Feasibility Analysis of Blockchain Technology in Addressing Supply Chain Finance Bottlenecks

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Abstract. Blockchain technology, initially introduced as the underlying technology for Bitcoin, has garnered significant attention for its decentralized advantages. This paper provides a comprehensive analysis of the feasibility of applying blockchain technology to address bottlenecks in supply chain finance. Starting with a brief introduction to blockchain technology, the paper explores its key characteristics, architecture, and consensus algorithms. Subsequently, it delves into the outlook for supply chain finance in China, highlighting the challenges faced by small and medium-sized enterprises (SMEs). The feasibility analysis examines the macro-environmental and technical aspects, demonstrating how blockchain's features, including immutability, decentralization, smart contracts, and transparency, can offer solutions to trust-related issues and reduce operational costs in supply chain finance. This analysis reveals the promising potential of blockchain technology in transforming the supply chain finance landscape.

Keywords: Blockchain, Supply Chain Finance, Feasibility Analysis, Small and Medium-sized Enterprises (SMEs), Decentralization

1 Introduction

Blockchain technology, originally introduced as the foundational technology behind Bitcoin in Satoshi Nakamoto's groundbreaking paper [1], has since evolved beyond its cryptocurrency roots. With its decentralized and immutable attributes, blockchain

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technology presents a promising solution to long-standing challenges within the realm of supply chain finance. This paper aims to provide an extensive analysis of the feasibility of applying blockchain technology to alleviate bottlenecks in supply chain finance, particularly within the context of small and medium-sized enterprises (SMEs) in China. Blockchain, at its core, represents a distributed database system that has the potential to address trust-related issues, operational inefficiencies, and cost burdens prevalent in supply chain finance. Through the establishment of transparent and tamper-resistant ledgers, decentralized decision-making processes, and programmable smart contracts, blockchain technology offers the opportunity to revolutionize SMEs' access to financing and streamline the operations of supply chain finance. The subsequent sections will delve into a more detailed analysis, beginning with an overview of blockchain's key attributes and architecture. We will then evaluate the current state of supply chain finance in China, with a specific focus on the financing challenges confronting SMEs. The feasibility analysis will subsequently explore both macro-environmental and technical aspects, illustrating how blockchain's distinctive features can effectively address these challenges. Through this analysis, we intend to illuminate the promising potential of blockchain technology's integration into supply chain finance, ultimately facilitating improved access to financing for SMEs while enhancing the efficiency of supply chain finance operations.

2 Feasibility Analysis of Blockchain Technology Addressing the Bottlenecks in Supply Chain Finance Development

Blockchain technology, initially introduced in the paper "Bitcoin: A Peer-to-Peer Electronic Cash System" by Satoshi Nakamoto [2], was originally conceived as the underlying technology for Bitcoin, not garnering significant attention at first. However, with the growing prominence of blockchain's decentralized advantages, it gradually drew interest, leading to the "blockchain hype" phenomenon.

2.1 A brief introduction to blockchain technology

Blockchain technology, fundamentally a distributed database system, has been defined differently by various institutions and scholars. In its narrowest sense, it serves as a database that links data blocks in chronological order using timestamp technology, creating an immutable distributed public ledger. In a broader context, blockchain technology offers a computational paradigm or solution. It utilizes an encrypted, chain-linked block structure for data validation and storage, employs distributed node consensus algorithms for data generation and updates, and utilizes automated script code (smart contracts) for programming and data operations, constituting a novel decentralized infrastructure and distributed computing paradigm. Blockchain can be categorized into permissionless and permissioned chains. Permissionless, or public chains, grant nodes the freedom to join and equal accounting rights, such as Bitcoin. Permissioned chains are further divided into consortium chains and private chains, where only authorized nodes can account for

transactions [3]. R3 Corda, for instance, represents a consortium chain, while private chains are typically used for in-house corporate systems, as shown in Table 1.

Table 1. Blockchain Model Comparison Table

Comparison Criteria	**Public Blockchain**	**Consortium Blockchain**	**Private Blockchain**
Degree of Decentralization	Fully Decentralized	Partially Decentralized	Centralized
Security Level	Low Relatively	High	High
Transaction Efficiency	High	Relatively High	Low
Representative Use Cases	Bitcoin, Ethereum	R3 Consortium	Mitsubishi UFJ Group

Blockchain's key characteristics include decentralization, immutability, programmability, and irreversibility.

