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RESEARCH ARTICLE

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Blockchain-driven supply chain finance solution for small and medium enterprises

Abstract Blockchain has attracted much attention in recent years with the development of cryptocurrency and digital assets. As the underlying technology of cryptocurrency, blockchain has numerous benefits, such as decentralization, collective maintenance, tamper-resistance, traceability, and anonymity. The potential of the blockchain technology (BT) is widely recognized in the financial field. Although some scholars have proposed the combination of blockchain and supply chain finance (SCF), the details of this combination is rarely mentioned. This study first analyzes the coupling between SCF and blockchain technology. Second, the conceptual framework of blockchain-driven SCF platform (BcSCFP) is presented. Third, the operation process of three SCF models on the BcSCFP is proposed. Finally, a case study combined with actual events is conducted. This paper has a positive practical significance in the operation and management of banks and loan enterprises.

Keywords blockchain technology, supply chain finance, risk management, smart contract, decentralization

1 Introduction

In recent years, more and more people are learning about blockchain because of the popularity of Bitcoin. Blockchain was first proposed in 2008. Nakamoto (2018) published the paper entitled *Bitcoin: A peer-to-peer Electronic Cash System*, which proposed an electronic cash system that does not rely on central institutions and is completely realized through point-to-point technology. Besides Bitcoin, blockchain can be applied to diverse fields, such as the Internet of Things (IoT) (Zhang and Wen, 2015), public services (Akins et al., 2014), reputation systems (Sharples and Domingue, 2016), and security services (Noyes, 2016). A consortium of companies, led by Walmart, has worked with IBM to identify how global food supply chains can benefit from blockchain. Walmart piloted the use of blockchain to track pork in China. Given its decentralized nature, blockchain can be applied to various financial services, such as online payment and supply chain finance (SCF) (Foroglou and Tsilidou, 2015; Peters et al., 2015).

Small and medium-sized enterprises (SMEs) have an important position in the economy. They play a key role in attracting investment and employment. However, due to their small scale, poor management, information asymmetry, and other factors, SMEs have difficulty in obtaining bank loans. SCF refers to comprehensive financial products and services provided by financial institutions that link the core enterprises in the supply chain and their related enterprises together. According to the different forms of enterprise guarantee, SCF can be divided into three categories, namely, advance payment financing, accounts receivable financing, and inventory pledge financing. In addition to these three basic models, many derivative models of SCF exist. Hundreds of credit cases, such as repeated pledge and empty bill pledge, broke out in the Chinese steel industry in 2012, involving more than 100 billion yuan. Banks and other financial institutions are cautious in dealing with SCF businesses, which causes difficultly for many SMEs to obtain loans and destroys the whole SCF ecology. SCF was highly recognized by the industry when it was proposed but has been limited by many problems for a long time. Thus, it could not play its ideal role. Since SCF was proposed, three bottlenecks have

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been found: 1) the authenticity of a transaction cannot be effectively confirmed, 2) transferring core enterprise credit to the end of the supply chain is difficult, and 3) risk control costs remain high.

Given the relatively low transaction frequency and the lack of mutual trust between multiple co-existing nodes, blockchain technology (BT) is well suited to SCF business scenarios. Blockchain can bring the following benefits to SCF. 1) Blockchain can solve the problem of authenticity of transaction background. Blockchain is a distributed ledger with the characteristics of persistency, auditability, traceability, and time-stamped, which can solve a financial institution's concerns about transaction background authenticity. 2) The credit of core enterprises can be transferred to the end of the supply chain. The blockchain platform can digitize and register bills, such as warehouse receipts, receivables, and acceptance bills, and support online pledges and transfers. After receiving a bill offered by the core enterprises, tier 1 suppliers or retailers split and transfer it to their suppliers or retailers. 3) A smart contract can guarantee the execution of contracts, which is a computer protocol designed to facilitate, verify, or enforce the negotiation or execution of a contract. The contract's contents are written into the blockchain platform through programming. Once the contract conditions are met, the smart contract automatically executes the agreement contents and realizes the transfer of property. 4) Blockchain can provide unprecedented data security. Given its tamper-resistance nature, the blockchain platform forms almost untampered records after a new block is recognized by most nodes. Moreover, the persistence can solve the problem of bills loss. 5) Digital assets can trace the flow of assets. Tokenization is an inevitable result of the development of blockchain although it is still at the theoretical level. For example, IBM and Veridium announced in 2018 that they plan to apply tokenization to carbon emission quotas. In this way, information about the flow of goods and pledge are recorded on the blockchain platform. The large-scale application of blockchain in SCF still faces many challenges, for example, the low level of digitization, the lagged infrastructure construction of the bill market and insufficient relevant laws. Moreover, many problems should be solved after blockchain is implemented, for example, the lack of motivation for core enterprises to participate, the security and legal issues of smart contract, and the cost of financial institutions' access to different blockchain systems.

Based on the analysis of recent research on blockchain and its application in the SCF, this study proposes a solution to the SCF to establish an SCF platform based on blockchain. Combined with the characteristics of SCF business, the conceptual framework of the blockchain-driven SCF platform (BcSCFP) is proposed, and the operation processes of three SCF models on the BcSCFP are given to illustrate some details. Moreover, a case study is conducted to verify the proposed solution based on the BcSCFP. The remainder of this study is organized as follows. Section 2 reviews the relevant literature of the BT and its application in SCF. Section 3 describes the integration scheme of blockchain and SCF, including the selection of blockchain, the node types on the BcSCFP, and the conceptual framework of the BcSCFP. Section 4 discusses the SCF operation process based on the BcSCFP, including advance payment financing, accounts receivable financing, and inventory pledge financing. Section 5 conducts a case study to verify the proposed solution based on the BcSCFP. Finally, Section 6 summarizes the conclusions and future work directions.

