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Supply chain finance: What are the challenges in the adoption of blockchain technology?

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ABSTRACT

As an emerging information technology, blockchain has aroused extensive discussions around the world and been suggested as a solution to address current issues in supply chain finance (SCF). The Chinese government also attaches great importance to this technology, and many Chinese state-owned enterprises have invested in establishing their own blockchain research and development centres. However, there is a lack of studies on identifying challenges when deploying this technology; theoretical framework and conceptual exposition are also scarcely seen. Therefore, the aim of this study is to investigate the challenges and obstacles in the adoption of blockchain technology in SCF. An exploratory case study of a Chinese state-owned enterprise was conducted to build up an initial conceptual framework. Semi-structured interview was applied to collect data from the case firm's employees, top management, and technical specialists. The results of the analysis indicate that in the adoption of blockchain technology, there are technological, operational, and other challenges. From a technological perspective, framework identification, cross-chain interoperability, and data governance are major barriers; whereas, from an operational perspective, the new business process and transformation in the entire supply chain are identified as challenges. Besides, other obstacles such as the elimination of jobs and regulatory issues are also not neglectable. This study contributes to research on blockchain and supply chains by shedding light on the challenges of blockchain adoption through an exploratory case study of a Chinese state-owned enterprise. A conceptual framework was generated as a basis for future research, and the findings also provide insights for companies that may or are planning to adopt blockchain technology.

1. Introduction

Originated from Small and medium-sized enterprises (SMEs) trade finance, the history of supply chain finance (SCF) can date back to 1940s and it is still an evolving concept (Tate et al., 2018). SCF is defined as the integration and optimisation of financing processes with suppliers, customers and other supply chain participants to benefit and facilitate supply chain activities (Pfohl and Gomm, 2009). It plays an important role in serving the supply chain and providing financial support to supply chain participants (Du et al., 2020) especially after the global financial crisis in 2008 and 2009, as SMEs begun to be affected by the credit crunch and suffering from financial liquidity problems (Jia et al., 2020). In order to find advanced methods to build up more stable financial flow (Caniato et al., 2019), SCF is increasingly taking the centre stage of attention from academics in the area of operations and supply chain management

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(OSCM) (Hofmann, 2005; Xu et al., 2018). Meanwhile, the digital transformation of supply chain has also drawn researchers' attention on the continuous innovation and evolution of information construction, and the increasingly crucial role of information technology in SCF has been emphasised by literature (Jia et al., 2020). The potential of blockchain, an emerging information technology, has been discussed as a solution to facilitate the financial collaboration and encourage the value creation in supply chain (Wang et al., 2021).

As a database architecture based on distributed ledger technology (DLT), blockchain was developed by Satoshi Nakamoto (2008), the unknown person behind the white paper of Bitcoin (Cole et al., 2019). Blockchain has the characteristics of immutability, decentralisation, and disintermediation (Bottoni et al., 2020; Cole et al., 2019; Sachdev, 2019), which allow itself to be used not only for digital currency, but also in other fields such as data security (Esposito et al., 2018) and supply chain traceability (Hastig and Sodhi, 2020). Blockchain technology has also been suggested as a solution to SCF, because its unique mechanism and characteristics can address the asymmetric data issue in warehousing, transaction records and logistics (Du et al., 2020). For example, Lycklama à Nijeholt et al. (2017) developed a blockchain-based framework - Dec Reg, for the industry in the Netherlands to support SCF service and solve the liquidity issues in small and medium enterprises (SMEs). The existing literature is mainly focused on the adoption of blockchain technology on preventing double financing fraud (Hofmann et al., 2017; Guerar et al., 2020), or addressing SMEs' difficulties when financing from their purchase orders (Dong et al., 2021; Wang et al., 2021); whereas the digital transformation on critical documents and how it might facilitate and optimise cross-border trading activities have not yet been explored very well.

As a novel concept that is still on its early stage, the challenges of blockchain technology when deployed into the supply chain need further investigation. As Wang et al. (2019a) noted, studies of how blockchain might benefit or disrupt supply chains are required considering the immaturity of this technology Regarding the actual cases of this technology on OSCM, some reflections have been given by certain scholars. For instance, from a technical perspective, Wu et al. (2019) indicated that the system throughput in blockchain seems hard to be guaranteed, especially compared to mainstream payment platforms such as Visa and PayPal; although this bottleneck is caused by the mechanisms of blockchain, a widely agreed solution has not been found. From a managerial perspective, some supply chain professionals might refuse to implement blockchain technology because they feel insecure and unwilling to exchange information with other supply chain members (Queiroz and Wamba, 2019). Besides, the cost of deploying or participating in a blockchain-based system needs to be considered (Wang et al., 2019b), especially for smaller firms that could fall into financial difficulties easily when having to make a significant investment in this new technology. As Browne (2017) indicated, that for the open source blockchain projects created on software development platform GitHub in 2016, only eight percent of them were still active in 2017. The high failure rate may be due to reasons such as the unexpected cost and other hidden issues, which would require further investigation. Bach et al. (2018) also warned that blockchain might be a new 'bubble' in the financial market that derived from speculative behaviour. They studied the example of Long Island Iced Tea, which announced moving from beverage business to blockchain and received a tremendous hike of 344% in its stock price just in two days after their announcement. The concerns mentioned above might might remind us that although blockchain is a new technology that has attracted much attention and is a claimed solution to many SCF problems, enterprises should consider carefully before implementing it.

As an emerging technology, conceptual expositions and theoretical frameworks are still scarcely seen in the discussion of blockchain technology and its implementation in supply chain. For researchers, the lack of robust empirical evidence and underlying theoretical foundation on blockchain adoption in SCF might induce the disparity between theory and practice (Wang et al., 2021), which means there is a need for further studies to explore this area of research from actual cases as the foundation of frameworks development to fill the gap in existing body of knowledge. Therefore, this study aims to provide initial evidence from an exploratory case study by answering the following research question.

RQ. What are the challenges of implementing blockchain technology in SCF?

