

Application of blockchain technology for resilient and sustainable supply chain management

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Abstract. This paper has explored how to integrate blockchain into supply chain management to achieve a resilient and sustainable supply chain for the future business. To achieve the purpose, this research uses semi-structured interview for data collection. The researcher of this study has identified the key problems to be solved by the BCSC mode. Results show that the potential risk suggested in this study in relation to the use of the BCSC is possible attack risk due to additional tasks that need to be completed other than the processes in traditional database. These additional tasks include signature verification, and attaining consensus. Moreover, there are different key applications of BCSC in both cross-border e-commerce and the general business environment, such as identification and traceability of products, enhancing the efficiency and speed of supply chain processes, and improving the financing, contracting and cross-border transactions. Finally, based on the findings of this research, it was determined that RFID could be incorporated with the BCSC. RFID will increase the traceability of the products that are on transit within a specific supply chain. This study has made contribution to the literature as it uncovers the positive side of using blockchain technology in supply chain management. As the existing literature do not extensively cover the future of businesses that integrate blockchain into their supply chain management processes.

Keywords: Blockchain; Sustainable supply chain management; Resilient supply chain; BCSC.

1. Introduction

With the increasing trend of globalisation, many multinational corporations have gradually established their global supply chains to enhance competitive advantages. While bringing in opportunities, economic globalisation has come with uncertainties in the business world, such as market competition, higher customer expectation, supply chain risk and complexity. Currently, the COVID-19 pandemic has heavily hit the global economy, where many problems associated with inefficient supply chains emerge. For example, in Wuhan China, due to the influence of COVID-19, the whole supply chain system was suffered a considerable impact. In particular, it appears issue related to food supplies and medical delivery. Ironically, it was not about the shortage of these important supplies but the inefficient supply chain management that tones of donations were piled up and backlogged in the Red Cross's warehouses. When thousands of people were suffered from inadequate food and medical supplies, the devastating pandemic raises the public's awareness of supply chain management's uncertainties, risks, and weaknesses.

Blockchain is treated as one of promising technologies and using new technology in supply chain management is believed to be one of the solutions to deal with this. The application of blockchain may change traditional ways of managing supply chains that are fragmented with limited materials exchange, internal competition, and price negotiations behind closed doors.

This topic, however, is relatively new, and the associated literature has been thin. So far, most scholars have focused on the application of blockchain to improve financial flow and information flow [3, 4, 5]. The increasing awareness of blockchain technology has led to increased research into the integration of supply chain and blockchain. Therefore, in the proposed research, this paper aims to investigate the research question: how to integrate blockchain into supply chain management to achieve a resilient and sustainable supply chain for the future business.

2. A Brief Literature Review

When looking at the potential of applying blockchain in supply chain management (OSCM) and operations, most studies have attempted to identify the common characteristics among supply chain management and blockchain. For instance, seen as a network structure, they compose different nodes, users, external and internal stakeholders [6, 7]. In addition, most companies/partners make decisions based on their own supply chain and blockchain is a decentralized network; both supply chain and blockchain requires a certain level of integration and collaboration. Another stream of research has focused on how the blockchain technology can be used in OSCM, where many studies looked into the traceability with the associated value of trust and transparency created by blockchain [8, 9, 10]. Chang, Iakovou and Shi (2019) further proposed a critical synthesis addressing how blockchain can affect trade operations and global supply chain. Recently, some researchers have started to relate blockchain technology to deal with the challenges faced by cross-border e-commerce, where the main focuses have been given to enhance relationships among business partners and improve supply chain integration by building trust, lowering risks and transaction costs. For instance, from a trust-building perspective, Deng (2020) proposed that blockchain is a natural match with cross-border payments, while Schmidt and Wagner (2019) believe that blockchain might influence supply chain relations amongst cross-border business partners to coordinate, for instance, delivering products from many suppliers and retailers to the clients.

In this area, Öztürk and Yildizbaşı (2020) composed a numerical sample to determine obstacles to the integration of blockchain into supply chain management. The researchers used an integrated multi-criteria decision-making approach to achieve an understanding of the applicability of blockchain technology into supply chain management processes. Employing fuzzy TOPSIS and fuzzy AHP approaches, the study found out that there were challenges stemming from the financial, technological, financial, organizational, and environmental constraints in the process of integrating blockchain into supply management processes. Specifically, the study explains that the blockchain integration process may be barred by challenges including high investment costs, data security risks, difficulties of integration in health and logistics sectors, and difficulties in achieving integration for highly complicated supply chains. Despite researching extensively on the challenges, the study fails to coherently build on the chances for adopting blockchain technology in supply chain management processes, the possible successes of the integration and the possibility of creating sustainable and resilient supply chain management processes even in the future.