2 Literature review

2.1 Blockchain technology

Blockchain is a distributed database that stores data through a chain structure. In the blockchain system, a consensus algorithm is used to record and update data, asymmetric encryption is used to protect user privacy and data security, and the smart contract is used to ensure the implementation of contracts (Li et al., 2018). Most existing literature on blockchain has started with the original white paper by Nakamoto (2018). The current literature on blockchain can be divided into two categories.

Some papers have focused on the improvement of the BT to overcome its challenges. In recent years, the blockchain platform's security problems occur frequently, resulting in considerable economic losses (Zamani et al., 2018). Given that the earliest application of blockchain was Bitcoin, which is a peer-to-peer payment system, security issues have become the biggest challenge in blockchain development (Lin and Liao, 2017). Common system vulnerabilities are likely to appear in the blockchain system, such as scalability and privacy leakage (Li et al., 2020). In particular, the smart contract in the blockchain system has been the focus of scholars (Wang et al., 2018).

Other studies have been mainly about the innovative application of blockchain in various fields, such as SCF, IoT, social service, and reputation system (Zheng et al., 2018). For example, Saberi et al. (2019) applied the BT to logistics management and used its advantages of visibility and transparency to collect data. Babich and Hilary (2019) pointed out the research direction of blockchain in the field of operations management (OM), analyzed the five advantages and five disadvantages of blockchain, and summarized the three research themes of BT application in OM. In addition to the above applications in operation and production, blockchain is widely used in product traceability. Pun et al. (2018) examined how BT can be used to combat counterfeiting through the consideration of the interplay between a manufacturer and a counterfeiter. Tian (2016) applied IoT to enhance food safety and proposed business processes in practical operation. Li et al. (2018)

proposed a cross-enterprise knowledge framework based on blockchain and established an open manufacturing environment. Álvarez-Díaz et al. (2017) emphasized the role of smart contract and proposed to use it instead of traditional paper documents to improve the settlement efficiency in logistics management.

2.2 SCF and application of blockchain in SCF

The history of SCF research can be traced back to the 1970s, when scholars began to study the relationship between operation management and trade credit (Budin and Eapen, 1970; Haley and Higgins, 1973). SCF aims to optimize supply chain cash flow with the upstream or downstream trade relationships and the credit endorsements of core enterprises (Wuttke et al., 2013). Burkart and Ellingsen (2004) showed that suppliers' observability of transactions reduces the asset transfer opportunities of borrowers. Fabbri and Menichini (2016) and Chod (2017) demonstrated that the observability of transactions also reduces asset replacement problems. Tang et al. (2018) proved the value of information advantage in the case of information asymmetry by taking the supplier's supply capacity as the source of risk. The above literature has proven that information transparency is important and that blockchain can help SCF businesses to achieve it. Scholars have also done a lot of research on the application of blockchain in SCF. Hofmann et al. (2017) discussed the advantages of blockchain in SCF and summarized the typical application examples in this field. Chod et al. (2019) identified one of the key benefits of blockchain adoption, which is the ability of the BT to obtain favorable financing conditions at low signal costs by opening a transparent window for SCF operations. In practice, given that blockchain can solve the problems of asymmetric information, low financing efficiency, and high financing cost in SCF, SCF platforms based on the BT have been emerging.

Although attempts have been made to propose the combination of the BT and SCF, these studies only theoretically analyzed the coupling between the two. The present study differs from the aforementioned studies because it focuses on many details, including the conceptual framework of the BcSCFP and the operation process of basic SCF models based on this platform.

3 Conceptual framework of the BcSCFP

To facilitate financing for SMEs in SCF, the BcSCFP is proposed as an integrated solution to organize and manage all related activities. It mainly serves five kinds of participants involved in SCF, namely, loan enterprise, core enterprise, provider of financial services, third-party logistics (3PL), and regulatory agencies. Section 3.1 introduces the blockchain types, Section 3.2 analyzes the node types on the BcSCFP, and Section 3.3 presents the proposed conceptual framework of the BcSCFP.

3.1 Selection of blockchain

According to the degree of decentralization, blockchain can be divided into three categories, namely, public, consortium, and private blockchain. The appropriate type of blockchain should be chosen given the characteristics of information transparency and privacy protection of the SCF business. Public blockchain is completely decentralized. Everyone can act as a node in the network without the need to gain access from anyone else. Each node in the public blockchain can join or exit the blockchain network and participate in the verification, storage and update process of the data on a blockchain. Private blockchain is centralized and suitable for an independent organization. Only specific nodes can join the blockchain, which facilitates the control and deployment of the central organization. Consortium blockchain is partially decentralized. During the operation of the blockchain system, its consensus process may be controlled by some specific nodes, and only these nodes in the chain can participate in the accounting process.

The access threshold of the public blockchain is excessively low, which is not conducive to privacy protection, and the transaction speed is also extremely slow. The rights in the private chain are concentrated, and only one entity can manage the data on the blockchain. Compared with public and private blockchains, the transaction processing speed of consortium blockchain is faster, and the node authority can be set. It is suitable for the SCF business scenario. From the above discussion, the BcSCFP mentioned in this study should use consortium blockchain.

3.2 Node types on the BcSCFP

The BcSCFP mentioned in this study uses consortium blockchain as the core technology, and the node types have five kinds (corresponding to the five kinds of participants involved in SCF). Each node shares its company's data to the platform. A smart contract can ensure the completion of a financing business on the platform. On this platform, each node performs its own duties. Point-to-point interaction can be completed between any nodes, and the data view authority can be changed according to the actual situation. In this way, the platform realizes information sharing and the credit transfer between them. The interaction and functions of each node are shown in Figs. 1 and 2. We mainly focus on the following four node types.