To address the research question, a state-owned multinational Chinese company is selected, which adopted the blockchain technology in 2017 to facilitate their key documents delivery process in commodities trading. The official white paper on China's blockchain technology published in 2018 indicated that this technology will be widely used in China's real economy in the following three years (Zhao, 2019). In the following year, the Political Bureau of the Central Committee of the Communist Party of China conducted a collective study on the current status and potential of blockchain technology, which reflects the Chinese government's high attention to this technology (Wang et al., 2020b). State-owned enterprises in China often rely on government policy incentives and subsidies to have strong market power and new technology development and application capabilities (Ma et al., 2021). In terms of blockchain technology, many large state-owned enterprises such as the People's Bank of China have invested in the establishment of their own research and development centres (Mann, 2019). The Chinese state-owned enterprise selected in this study is among the first enterprises to implement blockchain technology in SCF, and the experience of interviewees in enterprises can provide a reasonable perspective for the research question.

This article is organised as follows. The next section evaluates the existing literature and an initial research framework is developed. Section 3 is concerned with the methodology applied in this study. Section 4 presents key findings and analysis based on the data collected from the case firm. Section 5 discusses the theoretical and practical implications of this research. Section 6 concludes and also reflects on the limitation of this study as well as suggestions for future studies.

2. Literature review

2.1. Blockchain technology

Bitcoin is a digital currency that brings disruptive innovation to the traditional transaction environment which relies on third parties (Chang and Chen, 2020). Blockchain, as the underlying technology, has recently received much attention from industry and academia (Saberi et al., 2019). The heart of blockchain is the recording of all transaction data into blocks and the linking of those blocks into a chain (Queiroz and Wamba, 2019). Each block has a body with transaction data and a header with the hash value of the block before it, which is customarily called the "parent" block. This lets each block be linked vertically to be found or identified easily (Zheng et al., 2017). Fig. 1 illustrates the architecture of blockchain. The blocks with timestamps are chained by hash values, which are unique, and can prevent fraud because any changes in the block will immediately cause a change of the hash value (Nofer et al., 2017).

The three fundamental mechanisms of blockchain that make it unique are the distributed ledger, encryption, and consensus mechanism (Beck et al., 2017). There are two main architectures of software systems: centralised and distributed (Tama et al., 2017). A blockchain-based database can be considered a distributed system with an implementation layer that offers protection for data integrity (Drescher, 2017), because in this distributed system, all the transactions will be consistently recorded in the ledgers of all the participants. Rather than relying on a central server to store and validate data, each node in this network has a duplicate of the ledger, which can be updated independently (Trump et al., 2018). To prevent unauthorised changes, the transaction data will be encrypted using various algorithms and signed with a digital signature (Gorkhali et al., 2020). Chandel et al. (2019) indicated that the Elliptic Curve Cryptography (ECC) algorithm and the Rivest-Shamir-Adleman (RSA) algorithm are the two most common encryption algorithms in blockchain, both of which belong to asymmetric encryption. ECC seems more popular in recent years, probably because of its outstanding performance, such as its lower time complexity and smaller key size, which means less capacity is needed and less energy is consumed (Chandel et al., 2019). The benefits of ECC make it popular enough to be adopted by multiple popular protocols such as Bitcoin, secure shell (SSH), and Ethereum (Bos et al., 2014; Sarfaraz et al., 2021).

A consensus mechanism is the strategy that coordinates the nodes in the blockchain to ensure consistency within the system (Yuan et al., 2020). Swanson (2015) indicated that it is a set of rules or programs that allows multiple nodes to maintain and validate the state of a ledger. Any new transaction will not be added to the ledger immediately; the consensus mechanism ensures that it will be temporarily stored in a block for a period, and the information cannot be modified after that. Distinctive types of consensus algorithms, such as proof-of-work (PoW), proof-of-stake (PoS), and practical byzantine fault tolerance (PBFT), can be used depending on the type of blockchain and situation (Litke et al., 2019). The most widely mentioned algorithm is PoW because it is implemented by Bitcoin; however, PoW is often criticised for its high energy consumption and low transactions per second (TPS), which might eventually be replaced by other algorithms (Bach et al., 2018). Algorithms for blockchain are still in the process of evolution toward higher efficiency and flexibility in application scenarios.

Although there is no widely agreed definition, existing research has already suggested four main characteristics of blockchain and figured out how it can benefit operations and supply chain management (Pattison, 2022). Firstly, immutability or irreversibility is a fundamental blockchain characteristic, which is based on the connection of blocks and a cryptographic hash algorithm (Wang et al., 2019a). The hash value of a block is calculated by algorithms based on the data within the block. Because the header of each block contains the hash value of its parent block, any changes to transactions will change the hash value of the following blocks and can be easily detected (Sultan et al., 2019). Therefore, the security of the system can be enhanced, and all the records can be tracked and verified (Sachdev, 2019). Due to the underpinning mechanism, this characteristic can be more accurately described as tamper-evident structure (Politou et al., 2019), and it can make traceability and accountability more efficient when product quality issues occur and can improve transparency throughout the supply chain as well (Hofmann et al., 2017).

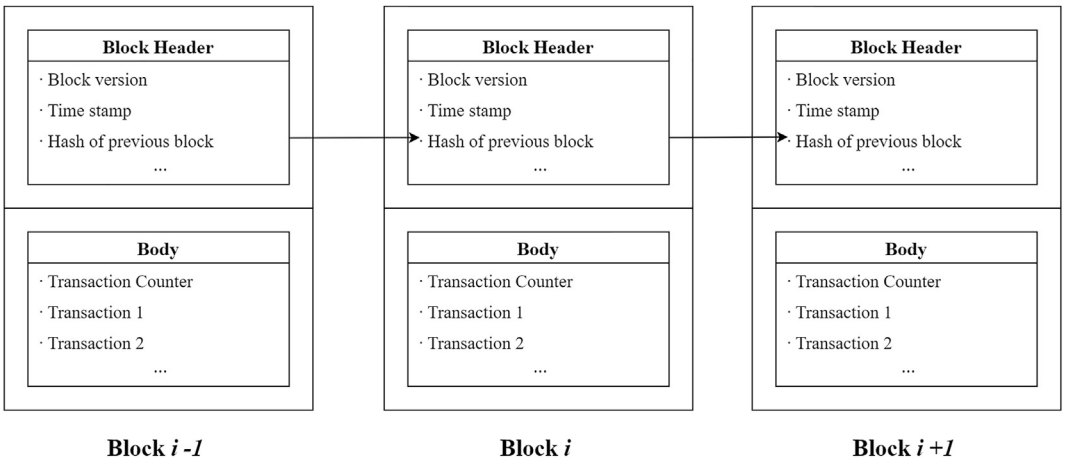

Fig. 1. Blockchain architecture.

