption and permission control, data access rights can be effectively managed, thereby reducing the risk of privacy leaks. They concluded that although complete anonymity and transparency are difficult to achieve simultaneously in a blockchain system, a balance point can be reached through technological innovation to protect data privacy while maintaining the core advantages of the system.

Mao et al. [20] focused on assessing the legal and compliance risks of BT in the field of construction industrialization SCF. They noted that while blockchain can enhance the transparency and security of transaction records, the lack of regulations specific to the technology is a major obstacle. They put forward recommendations for establishing a transnational legal framework to support the international application of BT and address potential legal issues. Their conclusions highlighted that through international cooperation and legislative reform, stronger legal support for the security and compliance of BT can be provided, thereby promoting its sustainable development on a global scale.

These studies provided theoretical support and practical evidence for the application of BT in the field of building industrial SCF, showing how blockchain can solve trust issues and improve efficiency in traditional supply chains, demonstrating how these risks can be managed through technological innovation and legal reform, and pointing the way for future research.

Analyzing the aforementioned studies on the application of BT in supply chain management, we can identify several key similarities and differences:

Table 2.1 Similarities and differences in blockchain research

Aspect	Similarities	Differences
Technological Benefits	All studies highlight blockchain's potential to improve transparency, efficiency, and security. Kouhizadeh et al. focused on transparency, Xue et al. focused on reducing costs.	
Automation	Common agreement on blockchain's capability to automate processes and reduce intermediaries through smart contracts, as indicated by Li et al.'s research.	

Aspect	Similarities	Differences
Compliance Challenges	All mention legal and regulatory challenges; Lee et al. discussed the need for a transnational legal framework.	
Application Areas	All focus on blockchain in supply chain management.	Varies: on sustainability, Li et al. and Fang et al. focused on data privacy risks in construction supply chains.
Technological Issues		Liu et al. discussed acceptance issues, Mao address data privacy protection solutions.
Research Methods		Liu et al.'s empirical analysis showcasing practical challenges and advantages in construction SCF.

Table 2.2 Relatedness of researches

Researcher(s)	Related Topics	Focus Area
Xue et al.	Similar to Kouhizadeh et al. in discussing efficiency and security but with a specific focus on transparency	General supply chain transparency
Li et al.	Automation focus aligns with general blockchain capabilities as noted by others.	Automation in payment management
Lee et al.	Compliance and regulatory discussions relate closely to overall legal challenges noted by other researchers.	Legal framework for blockchain across nations
Li and Fang et al.	Unique in focusing on sustainability within construction supply chains.	Sustainability and compliance in construction

Researcher(s)	Related Topics	Focus Area
Mao et al.	Related to general data security issues raised but with a specific focus on privacy in construction.	Data privacy in construction supply chains
Liu et al.	Concerns about technology acceptance overlap with general automation and efficiency discussions.	Technology acceptance in supply chains
Xue et al.	Provides foundational theoretical insights related to all blockchain discussions.	Theoretical foundation for blockchain applications

These same points and differences highlight the diversity and complexity of applying BT in supply chain management, as well as the multifaceted challenges that need to be addressed to promote its widespread adoption. These studies provide valuable perspectives for decision-makers, helping them better understand and utilize this technology.

Through in-depth analysis of these theories and conclusions, this project aims to further explore the specific application and potential challenges of BT in building industrialization SCF, so as to propose targeted solutions.

This chapter examines the current landscape of SCF in construction industrialization and the potential of blockchain to enhance efficiency and transparency. We found that blockchain can optimize payment processes, improve data security, and increase transparency and trust in the supply chain. Despite its benefits, challenges such as technological maturity, compliance, data privacy, and user adaptability hinder its adoption. This analysis provides a foundation for understanding blockchain's potential in this sector and highlights the need for further research to address these challenges and fully leverage blockchain in SCF, driving innovation and digital transformation in the industry.

CHAPTER 3

Survey Research

3.1 Research design

Against the backdrop of rapid development in financial technology, BT has shown enormous potential in solving multiple core problems in the financial industry due to its unique distributed ledger characteristics. BT can provide a decentralized, tamper proof, and highly transparent data storage environment, making it particularly attractive in the field of financial services [21-23].

By implementing BT, financial institutions can solve the long-standing problem of information silos. Information silos refer to data isolation caused by incompatibility or policy restrictions between systems, which hinders information sharing. In traditional financial ecosystems, different institutions often hold the same customer data, but these data are isolated from each other and updated asynchronously. Blockchain improves data utilization efficiency and reduces operational costs by establishing a shared and verifiable data platform that enables all authorized participants to access updated data in real-time. Blockchain has also shown great advantages in reducing the cost of financial services. Especially in the fields of SCF and cross-border payments, BT can simplify transaction processes and reduce the involvement of intermediaries [24]. For example, using blockchain platforms to process cross-border payments can avoid the need for multi-level clearing in traditional banking systems and directly transfer funds between buyers and sellers. This not only accelerates transaction speed, but also significantly reduces transaction costs. Blockchain provides stronger security through its natural encryption features. In financial transactions, security is one of the most important considerations. The encryption algorithm of blockchain ensures the security and integrity of data, and each transaction is verified through multiple nodes in the network. Any unauthorized changes would be detected and rejected by the system [25].

Although BT has brought many advantages, it also faces challenges in its widespread application. For example, the maturity of technology, processing speed, energy consumption issues, and uncertainty in laws and regulations may all become obstacles to its development. Therefore, continuing to study and address these challenges is key to further integrating BT into the mainstream financial services field.

3.2 Data collection methods

When conducting research on the application of BT in the financial industry, using survey questionnaires to collect data is an effective strategy that can help researchers gain a broad understanding of the application of BT in the actual financial environment. The following is a detailed description of the design and implementation process of the survey questionnaire [26-27].

The survey questionnaire design should collect data from different perspectives and evaluate the respondents' perception of the impact of BT through preset options, such as efficiency improvement, cost reduction, and security enhancement. The preparation of survey questionnaires should take into accounts the diversity of the target audience. The research subjects may include various financial institutions such as banks, insurance companies, investment funds, as well as technology companies that use blockchain for internal operations or customer service. Questionnaire design needs to ensure clear language and direct relevance of questions to ensure high-quality data is collected from financial technology professionals [28].

The distribution of questionnaires can be done through email, online survey tools, or direct access. Electronic methods have the advantages of low cost, wide coverage, convenient and fast data collection and organization. This project uses Question-Star (a professional online survey, examination, evaluation, and voting platform that focuses on providing users with powerful and user-friendly services such as designing questionnaires, collecting data, customizing reports, and analyzing survey results.) to create and distribute survey questionnaires, while also facilitating data analysis work in the later stage [29].

After the data collection is completed, some data with obvious bias items would be cleaned and processed to ensure the accuracy of the analysis. This includes checking for invalid or incomplete responses, handling missing values, and encoding open-ended responses into quantifiable data.

Through the above steps, the survey questionnaire method can not only help researchers gain a deeper understanding of the application status of BT in the financial industry, but also provide empirical data to support subsequent analysis and argumentation.

3.2.1 Survey content

The following is the content of the survey questionnaire:

We have designed a survey questionnaire to explore how BT can solve information silos, reduce financing costs, and improve the security and efficiency of financial transactions. We collect data to evaluate the practical application effect of BT in the financial industry.

Table 3.1 Questionnaire content

No	Questions	Answers
1	What is your gender?	A-Male B-Female
2	What is your educational background?	A-Undergraduate or below B-Undergraduate degree C-Graduate students D-PhD
3	What is your position?	A-Senior management (such as CEO/CTO/CFO, etc.) B-Middle level management (such as department managers) C-Technical Specialist D-Other (please specify: _____)
4	What is your institution type?	A-Banks B-Insurance companies C-Investment funds D-Financial technology companies E-Other financial service institutions (please specify: _____)
5	Has your organization adopted BT?	A-Yes B-No
6	What is the main purpose of using BT in your organization?	A-Improve data sharing transparency B-Reduce operational and financing costs C-Enhance transaction security -Improve efficiency D-Other (please specify: _____)
7	How do you think the efficiency of information sharing has changed after adopting BT?	A-Significant improvement B-Slight improvement C-No change D-Slight decrease E-Significant decrease

No	Questions	Answers
8	Has using BT helped your institution reduce financing costs?	A-Yes, significantly reduced B-Yes, slightly reduced C-No change D-Uncertain
9	How do you evaluate the effectiveness of BT in improving transaction security? -Very effective	A-Very effective B-Effective C-General D-Invalid E-Very poor
10	What is the biggest challenge you encounter in implementing BT? -Technical complexity	A-Technical complexity B-High cost C-Lack of professional talents D-Legal and compliance issues E-Technical acceptance F-Other (please specify: _____)
11	What do you think is the development potential of BT in the financial industry in the future, and what improvements are needed?	Open ended answer

The design of this questionnaire aims to comprehensively understand the application status and effectiveness of BT in the financial industry, identify existing problems and challenges, and provide data support and improvement direction for further research and practical application.

