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Research on the impact of blockchain technology on supply chain performance: The intermediary role of supply chain coordination and transparency in the blockchain industry

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Abstract

Purpose – The purpose of this study is to investigate the impact that the implementation of blockchain technology has on supply chain management by analysing the mediating effects of supply chain coordination, transparency, inter-organisational systems, and management capabilities.

Design/methodology/approach – The primary data were obtained by the distribution of a self-administered questionnaire, and the replies were evaluated using a Likert scale with five points. This study collected 300 valid questionnaires from December 2023 to March 2024. SPSS was used for data analysis, and PLS-SEM was used for structural equation modeling analysis.

Findings – Specifically, the findings of this research point to the existence of a statistically significant positive association between blockchain adoption (BCA), supply chain management capabilities (SCMC), inter-organisational systems (IOS), and supply chain performance (SCP). Mediation analysis highlights the critical role of supply chain coordination (SCC) and transparency (SCT) in enhancing SCP through BCA.

Originality/value -- This research makes a significant contribution to the body of knowledge concerning the implications of blockchain technology for supply chain management, offering practical implications for industry stakeholders and policymakers.

Keywords: Supply chain performance, supply chain transparency, supply chain coordination, blockchain adoption, supply chain management capabilities, inter-organisational system.

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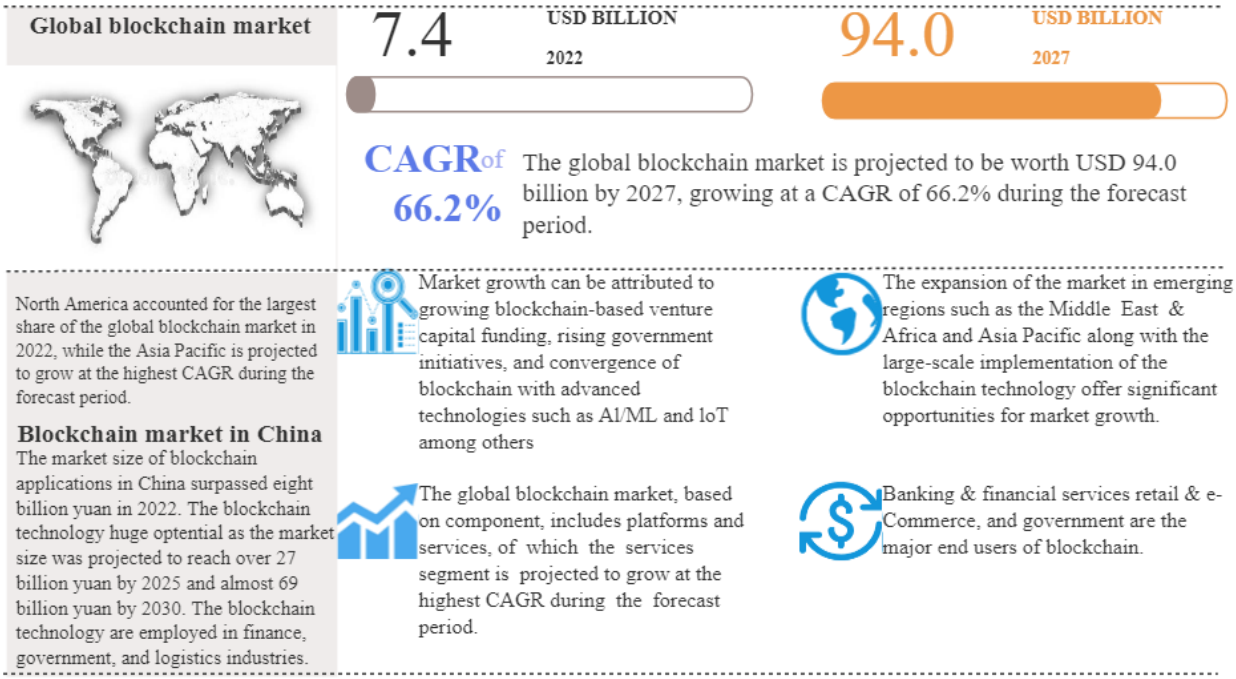
1. Introduction

The rapid growth of the digital economy and decentralized systems has led to the significant emergence of blockchain technology, which has assumed a pivotal role in digital business (Dwivedi et al., 2023). The growth of the platform economy, spurred by the progress of the digital economy and advancements in information technology and communications, particularly blockchain technology (BCT), has heightened focus on the need for innovation and adaptation in supply chain management (SCM) to address the requirements of the digital era (Latan et al., 2024). The predicted trajectory of the worldwide blockchain market suggests a projected value of US$94 billion by the year 2027, with an estimated compound annual growth rate of 66.2 percent throughout the forecast period (see Figure 1 for more information). This is based on relevant data. Furthermore, it is anticipated that the market size for blockchain applications in China will transcend 8 billion yuan by the year 2022. This is a projection that has been made. The market is expected to rise to more than 27 billion yuan by the year 2025 and to get close to 69 billion yuan by the year 2030. This indicates that blockchain technology has a significant amount of potential. The application of blockchain technology in China is primarily observed within the financial, government, and logistics sectors, as illustrated in Figure 1.

Figure 1. Blockchain market overview.



Source: Blockchain Market, Statista.

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Numerous scholarly inquiries have delineated several advantageous aspects of blockchain technology, including but not limited to the augmentation of business models, enhancement of supply chain security, facilitation of shipment traceability, provision of flexibility in product development, assurance of product safety, and fortification against market volatility (Hastig and Sodhi, 2020; Wang et al., 2020; Morkunas et al., 2019). Recent studies have demonstrated that the adoption of blockchain technology holds promise for fundamentally transforming various supply chain management business models, as well as optimising end-to-end supply chain processes, leading to enhancements in overall supply chain performance (Wamba et al., 2020). Nevertheless, there is a general paucity of empirical evidence supporting these assertions. The majority of extant literature in this field comprises descriptive or case studies, as evidenced by the works of Wang et al. (2020), Koh et al. (2020), Di Vaio and Varriale (2020), Chang et al. (2019), and Chong (2019).

According to Dolgui et al. (2019), the use of blockchain technology has resulted in considerable change. This transition has been launched within many areas of supply chain and operations management, which has led to the creation of real-time supply chain capabilities. One of the probable ways in which the implementation of the A-CDM system, which is founded on blockchain technology, might improve operational efficiency, effectiveness, and sustainable performance of airlines. Di Vaio and Varriale (2020) propose the utilisation of artificial intelligence technology within air transport systems to effectively mitigate disturbances stemming from both internal and external factors. The application of this technology aims to enhance the overall efficiency, effectiveness, and sustainable performance of the air transport process. Concurrently, Lenovo's implementation of blockchain technology enhances the cost-effectiveness and expediency of its procurement and sales operations, leading to enhancements in quality and efficiency within a condensed timeframe. The implementation of dual-chain integration results in a cost savings of over 15% in manual cross-checking expenses within the procurement and sales process (Xia et al., 2023).