(1) Decentralization

In Figure 1, Blockchain differs significantly from traditional centralized databases. Centralized databases typically store all data in a large central processor, making data backup and updates cumbersome. In contrast, blockchain is a distributed database, with each node storing all information. Even if one node encounters issues, other nodes' data remains intact, demonstrating decentralized storage.

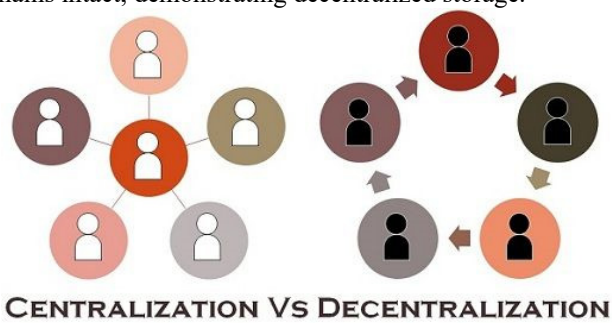

Fig. 1. Difference Between Centralization and Decentralization

(2) Immutability

Most traditional databases, often referred to as relational databases, are convenient to use and maintain but suffer from low data security. In contrast, blockchain databases are resistant to alterations and data manipulation, offering data immutability [4].

(3) Programmability

Blockchain's architecture model comprises six layers: data, network, consensus, incentive, contract, and application layers. The contract layer encapsulates various scripts, algorithms, and smart contracts, endowing blockchain technology with programmability.

(4) Irreversibility

Blockchain acts as a database that combines data blocks in chronological order using timestamp technology. Each block in the ledger contains the contents of all previous blocks, alongside the current transaction data. Once the content is validated, it cannot be altered.

2.2 Blockchain Technology Architecture Analysis

Blockchain primarily consists of six layers: data, network, consensus, incentive, contract, and application layers, with each layer employing distinct technologies, as shown in Figure 2.

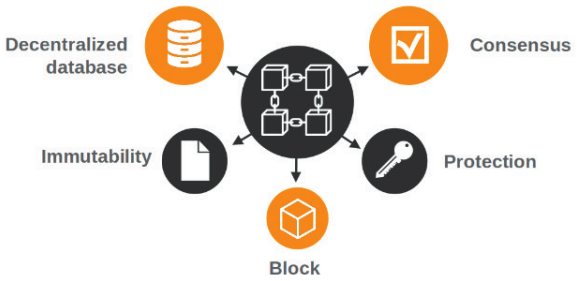

Fig. 2. Blockchain technology architecture

The data layer is responsible for storing data and transaction information within the blockchain. It comprises data blocks and a chain-like structure, utilizing a UTXO (Unspent Transaction Output) structure [5]. In Figure 3, unlike traditional databases that use ledger structures, blockchain leverages encryption, timestamps, hash functions, and chain structures for data immutability, query, location, and traceability.

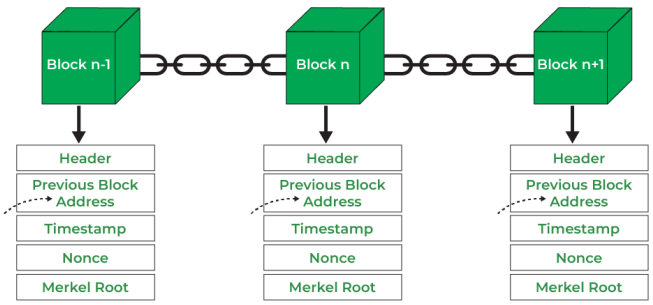

Fig. 3. Block data structure diagram

The network layer encompasses P2P (Peer-to-Peer) network technology, validation mechanisms, and propagation mechanisms. P2P network technology facilitates the

free entry and exit of nodes within the blockchain network. Nodes participate in verifying and recording transactions, subsequently disseminating validation and accounting results to all participating nodes.