Second, blockchain is a decentralised solution to traditional databases. Compared to centrally managed databases, the distributed architecture improves scalability because throughput and capacity can be increased by adding storage and compute nodes directly (Wang et al., 2020a). The distributed structure also enhances data security and avoids storing all the data in a central database (Drescher, 2017). Cole et al. (2019) indicated that a blockchain-based database is ideal for activities among multi-organisational networks such as logistics and supply networks because it encourages the sharing of data among enterprises.

Third, smart contracts are also a revolutionary feature that brings opportunities and benefits to the area of OSCM. It is a digital protocol or programme in the blockchain that can be automated and processed when specific conditions are met (De Giovanni, 2020). The triggering conditions and the corresponding actions are set using "If" statements (Wang et al., 2019b). The contract terms are agreed upon and signed by all the participants, then written in transactions on the blockchain network. Smart contracts are not "legal contracts" but can be considered the automatic execution of the transactions in a legal contract (Bottoni et al., 2020). Min (2019) indicated that blockchain technology can be integrated with the Internet of Things (IoT) to detect and prevent contractual fraud in the supply chain.

In addition, encryption-based security and privacy are important considerations. To prevent information leakage, hash encoding, and asymmetric encryption are applied in blockchain architecture (Ahmadi et al., 2020). All blockchain participants have public keys, but the private key is only available to the user who generates or identifies it. This means that, while transaction data is stored in a distributed environment, only authorised users can access and decrypt the information encrypted in the blockchain (Feng et al., 2019). Ma et al. (2019) described how Hyperledger Fabric, an open source blockchain technology maintained by the Linux Foundation, employs this feature for privacy protection in SCF.

2.2. Blockchain in supply chain finance

Originating from trade finance, the concept of SCF was developed in the 20th century for prepaid accounts (Du et al., 2020). It is the financial activity servicing enterprises in both upstream and downstream supply chain that drives rapid development (Zhang et al., 2021). In detail, Caniato et al. (2019) indicated that the goal of SCF is the alignment of information flows, product flows, and financial flows to optimise cash flow management within the supply chain. As the supply chain and manufacturing industries are gradually moving towards Industry 4.0, SCF is also transforming in the direction of intelligence and digitalisation (Liao et al., 2019). Increased literature has started to focus on the implementations of information technology, such as big data, the Internet of Things (IoT), and blockchain technology, in SCF (Du et al., 2020; Yu et al., 2021). Although blockchain technology is still in its infancy in SCF, researchers are positive about its prospects and potential strengths (Chang and Chen, 2020; Wang et al., 2021). Software companies such as IBM and Microsoft have also shown tremendous interest in the technology and have started developing blockchain services (Zheng et al., 2018).

Based on its unique characteristics and architecture, blockchain has been proposed as a solution for different SCF themes. One of them is preventing double-financing fraud based on its immutability and decentralised architecture (Mohammadzadeh et al., 2021). For example, multinational trading enterprises are experiencing delays when cashing their invoice, the statement that contains information such as the date and amount of goods (Fabrizio et al., 2019). The invoice is the proof of receiving the money, however, it often takes more than 20 days to cash an invoice after receiving it (Guerar et al., 2020). For SMEs, it would threaten their cash flow and create risks (Caniato et al., 2019). Therefore, many of them will choose factoring service providers (FSPs). Factoring is the process by which enterprises sell their invoices to FSPs and receive a certain percentage of the payment immediately (Salinger, 2006). When using factoring services, the FSPs take over the risks and cash the invoice for a portion of its original value (Song et al., 2021). During the factoring process, there is a common issue known as "double-financing fraud", which means that organisations or suppliers might use the same invoice for financing in multiple FSPs (Guerar et al., 2020). It is hard for FSPs and related organisations to examine if an invoice has been financed by other FSPs; thereby, there will be additional costs on reconciliation to reduce the risks, which could also be time-consuming for SMEs with urgent financial needs (Charfeddine and Umlai, 2021). Hofmann et al. (2017) suggested that blockchain technology can solve this issue by recording the invoice document into a distributed ledger and making it available to customs authorities or banks. There is, however, insufficient evidence or a successful case for this immature solution, and issues such as a lack of standardisation may arise (Babich and Hilary, 2019). It might take time for the establishment of relevant laws and regulations, but when developing blockchain-based solutions, the involvement of government agencies and observation from a legal perspective are inevitable (Dutta et al., 2020).

The potential of blockchain technology for purchase order (PO) financing is also discussed in the literature (Hofmann et al., 2018). PO finance happens before dispatching the goods, and it is developed to expand suppliers' access to capital and reduce the influence of financial constraints, especially when suppliers are SMEs (Reindorp et al., 2018). For suppliers, the difficulty of PO financing depends on the size and types of their buyers (Camerinelli and Bryant, 2014). In the traditional way, the credibility of a well-known buyer could only benefit its first-tier suppliers by providing the order statement. However, suppliers in other tiers usually suffer from financial shortages when receiving a new PO and thus need to seek assistance from banks or other FSPs. In addition, for banks or supply chain finance enterprises, verifying the order information can be costly as well (Chen et al., 2020), especially when suppliers cannot provide the PO information of a well-known buyer with good credit records. Wang et al. (2021) indicated that if the credibility of a buyer can be split and transferred to higher tiers of suppliers, the financing activities in the supply chain would be more efficient, and the resilience might also be enhanced. Omran et al. (2017) also emphasised the importance of elements such as trust and transparency within the supply chain for the adoption of SCF solutions. To address the problem of trust, Dong et al. (2021) suggested that blockchain technology can be a solution because, with the implementation of this technology, capital can be instilled into the higher tiers due to the improved transparency.