The literature in this area mainly focuses on the advantages of supply chain technologies. However, it does not explore in detail how such technologies can be applied in supply chains and their success rates. Therefore, the development of important supply chain management competencies (such as transparency and coordination) may be a vital link in the process of employing blockchain technology to improve supply chain performance. Furthermore, the link between the use of blockchain technology, supply chain performance, and supply chain competencies (such as transparency and coordination) has yet to be substantially studied (Sodhi and Tang, 2020). The purpose of our research is to fill this ongoing void by presenting the first empirical proof of the positive influence that BCT has on supply chain performance. This will be accomplished by demonstrating that supply chain management competencies such as

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transparency and coordination are beneficial to supply chain performance. For the purpose of this investigation, we are concentrating primarily on supply chain coordination and supply chain transparency as mediators between the adoption of blockchain technology and supply chain performance outcomes.

This choice is based on what Latan et al. (2024) emphasised, that supply chain management capabilities are the intermediary to achieve superior supply chain performance. This capability can improve supply chain responsiveness, flexibility, trust, and efficiency, ultimately improving performance in terms of cost-effectiveness, customer satisfaction, risk mitigation, and operational excellence (Laura, 2020; Iranmanesh et al., 2023). Therefore, our study attempts to address the following research questions (RQs):

RQ1: Does supply chain transparency mediate the relationship between blockchain technology adoption and supply chain performance?

RQ2: Does supply chain coordination mediate the relationship between blockchain technology adoption and supply chain performance?

RQ3: What impact does the adoption of blockchain technology have on supply chain performance?

RQ4: What impact does supply chain management capability have on supply chain performance?

Moreover, inter-organisational systems (IOS) are network information systems that effectively expand and connect organisational boundaries. In recent years, there has been growing interest among researchers and practitioners in examining the potential impact of Information Systems (IOS) on enhancing organisational performance (Asamoah et al., 2021). The International Organisation for Standardisation (ISO) allows organisations to optimise the utilisation of external resources accessible through partnerships to augment their internal resources and capacities for the mutual advantage of members within the supply chain network. The implementation of ISO standards offers significant advantages for the overall efficiency and effectiveness of the supply chain, as demonstrated by Asamoah et al. (2019). Several scholars have advocated for additional exploration of the relationship between ISO and supply chain performance (Agbenyo et al., 2018; Aydiner et al., 2019; Yu et al., 2018). Contemporary research primarily emphasises the external application of ISO within supply chain management, as well as the organisational management capabilities of IOS within the framework of supply chain management (Asamoah et al., 2019). The objective of this research is to investigate the intricate correlation between Information Systems and supply chain performance. Hence, this investigation formulates the subsequent research inquiries.

RQ5: How does the adoption of cross-organisational systems affect supply chain performance?

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RQ6: How does IOS affect supply chain management capabilities?

This research is grounded in the theoretical framework of the resource-based view (RBV) theory. The RBV theory posits that organisations possessing unique, valuable, and rare internal and external resources and capabilities are able to leverage these assets to pursue strategies that are challenging for rivals to replicate, thereby creating sustained competitive advantages (Kamboj and Rana, 2021).

The present study provides significant theoretical and scientific advancements in three pivotal areas. Initial priority is given to respond to the research proposal presented by Sodhi and Tang (2020) to carry out a thorough empirical evaluation of the association between the implementation of supply chain, SCMC (transparency and coordination), and SCP within a specific industry framework. The current study expands upon the research conducted by Agbenyo et al. (2018), Aydiner et al. (2019), and Yu et al. (2018) to gain a deeper comprehension of the correlation between ISO and SCP. In our analysis, we deliberately integrate antecedent, decision-making, and outcome perspectives in order to enhance the depth and comprehensiveness of our examination of relevant variables.

The subsequent section of the document commences with the formulation of the theoretical framework and hypotheses, subsequently followed by the description of the research methodology. Subsequent to this section, the empirical findings will be presented and deliberated upon. The concluding section provides an analysis of the findings, discusses the limitations of the study, and suggests future research opportunities.

2. Theoretical background and hypothesis development

2.1 Resource-based view (RBV) theory

This research employs the RBV theoretical framework to substantiate the suggested model and hypotheses, with the intention of determining whether or not there is a connection between the use of blockchain technology, the capabilities of supply chain management, ISO certification, and the performance of the supply chain. The Resource-Based View (RBV) hypothesis proposes that the distinctive and unrivalled resources and skills of a company are the source of the persistent competitive advantage that the company enjoys. The Resource-Based View (RBV) philosophy lays a strong focus on the value of the internal resources and competencies

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for an organisation rather than solely concentrating on the external environment and market competition (Madhani, 2010). According to the resource-based view of the firm, Barney (1991) asserts that firm performance is primarily driven by the resources possessed by the organisation. Additionally, superior firm performance is achieved through the strategic combination and development of these resources and capabilities.

The RBV literature underscores the significance of a firm's internal resources in driving its competitive advantage. In the context of inter-organisational systems, enterprises may consider IOS as a valuable resource that enables them to enhance their capabilities in areas such as connectivity, information sharing, and collaboration (Lyytinen and Damsgaard, 2011; Steinfield et al., 2005). Furthermore, RBV theory posits that organisations can attain a competitive advantage through the integration and development of resources, as well as the cultivation of core capabilities. Within the context of the IOS framework, it is imperative for enterprises to demonstrate proficiency in their capacity to engage in efficient communication, coordination, and collaborative efforts with external organisations. This encompasses the capacity to effectively oversee inter-organisational interactions, exchange knowledge, and engage in cooperative decision-making. The utilisation of IOS enables enterprises to enhance their supply chain management efficiency and foster stronger partnerships, consequently engendering competitive advantages (Sanders, 2007; Subramani, 2004; Wang and Wei, 2007). This study employs the use of ISO standards to validate its direct influence on the performance of the supply chain.

The RBV theory posits that firms utilise their distinctive resources, specifically the BCT, to enhance SCP and ultimately gain a competitive edge. Moreover, it is asserted that the SCC plays a crucial role in enabling organisations to achieve greater competitiveness and higher performance levels (Wu et al., 2006). As opposed to the direct influence that BCT has on the performance of an organisation, the possibility of supply chain competitiveness is dependent on the role that coordination and transparency play as mediator factors. This article is based on an expansion of supply chain capabilities, specifically focusing on the concepts of coordination and transparency as defined by Lee (2004). This study seeks to empirically examine the indirect influence of BCT adoption on supply chain performance by means of supply chain capabilities, specifically transparency and coordination. These capabilities are integral resources that afford organisations a competitive edge.

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2.2 Blockchain adoption (BCA)

Blockchain technology is a decentralized public ledger that offers a secure infrastructure for conducting transactions between multiple parties without the need for a centralized authority (Nakamoto and Bitcoin, 2008). The process of adopting blockchain technology encompasses irreversible and auditable operations, as well as the sealing of data and nearly instantaneous updates (Queiroz et al., 2019). The mitigation of integrity and trust concerns within peer-to-peer systems is facilitated through the implementation of blockchain technology, as blockchain networks encompass anonymous peers, thereby enhancing their dependability and credibility (Elhidaoui et al., 2022). The adoption of blockchain technology provides businesses, organisations, and individuals with the capability to authenticate transactions and revise data in a coordinated, open, and protected manner (Iranmanesh et al., 2023).