1) Provider of financial services. The provider of financial services refers to the financing institutions represented by the bank, which use the blockchain platform to check the authenticity of the transaction

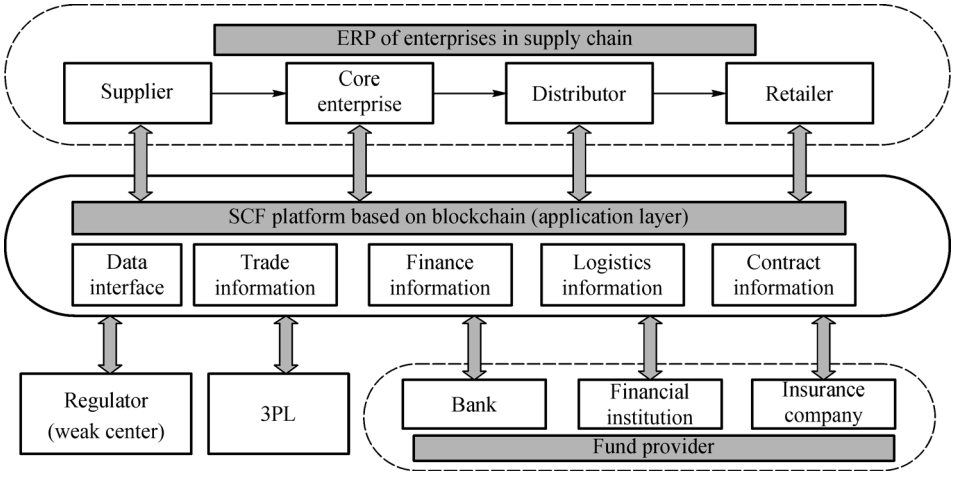

Fig. 1 Diagram of the interaction between nodes.

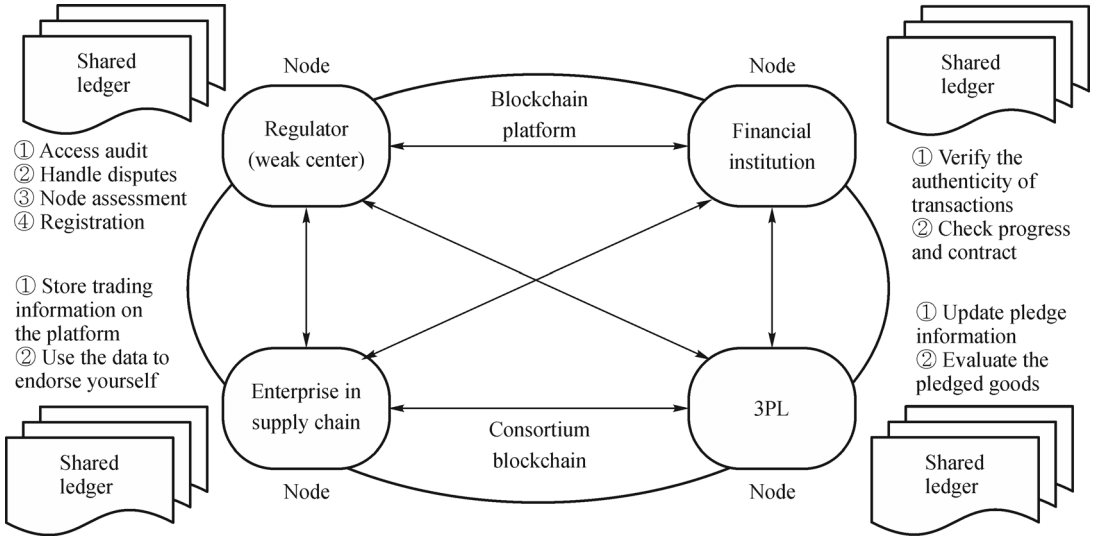

Fig. 2 Information flow and functions between nodes.

background of loan enterprises. In the traditional model, the bank does not have reliable transaction data of the enterprise due to asymmetric information when the enterprise submits a loan application. Thus, it needs to spend a lot of resources to verify the authenticity of the transaction and financial information. This way of credit investigation costs a lot, and the data obtained are not reliable. However, a lot of relevant information of enterprises in the supply chain is recorded on the BcSCFP, including the past trading records of enterprises, order status, and inventory information. Most importantly, the data on blockchain is tamper-resistant and reliable. As long as the financing institution has access to the data, it can inquire relevant information through the platform to judge the reputation of enterprises and decide whether to lend. This way reduces the cost of credit investigation and has high information credibility.

2) Loan enterprise. Loan enterprise refers to SMEs with capital constrained in the supply chain, including the core enterprise's upstream suppliers and downstream retailers. Under the traditional model, SMEs have difficulty in obtaining loans because these enterprises are relatively small in scale, unstable in operation, and high in risk. Financial institutions often do not prioritize these enterprises when dealing with loan business. With the BcSCFP, the transactions of enterprises can be completed on the platform, and the transaction records are stored on the platform in chronological order. Each node on the platform can query the information on the chain according to its own permission. Financial transactions on the blockchain are completed through smart contracts, which improve efficiency and reduce the frequency of moral disputes.

3) 3PL enterprise. As an auxiliary node of SCF business, the 3PL enterprise is responsible for helping financial institutions manage pledged goods and should update the status information of pledged goods on the

blockchain platform in time. Financial institutions can make decisions based on the information at any time. The IoT technology can accurately perceive the weight, location, outline, status, and other information of goods, which is one of the technical means of goods supervision. The combination of the blockchain platform and the IoT technology can realize the real-time update of goods information on the platform, making the information timely and accurate. At this point, the blockchain platform serves as the storage database of information, whereas the IoT technology serves as the means of information collection.

4) Regulatory agency. Regulatory agencies are government regulatory agencies, such as industrial, commercial, and tax bureaus. The entry of new nodes in the consortium blockchain needs to be reviewed by core enterprises and regulatory agencies. Regulators regularly conduct evaluation, and those whose credit is not up to standard are rejected by voting.