2.3. Challenges in blockchain adoption

Although the potential of this application has been discussed, investigations of the issues and barriers that arise when deploying this transformation are still required. Researchers have mentioned several challenges that might be encountered by enterprises in the adoption of blockchain technology. According to Wu et al. (2019), there may be scalability issues because, unlike a traditional centralised data storage system, which relies on a system administrator to control data access, blockchain-based databases must figure out how to scale and operate the system as more and more stakeholders become involved. Besides, as mentioned previously, the system throughput might also cause issues for the SCF system's performance considering the architecture of existing blockchain paradigms (Koteska et al., 2017). For example, compared to the modern credit card platform that can process seven thousand transactions per second, a blockchain based on Bitcoin can only handle seven transactions per second (Etemadi et al., 2021), which is a barrier that needs to be solved before further implementation.

Challenges from an operational perspective should also not be neglected. Although claimed to be a solution to trust issues in SCM and SCF (Dong et al., 2021; Babich and Hilary, 2019), blockchain itself, as an emerging technology, might need to be trusted by stakeholders before any adoptions (Hilary and Liu, 2021); however, it might be hard for enterprises and stakeholders to trust a new technology or data framework no matter how promising it may sound, and it might lead to organisations' unwillingness to share information (Sharma et al., 2018). For instance, buyers might refuse to authorise their credit to suppliers in deep tiers because they might be concerned about the trustworthiness of this new blockchain-based system (Kouhizadeh and Sarkis, 2018), and in the short term, it seems that they cannot benefit from it. The unwillingness to reduce information asymmetry is also mentioned in the literature as an obstacle to blockchain transformation. For enterprises, valuable information such as order quantities and procurement prices are usually considered a trade secret that they do not want to share (Du et al., 2020), while for current economic winners in the banking system or providing financial services, fear of losing their monopoly is one of the main reasons for resistance to blockchain adoption (Wang et al., 2019a). Furthermore, there is a lack of discussion in the extant literature regarding the challenges of the immature regulation of this technology, which might also raise concerns among stakeholders and become a barrier to the adoption of blockchain (Dutta et al., 2020).

Given the above literature review, a conceptual framework is developed (see Fig. 2). When investigating the challenges of blockchain technology implementation in SCF, two perspectives are mentioned by researchers: operational and technological. From a technological perspective, studies have discussed the scalability and throughput issues, whereas from an operational perspective, trust, regulatory issues, and the resistance from stakeholders with asymmetric information are identified as challenges for managers and the legal departments in enterprises. Elements from this conceptual framework will be examined, and other challenges might be complemented to generate a comprehensive framework.

3. Methodology

3.1. Research design

The methodology chosen for this research is the exploratory case study. A case study is suitable for investigating new phenomena in a real-world context, especially for research that requires an in-depth examination (Yin, 2009). Although existing research has explored the potential application of blockchain technology for SCF (Chang and Chen, 2020; Hofmann et al., 2017), there is a lack of

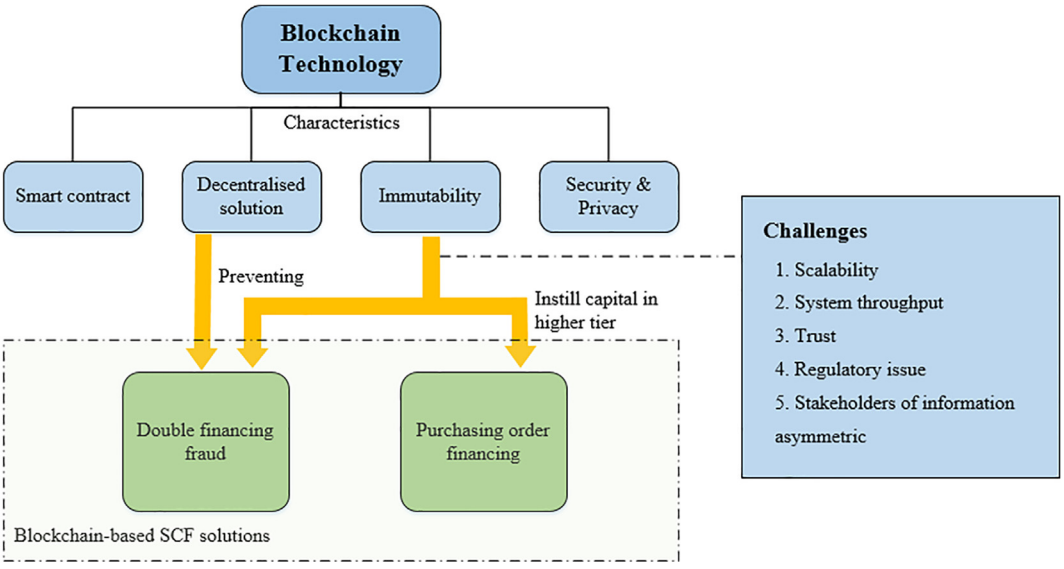

Fig. 2. Initial research framework.

evidence-based studies that investigate the challenges of adopting this novel technology (Babich and Hilary, 2019). Besides, Eisenhardt and Graebner (2007) indicated that, compared to multiple case studies, single-case research can investigate more in-depth evidence with a greater focus, which is appropriate considering the exploratory nature of this study. Therefore, an exploratory case study would be a reasonable choice for this research.

3.2. Data collection and analysis

To investigate the challenges of implementing blockchain technology in supply chain finance, a state-owned company in China was selected for this exploratory case study. This particular company was selected because the business scope of the case firm covers multinational commodity trading and supply chain financing. Most importantly, it started to develop its blockchain-based supply chain and logistics platform in 2017, and its first pilot received a satisfactory result in the same year.