The integration of blockchain technology within supply chain management is currently in its nascent phase, with a growing number of applications across various industries (Choi et al., 2018; Kuo and Kusiak, 2019). In Banerjee (2019), the distinguishing characteristics of the system are described. These characteristics include the exchange of information in real-time, the implementation of cybersecurity measures, transparency, dependability, traceability, and visibility. According to Bryant and Camerinelli (2013), the aforementioned characteristics assist in ensuring that all business operations are transparent, secure, traceable, and speedy and that automatic data verification is performed. The implementation of these capabilities has the potential to enhance the breadth and efficiency of supply chain management (Banerjee, 2019; Morkunas et al., 2019), facilitating the evolution from conventional to contemporary supply chains. The RBV theory posits that a company's competitive advantage is derived from the unique combination of its resources and capabilities. In the context of the adoption of blockchain technology, companies that utilise this technology acquire distinctive resources that augment their capabilities, potentially leading to a sustained competitive advantage within the supply chain. The present study posits the inaugural hypothesis:

Hypothesis 1: Blockchain adoption has a positive impact on supply chain performance.

2.3 Supply chain coordination (SCC)

Within the realm of manufacturing, the integration and coordination of supply chains, which constitutes the third component of agility, adaptability, and coordination, commonly known as the "3A" supply chain attributes according to Lee (2004), is referred to as SCC. It encompasses fundamental elements and has the potential to address the dynamic interruptions within supply

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chain management (Sodhi and Tang, 2021). The implementation of SRM has been shown to be an efficacious approach to enhancing supply chain efficiency. The attainment of coordination relies on the collaborative efforts of interdependent entities in pursuit of shared objectives through the exchange of resources and information (Arshinder et al., 2007), thereby potentially enhancing the performance of the supply chain.

The RBV theory posits an explanation and prediction of a company's management of its resources and capabilities (referred to as BCT) in order to attain a sustainable competitive advantage (Nandi et al., 2020). The RBV theory provides a framework for enterprises to systematically develop, integrate, and reconfigure their resources within their organisational processes and routines. This allows them to transform their unique resources into capabilities and, ultimately, gain a competitive advantage (Fawcett et al., 2011). One notable example is the iconic American retailer, Sears, which had held a prominent position in the U.S. market for more than a century. Despite its long-standing presence, the company experienced financial distress and ultimately filed for bankruptcy in 2018 due to declining sales and increased competition from online retailers. This downturn was attributed to a combination of declining sales and heightened competition from online retailers. For a prolonged period, the retailer was unable to adapt to shifts in consumer purchasing patterns following the emergence of the Internet in the 1970s. In this instance, Walmart prioritised the efficient organisation of its current cataloging systems, warehouses, and suppliers to create a distinctive operational structure that catered to both online and in-store shoppers through the application of business design logic. According to the RBV perspective, firms that possess a unique resource known as BCT must engage in systematic reconfiguration and/or upgrading of BCT in order to develop distinctive capabilities and gain a competitive advantage in both current and future market conditions (Eisenhardt and Martin, 2000).

According to the availability of capabilities for supply chain management that are based on BCT, it is also indicated that alternative techniques, such as formal contractual governance structures or informal connections, are somewhat less effective in terms of accomplishing supply chain coordination goals. The extensive historical utilisation of alternative governance mechanisms, coupled with a deficiency in comprehension and familiarity with BCT within supply chain contexts, may lead to the diminished operational effectiveness of BCT-enabled supply chains. In light of existing scholarly research, it is suggested that BCT exhibits greater efficacy compared to alternative governance mechanisms in enhancing supply chain performance through SCC. This assertion is supported by the distinctive characteristics of BCT, such as smart contracts (Lumineau et al., 2021; Zhu et al., 2022). Upon consideration of the aforementioned discussion, the second hypothesis is formulated:

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Hypothesis 2: Supply chain coordination plays complementary mediating roles in the relationship between blockchain adoption and supply chain performance.

2.4 Supply chain transparency (SCT)

Transparency can be understood as the extent of information that a corporation reveals to its various stakeholders, such as consumers and investors, regarding its operations and the commodities it offers (Sodhi and Tang, 2019). By implementing BCT across a wide range of supply chain operations, it is possible to make the process of achieving supply chain transparency easier to accomplish. This enables stakeholders to readily access and scrutinize information and transactions, consequently leading to enhancements in supply chain performance (Latan et al., 2024). Jeyaraj and Sethi (2012) posit that supply chain transparency may be attained through the implementation of enterprise systems that consolidate the operations of various entities, the automated dissemination of information with trading partners, and the embrace of data-sharing protocols and translation maps. The capacity to provide this functionality for supply chains is precisely what blockchain offers. Consequently, the SCT may be comprehended by utilising the RBV.

In recent times, a growing emphasis has been placed on the utilisation of innovation and technology to enhance transparency. The utilisation of blockchain technology is being observed across a diverse range of industrial sectors, including maritime supply chains for the enhancement of operational efficiency and transparency (Yang, 2019), as well as in leasing service platforms to provide customers with access to product information (Choi et al., 2020). Furthermore, certain fashion companies have integrated technological tools to enhance transparency within their supply chain networks. Everledger is a company that specializes in the tracking and tracing of verified masonry and has successfully encrypted the provenance data of more than 2 million diamonds (Hastig and Sodhi, 2020). The study by It has been demonstrated by Fosso Wamba et al. (2020) that the application of supply chain transparency has the potential to play a significant role in increasing the global supply chain competitiveness of businesses that are functioning within the supply chain industry. Numerous empirical studies suggest that the integration of BCT can enhance supply chain performance through SCT improvement (Bai and Sarkis, 2020; Rao et al., 2021). This indicates a potential positive relationship between BCT adoption and overall SCT enhancement.

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The capability of BCT to enhance SCP through SCT has been recognized. However, it is important to note that not all BCTs demonstrate the same level of effectiveness in achieving this capability. One potential outcome of the comparison between public blockchain technology and permissioned blockchain technology is the variance in levels of transparency. An additional pertinent consideration is the imperative for stakeholders to embrace transparency, which involves the dissemination of precise and reliable information (Latan et al., 2024). Hence, there is a possibility that the transparency may not be entirely comprehensive, giving rise to apprehensions that could diminish the anticipation of BCT, leading to successful SCT outcomes. Upon review of the preceding discourse and extant literature pertaining to the benefits of BCT transparency functionalities, the present study posits the formulation of the third hypothesis.

Hypothesis 3: Supply chain transparency mediates the relationship between blockchain adoption and supply chain performance.

2.5 Inter-organisational system (IOS)

The RBV theory posits that the strategic utilisation of resources to generate assets that are rare, valuable, not easily imitated, and under the firm's control can provide the firm with a competitive advantage over its rivals (Barney, 1991). The use of IOS as an organisational resource has the potential to enhance overall company and supply chain performance through various means. The implementation of IOS-based business intelligence has been shown to have a significant impact on the exchange, coordination, and integration of information within supply chains, ultimately leading to improvements in supply chain responsiveness and performance (Kumi et al., 2021). Moreover, IOS functions as an information system that extends across organisational borders, facilitating connections between companies and their supply chain partners. The IOS platform plays a crucial role in enabling the electronic integration of business transactions and processes across multiple business entities, thereby enhancing supply chain performance (Asamoah et al., 2019).

The utilisation of ISO standards for communication plays a pivotal role in facilitating the seamless transmission of information and fostering effective collaboration among stakeholders within the supply chain industry. The primary technologies and applications that facilitate the maintenance of communication between two parties encompass channel management, communication networks, messaging services and protocols, as well as specific communication standards (Chi and Holsapple, 2005). The utilisation and incorporation of intelligent IOS applications and technologies within supply chain partnerships facilitate the exchange of data warehouses and text mining, the sharing of warehouse databases and decision support systems,

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as well as the dissemination of digital documents and archives, and the transmission of information and knowledge acquisition, search, navigation, and retrieval, including group decision support systems and software agents (Anwar, 2022). The proficient utilisation of IOS allows enterprises to circumvent disruptions in demand. This serves to reduce supply chain inefficiencies, leading to enhancements in overall operational performance (Asamoah et al., 2021).