3.3 Research samples

In this project, the respondents mainly included decision-makers and technologists in a variety of financial institutions, ranging from large international banks to innovative fintech companies, ensuring the broad applicability and validity of the findings. In order to obtain a representative sample, the stratified random sampling method is adopted in this project [30-31]. Financial institutions are categorized by business type (e.g., banking, insurance, asset management, etc.), size (large, medium, small), and geographic location (China). A specific number of institutions were randomly selected for each category to ensure a diverse and comprehensive sample. In addition, to capture the full range of

different perspectives on BT, make sure the sample includes financial professionals in a variety of roles, from CEOs to CFOs, as well as risk management executives.

The role of enterprise size is indeed significant for several reasons. First, the scale of an enterprise often influences its approach to adopting and implementing BT. Large enterprises typically have greater resources, more sophisticated technological infrastructures, and larger-scale operations, which may enable them to adopt BT more readily and integrate it into their systems. In contrast, SMEs often face resource constraints and higher barriers to technological adoption, making their experiences and challenges with BT adoption distinct. Analyzing enterprise size provides valuable insights into the scalability and adaptability of BT solutions across different organizational scales. Understanding how BT is applied in large institutions versus SMEs allows the research to identify whether certain innovations or approaches are more suitable for specific contexts.

Finally, the inclusion of enterprises of various sizes enhances the representativeness of the findings. It ensures that the conclusions are applicable to a broad spectrum of financial institutions, rather than being skewed toward a particular segment. This diversity is crucial for providing actionable insights for policymakers, technologists, and industry leaders who aim to implement BT in a way that benefits organizations of all sizes.

The data collection process was conducted between April and May 2024, and a total of 100 valid questionnaires were collected. All data was processed anonymously, and participants signed informed consent to clarify how their information would be used and to confirm that their participation was voluntary. Through these measures, the project aims to protect the privacy rights of participants while ensuring the reliability of the collected data. In summary, enterprise size plays a pivotal role in ensuring the comprehensiveness and applicability of the research findings, particularly in the context of exploring BT adoption and its impact across diverse financial institutions.

3.4 Ethical considerations

When conducting research on the application of BT in the financial industry, it is crucial to ensure the ethics of the research. This includes protecting the privacy of participants, ensuring the confidentiality of data, and appropriately addressing any ethical issues that may arise [32-33].

The privacy of all individuals and institutions participating in this project is strictly protected. This means that no information that can identify individuals or organizations is disclosed in any publicly available material. When collecting data, all sensitive information is encoded or anonymized to prevent unauthorized access or data leakage. In addition, all data storage is encrypted and only authorized

research team members can access this data. This project ensures that all participants have a clear understanding of their purpose, methods, and the right to withdraw at any time. This is a crucial step in ensuring compliance with research ethics. This project complies with all applicable laws and industry standards to ensure legal compliance in the research design and implementation process. This includes but is not limited to data protection regulations, information security policies, and potential international regulations. The research team also regularly reviews the research process to ensure compliance with the latest ethical standards and legal requirements.

During the research process, any potential ethical issues is immediately reported to the research ethics committee, which provides recommendations and decisions for handling. This mechanism ensures that research maintains high ethical standards throughout the entire process. Through these measures, this project aims to not only generate valuable scientific knowledge, but also ensure that the research process is fair, transparent, and accountable to all participants. This commitment to ethics is the cornerstone of ensuring research quality and winning public trust.

CHAPTER 4

Analysis of blockchain SCF game in China’s construction industrialization

In the rapidly evolving field of construction industrialization in China, the integration of BT into SCF represents a transformative approach to overcoming longstanding challenges and unlocking new potentials. This chapter delves into the intricate dynamics and innovative financing models facilitated by BT, which promises enhanced transparency, security, and efficiency in transactions. This chapter explores the integration of BT into the SCF of China's construction industrialization, a pivotal innovation poised to revolutionize industry practices. It begins by addressing the current predicaments of traditional SCF, highlighting inefficiencies and challenges that hinder its potential. Subsequently, we introduce blockchain as a transformative solution, outlining its role in reshaping financing models through enhanced transparency, security, and efficiency.

By providing a comprehensive analysis of these elements, this chapter aims to offer insights into how blockchain can facilitate more effective financial interactions and foster a more cooperative and productive industrial environment in the construction sector.

4.1 Survey questionnaire data analysis

4.1.1 Background distribution of participants

In this project, a total of 100 industry reports on SCF and blockchain finance were collected April and May 2024. These selected reports focus on key areas such as how BT impacts financial institutions' operational efficiency, cost management, and data security, providing important data and insights into practical use cases and effects of blockchain for this project.

According to Figure 4.1 shows, senior executives such as CEOs, CTOor CFOs make up the largest proportion of respondents in financial institutions, at 40%. This group often has a decisive influence on the strategic direction of the company and the adoption of new technologies. Their perception and acceptance of BT directly affects the speed and breadth of the technology's rollout within the organization. Middle managers accounted for 25%, indicating that this segment of participants may have direct experience and in-depth understanding of the specific application of BT at the executive level. They face the challenges of technology implementation directly and evaluate how well the

solution works in practice, so their feedback is particularly important for understanding the practical effects of BT in solving information silos, reducing financing costs, and improving transaction security.

Technical specialists, as practitioners who directly deal with technology, their insights can provide valuable information on the operational performance, integration difficulty, and compatibility with existing systems of BT. Their feedback on technical details and application issues is crucial for evaluating the practical application obstacles and potential optimization directions of BT.

Participants in other positions may include legal advisors, marketing personnel, etc. Their views on BT may cover aspects such as compliance, market acceptance, and promotion strategies, all of which are key factors determining the long-term success of the technology. Overall, such a distribution of job backgrounds helps to comprehensively understand the current application status and challenges of BT in the financial industry from the perspectives of strategy, execution, and technology, providing a solid foundation for further research and decision-making.

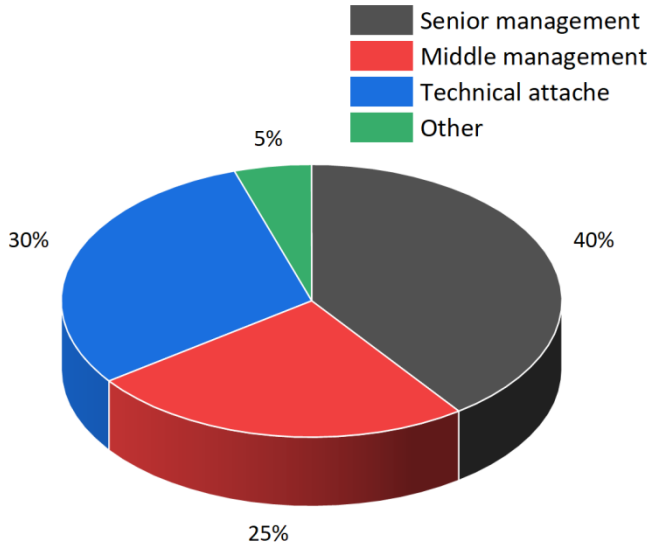


Figure 4.1 Background distribution of participants

4.1.2 The main application purposes of BT

Figure 4.2 shows the main purpose that participants believe their institution adopts BT. The figure shows that 45% of participants indicate that the main purpose is to improve data sharing transparency, 35% of participants indicate that it is to reduce operational and financing costs, 15% of participants believe it is to enhance transaction security, and 5% of participants are interested in improving efficiency. This data reflects that in the financial industry, BT is seen as a tool that can solve various problems. The largest proportion of participants focus on improving data sharing transparency, which

is directly related to the core advantage of blockchain - its immutable distributed ledger function. In the field of financial services, transparency is key to trust and efficiency, especially when dealing with complex transactions and multi-party operations. By improving data sharing transparency, BT can help reduce fraudulent behavior, improve regulatory compliance, and optimize customer service.

Reducing operational and financing costs is the second main objective, accounting for 35%, which reveals an important driving force for financial institutions to adopt new technologies - cost-effectiveness. Blockchain can simplify transaction processes, reduce intermediate links, thereby reducing transaction costs and time delays, which is highly attractive for any financial operation. For example, cross-border payments and SCF are two areas where BT can significantly reduce costs. The improvement of security is also an important factor, although only 15% of participants consider it as their primary objective. In the financial industry, transaction security is crucial, especially in the face of increasing cyber-attacks and fraudulent behavior. The encryption and decentralization characteristics of blockchain make it an ideal tool for improving financial transaction security.

Although only 5% of participants believe that improving efficiency is the main goal, this cannot be underestimated in the financial environment with increasing demand for high-frequency trading and real-time processing. BT provides the possibility of improving operational efficiency through automated processing and real-time update capabilities.

Based on these data, it can be seen that BT actually used in multiple applications in the financial industry, as well as the complex considerations of financial institutions when choosing technological solutions. These insights help to further explore how BT can be practically applied in the financial industry, and how to optimize these applications to better meet industry needs.