This exploratory case study is conducted through semi-structured interviews within the case company. A semi-structured interview is a type of interview that is based on pre-formulated questions but does not require the interviewer to strictly follow them (Myers, 2019). During the interview, new questions might emerge if needed. Compared to a structured interview, which must strictly follow the order of questions, and an unstructured interview, where interviewees are free to say what they want, a semi-structured interview seems more flexible and in line with the exploration nature of this research, considering the lack of theoretical foundation in this area of study.

A total of twelve interviews (with follow-ups) with the top management team, operational managers, and IT specialists were conducted. To cover a wide range of perspectives and to ensure data validity and reliability, the specific roles of the interviewees include the development group head, supply chain manager, blockchain developers, and IT consultants. The primary details of the interviewees are listed in Appendix 1. All the interviewees have been involved with the case company and have good knowledge of the blockchain-based platform in use. The interviewees were selected as they were involved in the case firm's blockchain technology application and development programme and have first-hand experience and knowledge in the studied area. During the interview, the interviewer initially offered a brief introduction of this study and the research aim. Then, interviewees were asked to introduce their occupation and their duties in the case company. Following that, the details of their blockchain-based supply chain platform development and challenges in implementing blockchain technology were discussed. The interview questions are open-ended questions to drill down and investigate further details (see Appendix 2). The interviews were carried out in two rounds, yet further contacts were made to seek more details or clarification of their answers. Each interview lasted between 45 and 60 min. All the interviews were recorded after obtaining consent from all the participants. The recordings were then transcribed for further data analysis.

Thematic analysis was adopted to identify patterns in interviewees' answers because it is a flexible tool for qualitative research and is in line with the exploratory nature of this study. Based on the data reduction process suggested by Miles and Huberman (1994), the transcripts were coded. Patterns and themes were identified and recorded in the case template. For example, we generated the codes "Employee's unwillingness to cooperate" and "Employee's concern about losing jobs" from the interview excerpts, and those codes were identified as sub-themes titled "The Elimination of Jobs," and this sub-theme was classified into the main theme "Other Challenges". The data analysis findings were shown to the interviewees to ensure a correct representation of their opinions. Other forms of data, such as annual reports, publicly available news, and company sites, were also assessed to triangulate the data because triangulation based on multiple data sources in a solitary case study can help test validity (Nancy Carter et al., 2014).

4. Findings and analysis

4.1. Case description

The case company is a state-owned multinational conglomerate company headquartered in Beijing, China. It is one of the largest trading firms in China, and its core business covers energy, financial services, chemicals, and agriculture. The firm owns over three hundred subsidiaries and is listed in Fortune's "Global 500". It is a market leader with an annual turnover of US$600 billion.

As a large multinational company, the firm had some issues with its commodities trading segment. Fig. 3 shows that in the traditional trade process, the physical commodity owned by the exporter needs to go through a protracted process to be received by the importer, which includes the participation and coordination of multiple individuals or organisations (customs, ship owners, banks in both exporting and importing countries, etc.). For importers, a longer arrival time means higher uncertainty and the loss of profits, while for exporters, the shipping time, cumbersome procedures, and complex paperwork also prevent them from getting their receivables on time. To improve the turnover rate and consider the problems in commodity trading, the case company believed that focusing on export

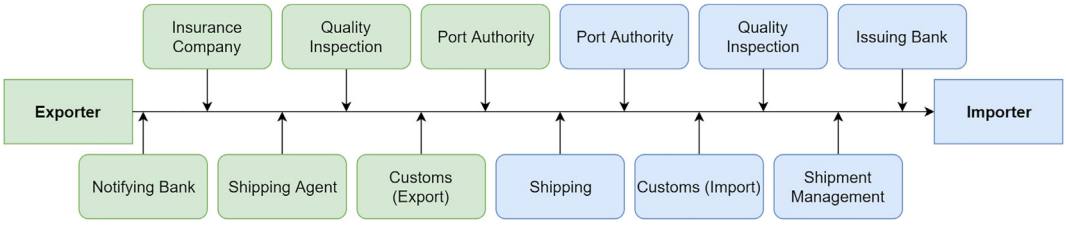

Fig. 3. Process for physical commodity from exporter to importer.

processes rather than logistics itself would be more efficient. Fig. 4 is a simplified diagram of the export process, which shows that the circulation and examination of the Letters of Credit (L/C) and Bills of Lading (B/L) are time-consuming. Moreover, the figure only presents the ideal situation when the supplier exports a physical commodity to the buyer, but in practice, with the involvement of multiple mediators, any delay will stop the circulation of documents and results in a longer processing time.

The current issues are affecting trading efficiency and might harm the resilience of the supply chain. Therefore, the case company decided to implement blockchain technology as a solution for their commodity trading sector. Fig. 5 presents the new workflow after blockchain transformation, which reveals that with the digitalisation of key documents such as the B/L (i.e., replaced by a digital B/L), real-time transfers of documents can be achieved. This transformation not only improves efficiency but also avoids the problem of losing paper documents. With this new process, the L/C can even be eliminated and replaced by telegraphic transfer (T/T). This is because the L/C was designed as a more secure payment mechanism; however, with the power of blockchain, the credit of the buyer can be ensured without the L/C. Thus, the authenticity of key documents can be guaranteed, and under this blockchain-based platform with high transparency, the delivery of physical documents can be safely replaced by digital transfer. Without the time cost and uncertainty in physical logistics, the trading process can be reduced significantly from 28 days on average down to same-day generation.