Additionally, the RBV theory highlights the significance of a firm utilising its internal resources in the creation of distinctive organisational capabilities that are difficult for competitors to imitate (Madhani, 2010). The scholarly discourse related to the RBV posits that a firm's capabilities can be cultivated through an intricate interplay of its resources (Amit and Schoemaker, 1993). The utilisation and deployment of IOS resources can be harnessed in distinctive manners to establish supply chain management capabilities for businesses (Asamoah et al., 2021). Following an examination of the preceding discourse, it is postulated that:

Hypothesis 4: Inter-organisational system has a positive impact on supply chain performance.

Hypothesis 6: Inter-organisational system has a positive impact on supply chain management capabilities.

2.6 Supply Chain Management Capabilities (SCMC)

From the RBV standpoint, the mere control of valuable resources does not suffice for the attainment of lasting competitive advantage. Organisations bear the obligation of cultivating the capacity to efficiently allocate resources in response to dynamic market conditions, thereby attaining enduring competitive superiority (Barney, 1991; Teece et al., 1997). The foundational components of supply chain strategy and a potential avenue for gaining competitive advantage are found in the capabilities and resources of supply chain management (Morash and Lynch, 2002). What is meant by the term "supply chain management capabilities" is the capacity of an organisation to recognise, make use of, and incorporate both internal and external resources or information in order to improve the overall performance of operations related to the supply chain (Wu et al., 2006). Barney (1991) proposed the RBV theory, which posits that firms able to cultivate advanced organisational and supply chain management capabilities are likely to attain superior performance. Consequently, the following research hypotheses are proposed:

Hypothesis 5: Supply chain management capabilities have a positive impact on supply chain performance.

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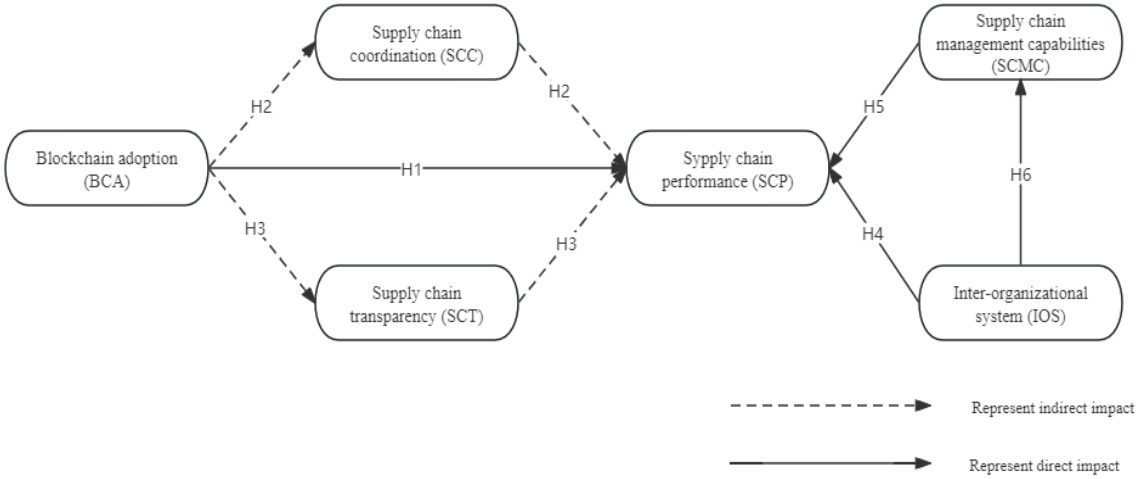
2.7 Research model

Figure 2 depicts the proposed and utilised research model in the current study.

Figure 2. Theoretical framework.



3. Methodology

The collection of primary data was accomplished via the distribution of a self-administered questionnaire, wherein responses were evaluated utilising a 5-point Likert scale. The 23 variable questions are outlined in Appendix A and have been modified from the aforementioned sources. Table 1 provides an account of the variable name, item code, the source of the variable, and the number of items encompassed within each variable.

Table 1. Description of variables used in the questionnaire.

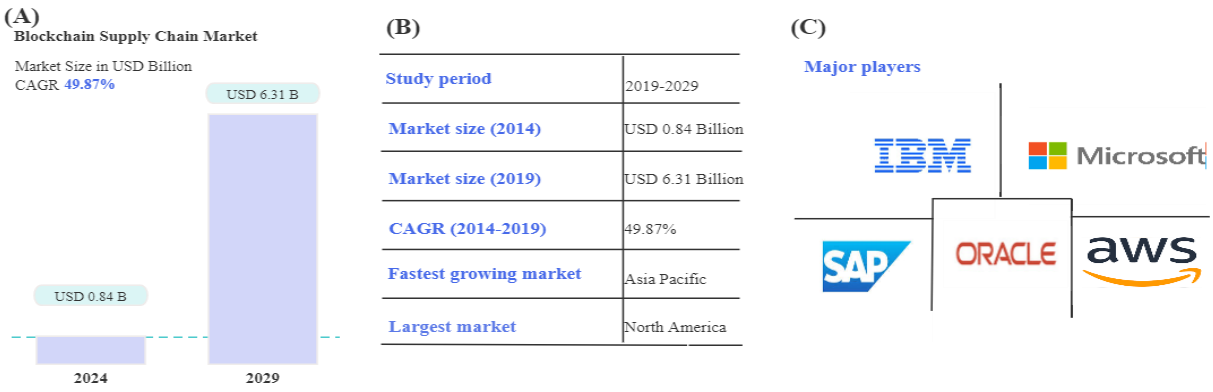
Item code	Variable name	Source	Items
SCMC1 to SCMC4	Supply chain management capabilities	Asamoah et al. (2021)	4
IOS1 to IOS4	Inter-organisational system	Asamoah et al. (2021)	4
SCP1 to SCP5	Supply chain performance	Asamoah et al. (2021)	5

SCC1 to SCC4	Supply chain coordination	Li and Liu (2023)	4
SCT1 to SCT3	Supply chain transparency	Wamba et al. (2020)	3
BCA1 to BCA3	Blockchain adoption	Latan et al. (2024)	3

3.1 Sampling and data collection

The present study involved the selection of the top 5 companies as the focal group, as determined by an analysis of the market size and share of the blockchain supply chain industry, as reported by Mordor Intelligence (www.mordorintelligence.com). The aforementioned organisations encompass IBM Corporation, Microsoft Corporation, Oracle Corporation, Amazon Web Services Inc., and SAP SE. The primary rationale for this is their position as the dominant entities in the blockchain supply chain sector, as illustrated in Figure 3. In their 2024 report, Mordor Intelligence Research and Advisory forecasts that the market size of blockchain in the supply chain is projected to increase from US$840 million in 2024 to US$6. 31 billion in 2029. The adoption of advanced business strategies, including collaboration, mergers and acquisitions, and partnerships, by these five companies is aimed at enhancing their competitive position and expanding their presence in the global market. This study has deliberately chosen these five companies in order to guarantee the dependability and consistency of the research target population. Moreover, in the selection of the sample, we employed purposive sampling, a method falling under the umbrella of non-probability sampling techniques. The sampling methodology utilised in this study involves purposefully selecting companies that exhibit indications of embracing Blockchain Technology (BCT) and incorporating it into their supply chain operations.