3.3 Conceptual framework of the BcSCFP

The conceptual framework of the BcSCFP includes six layers, namely, application, contract, incentive, consensus, network, and data layer. According to the characteristics of the SCF scenario, this study reforms the traditional architecture, as shown in Fig. 3, which is mainly reflected in the application, contract, and consensus layers. In the Bitcoin system, miners record the data on the blockchain through mining. After successful mining, the miner receives an amount of Bitcoin as a reward, which is the incentive mechanism in the Bitcoin system. The Bitcoin system needs such an incentive mechanism to ensure the normal operation of the system. In the application scenario of SCF, the nodes involve more enterprises than individuals. The purpose of nodes participating in accounting is not to obtain certain rewards but to use this platform to prove the authenticity of their own trade, which is conducive to their application for loans from financial institutions. Therefore, the setting of the incentive mechanism loses its meaning in this scenario. Thus, no incentive layer exists in this architecture.

Application layer. Application layer is the interface between each node and platform in the consortium blockchain. The processes of SCF business, such as credit investigation and review of financial institutions and regulatory agencies, are completed in the application layer. Transaction information, asset registration, and financing information are stored on the blockchain platform through the application layer. Loan enterprises can register their transaction records or asset information on the blockchain through the application layer to improve the transparency of company data. Financial institutions can inquire about the information of loan enterprises through the application layer to decide whether to give loans to enterprises and the amount of loans. 3PL enterprises update the logistics and inventory information through the application level. Regulators can interact with other nodes through the application layer, including the review of authority and dispute settlement. They can check the transaction or loan situation of enterprises at any time and trace the flow information of assets through digital assets.

Contract layer. Contract layer consists of smart contract, script code, and programming algorithms. Based on the blockchain data, the platform can enable users to create smart contracts or other decentralized applications by providing a flexible script code system and

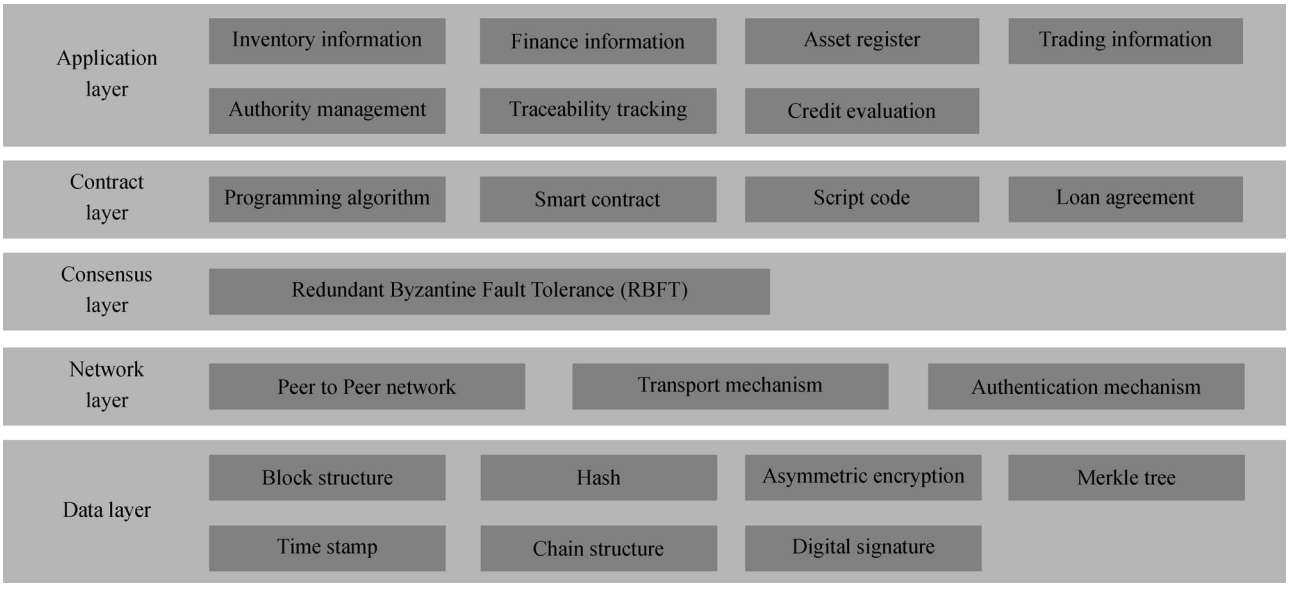

Fig. 3 Conceptual framework of the BcSCFP.

enabling data processing, asset management, and value transfer. The protocol content between each node is written into the blockchain in the form of a code. Based on the untamable data, the smart contract automatically checks whether the contract conditions are met and automatically executes the contract content, which can solve moral disputes in real life. Table 1 summarizes some types of these smart contracts and their related contents.

Consensus layer. Consensus layer ensures that all systems on the BcSCFP can reach a consensus effectively in a decentralized state, such as proof of work (POW), proof of stake (POS), and delegated proof of stake (DPOS). This platform chooses to use the Redundant Byzantine Fault Tolerance (RBFT) consensus mechanism improved by a hyperchain according to the characteristics of the co-existence of multiple entities and frequent transactions in the field of SCF. Compared with Practical Byzantine Fault Tolerance (PBFT), RBFT adds the mechanism of active recovery and dynamic node addition or deletion. It improves the flexibility and reliability of the consensus algorithm and can handle tens of thousands of transactions per second, which is suitable for the business scenario of SCF.

Network layer. The blockchain platform carries out information transmission through the network layer, which mainly includes Peer to Peer (P2P) network, information transmission protocol, and information verification mechanism. In the blockchain platform, the network architecture adopts P2P network, and every node is equal. The nodes on the blockchain can realize P2P communication and P2P value exchange without any central institution and server. This P2P information and value exchange mechanism reduces the cost of communication between enterprises, and each node has the same ledger, eliminating the possibility of tampered information.