Another transformation using blockchain is the digitalisation of warehouse receipts. A warehouse receipt is a document issued by an authorised warehouse to the depositor for the withdrawal of the warehoused commodity after receiving it. The warehouse receipt can be used for the transfer or warehouse receipt financing in addition to being used as proof of the received warehoused commodity and proof of quantity and quality of the commodity. However, traditional warehouse receipts contain issues such as a lack of transparency and are hard to examined, which lead to challenges in warehouse receipt financing. Therefore, after the successful transformation of import and export documents, the case company cooperated with a Chinese state-owned bank to establish an electronic warehouse receipt platform using blockchain technology, which allowed the digitalisation of warehouse receipts and made it easier to transfer them. The electronic warehouse receipt also had stronger credibility in warehouse receipt financing, which reduced the verification cost for banks and improved the processing efficiency of traditional warehouse receipts.

Although the blockchain transformation in the selected case company brought benefits to that company, challenges in adoption cannot be ignored. As one of the early adopters of blockchain technology in China, they still encountered many challenges when developing their blockchain-based supply chain and logistics platform. Investigating those challenges is necessary not only to help the company identify barriers in this transformation but also to serve as a reference for subsequent companies and organisations considering the use of blockchain technology.

4.2. Technological challenges

4.2.1. Choosing a proper framework

Before adopting blockchain technology, the first choice that the development team had to make was to choose a proper framework. A blockchain framework can be defined as the software solution that can simplify the process of deploying this technology (Quasim et al., 2020). In 2017, there were multiple frameworks or communities that could be potential options, such as Bitcoin, the Enterprise Ethereum Alliance (EEA), Quorum, and Hyperledger. Each of them has its own characteristics and respective advantages and shortcomings. For example, Bitcoin is the first blockchain framework that was developed for digital currency. It can provide a public environment and prevent the double-spending problem. However, the downside of Bitcoin is its low throughput. Without a restriction on the number of participating nodes, it would take a substantial amount of time for consensus, and the transaction efficiency in the system would be reduced. Besides, the smart contracts cannot be executed with the support of Bitcoin, which limits their implementation scenarios. Thus, the choice of blockchain framework should be cautious and strictly based on the requirements of applications.

When designing their blockchain-based commodity trading platform, the team members found that it was hard to choose a proper framework. Because at that time, the implementation of blockchain technology in the supply chain was still in its infancy. There was not a universal standard or a framework that was widely integrated worldwide. It was hard for them to predict which framework would become mainstream on the market, and it was possible that a novel framework would be developed and gradually replace traditional frameworks. If an inappropriate choice was made, the company might have to deal with a lack of marketized technical resources in the future. In that case, they may need to reconstruct the underlying technology or maintain and develop their framework on their own.

4.2.2. Cross-chain interoperability

Because of the variety of blockchain frameworks, interoperability among blockchain platforms or entities was also an important consideration. Interoperability allows retrieving and exchanging data between different blockchain networks (Pillai et al., 2020). With the globalisation of business, the development team at the case company also needed to consider future collaborations with other enterprises in their international business. The cross-chain activity can be classified into two types: isomorphic or heterogeneous. For the

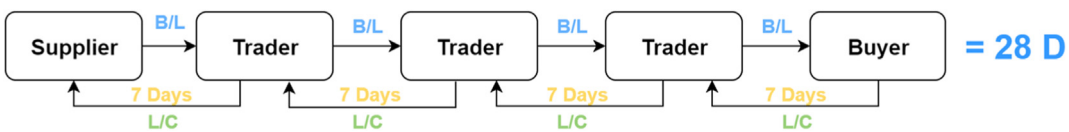

Fig. 4. Time consumption for traditional trading process.

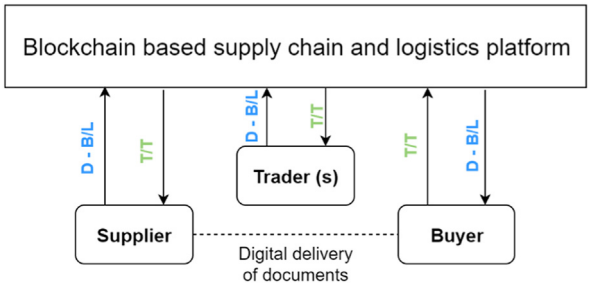

Fig. 5. Time consumption for blockchain-based trading process.

isomorphic type, since the entities share similar consensus mechanisms and underlying block architecture, the achievement of cross-chain activities will not be a huge issue. However, the technical experts in the firm indicated that in practice, the heterogeneous cross-chain situation took the majority, which means they had to deal with the difference in architecture and consensus in their financing activities.

Cross-chain interoperability issues pose challenges for case companies when interacting with business partners. For example, while blockchain technology is discussed as a solution to prevent double financing based on its immutability and decentralised architecture, first addressing how to synchronise the ledger when processing cross-chain bank transfers is required. If the synchronisation cannot be guaranteed, the double-spending problem can still occur, which would be a system vulnerability. Besides, the specialists at the case company also mentioned that efforts are needed for cross-chain transaction validation. For entities within the same consortium chain, it is easy to validate the legitimacy of a transaction. However, cross-chain interaction is a challenge for entities or participants on different blockchain platforms. They also indicated that, at present, there does not seem to be a strong incentive between platforms to develop and improve such docking.

4.2.3. Data governance

Another technical challenge for the case company's blockchain platform development was a shift in the data governance paradigm. In the traditional paradigm, each entity in the supply chain had its own database or data storage framework and had strong control over its data. After the blockchain transformation, the data had been moved to the blockchain, and the entities felt insecure about losing the governance of their data. Besides, when many transactions or collaborations occur, the calculation under encryption consumes a lot of computing power, which leads to system efficiency problems. The consensus needs of blockchain also cause efficiency issues and latency. For the case company, at the current stage, latency is not the main challenge, especially compared to the traditional way that delivers physical L/C and B/L; however, when they were planning to integrate their supply chain financial service sector into their blockchain environment, the latency was significant compared to the traditional database systems in banks or other financial service providers.

4.3. Operational challenges

4.3.1. Changes on finance process

The head of development in the company mentioned that, when implementing blockchain technology, some original finance processes had to be adjusted, and the information management system in the company also needed to be changed or even replaced, especially in the field of external connection processes. Employees in related positions (e.g., those used to negotiate with advising banks or issuing banks) also needed a new round of training, and the resulting training expenses and the time required for employees to become familiar with the novel processes could not be ignored. Besides, the investment in traditional business processes and information system construction had been huge. Therefore, those changes brought by the blockchain lead to a substantial sunk cost and a long run-in period.