Figure 3. Blockchain supply chain market size and share growing trends and forecasts from 2024 to 2029.



Source: Mordor Intelligence.
Note(s): Major players are sorted in no particular order.

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The study included a sample of managerial professionals from diverse supply chain departments, encompassing roles such as logistics, purchasing, warehousing, planning, operations, and quality management. All individuals possess a minimum of two years' experience in engaging with supply chain-related initiatives. Prior to commencing the primary survey, a pretest phase was administered, engaging professionals within the corresponding field. This stage is of paramount importance in order to ensure that the phrasing of the survey is unambiguous, precise, and thorough, in accordance with the criteria delineated by Rassel et al. (2020) and Fellows and Liu (2021).

The final version of the questionnaire was given to seventy supply chain managers for preliminary testing in order to evaluate the initial validity and reliability of the items contained within the questionnaire. Based on the results of our investigation, it appears that the items exhibit sufficient levels of validity and reliability. The fact that the loading factors for the aforementioned items were more than 0.5 indicates that there is a strong link between them and the underlying construct under investigation. Furthermore, it is worth noting that Cronbach's alpha (α) values above the threshold of 0.6, which indicates a significant degree of internal consistency among the items. Considering that the findings are in agreement with the criteria for preliminary analysis that were established by Malhotra (2020), it may be concluded that the results fulfil the requirements for preliminary analysis. The findings not only bolstered confidence in the validity and reliability of the questionnaire but they also confirmed that it was successful in capturing the components that were meant to be discovered through our research.

During the period beginning on December 20, 2023, and ending on March 20, 2024, the data collection was carried out. A total of five hundred questionnaires were successfully disseminated to the supply chain managers of five different firms. In order to enhance response rates, a variety of strategies were utilised. Initially, the incorporation of a cover letter is essential. The significance of their involvement should be emphasised. Subsequently, a weekly reminder email is dispatched. It is recommended that participants complete the questionnaire. Furthermore, we provided interviewees with the assurance of anonymity and confidentiality regarding their company's participation. In conclusion, monetary incentives were employed in addition to an entry into a lottery for participants who successfully completed the questionnaire. The measures were implemented in accordance with the recommendations outlined by Dillman et al. (2009) and Stoop et al. (2010). Furthermore, the results will be disseminated to supply chain managers in accordance with best practice guidelines upon their release. In order to mitigate response bias, specific measures were implemented. The items corresponding to each construct were arranged in a random order. The use of modified scale elements was implemented in order to improve clarity and decrease ambiguity. The measurement of the predictor variables and the result variables were separated by a period of time, which was

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referred to as a lag. The following steps were implemented in accordance with the protocols established by Podsakoff et al. (2012).

A total of 300 complete questionnaires were obtained, with no missing values, resulting in a recovery rate of 60.00 %. Muijs (2022) states that response rates ranging from 40 % to 65 % are commonly deemed acceptable in the majority of research studies. All qualified responses were recorded and systematically arranged using Microsoft Excel for further analysis. In order to mitigate potential nonresponse bias, a multivariate analysis of variance (MANOVA) was performed as recommended by Clottey and Benton (2020) and Muijs (2022). The analysis revealed no statistically significant variances between the test sample groups with respect to demographic variables, in line with findings by Vogel and Jacobsen (2021). This implies that there is no evidence of bias.

3.2 Measurements

To ensure the attainment of the necessary standard of measurement quality, the decision was made to employ pertinent questionnaire items previously utilised in scholarly research on inter-organisational systems, supply chain management, and business-to-consumer transactions. The data used in this study was sourced from a number of pertinent prior research efforts, namely those conducted by Asamoah et al. (2021), Li and Liu (2023), Wamba et al. (2020), and Latan et al. (2024). DeVellis (2022) advises the utilisation of items from prior research due to their extensive validation through multiple test-retest cycles, rendering them highly established and reliable measures. The initial section of the survey elicited information pertaining to the demographic characteristics of the respondent, whereas the subsequent section was designed to gather data for the purpose of quantifying the variables under consideration. All variables were quantitatively assessed using a 5-point Likert scale, where 1 indicated "Strongly Disagree" and 5 indicated "Strongly Agree".

3.3 Data analysis

The following section will elucidate the specific analytical tools and software chosen by the researcher for the purpose of conducting the aforementioned analyses. The study will utilise SPSS version 27 to conduct an in-depth exploration and analysis of the survey data. The present investigation employs partial least squares structural equation modeling (PLS-SEM). The evaluation of reflective measurement models involved the assessment of external loadings,

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composite reliability, convergent validity (Average Variance Extracted), and discriminant validity (Fornell-Lacker criterion). Subsequently, an examination was conducted to assess the moderating influences of SCC and SCT within the context of BCA and SCP.

A breakdown of the mean and standard deviation for each item is presented in Table 3. This indicates that the mean of each item was greater than three and was, for the most part, close to the number four (agreed). This suggests that the majority of those who responded to our survey agreed with the questions and acknowledged their existence. When compared to SCC2, which has the greatest mean at 4.03, SCT1 has the lowest mean, which is 3.81. Each of the six variables has a standard deviation that falls somewhere between 0.903 and 1.076. The SCC1 and SCT3 datasets have the largest standard deviation (1.076), whereas the BCA1 dataset of blockchain adoption has the lowest standard deviation (0.903).

Table 2. Central tendencies measurements of constructs.

Variables	Items	Mean	Standard Deviation
Inter-organisational system (IOS)	IOS1	3.56	0.961
	IOS2	3.62	0.820
	IOS3	3.56	0.929
	IOS4	3.53	0.941
Supply chain coordination (SCC)	SCC1	3.93	1.076
	SCC2	4.03	0.908
	SCC3	3.91	0.964
	SCC4	3.90	0.940
Supply chain transparency (SCT)	SCT1	3.81	0.949
	SCT2	3.93	0.955
	SCT3	3.90	1.076

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Blockchain adoption (BCA)	BCA1	3.98	0.903
	BCA2	3.88	0.926
	BCA3	3.82	1.001
Supply chain performance (SCP)	SCP1	3.89	0.977
	SCP2	3.95	0.929
	SCP3	3.82	1.032
	SCP4	3.87	1.005
	SCP5	3.88	1.013
Supply chain management capabilities (SCMC)	SCMC1	3.90	0.940
	SCMC2	3.91	0.997
	SCMC3	3.93	0.984
	SCMC4	3.79	1.008
	SCMC5	3.84	1.022

3.4 Demographic data

Detailed information on the respondents' demographics is shown in Table 3. In comparison to the number of male respondents, which was 145 (48.3 percent), there were 155 (51.7 percent) more female respondents. The group of respondents who are 56 years old or older has the largest number of respondents, which is 70 respondents (23.3%), while the category of respondents who are 45 to 55 years old has the lowest number of respondents, which is 17.3%. This is in relation to the age of the respondents. With regard to the level of education, the majority of respondents had a bachelor's degree (69.7%), followed by those who held a master's degree (28.7%), and lastly, those who held a master's degree accounts for 10.7% of the total. Most of the position of respondents are from purchasing managers (26.7 %), followed by

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logistics managers (20.7 %) and completed quality managers (19.7 %), while the lowest percentage of respondents belong to program managers (9.0 %).