Data layer. The technologies involved in the consortium blockchain data layer mainly include block structure, chain structure, hash function, asymmetric encryption, Merkle tree, timestamp technology, and digital signature technology. The verified inter-enterprise transactions, bank loans, inventory, and other information in the consortium blockchain are packaged into multiple blocks in chronological order. These blocks are arranged in a chain. In this process, the timestamp technology guarantees the time mark of data and the traceability of information. Hash function guarantees the privacy of information. Merkle tree is the storage form of data in the block, and each transaction corresponds to a unique hash value. The function of Merkle tree is to combine these unique hash values into a new hash value until only one hash value is left, which is the hash value of the whole block. Each enterprise or node in the consortium blockchain has a pair of keys, including private and public keys. The public key is public, whereas the private key is kept by ownership and cannot be inferred from the public key. In SCF, the public and private keys are mainly used for asymmetric encryption and digital signature to ensure the security of information and credibility of endorsement. Asymmetric encryption means that, when sending a file, the receiver's public key is used to encrypt it. The receiver decrypts the file with its private key, and no other secret key can decrypt the file. The principle is shown in Fig. 4. However, the principle of digital signature is relatively complex, as shown in Fig. 5. First, sender C hashes the contract and encrypts the hash value with its private key. Then, C sends the encrypted hash value and contract to recipient D. After receiving it, D uses C's public key to decrypt the hash value and perform hash operation on the file simultaneously. The digital signature is valid if the two hash values are equal.

4 SCF operation process based on the BcSCFP

The three basic models involved in SCF are advance payment financing, accounts receivable financing, and inventory pledge financing, which take place in different operation stages of enterprises. After the application of the BT, enterprises can complete the financing application on the platform, and the financial institution can obtain the information of loan enterprises through the platform. The

Table 1 Some types of smart contracts and their related contents

Smart contract type	Content of the contract
Repurchasing	When the retailer has surplus goods and the sales revenue is not enough to pay off the bank principal and interest, the surplus goods ownership and the payment for purchasing are automatically transferred
Goods supervision	When goods are stored in 3PL institutions, they are monitored by IoT technology, and the status information is uploaded to the BcSCFP automatically. When the status of goods reaches critical, the platform automatically alarms
Loan	This contract includes the loan contract content signed by the bank and the loan enterprise The loan is repaid automatically on the payment due date
Transport	In the process of transportation, the system monitors the distribution temperature, route, and other status in real time. If the temperature or other status information exceeds the standard, the system alarms automatically
Tax	Enterprises in the supply chain pay taxes automatically through this contract
Discount	When consumers buy a certain number of products, they can have automatic discounts through this contract

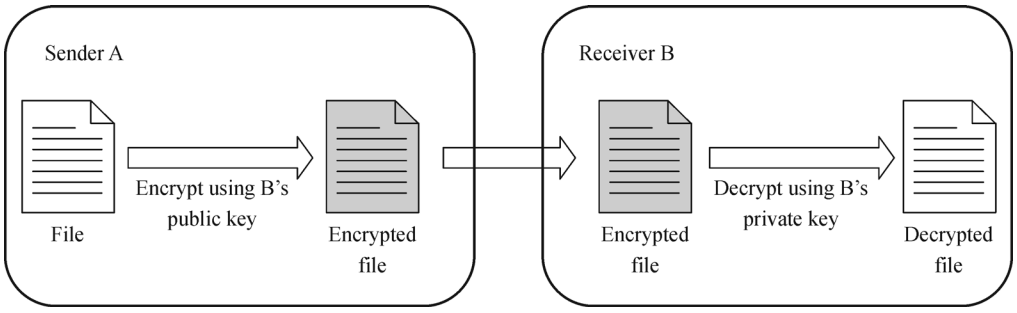

Fig. 4 Asymmetric encryption process.

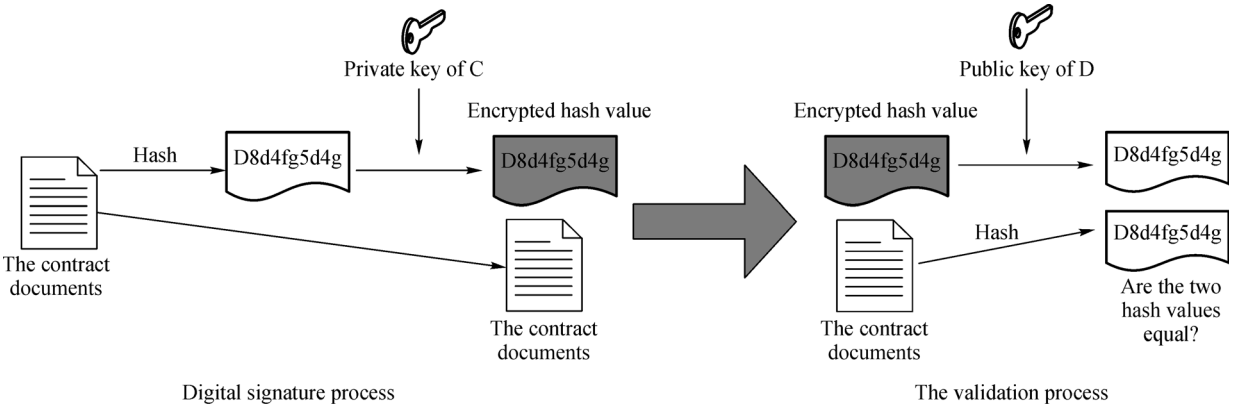

Fig. 5 Digital signature and authentication process.

process of the three basic financing models is greatly changed. This study redesigns the business process of the three basic financing models after the application of the BcSCFP. Sections 4.1, 4.2, and 4.3 introduce the redesigned operation processes of advance payment financing, accounts receivable financing, and inventory pledge financing, respectively.