4.3.2. Blockchain transformation in the whole supply chain

The development team indicated that in the process of supply chain globalisation, the goal of the blockchain transformation was to cover the entire supply chain and develop an ecosystem. To achieve this goal, engagement and collaboration from all the participants in the supply chain were vital. When there are more entities, stakeholders, and countries involved, the adoption of blockchain technology can be driven by the network effect (Koens and Poll, 2018). However, when they were developing their platform, they found that other enterprises and organisations lacked the driving force for this transformation. The consensus on the global supply chain is important to facilitate the adoption of blockchain technology among stakeholders; however, one of the major challenges in this case was the trust issue. Interviewees indicated that how to persuade companies and organisations to participate in this transformation has not been addressed, which means some of their supply partners were unwilling to involve in the blockchain-based system. Besides, the investment in this new platform was enormous as well. The head of the development team in the company indicated that their development cost in the preliminary stages was up to US$3 million, and the subsequent running of this platform cost at least US$1.5 million per year. Considering those research and development (R&D) costs, global commercial or policy incentives seem necessary.

One interviewee mentioned the concept of decentralised finance (DeFi), a financial model with blockchain as the underlying technology. In traditional centralised finance (CeFi), supply chain participants need banks, guarantors, and other multi-party institutions to complete financial transactions. One of the ultimate goals of blockchain transformation is the evolution from a CeFi to a DeFi environment; however, implementing DeFi in the entire supply chain is a complex process that is inseparable from the improvement of physical infrastructure and the transformation of the overall SCF environment. Moreover, as mentioned in the previous part, even if entities in the supply chain start to adapt to the new financial ecosystem, it will take time.

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4.4. Other challenges

4.4.1. The elimination of jobs

The digital transformation is an irreversible trend in global supply chains, and the introduction of blockchain technology has undoubtedly accelerated this process. The executives in the case company said that digital operations supported by blockchain technology were gradually eliminating a substantial number of jobs that were created because of flaws in traditional processes or centralised systems. Moreover, the assistance of these employees was required when designing and developing a platform based on blockchain technology. For the case company, when developing their digital warehouse receipt platform, one of the main challenges they encountered was the difficulty of motivating employees in these positions, and strong resistance was received in the preliminary stages of their development of the new platform. Because for employees, this structural transformation meant that they were about to lose their jobs in the near future, in which case they were still being asked to help develop the new platforms and even needed to assist the company on the transition before leaving their positions. Therefore, it is not difficult to understand that employees have a sense of crisis and resistance.

4.4.2. The regulatory issue

Another challenge was that in logistics and financing, current laws and regulations define the term “key documents” as the original paper copies, and whether the transformed digital documents on their blockchain platform could be included in this definition was still an unresolved issue. The immature regulatory environment affected the willingness of organisations and entities to adopt blockchain platforms to a certain extent. For the case company, the development team was also concerned about the potential issues arising from the legal gap. For example, when deploying a smart contract, which is an embodiment of a cross-subject execution contract, can its legal rights be recognised and protected like those of traditional contracts? The use of digital B/L also poses regulatory risks. An executive of the case company pointed out that current international trade still relies on physical B/L because, although digital B/L have been supported by new specific legislation in some countries, there are still many countries that have not updated their relevant regulations. Before the traditional legal system and the blockchain ecosystem are fully integrated, any legal issues and contract disputes on the platform may bring huge challenges.

5. Discussion

Our findings suggest that companies will meet technical, operational, and other challenges when integrating blockchain technology into supply chain finance. Starting from an enterprise that had already applied blockchain technology, this research explored the detailed challenges encountered by the case company from those perspectives and where those challenges came from.

From a technological perspective, companies may have to choose a blockchain framework in the initial stages of their adoption and take the risks associated with the future uncertainty of their underlying technology. People in the technology sector may also encounter difficulties with cross-chain interoperability when interacting with other companies or organisations due to the different architectures and consensus mechanisms of different blockchain platforms. The change in data processing and governance modes will also bring challenges such as scalability and low throughput, which is in line with the discussion in existing literature (Koteska et al., 2017). Based on the above discussion, we suggest the following proposition.

Proposition 1. *When considering the adoption of blockchain, the major technological challenges are*: 1) *the framework chosen*; 2) *cross-chain interoperability*; *and* 3) *data governance*.

From an operational point of view, changes in finance processes mean that this transformation needs time to be adopted and ultimately cannot be independent of the cooperation and collaboration of the global supply chain. Furthermore, as an innovative technology application, the regulatory issue must be addressed. When dealing with legal gaps, businesses or organisations must be aware of them. Finck (2018) indicated that regulatory techniques and laws must adapt to the evolution of this technology. Furthermore, in the process of transformation, the “elimination” of relevant jobs may cause companies to have to deal with resistance from employees who are concerned about losing their jobs, which might cause a crisis in the human resources team. Based on the discussions above, we propose the following propositions.

Proposition 2. *When considering blockchain adoption, major operational challenges include*: 1) *changing the finance process*; *and* 2) *blockchain transformation throughout the entire supply chain.*

Proposition 3. *When considering the adoption of blockchain, challenges such as* 1) *the elimination of jobs and* 2) *regulatory issues are also critical.*

Overall, these challenges encountered by the case company may be brought on by factors such as the immature technological environment and changes in trade patterns, which are common issues at the early stage of implementing innovative technologies. The popularity of blockchain is similar to that of Radio Frequency Identification (RFID), which was also an emerging technology two decades ago. When RFID started to be adopted into the supply chain, challenges such as the security threat, cost, and lack of standards to ensure interoperability among tags and readers from different manufacturers were also identified by researchers (Wu et al., 2006; Xiwen, 2012; Zhu et al., 2012). However, RFID has become a mature technology that has been widely adopted in logistics in recent years (Costa et al., 2021). Actions have been taken by researchers and practitioners to successfully reduce the cost and enhance the security of this technology (Juels, 2004). Consequently, identifying challenges when implementing blockchain could be beneficial for further studies to work on the potential solutions and benefit the overall development of this technology. Besides, the findings of this study can be a reference for any company or organisation that is preparing to transform to a new supply chain environment based on blockchain technology; they might need to consider these mentioned challenges and whether they can withstand this change before making any decision. The initial conceptual framework was updated and adjusted to a new conceptual framework following the analysis of results and discussions (Fig. 6).