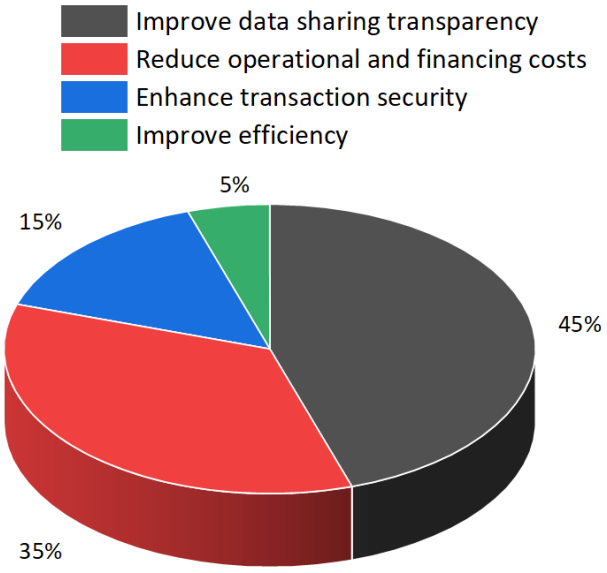


Figure 4.2 Survey results on the main application purposes of BT

4.1.3 The Impact of BT on information sharing efficiency

Based on Figure 4.3, the research results show a substantial positive impact of BT on information-sharing efficiency across various businesses, highlighting its potential as a valuable tool for enhancing operational capabilities. According to the data, 50% of respondents reported a significant improvement in information-sharing efficiency with the adoption of BT. This substantial percentage suggests that BT fundamentally transforms how information flows within and between organizations. By providing a decentralized, transparent, and secure platform for data exchange, BT reduces the need for intermediaries, minimizes duplication of information, and enhances the accuracy and speed of data sharing. For businesses, these benefits translate into faster decision-making processes, as data can be accessed and verified in real-time by all relevant parties. This improved information flow can lead to greater agility, allowing companies to respond swiftly to market changes or customer demands.

Moreover, 30% of respondents indicated a slight improvement, showing that even with partial or initial BT integration, companies can experience benefits in data handling and communication processes. These slight gains may represent the early stages of BT implementation, where businesses begin to streamline specific aspects of their operations, such as cross-departmental collaboration and supply chain communication, thereby reducing delays and misunderstandings. This level of improvement suggests that BT can yield incremental benefits that accumulate over time, encouraging businesses to expand their use of the technology.

On the other hand, 15% of respondents reported no noticeable change in information-sharing efficiency, which could indicate that the implementation of BT might be more effective in certain business models or industries. Companies that rely heavily on secure, rapid information exchange—such as those in finance, logistics, and supply chains—might gain more immediate benefits, while others may need to adjust their processes or invest more in training to fully harness BT's advantages.

Interestingly, a small portion of respondents, amounting to only 5% (3% reporting a slight decrease and 2% a significant decrease), noted a decline in efficiency. This decrease could be attributed to initial integration challenges, such as the need for substantial infrastructure changes, a lack of skilled personnel, or issues in adapting existing systems to BT. In such cases, companies may face short-term inefficiencies before realizing the long-term benefits, underscoring the importance of strategic planning and phased implementation when adopting new technologies.

Overall, the data suggests that for the majority of businesses, BT adoption enhances information-sharing efficiency, enabling more streamlined, transparent, and secure operations. The clear positive impact on efficiency provides a strong business case for investing in BT, particularly for industries where fast, reliable information exchange is crucial to competitive advantage.

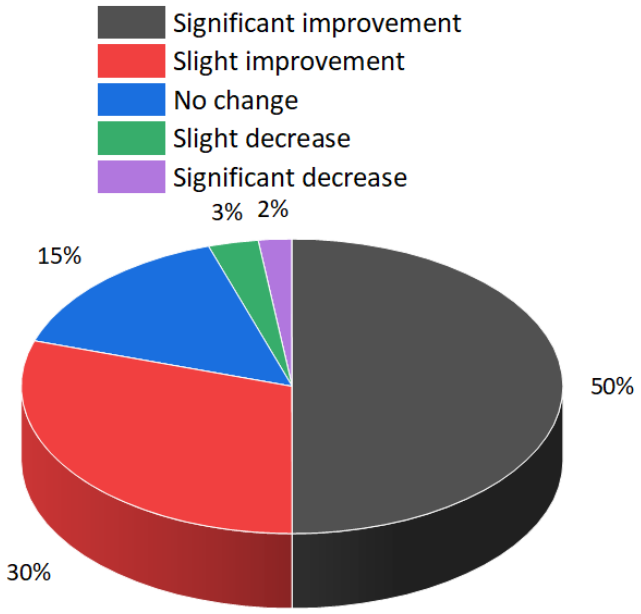


Figure 4.3 Research results on the impact of BT on information sharing efficiency

4.1.4 The effectiveness of BT in reducing financing costs

Figure 4.4 focuses on the evaluation of the impact of BT on reducing financing costs by participants. According to the data, 40% of participants believe that BT significantly reduces financing costs, 35% of participants feel a slight decrease, 20% of participants do not show significant changes, and 5% of participants express uncertainty about the effectiveness. These data highlight the practical application value of BT in reducing financing costs in the financial industry. In financial services, especially those that involve a large number of intermediate links and complex approval processes, such as cross-border payments, supply chain financing, and commodity transactions, traditional processes often involve multiple intermediaries, each step may bring additional time and monetary costs. BT, through its decentralized characteristics, can directly connect the demanders and suppliers of funds, reduce or eliminate traditional intermediary links, thereby reducing transaction costs and accelerating the flow of funds. Specifically, 40% of participants reported a significant cost reduction, which may reflect that after implementing blockchain solutions, they were able to experience an increase in fund processing speed and a significant reduction in related expenses. For example, using a blockchain platform for SCF solutions can enable suppliers to confirm orders faster and achieve rapid flow of funds, directly reducing capital occupation and related financial costs.

However, 20% of participants did not show significant changes, which may indicate that in some cases, the introduction of BT did not directly lead to cost reduction. This may be due to the high investment costs required in the early stages of technology integration, or because business models and market conditions limit the potential for cost savings. In addition, 5% of uncertain responses may

reflect uncertainty about the long-term benefits of technology or unresolved technical or operational issues encountered during implementation.

In summary, the data in Figure 4.4 reflects the positive potential of BT in reducing financial financing costs, while also highlighting potential challenges in achieving cost-effectiveness through widespread adoption. This provides an important empirical basis for further technological optimization and implementation strategies, and points out the key directions for future research and development.

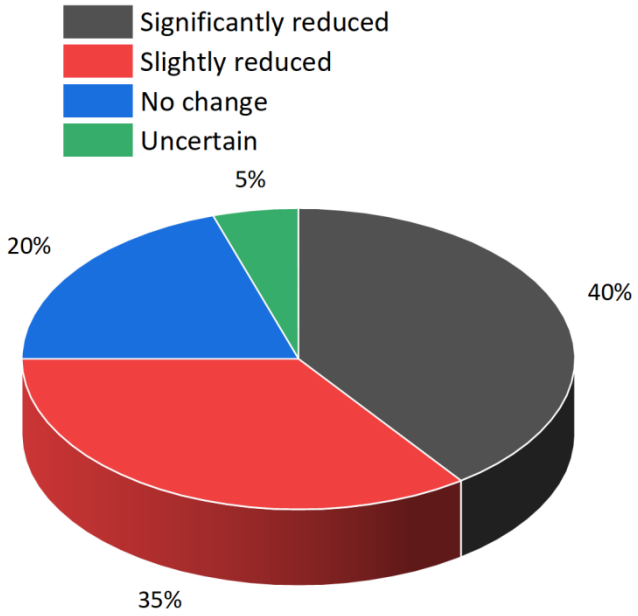


Figure 4.4 Research results on the effectiveness of BT in reducing financing costs

4.1.5 Evaluation of BT improving transaction security

Figure 4.5 explores the evaluation of participants on the effectiveness of BT in enhancing financial transaction security. Figure 4.5 shows that 45% of participants believe BT is very effective, 30% of participants believe it is effective, 15% of participants think the effect is average, 6% of participants think it is ineffective, and another 4% of participants think the effect is poor.

The data shows that the majorities of participants have a positive attitude towards blockchain in enhancing transaction security. The core features of BT, such as encryption, tamper proof records, and decentralized storage, are all key factors in improving security. These features make BT very effective in preventing data tampering, improving transparency, and reducing fraudulent behavior. Especially in the financial field, these features can significantly reduce risks in transactions, such as when executing smart contracts, conducting stock trading, or managing cross-border payments. 45% of participants believe that BT is highly effective, possibly because they have personally experienced how BT ensures the security and integrity of transactions. For example, transactions conducted using BT can

automatically verify the identities and qualifications of both parties and ensure the immutability of transaction records, which are difficult to achieve through traditional technologies.

