Technological Forecasting & Social Change 226 (2026) 124467

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Blockchain-enabled dynamic capabilities for supply chain ambidexterity: Empirical evidence from manufacturing firms for enhanced competence and flexibility

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A R T I C L E I N F O

Keywords:
Blockchain
Supply chain
Ambidexterity
Flexibility fit
Digital transformation

A B S T R A C T

This study utilizes the dynamic capability framework to investigate the relationship among Supply chain (SC) adaptability, SC alignment, SC ambidexterity, SC competence, and SC flexibility fit in blockchain technology (BCT) adoption to understand their interactions and contribution to firm performance (FPER). SCs are considered the primary mechanism by which businesses impact all aspects of our daily needs; however, the challenges caused represent an opportunity to integrate BCT, which may fundamentally alter the future of SCs. Anchored in the Dynamic Capability (DC) framework, this study leverages SmartPLS to examine insights from 283 survey participants across manufacturing firms in the UK and US. SC adaptability and SC alignment influence SC ambidexterity; SC ambidexterity positively influences SC flexibility fit, and SC flexibility fit influences SC competence. SC competence has a full mediation influence between SC flexibility fit and FPER. BCT moderates the relationship between SC ambidexterity and SC flexibility fit but not between SC competence and FPER. This study advances knowledge on how BCT deployment shapes supply chains, underscoring the critical role of a robust digital strategy in driving FPER. By reframing the discourse around competencies and strategic alignment, this study not only enriches the literature on digital transformation and supply chains but also opens new avenues for future research and managerial practice. Organizations need to think holistically rather than focusing on acquiring the best IT systems and bombarding employees with training to develop their competencies.

1. Introduction

Change is the most certain event to describe the manufacturing sector, authenticated by previous research that elucidates and emphasizes the need for new means that can facilitate to fulfill ever-increasing human requirements even in extreme situations (Paul and Chowdhury, 2021). When the change is disruptive, the stakeholders look for means that can help to maintain a stronger consumer position (Ivanov and Dolgui, 2021; Queiroz and Fosso Wamba, 2021). Information technologies disruptively reshape different contexts such as innovation management, societal development, especially supply chains, and manufacturing management (Akter et al., 2021; Rana et al., 2022). Hence, in such scenarios, digitalization is an effective tool to gauge and verify the impact of such disruptive changes on the entire value chain (Vafadarnikjoo et al., 2021). Digital applications combined with operational adjustments produce long-term performance benefits (Hossain et al., 2017). According to Hossain et al. (2020), the most effective approach to digitizing supply chains combines cutting-edge technologies with reinvented business procedures. Supply chains (SC) are the main mechanism businesses can use to impact the world. In this rapidly evolving and disruptive environment, to attain market dominance and stay competitive, supply chains should invest significantly in data-driven innovation capabilities (Sultana et al., 2022). However, different SCs need different strategic choices and information needs (Sheel and Nath, 2019).

Additionally, enterprises are exposed to a distinct set of hazards

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https://doi.org/10.1016/j.techfore.2025.124467
Received 8 July 2024; Received in revised form 30 September 2025; Accepted 28 November 2025
Available online 4 March 2026

when sourcing from a worldwide SC base, necessitating active planning and risk management (Reuter et al., 2010). In order to (1) support frequent organizational role switching, (2) respond to the introduction of new digital technologies and changing customer needs, and (3) respond to the heightened competition brought on by the blurring of market boundaries and the removal of entry barriers (Chakravarty et al., 2013; Verhoef et al., 2021). Modern SCs must be adaptable and resilient in order to accomplish these goals. SC managers can maintain their competitive edge by rethinking current procedures with the most flexibility possible while incorporating new competencies from the environment and other corporate divisions (Cao et al., 2009). As opposed to this, resilience in the SC refers to the capacity to respond to sudden disruptions and return to the prior or higher performance level (Sharma et al., 2025).