4.1 Advance payment financing

Regarding advance payment financing, on the premise of repurchasing from a core enterprise, SMEs apply for loans from a financial institution using the potential future inventory. After an agreement is reached, the core enterprise stores the goods in the 3PL enterprises chosen by the financial institution, and the financial institution has the right to take the delivery. The loan enterprise pays the deposit to the financial institution in batches to distribute the goods until all the goods are taken. If the loan enterprise defaults or has no repayment ability, the core enterprise repurchases the goods unconditionally. Advance payment financing mainly includes signing contracts, feasibility analysis, and lending. The new process on the BcSCFP is shown in Fig. 6. The specific explanations are as follows.

1) Core enterprise signs contracts with retailer (online and offline), and the platform generates smart contracts based on the contracts. The core enterprise agrees that the retailer applies for loan from a financial institution to pay for goods.

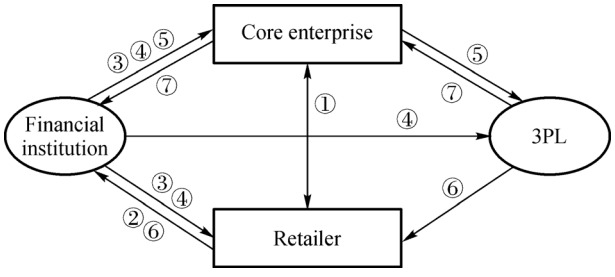

Fig. 6 Process of advance payment financing in the BcSCFP.

2) The retailer applies for a loan from a financial institution online on the BcSCFP.

3) The financial institution accesses the operating information of the retailer and reviews the authenticity of the contract and historical transaction records through the BcSCFP.

4) The financial institution signs repurchase contract with the core enterprise, regulatory agreement with the 3PL enterprise, and loan contract with the retailer, which are signed digitally by both parties. The platform generates

the repurchase smart contract, supervision smart contract, and loan smart contract.

5) The financial institution issues the corresponding acceptance bill to the core enterprise. After receiving the bill, the core enterprise delivers the goods to the designated 3PL enterprise. The warehouse receipt and bill information shall be uploaded to the BcSCFP.

6) The retailer pays a deposit to the financial institution and receives a bill of lading issued by the financial institution. The retailer then receives delivery. This process is repeated until all goods are received. Delivery records are documented on the BcSCFP.

7) A repurchase smart contract is triggered when the retailer is unable to pay the deposit on time. The smart contract automatically transfers the repurchase payment from the core enterprise account to the financial institution account. The right of goods is automatically converted.

4.2 Accounts receivable financing

Accounts receivable financing refers to the financing method by which suppliers apply for loans from a financial institution with accounts receivable issued by core enterprises as collateral. When a core enterprise repays, it first repays to the financial institution and then the supplier. At present, the difficulties faced by accounts receivable financing are mainly the examination of transaction background and the authenticity of debt. Huang et al. (2018) proposed the specific operation process of accounts receivable financing after the use of the BT. The process designed in this study highlights the role of the smart contract, including financing applications, the confirmation of the authenticity of accounts receivable, and lending. The financing process is shown in Fig. 7. The specific explanations are as follows.

1) Upstream supplier signs supply contracts with the core enterprise (online and offline). The blockchain generates a smart contract based on templates. Accounts receivable is formed after delivery.

2) The supplier applies for financing from a financial institution online on the BcSCFP with accounts receivable and uploads an accounts receivable voucher.

3) The financial institution accesses the information of this supplier and confirms the authenticity of receivables through the BcSCFP. Based on the obtained information, the financial institution analyzes the feasibility of the financing business.

4) After the confirmation, the financial institution signs a financing agreement with the supplier, which stipulates the loan amount, repayment time, and other information. The blockchain generates a loan smart contract according to the agreement content.

5) The financial institution pays the financing funds to the supplier.

6) The loan smart contract is triggered after the expiration of accounts receivable. The blockchain platform deducts money from the core enterprise account automatically, and transfers part of it to the financial institution account and the rest to the supplier account.

4.3 Inventory pledge financing

Inventory pledge financing refers to the way enterprises apply for loans from financial institutions using their inventory and goods as collateral. In this process, the 3PL enterprise needs to evaluate and supervise the goods to help the financial institution to evaluate the business. Inventory pledge financing mainly includes the warehousing of goods, financing application, feedback of goods information, and other steps, as shown in Fig. 8. The specific explanations are as follows.

1) An enterprise submits online financing applications to a financial institution using its inventory as collateral on the BcSCFP and uploads goods information.

2) The financial institution entrusts the 3PL enterprise to evaluate the pledge. The 3PL enterprise issues an evaluation report to the financial institution and uploads the information to the platform as the initial information.

3) If the collateral information is true and qualified, the financial institution signs a loan agreement with the loan enterprise and a goods supervision agreement with the 3PL enterprise. According to the content of the agreement, a loan smart contract and a supervision smart contract are generated.

4) The loan enterprise puts its own goods into the warehouse of the 3PL enterprise, which is connected to the

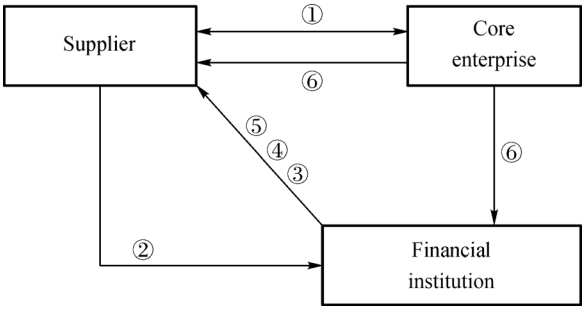

Fig. 7 Process of accounts receivable financing in the BcSCFP.