However, a small percentage (10% in total) of participants expressed negative or neutral views on the security of BT. This may be because they encountered technical issues during the implementation process, such as scalability limitations or difficulties integrating with existing systems, which may affect their perception of the overall utility of the technology. In addition, although BT itself has high security, the security of the system also depends on the implementation method and the security measures of the surrounding systems. If these aspects are not properly handled, it may also lead to participants questioning safety.

Overall, the data in Figure 4.5 shows that although BT is considered highly effective in improving financial transaction security, there are still some differences in the evaluation of its effectiveness. This emphasizes the need for sufficient research and resolution of potential technical challenges when promoting BT, to ensure that all users can experience the security benefits it brings.

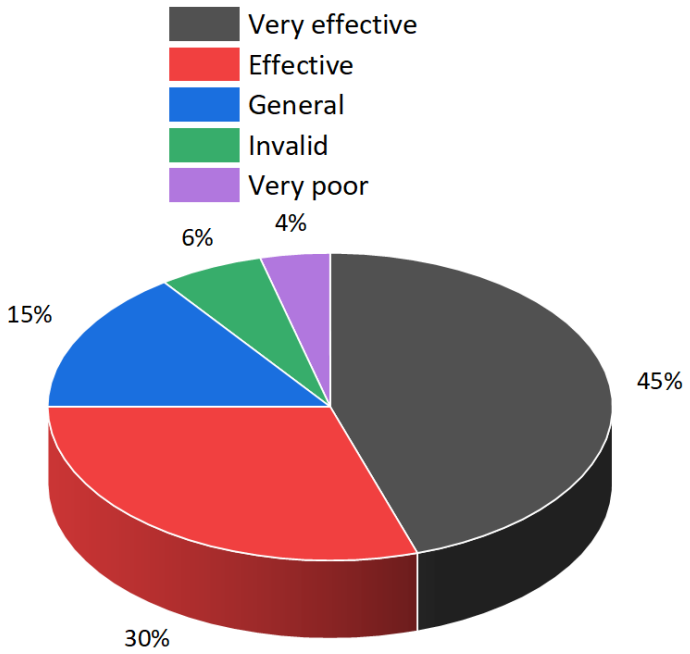


Figure 4.5 Evaluation and research results of BT improving transaction security

In the questionnaire data analysis in section 4.1, we can find that current SCF has significant deficiencies in information sharing efficiency, financing cost and transaction security. Participants generally believe that the traditional SCF model has obstacles in multi-party collaboration and real-time data transmission, which not only increases the cost burden of enterprises, but also increases the risk caused by information asymmetry. In this context, BT, as a decentralized data management platform, has the potential to increase transparency, reduce costs, and enhance transaction security.

Therefore, section 4.2 would further explore the specific application of blockchain in building industrialization SCF, analyzing how it can solve these key problems through innovative financing models to provide more efficient and secure financial support for all parties in the industrial chain.

4.2 Financing models for blockchain supply chain in construction industrialization

4.2.1 Current predicament of SCF

Combined with the thoughts induced by the Grounded Theory [34] the context in which grounded theory is used in this section seems to involve systematically identifying and classifying factors that hinder the development of SCF in the context of building industrialization. Grounded Theory is a qualitative research method used to analyze qualitative data from industry reports, literature, or survey feedback, thereby enabling researchers to construct a theoretical framework of the challenges SCF faces in the field. Six major categories of 12 factors hindering the development of SCF were summarized, as shown in Table 4.1 that easier to read and clear.

(1) Credit

Factor 1: Obstruction in the Multi-level Transmission of Credit

Traditional SCF has to some extent alleviated the problem of credit impairment for individual SMEs in the supply chain. However, the problem of the difficulty in multi-level transmission of credit from the core enterprise to various levels of SMEs still exists, hindering the financing activities of SMEs in China's construction industrialization. The credit enhancement activities of SCF rely on the credit guarantee of the core enterprise, which is mainly based on the receivables generated by trade contracts, with the pure credit of the core enterprise as a supplementary measure. Under the traditional SCF model, primary suppliers can obtain financing services based on their receivables, while secondary suppliers either have difficulty obtaining credit guarantees for financing or bear high interest rates for financing, increasing the financing cost for SMEs and squeezing their survival space. Currently, primary suppliers with stable and direct trade transactions with core enterprises are able to obtain credit endorsements from the core enterprise and obtain financial support from financial institutions by pledging their receivables. However, due to the lack of direct trade with the core enterprise, the lack of transparency in the information of the enterprises themselves, and the difficulty in verifying the rights and transfer data of accounts payable and accounts receivable, financial institutions often refuse to lend to these kinds of enterprises based on risk control considerations. At the same time, the lack of interconnection between enterprises and banks increases the difficulty of

integrating the four flows (capital flow, information flow, logistics, and commercial flow), raising the cost of obtaining information and increasing the difficulty of risk control, thereby exacerbating the problem of SME financing difficulties.

Factor 2: Blank Credit Records of SMEs

Enhancing credit through the supply chain is a feasible way for traditional supply chain financing to meet certain financing needs. However, key issues such as the lack of transparency in the information of SMEs, insufficient credit accumulation, poor credit awareness, and weak credit management still exist, and the public transparency and gradual accumulation of enterprise credit data are still important paths for establishing the general credit of enterprises in China's construction industrialization [35].

(2) Information

Factor 3: Existence of Information Islands in the Supply Chain

In the entire industry chain, enterprises in the supply chain often refuse to share the information and data they hold with other enterprises due to their own interests and risk avoidance considerations, making it difficult to integrate system information and achieve unified layout, leading to the phenomenon of "information islands." The supply chain covers the entire process, including raw material procurement, product manufacturing, product circulation, and product sales, involving a large number of supplier levels. Real-time product demand information in the market is transmitted through layers of upstream and downstream suppliers, and by the time the information reaches the upstream suppliers, it has already been distorted, leading to overproduction and stockpiling of goods [36]. High inventory puts tremendous pressure on capital return for enterprises, greatly reducing capital expenditure in areas such as research and development and undermining the core competitiveness of enterprises. The lack of information transparency and asymmetry in the information of enterprises in the supply chain increase the difficulty of verifying the authenticity of information, and also provide opportunities for those intending to falsify information, hindering the smooth operation of SCF. Financial institutions incur high time and cost in verifying false information, including false customers, forged transactions, false reporting of fund usage, forged warehouse receipts, and forged receivables, making it difficult to verify the authenticity of the data. There are loopholes in the supervision of SCF, making it easy to breed profit-driven and collusive loan fraud phenomena between enterprises and between banks and enterprises, including but not limited to arbitrage, tax evasion, and fund diversion through repeated pledge of warehouse receipts, fraudulent false trade information, fraudulent specialized loan funds, increasing the financial risks of financial institutions, undermining the confidence in conducting financing business, and damaging the interests of regular financing enterprises [37].

(3) Collaboration

Factor 4: Insufficient Participation Motivation of Core Enterprises

The development of SCF business relies on the credit endorsement of core enterprises, which assume both the responsibility of accounts payable and the repurchase responsibility. The effectiveness of the transfer of accounts receivable bonds requires the confirmation of core enterprises, and without active participation from core enterprises, supplier financing businesses are difficult to carry out smoothly. Core enterprises with good credit and sufficient collateral assets do not lack financing channels. In addition, the benefits of core enterprises participating in accounts receivable financing have a delayed effect, and short-term benefits are not visible. Therefore, core enterprises lack motivation to participate in SCF, as they have low liability ratios and sufficient cash flow.

Factor 5: Vicious Cycle Caused by Upstream and Downstream Competition

There are many participants in the supply chain, and the communication and cooperation between different participants are mixed together. At the same time, this is also a complex game relationship. Upstream and downstream enterprises allocate profits based on their position in the industry chain. Enterprises with strong R&D capabilities and core resources often occupy the dominant position in the industry chain and obtain most of the profits. When considering the benefits, leading enterprises often encroach on the profits of other enterprises in the chain. Once the balance of power between them is disrupted, the supply chain would fall into a vicious cycle of mutual losses.

Factor 6: Fragmentation of Enterprise Credit

When SMEs apply for financing, they often need to register with multiple platforms, multiple banks, or multiple core enterprise systems, and handle financing business in different systems. In this process, SMEs are forced to bind multiple accounts and identities, and also pay duplicate fees for using multiple systems. The multiple identities of network users lead to the fragmentation of enterprise network business data, making it impossible for SMEs to form a complete picture of their credit status, exacerbating the problem of credit accumulation and financing difficulties for SMEs.

(4) Risk

Factor 7: Insufficient Traditional Regulatory Measures

The advancement of financial technology profoundly affects the development of SCF, not only enriching the types of SCF products and accelerating the replacement of SCF products, but also improving industry efficiency, but also bringing new risks and hidden dangers. It is now very difficult to monitor, identify, and avoid these risks using traditional regulatory measures, and many companies with insufficient credit would forge vouchers or transaction records to gain illegal benefits, posing a huge challenge to the development of the financial industry.