The consensus layer is where consensus mechanisms come into play. Consensus mechanisms address the issue of data consistency and correctness among different ledger nodes. Centralized databases provide data from a central source, ensuring strong consistency. In contrast, blockchain, as a distributed database, faces the challenge of weak consistency, necessitating consensus mechanisms. Popular consensus algorithms include Proof of Work (PoW), Proof of Stake (PoS), and Delegated Proof of Stake (DPoS), selected based on specific business requirements [6], as shown in Table 2.

Table 2. Consensus Algorithm Comparison Table

Consensus Algorithm	**Advantages**	**Disadvantages**
POW	Decentralization	High resource consumption, long transaction confirmation times
POS	Reduced resource consumption	Vulnerable to coin age attacks, resource inequality
DPOS	High throughput	Potential for the formation of an oligarchy or centralization
PBFT	High throughput, short transaction confirmation times	Fixed number of nodes

The incentive layer encompasses issuance and distribution mechanisms. In blockchain, participants contribute computational power (mining) to support operations, akin to labor in the real economy. To incentivize active participation, suitable incentive mechanisms are designed.

The contract layer serves as the technical foundation for flexible programming and data operations within the blockchain system. It includes various script codes, algorithmic mechanisms, and smart contracts. Smart contract technology can be applied across multiple scenarios, including finance and energy, offering high efficiency, real-time execution, low human intervention risk, decentralized authority, and cost-effectiveness.

The application layer interfaces with various application scenarios, such as digital currencies, finance, energy, copyright, and more. The programmability of blockchain technology lays the groundwork for programmable currency, finance, and even society in the future.

3 Feasibility Analysis of Applying Blockchain Technology in Supply Chain Finance

In China, various macro and micro factors have hindered the development of supply chain finance, with a key issue being the low level of trust among enterprises within the supply chain. Blockchain technology serves as a potential solution to address trust-related challenges, offering a viable solution.

3.1 Outlook Analysis

In China, the financing options for small and medium-sized enterprises (SMEs) primarily include commercial financing from supply chain partners, bank loans, or securities market financing. SMEs face challenges in raising funds due to their small scale and higher risk profile [7]. Few qualify for listing or bond issuance, reducing their chances of using securities market financing. Consequently, SMEs often rely on commercial financing or bank loans, but their inability to effectively control risk makes it challenging to secure financing from traditional financial institutions. According to data from the China Banking and Insurance Regulatory Commission, by the end of 2018, the balance of loans provided by banking financial institutions to micro and small enterprises in China was CNY 33.49 trillion, accounting for only 23.81% of the total loan balance of banking financial institutions. Data from the Ministry of Industry and Information Technology indicates that 33% of medium-sized enterprises, 38.8% of small enterprises, and 40.7% of micro-enterprises in China have unmet financing needs. According to a survey on "Financing Gaps in Emerging Market SMEs" published by the World Bank, China's unmet financing gap for formal-sector micro, small, and medium-sized enterprises (MSMEs) is close to USD 1.9 trillion, with a financing gap rate of 43% and a contribution to GDP of 17%. With over 23 million constrained MSMEs in China, and 41% and 42% of micro and small enterprises, respectively, facing financing constraints, it is evident that there is significant demand for financing among MSMEs, offering promising growth prospects.

Integrating blockchain technology can address current trust and security issues, effectively reduce the cost of financing for MSMEs, and enhance financing efficiency, making it of paramount importance for the development of supply chain finance.

3.2 Feasibility Analysis

The application of blockchain technology in supply chain finance holds significant promise. However, it requires further exploration to determine if blockchain technology can seamlessly integrate with supply chain finance and effectively transform it.

(1) Macro Environmental Feasibility Analysis

According to relevant data, as of the end of 2017, there were a total of 372,929 large-scale industrial enterprises in China, with small and medium-sized enterprises (SMEs) accounting for 98% of them [8]. This underscores the vital role of SMEs in China's economic landscape. However, the small scale and limited creditworthiness of SMEs have led to a lower success rate in securing financing through the securities market. Supply chain finance, designed to alleviate the financing difficulties of SMEs, has garnered significant attention from both the government and industry. Yet, the emergence of supply chain finance has not addressed the fundamental issue of trust among enterprises, which remains a major obstacle to SMEs accessing financing. The introduction of blockchain technology can enhance the sense of security for on-chain enterprises and offer a new approach to rebuilding trust mechanisms among businesses. Currently, both the government and the industry are actively researching blockchain technology, with policies aimed at promoting its application in the supply chain sector. Real-world use cases of blockchain technology in supply chain finance are also on the rise, signifying the growing maturity and relevance of research findings.