Table 3. Demographic information.

Description	Frequency	Percentage
Gender		
Male	145	48.3
Female	155	51.7
Age		
18 to 25 years old	59	19.7
26 to 35 years old	59	19.7
36 to 45 years old	60	20.0
46 to 55 years old	52	17.3
56 years and above	70	23.3
Highest education		
Degree	182	69.7
Master	86	28.7
PhD	32	10.7
Position		
Logistics manager	62	20.7
Program manager	27	9.0
Purchasing manager	80	26.7
Quality manager	59	19.7
Transportation manager	34	11.3
Warehouse manager	38	12.7

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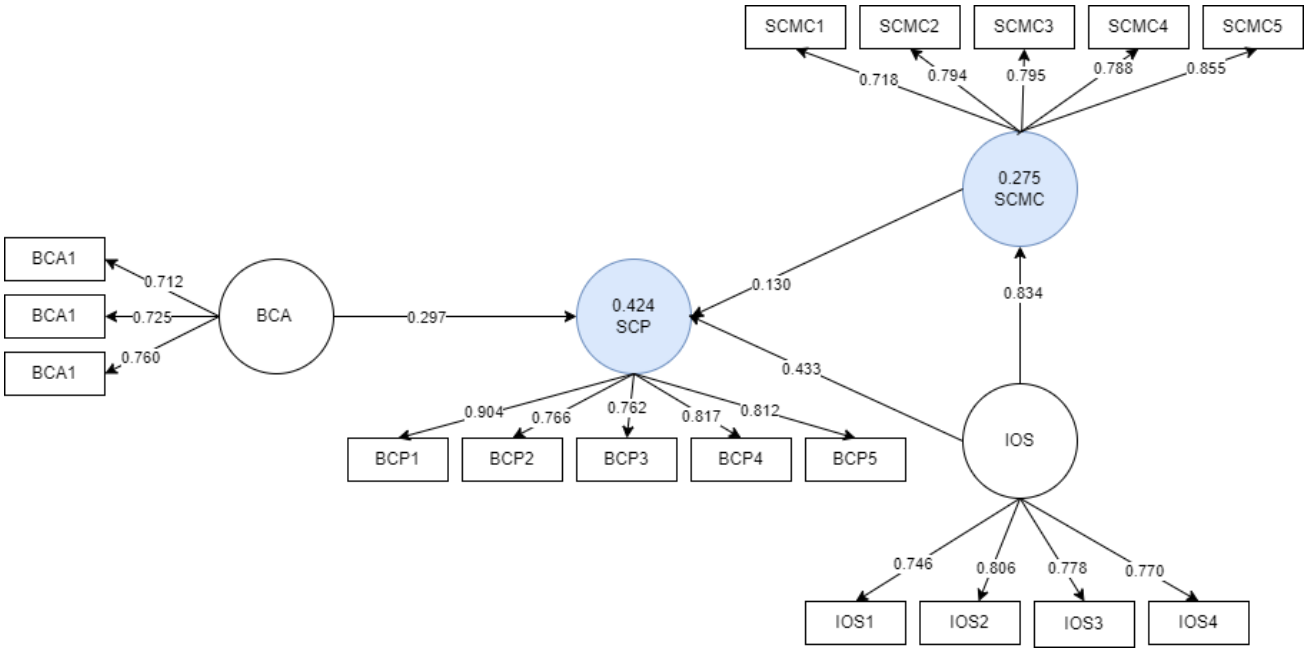
4. Results

4.1 PLS-SEM measurement model

Figure 4 illustrates the measurement model that serves as the basis for the PLS-SEM. Mondéjar-Jiménez et al. (2016) found that items are deemed to be dependable if their external loading exceeds or marginally falls short of the threshold of 0.70. In this instance, it was observed that all items demonstrated external loadings exceeding the threshold of 0.7. Hence, the assumption of the reliability of the items is established. It should be noted that the R^2 for SCP is 0.424, whereas the R^2 for SCMC is 0. 275. The R^2 for the SCP model is 0.424, suggesting that 42.4 % of the variation in SCP can be accounted for by the independent variables BCA, SCMC, and IOS. The residual 57.6 % is attributed to other factors, while 27.5 % of the variance in SCMC is accounted for by IOS. The residual 72.5 % of the remaining variance can be attributed to other influencing factors.

Figure 4. PLS-SEM structural model.



4.2 Reliability and validity

According to the results of the Cronbach's Alpha and composite reliability study, which are presented in Table 4, it can be concluded that all of the variables have a high level of internal

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consistency dependability since their values are more than the threshold of 0.7. Moreover, it is essential to take into consideration that the average variance extracted (AVE) for each of the constructs in the study was greater than 0.5, thus demonstrating a strong level of convergent validity, as indicated by Hair et al. (2010).

Table 4. Construct reliability and validity.

Variables	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Inter-organisational system (IOS)	0.862	0.813	0.614
Supply chain coordination (SCC)	0.799	0.723	0.580
Supply chain transparency (SCT)	0.841	0.720	0.628
Blockchain adoption (BCA)	0.792	0.700	0.527
Supply chain performance (SCP)	0.710	0.858	0.517
Supply chain management capabilities (SCMC)	0.893	0.863	0.623

Discriminant validity was evaluated according to the criteria outlined by Fornell and Larcker. The results presented in Table 5 indicate that the square root of the AVE for each variable exceeds the highest squared correlation with any other variable, suggesting the presence of discriminant validity among all variables.

Table 5. Fornell-Larcker criterion.

	BCA	SCP	SCT	IOS	SCMC	SCC
BCA	0.856					
SCP	0.784 (0.000***)	0.989				

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SCT	0.847 (0.000***)	0.742 (0.000***)	0.792			
IOS	0.791 (0.000***)	0.767 (0.000***)	0.791 (0.000***)	0.784		
SCMC	0.661 (0.000***)	0.731 (0.000***)	0.652 (0.000***)	0.693 (0.000***)	0.789	
SCC	0.755 (0.000***)	0.969 (0.000***)	0.7 (0.000***)	0.732 (0.000***)	0.732 (0.000***)	0.762

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10% respectively. The diagonal number is the root value of the factor AVE.

The model fitting index depicted in Table 6 demonstrates a GFI of 0.924, suggesting that the model exhibits a satisfactory fit. Furthermore, it should be noted that a higher value of NNFI indicates superior model performance.

Table 6. Model fit.

Common indicators	x^2	df	P	Chi-square degrees of freedom ratio	GFI	NNFI
Judgment criteria	-	-	>0.05	< 3	> 0.9	> 0.9
value	2763.838	215	0	12.855	0.924	0.933

Note: GIF = goodness of fit index, NNFI = non-normed fit coefficient.

The study utilised a bootstrapping method consisting of 300 resamples to examine the statistical significance of the hypotheses. According to the findings of the structural model analysis that are shown in Table 7, BCA exhibits the highest beta coefficient of 0.275 in relation to SCP, whereas IOS follows with a beta coefficient of 0.511, and SCMC displays the lowest beta coefficient at 0.070. The study found a positive correlation between BCA, SCMC, and IOS with SCP. The study found a statistically significant positive correlation between IOS and SCMC, as indicated by a p-value of less than 0.05.

Table 7. Structure model results.