Factor 8: Difficulty in Inertia Transformation of Traditional Risk Control Thinking

The development of SCF has gone through three stages, from SCF 1.0, SCF 2.0, to SCF 3.0. At present, inventory financing and prepayment financing are still the mainstream products of SCF, accounting for 75% of the market share, and the risk control thinking still mainly revolves around traditional collateralized loans, while factoring financing based on the principle "self-liquidating" accounts for only 25%. Due to risk control considerations, financial institutions cannot solely rely on the repayment of the buyer as the primary source of repayment for credit [38].

(5) Cost

Factor 9: High Interest Rates for SME Financing

Core enterprises with relatively transparent information and more mortgage assets can easily obtain low-interest bank financing. Primary suppliers, based on the credit endorsement of the core enterprise, can also obtain low-interest bank financing, while secondary suppliers, due to their distance from the core enterprise and lack of direct trade relationship with the core enterprise, often face higher financing interest rates, and the interest rates for tertiary suppliers and lower-tier suppliers are even higher.

Factor 10: High Collaboration Costs and Low Efficiency

The information systems of various organizations have not yet formed unified data standards, and the data generated at various nodes and links in the supply chain is stored in different systems. The capital flow, logistics, and business flow data in the supply chain have not been integrated and cannot be shared in real-time automatically. In order to control risks, the participants of SCF need to regularly check the data of capital flow, logistics, and business flow. For industries with long supply chains, the cost of regular reconciliation is high, and the difficulty of reconciliation is also great. In the financial market, information asymmetry leads to difficulty in acquiring and verifying information, and credit and information intermediaries increase the cost of fund transactions. Due to the difficulty in acquiring information, the farther suppliers are from the core enterprise, the less transparent the information, and the higher the relative cost of cooperation [39].

(6) Technology

Factor 11: Low Overall Level of Informatization

The level of informatization in many domestic industries is insufficient, and the problem of insufficient informatization in the construction industry is particularly severe, which greatly restricts the development of SCF. The digitalization level of SCF affects the transparency, credibility, traceability of information on the chain, ensuring the authenticity of transaction information on the chain, and at the same time, it is an important guarantee for the integration degree of the supply chain. However, traditional SCF faces the challenge of the level of informatization.

Factor 12: Lack of Resilience

Currently, most SCF platforms adopt a centralized architecture, led by a single center organization of financial institutions, core enterprises, or logistics enterprises, which is responsible for maintaining the platform operation, transaction data, and user data storage. Centralized storage mode has significant data security risks, making it vulnerable to data loss or attacks that could cause the entire platform to be paralyzed, affecting the continuity and reliability of system services.

Table 4.1 Classification and description of obstacles to the development of SCF

No	Description
Factor 1	Traditional SCF has alleviated the credit shortage of SMEs to some extent, but it is still difficult to transfer credit between core enterprises and multi-level SMEs, resulting in financing obstacles.
Factor 2	The credit information of SMEs is not transparent and the credit accumulation is insufficient, which makes it difficult to meet the financing needs.
Factor 3	Supply chain enterprises are reluctant to share information due to interest considerations, resulting in information island phenomenon, which hinders the smooth operation of SCF.
Factor 4	The short-term returns of core enterprises participating in SCF are not obvious, which affects the smooth development of financing business.
Factor 5	Each participant in the supply chain falls into a vicious circle due to competition, which leads to the loss of the overall interests of the supply chain.
Factor 6	The repeated registration of SMEs in different platforms and banking systems makes it difficult to accumulate credit and increase the difficulty of financing.
Factor 7	The development of fintech has brought new risks to SCF, which are difficult for traditional regulation to effectively identify and monitor.
Factor 8	The development of SCF has not broken away from the risk control thinking of traditional guaranteed loans, which makes it difficult to effectively promote new SCF products.

No	Description
Factor 9	Due to low information transparency, unsecured assets and other reasons, SMEs face higher financing rates.
Factor 10	The information system of supply chain has not realized the unified data standard, which leads to the cost and difficulty of checking the data of capital flow, logistics and business flow.
Factor 11	The overall informatization level of the domestic industry is insufficient, which affects the development of SCF.
Factor 12	The centralized architecture of several SCF platforms has affected the service continuity and reliability of the platforms.

4.2.2 Blockchain-based financing models

In section 4.2, in view of the limitations of traditional SCF models, we analyze how BT can play an important role in the financing model of the industrial supply chain of buildings. However, in order to deeply understand the application effect of the technology in SCF and its impact on the behavior of different participants, it is particularly necessary to further explore the game model of blockchain SCF. Therefore, section 4.3 would construct and analyze the key players in building industrial SCF and their strategic choices from the perspective of game theory in order to more fully reveal how blockchain affects and optimizes cooperative behavior in SCF.

(1) Reverse factoring financing based on blockchain

The general contractor (core enterprise) and the upstream primary building material supplier sign a trade contract on the blockchain financial platform and record the transaction information on the chain. At this point, the primary building material supplier receives the first accounts receivable equal to the value of the contract; based on the trade records of accounts receivable on the blockchain financial platform, the primary building material supplier applies to sign a factoring contract with a financial institution (factor) to transfer part or all of the accounts receivable. Upon receiving the application, the financial institution verifies the validity of the accounts receivable with the general contractor online. The general contractor confirms the accounts receivable online and issues electronic bills of exchange equal to the accounts receivable to the primary building material supplier. The primary supplier then splits the electronic bills of exchange, using part of it for discounting to obtain a

loan from the financial institution. After the primary supplier (buyer) signs a trade contract with the secondary supplier (seller), forming a second accounts receivable, which is less than the first accounts receivable minus the discounted portion, the secondary supplier signs a factoring contract with the financial institution to transfer the second accounts receivable. The primary supplier confirms and issues electronic vouchers to the secondary supplier. The same pattern is repeated for the third-level supplier to obtain electronic voucher financing, and so on.

(2) Warehouse Financing Based on Blockchain

Building material suppliers (core enterprises) sign purchase and sales agreements with general contractors and broadcast the transaction information on the blockchain-based SCF platform, agreeing that the building material suppliers would sell building materials to the general contractors. The general contractor applies for loan financing from banks or other financial institutions based on the trade contracts signed with the building material suppliers. The financial institution reviews the authenticity of the on-chain transaction information and the credit information of the enterprise, and decides whether to lend to the general contractor after risk assessment. For approved loan applications, the financial institution issues electronic acceptance bills to the building material suppliers. The financial institution signs a warehousing agreement with the logistics company, which undertakes the transportation of the building materials sold by the building material suppliers and pledges warehouse receipts to the financial institution. After the general contractor pays a certain amount of collateral to the financial institution, they apply to the financial institution to withdraw the corresponding value of the goods. Once the financial institution receives the collateral, it triggers smart contracts to automatically issue a delivery order to the general contractor, instructing the logistics company to release the corresponding goods to the general contractor. This process continues in a loop until the general contractor has paid the full amount of the acceptance bill collateral and withdrawn all the goods. The building material suppliers provide guarantees for the quality of the goods to the financial institution and promise to repurchase the goods at the request of the financial institution if the general contractor fails to pay the collateral and withdraw the goods according to the agreement. The entire process takes place on the blockchain-based SCF platform.

4.2.3 BT practical application solution

In the face of challenges such as technology integration and deployment costs, there are several innovative ways the construction industry can reduce complexity and increase efficiency. First, the adoption of modular technology can significantly reduce the complexity of system integration. By modular integration of BT with existing supply chain management systems, construction companies

can gradually introduce new technologies without completely replacing existing systems, thereby reducing the difficulty and cost of technology deployment.

Secondly, smart contracts, as an automated execution protocol, can reduce manual intervention and manual operation, and reduce the error rate in the execution process. This not only improves the efficiency of execution, but also reduces the reliance on intermediaries, thereby reducing the costs associated with traditional financial operations. By introducing smart contracts into construction projects, project parties can automatically trigger payments, material purchases and other operations under preset conditions, ensuring the efficient flow of funds and resources.

Finally, cross-industry technical cooperation is also an important way to reduce technical complexity. For example, construction companies can work with technology companies to jointly develop a blockchain application platform suitable for the construction industry and solve the scalability and data interoperability problems of the platform. Through this cooperation, the implementation of technical solutions can be more smoothly connected with the specific needs of the industry, so as to achieve the rapid landing of technology.

Through these innovative solutions, the construction industry can reduce the complexity of technology deployment without sacrificing efficiency and transparency, and reduce costs and increase market competitiveness in the process of achieving SCF optimization.

4.3 Construction industrialization SCF game model construction

4.3.1 Players in the construction industrialization SCF game

In this project, we reviewed literature and data related to SCF and combined the analysis of SCF models with the players in construction industrialization. We categorized the main players in SCF as construction supply chain trading parties, financing platform providers, risk management parties, and fund providers. Based on the analysis of the main players and the simplified model required for blockchain-based SCF, this project selected general contractors, (technology) financial institutions, logistics companies, and various levels of building material suppliers as the subjects of the game theory research.