(2) Technical Feasibility Analysis

Blockchain technology incorporates various technologies, including smart contracts and cryptography, making it highly compatible and extensible. Essentially, blockchain serves as a distributed database, where each node in the network is equal and operates as a small database with identical data. Consequently, errors in one small node do not affect the overall blockchain, enhancing reliability. Supply chain finance management information systems, when transformed using blockchain technology, benefit from increased reliability. Moreover, blockchain technology is open-source and possesses programmable features. Clients can write code based on their specific business needs, enabling functionalities such as automatic signing and intelligent supervision through smart contract technology. Additionally, blockchain's timestamp technology and unique chain structure enable data traceability, enhancing data credibility and reducing risks associated with supply chain finance operations. From a technical standpoint, blockchain is fundamentally a decentralized distributed database with characteristics that offer solutions to traditional supply chain finance services in four main aspects.

(1) Blockchain Immutability and Trust Rebuilding

Blockchain integrates technologies such as timestamps, cryptography, and chain structures, providing it with an inherent immutability feature. Enterprises on the blockchain, as well as financial institutions, assess and audit companies primarily based on system data during transactions. However, traditional centralized databases, managed by administrators, can be manipulated, modified, or deleted by database-registered users or even hackers. In contrast, blockchain-based databases, supported by consensus mechanisms and timestamps, make data tampering challenging. This ensures the authenticity of data and transactions, enabling the re-establishment of trust mechanisms among transaction parties.

(2) Blockchain Decentralization and Cost Reduction

Blockchain technology allows decentralization, where each participant is a node in the blockchain network. Information and data are shared among nodes, ensuring

equality among participants. This eliminates the need for third-party intermediaries during transactions, reducing transaction costs while mitigating third-party risks. Furthermore, traditional supply chain finance involves complex trust maintenance due to the complexity of participants, resulting in high credit maintenance costs. Operating supply chain finance tools based on blockchain technology can enhance information sharing, further lowering credit maintenance costs for enterprises.

(3) Blockchain Smart Contract Integration and Efficiency Enhancement

Supply chain finance operations are often complex, involving intricate business processes with numerous human-computer interaction points, leading to reduced operational efficiency and accuracy. Blockchain technology offers high compatibility and, when integrated with smart contract technology, enables automation of contract signing and intelligent supervision within supply chain finance operations. It simplifies business processes, reduces human-computer interaction points, and enhances operational and transaction efficiency.

(4) Blockchain Transparency and Risk Mitigation

Blockchain requires nodes on the chain to competitively account for various transaction information and data based on consensus mechanisms. This ensures data consistency and allows for data traceability through hash values, enhancing data transparency while reducing operational, credit, and other risks faced by enterprises. Overall, the application of blockchain technology in supply chain finance demonstrates substantial feasibility, offering solutions to long-standing challenges in the industry.

4 Conclusion

In summary, this paper has provided a thorough analysis of the feasibility of integrating blockchain technology into the supply chain finance sector, particularly concerning the challenges faced by small and medium-sized enterprises (SMEs) in China. Blockchain's unique attributes, such as immutability, decentralization, smart contracts, and transparency, have been explored in the context of addressing trust-related issues and reducing operational costs in supply chain finance. The macro-environmental analysis underscores the critical role of SMEs in China's economy and the pressing need for innovative solutions to their financing challenges. Blockchain technology has emerged as a potential remedy to these issues, and its adoption is being actively promoted by both governmental and industrial entities. On the technical front, blockchain's compatibility, decentralization, smart contract capabilities, and data traceability offer compelling solutions for traditional supply chain finance problems. From immutability and trust rebuilding to cost reduction, efficiency enhancement, and risk mitigation, blockchain demonstrates substantial feasibility.

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