Hypothesis	Path	Beta	Standard	T	P Value	Results

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			Deviation	Statistics		
H1	BCA→SCP	1.54	0.275	5.998	0.000***	Supported
H4	SCMC→SCP	0.142	0.070	2.043	0.000***	Supported
H5	IOS→SCP	0.511	0.257	1.989	0.000***	Supported
H6	IOS→SCMC	0.903	0.082	11.002	0.000***	Supported

4.3 Mediation analysis

The findings presented in Table 8 indicate that the path coefficient (Beta) for the BCA → SCC → SCP path is 0.577, and the corresponding p-value suggests a statistically significant relationship ($p < 0.05$). Thus, it can be concluded that hypothesis H2 is substantiated, suggesting that the mediation of BCA on SCP through SCC is of considerable significance. Furthermore, for the BCA→SCT→SCP pathway, the path coefficient was determined to be 0.504 with a p-value of 0.000 ($p < 0.05$), indicating statistical significance. Hypothesis H3 is found to be supported, suggesting that the mediated effect of BCA on SCP through SCT is statistically significant.

Table 8. Specific indict effects.

Hypothesis	Path	Beta	P Value	Results
H2	BCA→SCC→SCP	0.577	0.000***	Supported
H3	BCA→SCT→SCP	0.504	0.000***	Supported

5. Discussion

5.1 Blockchain adoption (BCA)

According to the RBV theory, which proposes that a company's resources and capabilities play a role in defining its competitive advantage, our study reveals that the use of blockchain technology has a favourable influence on the performance of supply chains. This finding is in line with the RBV theory (Barney, 1991). In the context of the widespread adoption of blockchain technology, organisations that employ this technology gain access to distinctive

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resources that augment their operational capacities. The use of blockchain technology in the management of supply chains has the potential to bring about a number of benefits, including increased transparency, security, traceability, quicker data verification, and enhanced efficiency (Bryant and Camerinelli, 2013). The improvements not only serve to optimise current procedures but also aid in the shift from conventional to contemporary supply chain management methodologies.

The study conducted by Munir et al. (2022) underscores the significant and beneficial effects of incorporating blockchain technology into supply chain operations, thereby emphasising its potential for transformative impact. The fundamental features of blockchain technology, including real-time information sharing, network security, transparency, reliability, traceability, and visibility, serve to uphold the integrity and credibility of all business processes (Alsmadi et al., 2023). The identified characteristics not only mitigate potential risk but also enhance operational effectiveness, facilitating prompt responses by organisations to fluctuations in market demand and disruptions within the supply chain.

Additionally, our research outcomes add to the expanding empirical knowledge affirming the effectiveness of blockchain technology in the management of supply chains. The utilisation of blockchain technology within supply chain management is currently in the early stages of development, yet its integration across diverse sectors is experiencing swift and notable growth. The distinctive attributes offered by blockchain, including immutable and auditable transactions, sealed data, and near-instant updates, address the integrity and trust concerns inherent in peer-to-peer systems (Duan et al., 2024). The integration of blockchain technology facilitates businesses, organisations, and other users to authorize transactions and update data simultaneously, with transparency and heightened security.

Our findings present valuable insights that can be used by practitioners and policymakers to inform their actions and decisions. It is important for companies who are considering using blockchain technology in their supply chain operations to recognise the possibility of increasing their competitive advantage by optimising resource allocation, enhancing operational efficiency, and mitigating risk. Investing in blockchain technology enables companies to strategically position themselves as innovators and gain a competitive edge within the evolving terrain of contemporary supply chain management (Alsmadi et al., 2023).

In conclusion, our research offers empirical evidence affirming the advantageous influence of blockchain implementation on supply chain efficacy. The implementation of blockchain technology has the potential to improve the competitiveness, efficiency, security, and

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transparency of supply chain operations for businesses. For the purpose of fully capitalising on the disruptive potential of blockchain technology in the management of supply chains, it is imperative to undertake additional research and undertake practical measures.

5.2 Supply chain coordination (SCC)

Based on the findings of the study, it has been established that supply chain coordination plays a mediating role in the connection between blockchain adoption and supply chain performance. This highlights the relevance of effectively integrating and coordinating operations within the supply chain. Within the theoretical framework of supply chain integration and coordination, the finding is consistent with the theory, emphasising the significance of agility, adaptability, and coordination in managing dynamic disruptions in SCM (Queiroz and Wamba, 2019). Through the utilisation of blockchain technology, businesses have the ability to optimise supply chain connectivity, ultimately leading to advancements in supply chain efficiency.

According to the RBV theory, organisations strategically manage their resources and capabilities, such as firm-specific knowledge, skills, and technologies, in order to achieve long-term competitive advantage (Noor, 2022). This viewpoint underscores the necessity of methodically incorporating and reallocating resources in order to cultivate distinctive capabilities, ultimately leading to a competitive advantage in the marketplace (Queiroz and Wamba, 2019). Moreover, the presence of behaviourally-based SCC capabilities implies that conventional governance mechanisms, including formal contracts or informal relationships, may have limited effectiveness in attaining SCC objectives (Zhang et al., 2024). The literature has indicated that BCT incorporating smart contracts may offer an enhanced governance mechanism compared to other alternatives for enhancing supply chain performance through SCC (Alsmadi et al., 2023).

In conclusion, the established hypotheses underscore the significant impact of SCC in optimising the advantages of integrating blockchain technology into supply chain operations. The imperative is for organisations to prioritise the improvement of SCC capabilities by strategically implementing blockchain technology in order to secure a competitive edge within the continuously evolving supply chain management environment.

5.3 Supply chain transparency (SCT)

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The results of our study offer empirical confirmation for Hypothesis 3, positing that Supply Chain Transparency (SCT) acts as a mediator in the relationship between the implementation of blockchain technology and the efficiency of the supply chain and its performance. The empirical findings are consistent with the theoretical framework, which suggests that blockchain technology has the ability to improve the transparency of supply chains, which would then lead to an increase in overall operational efficiency. The present discourse will analyse the ramifications and revelations produced by our findings.

The present study contributes to the expanding body of literature underscoring the vital significance of transparency in contemporary supply chains. According to Sodhi and Tang (2019), transparency encompasses the provision of information pertaining to upstream operations and product transactions to various stakeholders, such as consumers and investors. The implementation of blockchain technology in businesses enables enhanced transparency by enabling effortless exchange of information within their supply chain networks. The findings align with the claims made by Jeyaraj and Sethi (2012), positing that transparency may be attained by means of aligning organisational activities, automating information exchange with business partners, and embracing data-sharing protocols. The intrinsic attributes of blockchain, including immutability and decentralized consensus, establish a robust infrastructure for ensuring transparency and traceability within the supply chain.

Additionally, the results of our study underscore the capacity of blockchain technology to bring about significant improvements in supply chain performance. Utilising blockchain technology for supply chain management enables organisations to optimise processes, minimize inefficiencies, and mitigate the risks stemming from unequal access to information. The capacity to monitor and trace products in a real-time manner has the potential to enhance accountability and trust within supply chain partnerships, thereby ultimately enhancing operational effectiveness and customer contentment. The case studies referenced in our review of literature, including the implementation of blockchain technology in maritime logistics and the tracking of luxury goods, provide clear examples of the practical advantages of adopting blockchain in various industrial contexts.