The ever-increasing population and increasing consumption patterns pose severe concerns for SC (Kamble et al., 2020; Khan et al., 2021). Organizations can overcome these disruption threats to their SC by developing other capabilities, such as SC adaptability, SC alignment, and SC ambidexterity (Naclerio and De Giovanni, 2022; Aslam et al., 2020b; Bui et al., 2021; Feizabadi et al., 2019; Wamba et al., 2020). Ambidexterity enables organizations to react swiftly to short-term volatility while being adaptive enough to reorganize the SC's structure and resource base for long-term efficiency improvements (Lee, 2004). Amazon is a fantastic example of a company that consistently looks for the most creative business concepts to meet customer demands before recognizing those needs (Lerner et al., 2018). Adaptable organizations can change their condition quickly and affordably (Swafford et al., 2006; Sodhi et al., 2021). By guaranteeing a fair distribution of risks, costs, and rewards among all participants from a strategic perspective and business processes, alignment aids in creating incentives among the participating agents within the SC internally and externally (Tiwari et al., 2015). However, in 2020, the global SC network suffered a shock, causing factories' temporary closure, global transportation disturbance, and delayed deliveries (Sodhi et al., 2021). Companies with lower digital infrastructure levels have faced substantial business/operational disruptions, including reduced supply, logistics supplier disruptions, and difficulties meeting contractual obligations (Hedwall, 2020). In shifting to a “recovery mode”, many organizations have begun exploring advanced technologies, including big data analytics and blockchain technology (BCT), to regain control and support their SC flexibility and agility.

BCT has recently attracted a lot of interest and attention as a disruptive technology (Garg et al., 2025). Because it enables organizations to remove transaction costs and access resources on the outside as readily as the inside, its potential benefits have encouraged organizations to investigate implementing this technology (Kouhizadeh et al., 2023; Kouhizadeh et al., 2021; Tapscott and Tapscott, 2017). Many businesses use BCT to track and authenticate products (Kouhizadeh et al., 2021). Information and communications technology (ICT), food and agriculture, and pharmaceuticals are some industries that have profited from implementing BCT inside their SC (Kshetri, 2022; Innovation at Work, 2021). BCT is thought to be a method for addressing supply chain management (SCM) traceability issues (Lu et al., 2019), enhancing SCM transparency (Rao et al., 2021; Zelbst et al., 2019), and fostering cooperation and trust between businesses and their suppliers as well as throughout the entire SC network.

Additionally, when paired with other cutting-edge technologies, blockchain-enabled smart contracts can increase efficiency through decentralized SC operations (Wamba and Queiroz, 2020a, 2020b, 2020c; Zelbst et al., 2019). The difficulty offers a chance to integrate BCT, a technology that can significantly alter the course of SC (Hewett, 2020). With increasing requests for study on various BCT elements in many SC fields from reputable journals, BCT has attracted a lot of research attention (Yap et al., 2025). BCT should be a part of a larger SC strategy deployed holistically to produce versatile, resilient, and sustainable SCs to prevent disturbances, even though BCT may present chances to enhance SCM (Kamble et al., 2021a, 2021b).

While existing literature has already investigated these capabilities and how they may influence each other in the SC context (Gawankar et al., 2020). However, there are lack of reach on how combining these capabilities may affect other SC measures, such as SC flexibility fit (Luo and Yu, 2016; Rojo et al., 2016) and SC competence (Asghar and Ilyas, 2019; Bui et al., 2021; Weng, 2020a, 2020b), improving firm performance (FPER) (Bui et al., 2021; Kamble et al., 2021a, 2021b). When it comes to BCT, there needs to be more literature on its influence on SC flexibility, competence, and firm performance (Sundarakani et al., 2021). With the new abilities offered by BCT (SC tracking, tracing, transparency, and smart contracts), SC responsiveness and overall performance can be improved further to increase FPER.

Since, there is a lack of empirical studies; although BCT's impact on SC has been investigated recently, most contributions are qualitative and conceptual (Kouhizadeh et al., 2021; Lohmer et al., 2020; Nandi et al., 2020; Wamba and Queiroz, 2020a). Wamba and Queiroz's (2020a, 2020b, 2020c) empirical study on BCT diffusion in SCs called for more empirical studies on BCT's impact on SCs to better understand this emerging technology. Further, despite organizations and academia's urgent need to deploy BCT to regain control of SC networks, understanding of how BCT contributes to SC ambidexterity, competencies, and flexibility remains limited (Belhadi et al., 2021; Omar et al., 2020). Hence, the authors emphasize three critical gaps in the existing research related to BCT–SC where critical constructs (such as SC adaptability, SC alignment, SC ambidexterity, SC flexibility fit and SC competence) are not studied together in literature and are found standalone. Further, there are only handful of studies that have investigated the impact of BCT on these capabilities combined. Finally, few researchers have investigated all these capabilities under BCT technology on the global SC.