(1) Construction supply chain trading parties

Construction supply chain trading parties refer to the buying and selling parties involved in the supply chain trade, namely, buyers and sellers. In the context of construction industrialization, in the upstream construction supply chain trade, the general contractor acts as the largest buyer, positioned at the top of the trade chain, and extending down to the primary building material suppliers, secondary

building material suppliers, and lower-level N-level building material suppliers. When the general contractor trades with the primary building material suppliers, as the buyer, if the primary building material supplier does not have strong indispensability, the general contractor often holds a strong negotiation position and pricing power. At this point, the general contractor tends to maintain sufficient cash flow and occupies the funds of the weak party, the primary building material supplier, in this trade. Similarly, when the primary building material supplier trades with the secondary building material supplier, as the buyer with strong bargaining power, the primary building material supplier also tends to occupy the funds of the weaker party, the secondary building material supplier, to maintain sufficient cash flow, and so on. It is evident that the weaker party is often SMEs in the construction supply chain, and these SMEs often need to obtain funding through borrowing to maintain production and business operations. This is the main reason for the existence of demand for SCF. In the context of construction industrialization, the trading parties in the SCF mainly include general contractors, primary building material suppliers, secondary building material suppliers, and lower-level N-level building material suppliers, real estate developers, distributors, and consumers. This project selected general contractors and various levels of building material suppliers with strong financing needs as the subjects of the game theory research.

(2) Financing platform providers

Financing platform providers need to provide a secure and reliable interactive environment for the participants in SCF, allowing financing demand parties (SMEs among building material suppliers) and fund providers (financial institutions) to use the platform. In the context of BT-supported construction industrialization SCF, the financing platform providers mainly include technology financial companies, BT service companies, financial institutions, and core enterprises (general contractors or developers). Leveraging BT, data resources, financial support, or core positions, financing platform providers build blockchain SCF platforms. These platforms utilize data such as bills, orders, financial status, and logistics information to help SMEs obtain financing and provide loan decision-making basis for financial institutions. Technology financial companies have the technological advantages of BT service companies and the financial advantages of financial institutions, giving them significant leverage. For example, Ant Group's Double Chain SCF Service Platform digitizes accounts receivable as separable credit vouchers, thereby achieving credit transmission and circulation within the supply chain, addressing the problem of expensive and difficult financing for SMEs at the end of the supply chain. Therefore, in the context of construction industrialization, the main providers of blockchain financial platforms include technology financial companies, BT service companies, financial institutions, and core enterprises (general contractors or developers). In SCF, the main role of platform providers is to provide risk management services for the credit of financing. Considering practical situations and

the need for a simplified model, this project selected technology financial institutions as the subjects of the game theory research.

(3) Risk management parties

Before the application of BT in SCF, risk management parties mainly needed to integrate trade information, logistics data, and other financing-related data from both sides of the supply chain. In inventory financing models, inventory in trade is an important basis for financing activities due to its low liquidity. Risk management parties not only need to integrate logistics information from supply chain trade but also need to verify the authenticity, completeness, and timeliness of this information to ensure accurate understanding of the logistics information, avoiding information deviation. The development of information technology and big data provides technical support for risk management parties to store, analyze, and control financing risks based on logistics information. By utilizing big data, risk management parties can conduct statistical analysis and create profiles of large amounts of logistics information. Based on these profiles, they can understand trade characteristics and the behavioral status of all participating entities, comprehensively understanding the operation of the supply chain and controlling financing risks. In traditional SCF, platform providers are mainly responsible for collecting and integrating trade and logistics data, while risk management parties are primarily responsible for data analysis and risk control. Therefore, in traditional SCF, risk management parties may sometimes be specialized service organizations, such as logistics companies and business firms, and at other times, they may be core enterprises in the supply chain, such as large building material manufacturers.

With the application of BT in SCF, BT becomes an important technical guarantee for the authenticity, tamper resistance, and transparency of logistics information. With the support of BT, the boundaries between risk management parties and financing platform providers have become blurred, and in many cases, the same entity may simultaneously serve as both a platform provider and a risk management party. For example, IoT + blockchain + supply chain management services provided by sensing technology serve as both a platform provider and a risk management party. By utilizing IoT + BT, this system collects and integrates trade and logistics data, ensuring the authenticity and timeliness of the data. It also utilizes AI + big data for data analysis and profiling. Therefore, in blockchain-based SCF, risk management parties may include logistics companies, technology financial institutions, BT service companies, financial institutions, and core enterprises (general contractors or developers). Considering practical situations and the need for a simplified model, this project selected logistics companies and technology financial institutions as the subjects of the game theory research.

(4) Fund providers

Fund providers can generally be commercial banks, factoring companies, investment companies, and other financial institutions, with their main responsibility being to provide direct loan financing or

guarantee loan financing. Due to risk aversion, traditional financial institutions tend to cooperate with large enterprises and are more cautious in providing financing services to SMEs, with higher loan interest rates. At the same time, traditional financial institutions offer fewer types of financial products, operate in a narrower service area, allocate financial resources unevenly, have low service efficiency, poor risk pricing abilities, and are inhibited by segmented supervision that suppresses financial innovation. With the transparency provided by BT, financial institutions find it more convenient and accurate to quantify and control risks, making financing services more friendly to SMEs. This project selected financial institutions as the subjects of the game theory research.

4.3.2 Game analysis of construction industrialization SCF

In the blockchain-based SCF ecosystem, the general contractor plays the role of the core enterprise (buyer) and holds a dominant position in the supply chain. When participating in SCF, the general contractor incurs certain time and labor costs and is subject to credit restrictions when dealing with building material suppliers. Directly, participation in SCF allows the general contractor to finance accounts receivable, reduce its debt ratio, and optimize its financial statements. Simultaneously, it can transfer accounts receivable to financial institutions, improve the efficiency of fund utilization, reduce its own risks and management costs without increasing its liabilities. Indirectly, by integrating cash flow and information flow, the general contractor can enhance supply chain management, stabilize its own supply chain, and establish an integrated financial supply system and risk assessment system. Additionally, policy orientation and social responsibility can also motivate the general contractor to participate in SCF. For the interests of the general contractor, there are two strategies: providing guarantees and not providing guarantees. They hope to participate in SCF under low-cost and low-risk credit to maximize benefits.

In the blockchain-based SCF ecosystem, the financial institution plays the role of the fund provider and may also serve as a risk management and financing platform provider. SMEs financing demands in the construction industry are immense and difficult to obtain support from financial institutions or face high financing costs. However, financial institutions hold a large amount of idle funds that are not effectively utilized. For financial institutions, there are two strategies: lending and not lending. They aim to control risks to the greatest extent possible, make effective use of idle funds, and maximize profits.

In the blockchain-based SCF ecosystem, logistics companies play the role of logistics and warehousing, recording real-time information of building material logistics and warehousing on the blockchain. Logistics companies face challenges in managing and controlling goods and risks. For logistics companies, there are two strategies: cooperation and observation. They aim to control goods

and risks to the greatest extent possible, increase their control over the supply chain, and ensure the maximum profits for the company [40].

In the blockchain-based SCF ecosystem, various building material suppliers play the role of financing parties (sellers). With their vast numbers, they constitute indispensable roles in the supply chain. Building material suppliers have immense financing demands, but due to small enterprise scale, lack of transparency in information, and lack of collateral, they face difficulties and high financing costs. For building material suppliers, there are two strategies: cooperation and observation. They hope to obtain as much financing as possible at the lowest possible cost, abide by agreements, and maximize long-term cooperation benefits.

All stakeholder's hope to obtain maximum benefits at the lowest cost and risk. However, their interests are related to each other's behavior. In situations of information asymmetry, the strategic choices and expected benefits of all stakeholder's conflict, leading to conflicts of interest. Therefore, this project establishes a game model based on prospect theory to identify decision-making behaviors and factors influencing them under situations of conflicting interests.

In section 4.3, through the construction and analysis of the game model, the roles and behavioral strategies of key participants in the construction industrialization SCF are identified, and the potential of BT in promoting cooperation and optimizing financing models is revealed. However, to achieve effective cooperation, it is necessary not only to consider the strategic choices of the participants, but also to analyze the key factors that affect their cooperative behavior. Therefore, section 4.4 would further explore the influencing factors of cooperative behavior based on the previous game model, in order to provide theoretical support and practical reference for the practical application of blockchain SCF in construction industrialization.

4.4 Influence factors of cooperation behavior of participants in construction industrialization SCF

4.4.1 Strategies and challenges for updating the financial technology regulatory framework

The rapid progress in the field of financial technology poses serious challenges to traditional regulatory frameworks, especially as technologies such as blockchain, artificial intelligence, and big data gradually penetrate into various aspects of financial services. The introduction of these technologies not only changes the operational mode of financial markets, but also raises a series of legal, ethical, and regulatory issues. Therefore, updating and strengthening regulatory frameworks has become particularly important to ensure the stability, transparency, and fairness of the financial system.