Additionally, our findings emphasise the significance of stakeholder acceptance and trust in utilising blockchain-enabled transparency to enhance supply chain performance. Latan et al. (2024) underscore the importance for stakeholders to engage in transparency initiatives and to have confidence in the genuineness of disclosed information, the purpose of which is to facilitate the interaction between the adoption of blockchain technology and the performance of supply chains. It is imperative to acknowledge and respond to the concerns of stakeholders while promoting a culture of transparency and accountability with the purpose of fully

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capitalising on the potential advantages that may be gained from implementing blockchain technology within the context of supply chain management.

5.4 Inter-organisational system (IOS)

This research presents empirical findings that substantiate Hypotheses 4 and 6, which propose that IOS has a favorable influence on both supply chain performance and supply chain management capabilities. The conclusions of this study align with the RBV theory, which underscores the significance of resources in establishing a lasting competitive advantage for organisations.

The findings underscore the significance of Information Systems in enhancing the operational efficiency of supply chains. According to the RBV, firms have the potential to attain competitive advantage through the utilisation of resources that are scarce, valuable, inseparable, and within their jurisdiction (Barney, 1991). The use of IOS serves as a critical resource for organisations, enabling the exchange of information, coordination, and integration among supply chain partners. This, in turn, contributes to the enhancement of supply chain responsiveness and overall performance (Kumi et al., 2021). The implementation of IOS enables the electronic integration of business transactions and processes between different organisations. As a result, this makes communication and cooperation more effective, which eventually results in increased levels of customer satisfaction and enhanced operational efficiency (Asamoah et al., 2019).

Moreover, our research results underscore the significance of IOS in bolstering the capabilities of supply chain management. According to the RBV theory, organisations have the potential to cultivate distinctive organisational capabilities by effectively utilising their resources in ways that are not easily imitable by their competitors (Madhani, 2010). The synergistic interplay of diverse organisational assets plays a pivotal role in fostering the cultivation of organisational capabilities (Amit and Schoemaker, 1993). The use of IOS as a multifaceted organisational resource allows enterprises to efficiently oversee and allocate resources to improve their capabilities in supply chain management (Asamoah et al., 2021). By utilising IOS for the purpose of data exchange, collaboration, and decision support, organisations have the potential to enhance inventory management, demand forecasting, and logistics coordination, ultimately leading to improved efficiency in overall supply chain management.

Additionally, our research emphasises the strategic significance of IOS in contemporary supply chain management. The implementation of IOS enables uninterrupted communication and cooperation between supply chain partners, facilitating the exchange of vital information,

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synchronisation of activities, and prompt response to dynamic market conditions. The findings align with prior research that has emphasised the significance of IOS in mitigating demand distortions and enhancing the effectiveness of supply chain operations (Asamoah et al., 2021).

In conclusion, our research offers empirical evidence to substantiate the favorable influence of IOS on the enhancement of supply chain performance and the development of supply chain management capabilities. Via elucidating the processes via which IOS promotes organisational efficiency and competitiveness, our research provides practitioners who are interested in utilising technology-driven solutions to optimise supply chains with useful insights that can be used to improve supply chain efficiency. In future studies, it is imperative to delve into the distinct attributes and roles of IOS that have the greatest impact on the effectiveness of supply chain operations and managerial capabilities. Additionally, researchers should examine potential moderating factors that could affect the correlation between IOS and organisational performance.

5.5 Supply Chain Management Capabilities (SCMC)

The results of our study suggest that the SCMC is associated with a beneficial influence on SCP. This discovery aligns with the RBV theory, which underscores the significance of organisational capabilities in fostering sustained competitive advantage. A range of supply chain operations may be made easier with the help of the Supply Chain Management Capability (SCMC), which comprises an organization's ability to identify, use, and incorporate both internal and external resources or data (Wu et al., 2006). Based on the RBV theory, organisations that cultivate advanced organisational and supply chain management capabilities are expected to attain superior performance outcomes (Barney, 1991). The findings of our study support this claim by illustrating a favorable association between SCMC and SCP.

The significance of SCMC as a crucial component of supply chain strategy and its potential to confer competitive advantage has been established in the literature (Morash and Lynch, 2002). The development of effective SCMC empowers organisations to effectively synchronize intricate supply chain operations, enhance processes, and promptly adapt to fluctuations in the market environment. In the strategic management of resources, information flows, and relationships with supply chain partners, organisations have the potential to enhance operational efficiency, minimize expenditure, and optimise overall performance. Moreover, SCMC significantly contributes to the improvement of supply chain resilience and agility. In the current rapidly changing and unpredictable business landscape, it is imperative for organisations to possess the capacity to effectively respond to disruptions and swiftly capitalize on emerging opportunities. The SCMC allows companies to forecast and reduce risks,

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coordinate responses throughout the supply chain network, and sustain operational continuity, ultimately enhancing supply chain performance in spite of adversities.

The empirical evidence presented in this study illustrates the advantageous effects of SCMC on SCP. Our conclusions emphasise the strategic significance of allocating resources toward the enhancement and cultivation of robust SCMC. In the future, organisations ought to prioritise the improvement of SCMC through ongoing education, innovativeness, and cooperation in order to sustain a competitive edge and adeptly respond to shifting market forces. Furthermore, it is recommended that future research endeavors delve into the particular mechanisms by which SCMC impacts the different aspects of SCP and examine the moderating factors that could potentially influence this relationship in diverse organisational settings.

6. Conclusion

Through the use of the partial least squares structural equation model (PLS-SEM) technique, this research investigates the influence that the implementation of blockchain technology in supply chain management has on the overall performance of supply chain operations and further examines supply chain coordination, supply chain transparency, Inter-organisational systems and the mediating role of supply chain management capabilities. Following the completion of the data analysis and the interpretation of the findings, we came to the conclusion that the use of blockchain technology has a highly substantial and favourable effect on the performance of supply chain operations. The implementation of blockchain technology has the potential to enhance the supply chain's transparency, security, and efficiency, thereby strengthening the operational efficiency of the supply chain and improving competitive advantage.

In addition, we arrive at the conclusion that the link between blockchain adoption and supply chain performance is mediated by supply chain coordination and supply chain transparency. The promotion of coordination and information transparency among the many stakeholders involved in the supply chain demonstrates that blockchain technology has the potential to indirectly improve supply chain performance. In addition, it has been demonstrated that cross-organizational systems and competencies for supply chain management have a substantial and favourable influence on the performance of supply chains. This shows that by effectively utilising cross-organisational systems and improving supply chain management capabilities, organisations can further optimise supply chain operations and improve performance levels.

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However, this study also has some limitations. First, the extent to which the findings of the research may be generalised may be restricted due to the fact that the sample data is restricted to certain sectors or areas, each of which may have significant constraints. Second, this research was conducted using a cross-sectional approach, which meant that it was impossible to document temporal shifts or dynamic development. Therefore, in order to get a more in-depth comprehension of the influence that blockchain technology has on supply chain management, it is possible that future studies may take into consideration the possibility of adopting a longitudinal design.

It is suggested that future research directions include further investigation into the application of blockchain technology in a variety of industries and regions, as well as the investigation of the impact that the integration of blockchain technology with other emerging technologies (such as artificial intelligence, the Internet of Things, and so on) will have on supply chain management. Moreover, the link between elements such as supply chain coordination, supply chain transparency, inter-organizational systems, and supply chain management competencies is something that may be investigated further, as well as their mechanisms of action on supply chain performance.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, Chen, upon reasonable request.

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Declarations of Interest

None.