Hence, this study combines these capabilities with BCT to understand their interactions and how they contribute to FPER. Utilizing the dynamic capability (DC) framework, the study examines three research questions (RQs):

- **RQ1.** Is there a significant relationship between SC adaptability, SC alignment, and how they influence SC ambidexterity?

Studying SC adaptability and SC alignment is essential because both are foundational capabilities that enable firms to balance exploration and exploitation—i.e., achieve SC ambidexterity. Adaptability allows supply chains to respond to disruptions and evolving market demands, while alignment ensures that partners' goals, resources, and processes are coordinated effectively. Examining their relationship with ambidexterity is significant, as it reveals how firms can simultaneously pursue flexibility and efficiency, which is critical for resilience, competitiveness, and long-term performance in today's volatile business environment.

- **RQ2.** What are the direct and indirect relationships among SC adaptability, SC ambidexterity, SC flexibility fit, and SC competence, and can they contribute to FPER?

Investigating the relationships among SC adaptability, SC ambidexterity, SC flexibility fit, and SC competence is important because these constructs jointly determine how supply chains navigate volatility while maintaining efficiency. By examining their interplay, we can uncover not only which capabilities have the strongest impact on FPER, but also the mechanisms such as ambidexterity. This approach provides both theoretical insight into capability configurations and practical guidance for managers seeking to design supply chains that are simultaneously resilient, flexible, and performance-oriented.

- **RQ3**. Does BCT adoption positively moderate SC flexibility fit, SC competence, and FPER?

Studying whether BCT adoption positively moderates the relationships among SC flexibility fit, SC competence, and FPER is important because BCT provides unique capabilities—such as transparency, traceability, and automation—that can strengthen how supply chains coordinate and adapt. While flexibility fit and competence are critical drivers of ambidexterity and performance, their effectiveness may depend on the extent to which firms leverage digital technologies. Exploring BCT's moderating role therefore helps reveal whether technology adoption amplifies the benefits of these capabilities, offering both theoretical insights into digital transformation and practical guidance for firms seeking performance gains through blockchain-enabled supply chains.

The author applied SmartPLS on a sample of 283 respondents from manufacturing firms in the UK and US. This research advances dynamic capability and ambidexterity literature in a blockchain contex.t This findings can aid SCM academics and practitioners worldwide, on aligning digital strategy with BCT adoption helping them attain a competitive advantage in an increasingly harsh SC environment.

The remainder of the paper is organized as follows. The theoretical and literary foundation is presented in Section 2. Conceptualization and the creation of hypotheses follow in Section 3. The methodology is described in Section 4. The empirical analysis and findings are presented in Section 5, the discussion is covered in Section 6, and the conclusion, ramifications, and areas for further research are covered in Section 7.

2. Background literature

2.1. Dynamic capability (DC) framework

The resource-based view (RBV) (Barney, 1991), which is seen as an enlargement of the DC framework, examines how and why some organizations can obtain a competitive edge in a difficult and rapidly evolving market (Winter, 2003; Zahra et al., 2006). "Capabilities" refers to the crucial role of strategic management in adjusting, integrating, and reconfiguring organizational skills, resources, and functional competence to match the needs of the changing environment, according to Teece et al. (1997). The ability to adjust skills to attain congruence with the shifting corporate environment is called "Dynamic". Teece (2007) expanded DCs' scope as the ability to perceive opportunities (sensing), effectively take those opportunities (seizing), and reorganize firms' resource allocation (reconfiguring). Firms must, therefore, be able to profitably utilize their current positions and assets while examining new markets and technological developments and rearranging organizational resources to take advantage of current and potential opportunities (Teece, 2007). According to Eisenhardt and Martin (2000) and Teece (2007), DC is viewed as an antecedent of resources that creates a competitive advantage in a dynamic market. It is essential for adjusting to and even profiting from a quickly changing environment.