In the context of the construction industry, financial technology has profound implications, particularly in the area of SCF. SCF, as an innovative financial model, utilizes technological tools to improve the efficiency of financing within the supply chain. By leveraging blockchain for transparent and traceable transactions, SCF can streamline the financial flows between contractors, suppliers, and investors, reducing the risk of financial bottlenecks and delays in construction projects. The integration of big data and artificial intelligence enables real-time monitoring of cash flows and project progress, allowing for proactive risk management and more accurate financing decisions.

However, as SCF increasingly influences the construction sector, it poses new challenges to the existing regulatory frameworks. The application of digital tools in SCF introduces issues related to data security, financial transparency, and fraud prevention. Regulatory agencies must adapt to these changes by strengthening their focus on SCF mechanisms and ensuring that technological innovations do not lead to systemic risks in the construction industry. Furthermore, regulatory bodies should consider the impact of SCF on cross-border construction projects, as digital financing tools enable global supply chains. The globalization of construction financing requires international cooperation to create unified regulatory standards for SCF across borders, ensuring that financial transactions remain secure and transparent in the international construction market.

Regulatory authorities should prioritize consumer protection in the context of SCF, particularly with regard to data privacy and cybersecurity. As SCF tools become more embedded in the construction industry, protecting sensitive financial and operational data becomes essential to maintaining stakeholder trust and the integrity of the financing process. Thus, enhancing the regulatory framework for SCF is critical to ensuring that its integration into the construction industry supports not only efficiency but also sustainability and fairness.

Through these measures, regulatory frameworks can not only keep up with the pace of financial technology development but also provide a solid foundation for the healthy and stable development of both the financial and construction sectors. This requires regulatory agencies to maintain a high level of vigilance and adaptability to cope with the constantly changing fintech environment and its impact on industries such as construction.

4.4.2 The practical application of SCF in the construction industry

In the context of financial technology, BT has been widely recognized for its ability to address critical issues in SCF, such as information silos, high financing costs, and performance risks. While the applications of BT in traditional industries like retail and logistics are often cited, its potential in the construction industry, particularly in SCF, is becoming increasingly significant. Construction projects typically involve multiple stakeholders—contractors, subcontractors, suppliers, and financiers—each

of which faces challenges such as delayed payments, fragmented financing sources, and operational inefficiencies. SCF, integrated with BT, can provide a much-needed solution to these problems by offering transparency, streamlining financial flows, and enhancing overall project efficiency.

The application of BT in SCF addresses the long-standing issue of information silos within construction supply chains. By creating a decentralized, transparent ledger of all transactions, blockchain ensures that data is shared securely among all stakeholders, reducing the potential for errors and fraud. In construction, this could translate to more efficient tracking of financial transactions, materials, and milestones. For example, by utilizing blockchain, construction companies can automate the process of verifying material deliveries and project milestones, ensuring that payments are made only when the agreed conditions are met. This eliminates delays that often arise from manual processing and disputes over delivery verification, ultimately improving cash flow for suppliers and subcontractors, who are often dependent on timely payments to maintain operations.

In terms of reducing financing costs, blockchain-based SCF solutions significantly improve transparency and shorten the capital cycle. Traditional construction financing often involves multiple intermediaries, resulting in higher costs and delays. Blockchain can streamline this process by reducing the need for third-party verification and documentation. A blockchain-enabled SCF platform can directly connect contractors with financiers, ensuring that funds are released efficiently as project milestones are verified on the blockchain. This not only reduces the cost of financing by cutting out unnecessary intermediaries but also facilitates access to financing for SMEs in the construction industry, which typically struggle to obtain traditional bank loans. Through blockchain-based solutions, SMEs can gain access to financing based on verified accounts receivable or project progress, reducing the burden of upfront capital requirements and making the construction process more agile.

Blockchain also plays a significant role in reducing performance risks in construction projects, which are often plagued by delays, poor-quality materials, and fraud. One of the key advantages of blockchain in SCF is the use of smart contracts, which can automatically execute and enforce the terms of an agreement once predefined conditions are met. In the construction industry, smart contracts could automate payments based on the verification of construction milestones or the delivery of materials. For instance, once a supplier delivers materials to a construction site and the delivery is verified via blockchain, the smart contract can automatically trigger payment, reducing the risk of disputes or delays. This enhances trust between contractors and suppliers and ensures that all parties meet their obligations, thus reducing the likelihood of project delays and cost overruns.

Moreover, BT's ability to offer real-time tracking and monitoring also allows for more effective risk management. BT provides a tamper-proof record of all transactions, making it easier for stakeholders to identify potential issues early. For example, contractors can track the status of their payments and material deliveries in real time, enabling them to make more informed decisions about

cash flow management and procurement. This real-time visibility is especially critical in large-scale, multi-phase construction projects where delays in one phase can have cascading effects on the entire project timeline.

By addressing the core challenges of information fragmentation, financing inefficiencies, and performance risks, SCF integrated with BT has the potential to drive significant improvements in the construction industry. The use of blockchain enables a more efficient, transparent, and secure financing process, enhancing trust between stakeholders, reducing the cost and complexity of financing, and improving the overall financial stability of construction projects.

Through these practical applications, SCF, when powered by BT, can foster a more resilient and innovative construction supply chain, ensuring that projects are completed on time, within budget, and to the desired quality standards. As BT continues to evolve and optimize, its integration into the construction industry's SCF practices is poised to offer long-term benefits, promoting efficiency, reducing financial risk, and supporting sustainable growth within the industry.

4.4.3 Perception of benefits; perception of costs

Perception of benefits refers to the perceived positive consequences of a particular behavior by individuals or organizations [41]. Costs can inhibit the adoption of innovative technologies. Adopting BT requires substantial management and implementation costs, as well as investments in operations, hardware infrastructure updates, and talent training costs. Enterprises that perceive these costs as too high or unsustainable for economic investment may be reluctant to adopt blockchain-based SCF systems. Therefore, perception of costs can influence the adoption of blockchain SCF systems by SCF enterprises. This project defines perceived costs as the negative feedback that participants in construction SCF can perceive when using blockchain for financing, primarily including investments in operational management, hardware infrastructure updates, and talent training costs, as well as potential loss risks from failed transformations.

4.4.4 Hierarchical structure

In the organizational structure of SCF, each type of participant has its own functions and requirements. The objectives of the supply chain system are decomposed and transmitted from top to bottom, with each entity completing its tasks based on the system and processes of the supply chain to ensure the achievement of overall goals. Based on blockchain-based SCF systems utilizing distributed data structures, SCF entities (core enterprises in the supply chain, upstream and downstream SMEs, financial institutions, and logistics companies) have a high level of decision-making autonomy and do

not need to take actions within the framework and systems of central enterprises. A distributed organizational structure differs from a centralized one, and its role in coordinating network entities and evolving cooperative behaviors is also different. Therefore, different types of hierarchical structures have different impacts on the behavioral choices of entities. We aim to discuss the impact of this hierarchical structure on collaborative and conflicting behaviors of entities. Specifically, we want to study the influence of the composition ratios of the four types of entities on employee cooperation and conflict behaviors [42].

4.5 Summary

This chapter explores the potential of BT to enhance information transparency, reduce financing costs, and optimize transaction security through an in-depth analysis of the application of BT in building industrial SCF. First of all, we reveal the shortcomings of current SCF in information sharing, financing costs, and transaction security through questionnaire survey data, and clarify the applicability of BT as a solution. Specifically, in the construction industry, SCF often suffers from delays in payment cycles, fragmented communication between contractors and suppliers, and the complex nature of financing arrangements involving multiple intermediaries. These issues lead to inefficiencies, increased operational costs, and strained relationships among project stakeholders. BT, with its decentralized and transparent ledger system, can address these challenges by providing real-time visibility into transactions, reducing the reliance on intermediaries, and ensuring that payment milestones are met based on verified project data.

Then, by building a game model, we identify the key participants in SCF—such as contractors, subcontractors, suppliers, and financial institutions—and their strategic choices. In the context of the construction industry, the behavior of these stakeholders is often influenced by cash flow management concerns, payment delays, and the risk of non-performance. Blockchain's ability to provide an immutable, transparent record of all financial and operational transactions can help align the interests of these parties by ensuring that payments are processed quickly and accurately once project milestones are verified. This can incentivize timely performance, reduce financing costs, and promote greater cooperation among participants.

In addition, we explore the key factors that influence cooperative behavior, highlighting the impact of policy support, competitive pressures, perceived costs and benefits, and organizational hierarchy on decision-making among participants. In the construction industry, policy support, such as government incentives for adopting blockchain in SCF, could play a critical role in accelerating the adoption of blockchain-based solutions. Competitive pressures also influence construction firms to

adopt more efficient financing models, while the perceived costs and benefits of implementing BT, including the initial setup costs and long-term savings, are important factors in decision-making. Organizational hierarchy, such as the role of project managers and financiers, affects how information and financial flows are coordinated, which can be optimized through blockchain's transparency and automation features.