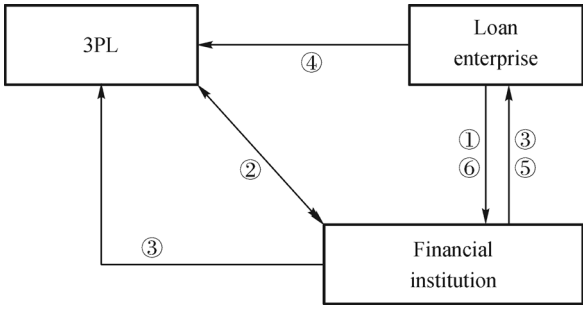

Fig. 8 Process of inventory pledge financing in the BcSCFP.

BcSCFP through the IoT technology. The status of collateral is uploaded to the platform in real-time. The 3PL enterprise is obliged to update the status information on the BcSCFP. When the price of goods reaches the warning line or the state changes, the supervision smart contract is triggered, and the BcSCFP alarms automatically.

5) The financial institution lends money to the loan enterprise.

6) When the loan expires, the loan smart contract is triggered, and the corresponding repayment is automatically transferred from the account of the loan enterprise to the account of the financial institution. The platform conducts the relationship transfer of goods right automatically.

5 Case study

To verify the proposed solution based on the BT, a case study is conducted to demonstrate its effectiveness for the accounts receivable financing mentioned above. Combined with the Black Swan event of Noah Holdings Ltd. in China, a BcSCFP-driven accounts receivable financing scenario is set up for capital-constrained enterprises in the supply chain. The comparison and discussion are then given to summarize this case study.

5.1 Scenario descriptions

Before setting up the scenario, the Black Swan event of Noah Holdings Ltd. is reviewed. In July 2019, Noah Holdings Ltd., one of China's largest wealth managers, levied the accusations of fraud against Camsing International Holding Ltd. because of a 3.4 billion yuan asset management product that is in danger of default. Affected by this event, Camsing's stock plunged by 80% in Hong Kong. Noah's shares fell by 20% in New York after it said that its affiliates provided supply chain financing involving third-party companies related to Camsing. This would be a serious blow to the confidence of investors, including banks and investment institutions, especially given the current high macro-economic uncertainty and low-risk appetite among clients. According to Noah's statement, the underlying assets of the product are backed by accounts payable from Beijing JD Century Trade Holdings Ltd. to Camsing. However, JD Century Trade's parent denied any involvement. They claimed that Camsing falsified JD's business contracts, engaging in fraudulent behavior.

Camsing was a capital-constrained enterprise. The company borrowed money from Noah, which was backed by accounts payable from JD. Noah lent Camsing without verifying the authenticity of the accounts receivable. The key to this supply chain financial fraud is that the authenticity of the transaction background was not checked.

A financing scenario of BcSCFP-driven accounts receivable is proposed to facilitate SCF implementation for capital-constrained enterprises and financial institutions. The specific steps according to the solution proposed in this study are shown in Fig. 9. Each phase is explained in detail. The procedures are as follows.

• Establishment of trade background (Steps ①–③)

The real trade background is the prerequisite for the application of accounts receivable financing. Therefore, capital-constrained enterprises need to prove to banks or financial institutions that they have potential assets before applying for accounts receivable financing. Accounts receivable plays this role in the following scenario. First, JD orders from Camsing, and both parties sign an order contract. The signing of the contract is conducted online and offline, and the corresponding smart contract is generated on the BcSCFP. Camsing then ships the order goods to JD. Finally, JD delivers the receivables to Camsing. At this point, the trade background is established, and Camsing can apply for accounts receivable financing using receivables.

• SCF application and verification (Steps ④–⑤)

In this phase, the capital-constrained enterprise, Camsing, raises its accounts receivable financing application to a financial institution on the BcSCFP. Supporting information should be digitalized and submitted. The applicant should provide the financial institution with proof of its potential assets, such as accounts receivable. In this scenario, Camsing should provide two kinds of information, namely, the information related to receivables used for financing, such as ordering contracts and receivables' receipts, and the retailer's financial information, which could prove the operation condition and capital needs.

Then, the financial institution, Noah, notifies JD and begins evaluating loan applications with their own regulations. In this stage, the BcSCFP has obvious advantages. Noah can directly obtain the verified business information and financial status of the enterprise on the BcSCFP and use them to make loan decisions. Compared with the previous verification method, the BcSCFP has two advantages: 1) the shortened verification time and reduced time cost, and 2) reliable information and accurate verification, which could reduce the risk of financial institutions.

• SCF approval and repayment (Steps ⑥–⑦)

After verifying the information through the BcSCFP, the financial institution, Noah, issues loans to the capital-constrained enterprise, Camsing, if it finds that the trade background is true and the financial situation is good. Otherwise, the SCF business does not proceed. In this SCF business, the financial institution signs loan contracts with loan enterprises, and corresponding smart contracts are uploaded to the BcSCFP. According to the contract, JD makes its repayment after the loan expires. The contract is executed by the smart contract, which is automatically enforced as long as the conditions in the contract are met.