2.2. SC ambidexterity

For the first time, Duncan (1976) coined the term "ambidexterity" to describe the management trade-off brought on by twin organizational systems: one to align current certainties and one to adapt to new possibilities. According to Pertheban and Arokiasamy (2019), organizational ambidexterity is the capacity of organizations to simultaneously leverage their existing skills and pursue new chances. Creating this (exploitation/exploration) practice can aid managers in maintaining their competitive edge, promoting optimal adaptability, and fine-tuning current procedures while incorporating new skills from other departments and the surroundings (Rojo et al., 2016). According to O'Reilly III and Tushman (2008), DCs assist a company's ability to be ambidextrous and simultaneously compete in established and expanding markets. According to the DC perspective, ambidexterity is now defined as the ability to dynamically balance exploration and exploitation.

In contrast, capability-shifting processes alter the exploration-exploitation balance, and capability-building activities balance them (Zhou et al., 2020; Malodia et al., 2021). In the context of SCM, exploration is the ongoing pursuit of information and solutions to address market changes, enhance flexibility, and take advantage of new business opportunities (Abernathy and Clark, 1993). In order to achieve relational (informal, self-enforcing) and contractual (formal, hard-won agreements) governance components, such as the attainment of innovation and cost performance, in the purchasing organization, an ambidextrous SC is required (Güemes-Castorena and Ruiz-Monroy, 2020, p. 5). According to Güemes-Castorena and Ruiz-Monroy (2020), an SC is considered "ambidextrous" if it retains operational excellence while pursuing ongoing innovation and the capacity to maintain balance. Efficiency and flexibility, alignment and adaptability, and exploitation and exploration are all used simultaneously by ambidextrous ability (Gibson and Birkinshaw, 2004).

2.3. SC flexibility fit

SC flexibility is the degree to which SC can adjust to shifting business conditions instead of being compelled to do so (Blome et al., 2014; Gosain et al., 2004). SC flexibility affects the approach in which an organization responds to critical changes in the external environment and, at the same time, creates competitive advantages (Chan et al., 2017; Olan et al., 2022). However, difficulties arise as the concept of flexibility is much debated in the literature. While firms can be less flexible but more efficient (the configuration is required by its operational environment), their excess flexibility can harm performance if the environment does not need it (Verdú-Jover et al., 2006).

There has even been a proliferation of research articles that assessed the flexibility literature (Martínez Sánchez and Pérez Pérez, 2005). Though the published works have inspected different aspects of flexibility and their various choices, interpretations, and demands for flexibility being categorized and measured (Tang and Tomlin, 2008), only a handful of works have explored flexibility fit. According to the DC viewpoint, SC flexibility principally pertains to fit, which enables enterprises to quickly and efficiently adjust inter-organizational processes to the changing environment through learning backed by information technology (Gosain et al., 2004). Therefore, the environment's characteristics determine how well an organization's SC flexibility fits that environment (Turhan and Akman, 2022). As an explanatory variable for performance, the SC flexibility fit is determined by examining the fit between the level of actual flexibility and that demanded by the environment (the "flexibility gap"; Rowe and Wright, 1997; Sanchez, 1995; Wright and Snell, 1998; Akhtar et al., 2022). For instance, Yu et al. (2012) suggested that firms should prioritize flexibility coalignment in an uncertain and heterogeneous environment, prioritize demand management flexibility fits in a stable but heterogeneous environment, and concentrate on physical distribution flexibility in an uncertain and homogeneous environment while maintaining relatively rigid levels for other activities.

2.4. SC competence

Organizations must cultivate and protect their core competencies to reap the full benefits of developing an agile SC, which requires several SC abilities (Ngai et al., 2011). According to Chow et al. (2008), SC competence is a set of organizational, managerial, technological, and strategic characteristics and skills that businesses have acquired through time, allowing them to react quickly to market changes. The three elements of SC competency, according to Ngai et al. (2011), are

- management competence (top management's role and vision, as well as employees' competence),
- operational competence (SC integration, flexibility, and learning orientation), and
- IT competence (IT integration and flexibility).

According to Hove-Sibanda and Pooe (2018), other SC competencies may be the capacity to manage inventory efficiently, accurately predict customer needs and orders, manufacture high-quality goods, and create low-pollution manufacturing and delivery operations.