In summary, the research in this chapter provides a theoretical basis for the practical application of blockchain in SCF, specifically in the construction industry, and offers valuable insights into how SCF can be optimized to overcome the unique challenges faced by the construction sector. By addressing the inefficiencies in financing, improving transparency, and reducing risks, blockchain-based SCF solutions can significantly enhance the financial and operational dynamics of construction projects, providing a reference direction for future decision-making and implementation in the field.

CHAPTER 5

Conclusion

5.1 Final conclusions

This project explores the application of BT in the financial industry and its impact on information sharing efficiency, financing costs, and transaction security by designing and analyzing a survey questionnaire. Through extensive surveys of practitioners from different financial institutions, we have obtained direct feedback on the practical application effects of BT, revealing its value and potential in the current financial ecosystem.

BT is widely believed to significantly improve the transparency and efficiency of information sharing. The survey results show that the majority of participants believe that BT is very effective in improving information sharing transparency, due to its core feature—the decentralized distributed ledger, which ensures real-time updates and immutability of data. This is particularly important for breaking the long-standing phenomenon of information silos in financial services, which helps to improve the operational efficiency and response speed of the entire financial system.

Blockchain also shows enormous potential in reducing financing costs. By reducing intermediate links and simplifying transaction processes, blockchain helps to reduce transaction costs and improve liquidity of funds. Survey data shows that most financial institution practitioners have experienced the practical benefits of BT in reducing operating costs, especially in areas such as cross-border transactions and SCF.

In terms of improving transaction security, BT has also received high praise. Due to its powerful encryption technology and decentralized characteristics, blockchain greatly enhances the security of transaction data, reducing the possibility of data tampering and fraud. The vast majority of participants believe that BT is at least effective in enhancing the security of financial transactions, providing a strong security tool for the financial industry.

However, despite the many advantages brought by BT, it still faces challenges in practical applications. This includes the complexity of technology integration, compatibility issues with existing systems, and initial deployment costs in some cases. These challenges require financial institutions to carefully plan and adequately prepare when adopting BT.

In addition to its impact on traditional financial services, BT also holds transformative potential for other sectors, particularly the construction industry. The construction sector, characterized by fragmented supply chains, complex financing structures, and long payment cycles, can benefit

immensely from BT-enabled SCF solutions. Blockchain can provide real-time visibility into financial transactions, ensuring that contractors and suppliers are paid on time as project milestones are met, thus improving cash flow and reducing operational risks. BT can also improve transparency in project financing, enabling better tracking of material deliveries, project progress, and financial settlements, which helps to streamline procurement processes and reduce delays.

For SMEs in the construction industry, BT presents a unique opportunity to overcome common financing barriers. In many cases, SMEs face significant challenges accessing credit or financing due to their lack of credit history or limited collateral. BT-based SCF solutions can help mitigate these challenges by offering more transparent financial data and reducing the risk assessment costs for lenders. By using blockchain to verify accounts receivable or project progress, SMEs can demonstrate their financial stability and improve their chances of obtaining financing at favorable rates, thus leveling the playing field for smaller firms in the competitive construction market.

As for the technical challenges posed by BT, particularly the complexity of integrating new technologies into existing systems, there are several innovative solutions aimed at simplifying these complexities. Modular integration, for instance, allows for the gradual implementation of BT, enabling organizations to adopt new systems without fully replacing their existing infrastructure. Furthermore, the use of smart contracts can automate key processes such as payment processing, reducing manual intervention and minimizing the risk of errors or fraud. By automating contract execution, blockchain can ensure that all parties in a transaction adhere to agreed terms, thus reducing the complexity of managing multi-party projects.

By leveraging BT, the project highlights actionable solutions to overcome systemic issues, including limited access to credit, fragmented financing, and operational inefficiencies that disproportionately affect SMEs. BT's decentralized architecture ensures the transparency and immutability of transaction records, which is particularly valuable for SMEs that often struggle with creditworthiness and trust barriers within traditional financial systems.

The project also explores innovative strategies to address the technical complexity and scalability challenges of BT in SCF. Solutions include modular integration of BT with existing construction supply chain systems to reduce deployment barriers and costs. Additionally, the application of advanced blockchain technologies, such as sharding and cross-chain protocols, demonstrates how scalability can be enhanced without compromising efficiency or security. These approaches not only improve system performance but also provide a sustainable path for integrating BT into broader financial ecosystems, making it more accessible to diverse stakeholders within the construction industry

Finally, scalability and sustainability remain critical considerations for the widespread adoption of BT. Blockchain's current limitations, particularly in terms of transaction speed and energy consumption, pose challenges to its scalability. To address these concerns, ongoing developments in layer-2 solutions

and proof-of-stake consensus mechanisms are expected to enhance the scalability of blockchain networks while reducing their environmental impact. These innovations make it more feasible for industries like construction to integrate blockchain into their operations without sacrificing efficiency or sustainability. Additionally, the interoperability between different blockchain platforms is a key area of focus, ensuring that various blockchain networks can communicate and work together seamlessly. This cross-platform compatibility can help ensure that blockchain can scale across industries and maintain its relevance as a long-term solution for financial and operational challenges in diverse sectors.

In summary, BT holds immense transformative potential for the financial industry, offering improvements in information flow, cost reduction, and transaction security. Its impact extends beyond traditional financial services, with significant implications for sectors like construction and SCF. To fully harness these advantages, financial institutions and industries like construction must actively explore and refine blockchain's practical applications, focusing specifically on solutions tailored to industry-specific needs and addressing associated technical and operational challenges. With targeted efforts to simplify integration, enhance scalability, and ensure sustainability, BT is poised to revolutionize the financial services landscape and beyond, driving greater efficiency and innovation in industries worldwide.

5.2 Limitations

First, although this research thoroughly explores the potential applications of BT in SCF for construction industrialization, the adoption of BT in the construction industry is still at an early stage. The widespread implementation of BT faces various challenges, including technological maturity, costs, and user adaptability, which may limit the practical feasibility of the study's conclusions.

Second, the data collection in this study primarily relies on survey questionnaires and literature analysis, which may constrain the diversity of data sources. The opinions of survey participants might not fully represent the general situation of the construction industrialization sector, especially considering potential regional and market differences that were not adequately captured.

Third, the research focuses on the application of blockchain in the context of China's construction industrialization, which may limit the international applicability of its findings. In other countries or regions, variations in policies, regulations, and market environments could necessitate further adaptation and validation of the study's results.

Lastly, while this study constructs a game-theoretical model to analyze participant behaviors, the model is based on certain simplified assumptions and does not fully encompass the complex dynamic

relationships within the construction industrialization supply chain. Such simplifications might impact the precision and comprehensiveness of practical applications.

To enhance the breadth and applicability of the research, future studies could expand the sample coverage, investigate scenarios in international contexts, and incorporate more dynamic and contextual variables to further explore the potential of BT in SCF for construction industrialization.

5.3 Future research

The application of BT within SCF in the construction industry has shown promising results. However, to fully realize its potential, specific challenges need addressing and opportunities for expansion must be explored.

1. Technology Integration and Compatibility: Future studies should concentrate on merging blockchain with existing financial systems specific to the construction industry. It should aim at reducing compatibility issues between blockchain solutions and traditional financial infrastructures to facilitate seamless integration, thus boosting adoption rates and enhancing effectiveness within SCF.

2. Scalability and Performance Optimization: As blockchain finds more applications in SCF, the need to manage larger volumes of transactions and data becomes crucial. It should focus on developing new consensus mechanisms, data compression techniques, and parallel processing strategies specifically suited for the high demands of the construction industry.

3. Legal Regulations and Compliance: The broader use of blockchain in SCF brings forth complex regulatory challenges, particularly in the construction industry known for its stringent regulations. Future research should focus on constructing compliant blockchain frameworks and solving cross-border regulatory cooperation issues, essential for the technology's long-term success in global markets.

4. Cross-Industry Applications: Exploring blockchain applications beyond financial transactions to areas such as project management, procurement, and compliance in construction can unlock new opportunities. This exploration could lead to innovative solutions that streamline operations and reduce costs across the construction supply chain.

5. User Acceptance and Behavior Research: Understanding the acceptance and use behavior of BT among stakeholders in the construction industry is vital. Future studies could investigate the factors influencing user acceptance and develop strategies to foster trust and routine use of blockchain in SCF applications.

6. Integration of Blockchain and Artificial Intelligence: Investigating how blockchain can be enhanced with AI to optimize SCF processes in the construction industry could revolutionize decision-making, transaction monitoring, and risk management.

As the application of BT in SCF in the construction industry gradually expands, these changes have a profound impact in the future. By addressing key challenges such as technology integration, performance optimization, regulatory compliance, cross industry applications, user acceptance, and the integration of blockchain and artificial intelligence, we can further unleash the potential of blockchain. This can not only help enhance the efficiency and transparency of the industry, but also promote the comprehensive upgrading of SCF in the construction industry. We believe that through these improvement measures, it can significantly enhance the results of our current work and lay a solid foundation for future development.

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