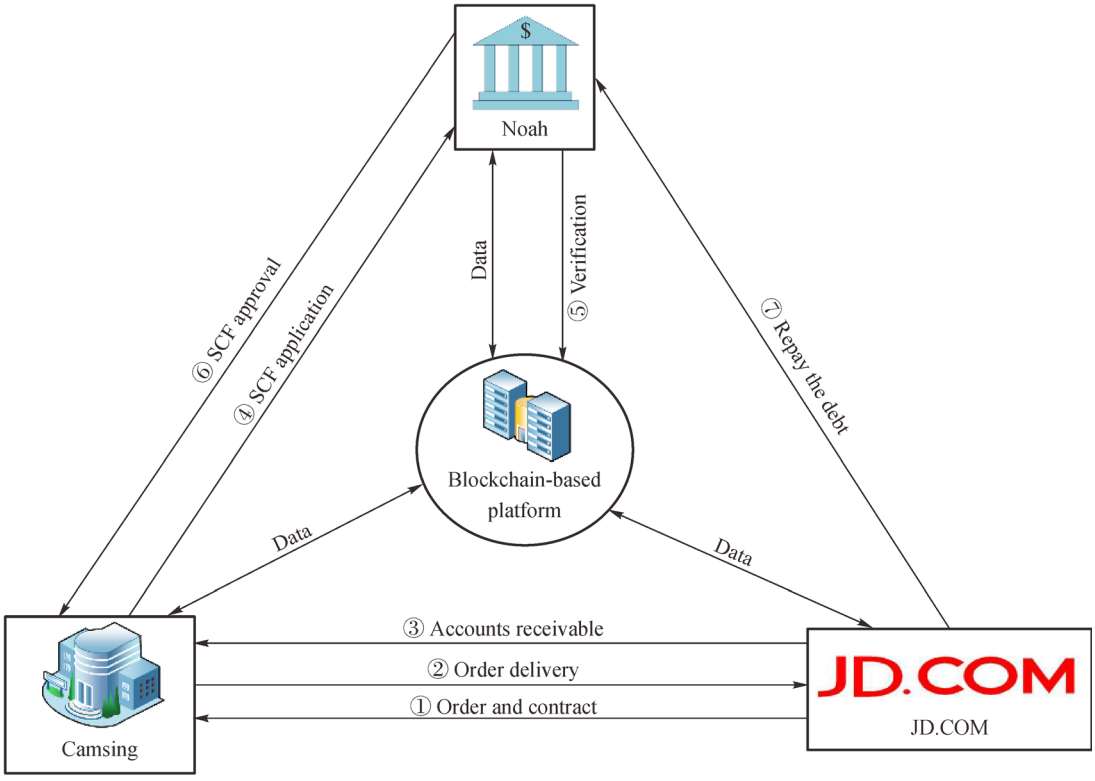

Fig. 9 BcSCFP-driven accounts receivable financing scenario.

This means that the execution of the contract is affected by external factors, avoiding a lot of moral hazards. Thus, the risk events in this case can be largely avoided.

5.2 Comparison and discussions

The above scenario description shows that the root cause of the problem is that Noah did not check the authenticity of accounts receivable. However, if Noah follows the steps of the BcSCFP, such a risk event is evitable. The proposed BcSCFP facilitates the implementation of SCF to support the financing of SMEs in a supply chain. A comparison between traditional and BcSCFP-driven SCF models is given in Table 2. Several merits could be summarized.

First, the BcSCFP-driven model could provide financing business for more enterprises. Under the original model, the credit of core enterprises can only be transferred to tier 1 suppliers or retailers, and only these enterprises can make loans through SCF. However, SMEs that need financing often find obtaining financing difficult and usually do not directly trade with core enterprises. The platform's ability to split and deliver credit can solve this dilemma. Enterprises at the end of the supply chain can be endorsed by the core enterprises through this feature.

Second, the BcSCFP deals with the asymmetric

Table 2 Comparison between traditional and BcSCFP-driven SCF models

Items	Traditional SCF	BcSCFP-driven SCF
Service object	Primary suppliers and retailers	SMEs in the supply chain
Interaction method	Paper document	Online and offline
Risk management	Advance evaluation	Real-time monitoring
Availability of credit	Difficult and expensive	Low cost, convenient
Credit transfer	Only to tier 1 suppliers and retailers	To the end of the supply chain
Bank human cost	Expensive human costs for checking	Almost no human cost
Bank verification time	Long	Short
Repayment guarantee	No	Smart contract

information of the supply chain. The related information for all enterprises is collected on the BcSCFP, including operation condition, financial condition, and credit condition through IoT or interfaces between information systems. Once the data are stored in the blockchain platform, they cannot be tampered due to the non-tampering feature of the BT. Each node of the platform can view the platform data according to its own permission, which guarantees data consistency and information symmetry.

Third, the BcSCFP improves the operation efficiency of SCF. Based on the trusted data on the BcSCFP, financial institutions can quickly obtain the transaction background, eliminating many verification procedures.

Fourth, the BcSCFP reduces the financing risk and risk control cost of financial institutions. This reduction is mainly reflected in the following two aspects. On the one hand, the real data on the blockchain platform enables financial institutions to have a good understanding of the trading background of loan enterprises. Thus, the bank does not have to spend a lot of time and human cost to investigate the authenticity of the transaction and the contract. On the other hand, using a smart contract can reduce many moral hazards to decrease the default rate.

6 Conclusions and future directions

This study proposed a solution for SCF to establish an SCF platform driven by the BT. Combined with the characteristics of SCF business, the conceptual framework of the BcSCFP is proposed, and the operation processes of three basic SCF models on the BcSCFP are given to illustrate some details. Moreover, a case study is conducted to verify the proposed solution based on the BcSCFP. The solution has several advantages: 1) The business processes are secure and trusted, 2) the platform information is systematic and transparent, 3) the core enterprise credit can be split, 4) the smart contract can be executed, and 5) a combination of technologies can be used. The supply chain financial solution based on blockchain is a turning point, enabling the financial institution to launch more financial products.

Although the BT can solve many issues in SCF, few other problems still cannot be solved. For example, the BT can only ensure that the information on the blockchain is not tampered with. The authenticity of the information before they are uploaded to the blockchain cannot be guaranteed. In other words, blockchain cannot solve the problem of source data fraud. For future work, quantitative research on the impact of blockchain on SCF should be emphasized. Besides, core enterprises are less motivated to join the blockchain at present. Thus, how to encourage core enterprises to join the blockchain is also a problem that needs to be studied in the future.

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