2.5. Blockchain application in SCs

Collaboration between SC partners is vital to develop and maintain an agile, sustainable SC network. This enables organizations to achieve coordination, benefitting from complementarities and improving decision-making in SCs (Lee, 2004). By sensing, seizing, and reconfiguring quickly to change and enhance scanning for new possibilities and consumer trends, BCT adoption can assist in achieving this goal (Ozdemir et al., 2021; Abdalla and Nakagawa, 2021; Cichosz et al., 2020; Sangari and Razmi, 2015). Several BCT characteristics set it apart from competing technologies, making it unique and innovative:

- eliminating the need for mediators and decentralizing commercial contact through consensus-based mutual agreement (Bashir, 2018; Cui and Idota, 2018);
- serving as a reliable record keeper and promoting data immutability and non-repudiation (Lo et al., 2017; Zheng et al., 2017; Sharma et al., 2022a, 2022b);
- Allowing robust pseudonymity by not requiring identity reveal when transacting or transferring data, while distributed consensus techniques (smart contracts) enforce fair, unchallengeable transactions between untrustworthy contractual parties (Kanza and Safra, 2018; Ouaddah et al., 2016; Sharma et al., 2022a, 2022b);
- Giving undeniable evidence of the origin of the data, all transaction data may be recovered at any time or location, fostering confidence and provenance (Rahman et al., 2020; Rejeb et al., 2021; Sachdev, 2019; Yu et al., 2022).
- There are no administrators or information custodians; all network participants have the same status and rights (Kurpjuweit et al., 2021; Rejeb et al., 2021).

The impact of BCT has been acknowledged by the SC community, inspiring numerous multinational corporations, such as Walmart and Glencore, to include BCT in their SCs to increase productivity and performance (Kouhizadeh et al., 2021). BCT adaptation is starting to gather momentum in various products/services, including transportation (Hîrţan et al., 2020; Lei et al., 2017; Yuan and Wang, 2016); retail chains (Chakrabarti and Chaudhuri, 2017; Miraz et al., 2020); automotive (Dorri et al., 2017; Fraga-Lamas and Fernández-Caramés, 2019); and agro-foods (Rogerson and Parry, 2020; Stranieri et al., 2021). Interest has grown in deploying blockchain-as-a-service under the Internet of Things (IoT) as the hosting environment to offer pre-made applications, such as SC tracking and cash-flow tracing, that can be integrated into the cloud (Kernahan et al., 2021; Lu et al., 2019; Samaniego et al., 2016).

3. Model and hypotheses development

This study uses the DC framework to formulate a research model to understand how specific supply chain capabilities interact with each other to contribute to FPER (see Fig. I). The DC framework has been increasingly utilized to investigate SC sustainability, agility, and resilience through sensing, seizing, and reconfiguring (Wamba et al., 2020). Sensing is compatible with SC visibility, which enables tracking upstream and downstream inventories, supply and demand patterns, production and purchasing, and other factors (Lee and Rha, 2016; Wamba et al., 2020). SC agility also requires dynamic sensing, responsiveness, and flexibility (Dubey et al., 2015; Shashi et al., 2020; Ecer and Torkayesh, 2022). Market sensing allows managers to understand the market situation better, improving their chances of identifying and acting on uncertainties and market trends (Aslam et al., 2020a; Jermsittiparsert and Pithuk, 2019). Seizing, in SCM, takes place before