Similarity, Saberi et al. (2019) conducted a research study to determine the relationships among sustainable supply chain management and blockchain technology. In its findings, the study documents that blockchain technology is capable of improving traceability, transparency and security of supply chain management processes. More specifically, the study highly inclines towards finding out how companies can overcome potential barriers while integrating blockchain technology into supply chain management. The article, however, agrees that the integration of blockchain into supply management processes is still in its early stages and, as such, relatively fewer studies are concerned with insights into adopting blockchain technology into supply chain management. This research aims to address this research gap as it will lay provisions regarding insights into implementing blockchain technology within supply chain management processes. In this area, Blossey et al. (2019), through an application perspective, conducted a research study to identify the application of blockchain technology into supply chain management. In its preliminary assertions, the study agrees to the fact that blockchain technology has experienced much hype in facilitating cryptocurrency and that, contemporarily, there are applications of considerable attention to the use of blockchain technology outside the financial sector. The authors, however, explain that the application of blockchain in supply chain management as an area of research is still in its early stages; therefore, derived conclusions may be preliminary. Additionally, only focused on the manufacturing and logistics sectors.

After briefly reviewing the relevant studies, the author has identified the potential research gap. First, given the existing studies often focused on one aspect of blockchain applications in OSCM, in particular traceability, the adoption of blockchain technology have not been systematically discussed.

Moreover, rarely has journal articles attempted to relate blockchain to the integration of supply chain management regarding how blockchain can help reduce uncertainties and risks so as to provide value for companies. Third, given that supply chain-related research has shifted from blockchain to broader distributed ledger technology concepts, future research needs to consider integrating other types of new IoT into applied blockchains in OSCM.

3. Research Questions and Research Objective

The blockchain technology is still in its infancy. However, it has shown considerable development potential in the field of OSCM. Therefore, this study aims to explore the impact of blockchain applications on the sustainability and resilience of supply chain management, with a special interest given to how the “blockchain plus supply chain” or “blockchain-enabled supply chain” (BCSC) mode can integrate business supply chains in an increasingly globalised business context. Specifically, this research aims to answer below research questions:

How does BCSC bring in value to business supply chains?

What are the key problems to be solved by the BCSC mode?

What are the potential risks brought by the BCSC mode, if any?

What are the key applications of BCSC?

The applications in the general business environment;

The application in cross-border e-commerce.

How can we incorporate BCSC with other technologies (IoT) to improve business supply chains?

The integration of supply chain resources flows associated with logistics, information, and finance, enabled by BCSC+IoT

4. Research Design

The theoretical premises of the research is on the basis of four different theories, covering resource-based view (RBV), transaction cost analysis (TCA), principal-agent theory (PAT), and network theory (NT), which are used to help develop research questions that are relevant for the industry as well as theory-based [20, 13]. Therefore, the conceptual analysis framework for the BCSC model is mainly based on these theories. In addition, building the conceptual framework of BCSC is based on the following criteria, including 1) functionality (i.e. whether or not the BCSC model can satisfy various functional and unfunctional needs); 2) feasibility (whether or not the BCSC model can benefit players along the supply chain and match the current supply chain structure); 3) extendability (whether or not the BCSC can be extended to include other types of business supply chains, e.g. supply chain finance).

This research is based on qualitative research method; that is: semi-structured. In addition to referring to the existing literature, the author has conducted interview and filed visits to the 5 targeted Chinese e-commerce companies and 10 relevant stakeholders, such as government officials, logistic firms, suppliers, and consumers during 2021 September to May, 2022. Interview time for each respondent is 30 minutes. Through conducting interviews, it is able to gather different players' views and the questions covered in semi-structured are designed based on the results of previous scholars. The author has asked questions to supply chain management staffs, and other relevant stakeholders about their willingness to implement BCSC regarding, for an example, BCSC's extra cost, asking about consumers' willingness to accept BCSC, asking about suppliers' feasibility of implementing BCSC (efficiency, difficulties, and risks of integrating resources), and asking about governmental officials' relevant policy implications and regulations. What is more, the results gathered from interviews provide the data for analysis and thematic analysis method is used for data analysis.

5. Findings and discussion

This section presents the results of empirical research, while comparing the results of the empirical research with previous literature. In terms of key problems to be solved by the BCSC mode, all the respondents of the study agreed that a block-chain enabled supply chain (BSCSC) would address the traceability challenges of products in different stages of the supply chain. For example, interviewee 6 stated, “The existing traceability systems in the supply chain mainly use a centralized, or distributed architecture, and especially in centralized architecture there are high risks of single node attack or even data tampering. The use of the BCSC eliminates such risks in the traceability aspect.” Whereas, interviewee 4 points out that the use of the BCSC will increase the level of transparency in the supply chain network. In addition to that, interviewee 1 noted: “the use of the blockchain in the supply systems will reduce issues related to information disclosure, and increase the level of efficiency in the supply chain in China by improving the level of coordination, reducing counterfeiting of products”. Interviewee 7 added that it will increase access to financing, which will build trust among the parties involved in the supply process.

For the potential risks brought by BCSC mode, interviewee 3 noted: “the only potential risk may exist in a small supply chain, which can be susceptible to a 51% attack because of the additional tasks such as signature verification and attaining consensus that are needed”. However, she noted that “the likelihood of this attack being successful is highly unlikely”.