The results of this study have both theoretical and managerial implications. From a theoretical perspective, this study explored the challenges when implementing blockchain in SCF with the support of empirical evidence, and a structured result is summarised, which initially filled the gap in evidence-based research on this topic. The propositions suggested offer direction and help guide future research in related topics. From a managerial perspective, the results provide guidance for enterprises or organisations that seek to implement blockchain as their supply chain solution. By understanding the challenges of the case company, preparation and evaluation can be made by managers or practitioners in related areas.

6. Conclusion

Previous studies have rarely discussed the challenges of implementing blockchain technology into SCF, especially with the support of evidence from cases. In this study, we attempted to fill the research gaps by exploring the challenges of the adoption of blockchain technology by a state-owned company in China, which was one of the first companies in China and the world to adopt blockchain technology in their SCF. After an exploratory case study based on semi-structured interviews with top management and technical specialists in the case company, a conceptual framework is generated from the results, and propositions are suggested accordingly. This study offered an initial attempt to explore the barriers to the adoption of blockchain technology, which is a new phenomenon around SCF. The result shows that during the adoption of this technology, there were challenges from a technological perspective, such as framework choice, interoperability, and data governance. From operational considerations, the transformation to a new finance process and the entire supply chain can both be challenging for firms that deploy blockchain. Other challenges, such as the elimination of jobs and the immaturity of laws and regulations, cannot be neglected as well. Although some of the challenges are not unique to SCF but also happen when adopting blockchain in other sectors of supply chain management, they were still suggested and emphasised by

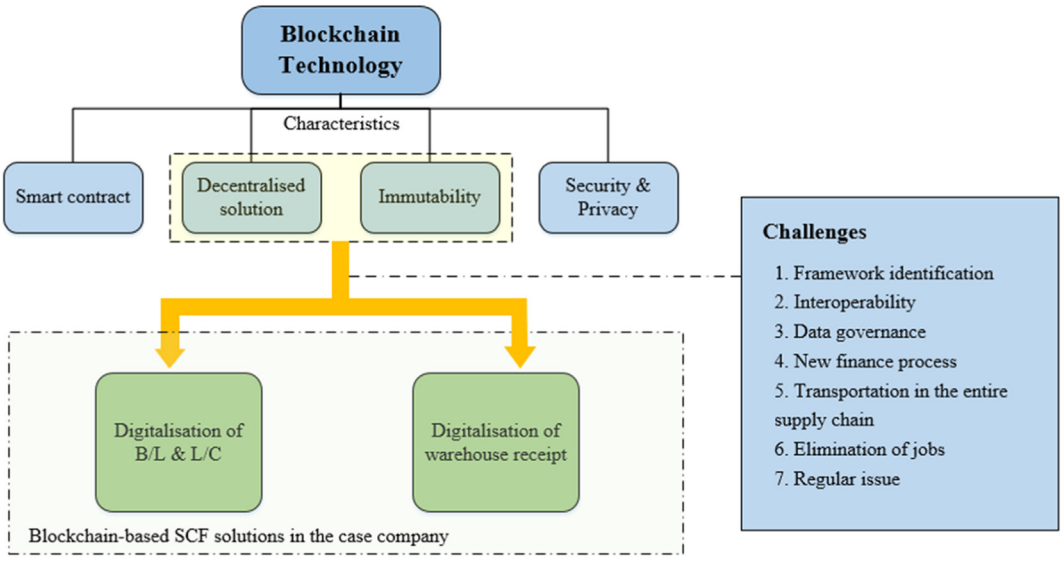

Fig. 6. The final conceptual framework.

interviewees, and it is important to take careful consideration of them before the adoption of blockchain technology in SCF.

Limitations still exist in this study. For example, the chosen case company is a state-owned enterprise that could develop its own blockchain platform and invest in it constantly. Nevertheless, for SMEs, there might be cost-related challenges that are not considered in this study. Besides, the case method contains generalisability issues, and to examine the challenges proposed in this study, further study with a larger and more diverse population can be conducted. In future research, scholars might also be interested in investigations and discussions on solutions to the challenges mentioned in this study.

Appendix 1. Overview of interviewees

Code of interviewee	Occupation	Education level	Age group
I1	Development group head	Postgraduate	31–40
I2	Commodity trader	Graduate	31–40
I3	Blockchain developer	PhD	31–40
I4	IT consultant	Postgraduate	31–40
I5	Commodity trading consultant	Graduate	41–50
I6	Blockchain developer	Postgraduate	20–30
I7	Commodity trader	Graduate	20–30
I8	IT consultant	PhD	31–40
I9	Blockchain developer	PhD	20–30
I10	Supply chain manager	Graduate	41–50
I11	Commodity trading consultant	Postgraduate	31–40
I12	Supply chain manager	Postgraduate	31–40

Appendix 2. Semi-structured interview questions

Phase 1 Description of the research

1. ***Introduce the research background and research aim***
2. ***Describe the research framework and the questions in the following part***

Phase 2 General information of the interviewees

1. ***What is you occupation in the department?***
2. ***Describe the business function of your job.***

Phase 3 Case information and challenges in this transformation

1. ***Please describe the project in this case. What kind of blockchain transformation happened in this case? When was it started? When was the first successful pilot developed?***
2. ***What technical challenges have you encountered so far?***
3. ***What operational challenges have you encountered so far?***
4. ***Were there any other challenges you have met in this project?***

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