The interview results also give explanation for the applications of BCSC in the general business environment. For example, interviewee two stated that she worked in a pharmaceutical company where BCSC will enhance the identification and traceability of prescription drugs, and promote the protection of the consumers from counterfeit, harmful, or even stolen products. She highlighted that this is also applicable in other industries such as electronics, clothing, and other manufacturing industries. In this area, interviewee 8 said that: “BCSC will be applied in a manner that will enhance the efficiency and speed of the supply chains, and ultimately contribute to the reduction of disruptions”. He stated that “in large, or complex supply chains, any form of delays in the supply chain can contribute to excess inventory, or stock-outs, which tend to have a negative impact on the supply chains”. However, with the use of the BCSC, such challenges will be addressed.

The findings also support the BCSC’s application in cross-border e-commerce and agrees that it will improve financing, contracting, and cross-border transactions. For example, interviewees 5 and 9 both emphasized BCSC improving cross-border trade through the connection of inventory, information, and all the financial flows and sharing them with all the transaction parties in the supply chain. In particular, interviewee 5, noted: “the use of a blockchain will increase the ability of companies in different parts of the world to reconcile their purchase orders, invoices, and payments easier than when using manual, or company’s resource planning (ERP) systems”.

For the incorporation of BCSC with IoT, according to interviewee 9, “RFID tags can be incorporated into the BCSC. The reason for this is that it will contribute to the improvement of traceability, and also eliminate the probability of counterfeits in the supply chain”. A combination of RFID tags and BCSC will increase the security of high-value assets as was opined by interviewee 10.

The results in this research are in line with some achievements from past studies. The researcher of this study was keen on identifying the key problems to be solved by the BCSC mode. The respondents of study mentioned issues such as traceability, and data tampering. This was in line with the findings of whose study findings indicated that blockchain technology will contribute to improving the traceability, and security of the supply chain management processes. In particular, the findings of based on the responses of the interviewees suggest that the use of blockchain technology in supply chain management will overcome these barriers mentioned while enhancing the efficiency of supply chains.

The researcher observed that the only potential risk that was suggested in this study in relation to the use of the BCSC is the 51% attack because of the additional tasks that need to be completed other than the processes in the traditional database. These additional tasks include signature verification, and attaining consensus. However, as it was pointed out in the results of this study, the likelihood of

the 51% attack or the double spend attack being executed in the BCSC is minimal. Finally, based on the results of this study, it was determined that RFID can be incorporated with the BCSC. RFID will increase the traceability of the products that are on transit within a specific supply chain. In addition to that, it ensures that the likelihood of counterfeiting at any stage of the supply chain is minimal. It increases the efficiency of the supply chain, and helps build trust among different suppliers.

There are different key applications of the BCSC in both the general business environment, and cross-border e-commerce such as identification and traceability of products, enhancing the efficiency and speed of the supply chain processes, and improving the financing, contracting and cross-border transactions. The findings of this study were in line with Deng (2020) who noted that blockchain is deemed as a natural match in relation to cross-border payments. It is also supported by who note that blockchain can influence, or increase the supply chain frequency for the cross-border business partners to cooperate and coordinate. The basis of this is that, the BCSC will likely improve the trust level between suppliers, and even with their consumers and reduce the need to meet face-to-face, or use referrals. The system will authenticate legit dealers that suppliers can deal, or interact with, and this increases the efficiency level of the domestic and global supply chains.

6. Summary

In conclusion, this paper has explored how to integrate blockchain into supply chain management to achieve a resilient and sustainable supply chain for the future business. To achieve the purpose, this research is based on semi-structured interview. The researcher of this study has also identified the key problems to be solved by the BCSC mode. The respondents of study mentioned issues such as traceability, and data tampering. The researcher observed that the only potential risk suggested in this study in relation to the use of BCSC is the possible attack risk due to additional tasks that need to be completed other than the processes in the traditional database. These additional tasks include signature verification, and attaining consensus. Moreover, there are different key applications of the BCSC in both the general business environment, and cross-border e-commerce such as identification and traceability of products, improving the efficiency and speed of the supply chain processes, and improving the financing, contracting and cross-border transactions. Finally, based on the findings of this study, it was determined that RFID could be incorporated with the BCSC. RFID will increase the traceability of the products that are on transit within a specific supply chain.

This research study has strived to understand the application of blockchain technology in supply chain management as a way of developing sustainable and more resilient organizations now and in the future. This study makes contributions to the literature as the topic is relatively new and that most literature sources were inclined towards understanding the challenges involved in integrating blockchain technology into supply chain management. Most of the sources were on the negative side. This study offers some insights to the positive side of integrating blockchain technology into supply chain management. Additionally, the existing literature do not extensively cover the future of businesses that integrate blockchain into their supply chain management processes. As a relatively new process, there are likely to be future risks that companies may have to face as they hope to use blockchain technology in supply chain management.

Although this research contributes to the literature and practice, due to time and resource constraints, this paper only adopts the method of qualitative research and interviews a limited sample. In order to expand the applicability of research conclusions, more samples can be studied, and quantitative methods can be considered.

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