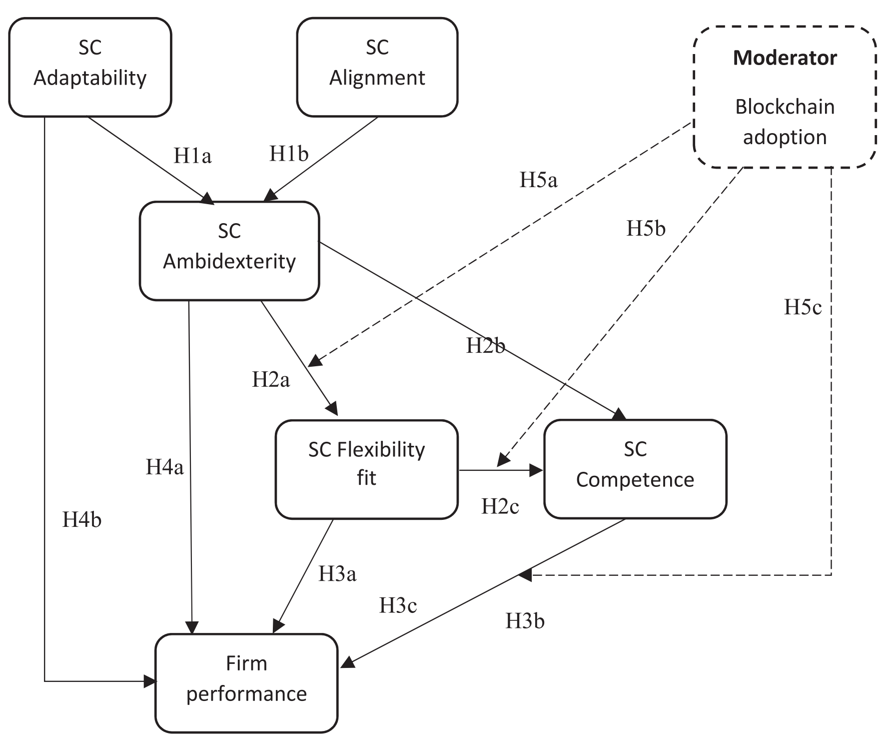

Fig. I. Conceptual research model
The figure below is a visual representation of the conceptual research model, showing the relationships between variables, constructs, and hypothesized connections within the study.
Note: SC: Supply Chain.

sensing or responding to a disturbance so threats can be avoided (Fan et al., 2016). A firm with high SC flexibility in a changing environment implies a firm's DC in seizing risky opportunities (Luo and Yu, 2016; Spanuth et al., 2020). Seizing capabilities allow SC partners to develop flexible, agile SC infrastructures offering short-term responses to marketplace changes (Aslam et al., 2020a; Wamba et al., 2020). SC agility is related to seizing, as SCM problems should be addressed speedily to respond to the changing marketplace environment (Lee and Rha, 2016; Ho et al., 2022). Finally, the ability to reconfigure SC resources to respond to changes underpins SC agility (Sangari and Razmi, 2015) and flexibility (Rojo et al., 2016; Lv et al., 2022).

For this study, the independent variables in the proposed model are SC adaptability, SC alignment, SC ambidexterity, SC competence, and SC flexibility fit. The study also examines the moderating role of the adoption of blockchain (BCT) on the association between SC adaptability and SC flexibility fit, SC flexibility fit and SC competence, and SC competence and FPER (see Fig. I). The operational description of all variables under the study is presented in Table I.

3.1. The role of SC adaptability and SC alignment in SC ambidexterity

3.1.1. SC adaptability

The ability of a corporation to respond to the market in terms of strategies, goods, and technology is referred to as SC adaptability (Lee, 2004). As a response, the SC configuration may be flexible (e.g., by creating new supply bases, moving production facilities, or outsourcing). Because both the SC structure and resource base are translated over a long period of time as a result of market changes, SC adaptability can, therefore, be viewed as a transforming and ambidextrous DC (Eckstein et al., 2015). An organization needs an SC to respond swiftly to short-term fluctuations and extreme variations while staying sufficiently adaptable to reorganize the SC's structure to increase long-term efficiency (Lee, 2004). This is known as SC ambidexterity. Hence, we hypothesize:

H1a. SC adaptability positively influences SC ambidexterity.

3.1.2. SC alignment

According to Aslam et al. (2020b), organizations should implement an ambidextrous strategy that balances adaptability and alignment to minimize the effects of SC disruptions. SC networks can alter their configuration flexibly to align members' goals thanks to the characteristics of SC alignment, which include transparency, information sharing, training and development, communication-based on local needs, and performance awards (Dubey et al., 2015). According to Derwik and Hellström (2017) and Vishnu et al. (2019), SC alignment is a strategic capability (at the intra-organizational level) that enables integration among operating processes and facilitates intra-organizational integration through closer relationships with suppliers and distributors. According to the DC perspective, SC alignment is a managerial skill/ability essential to the success of an organization (Cooper-Rooney, 2018). Since the ability to adapt SC design to market changes while aligning SC partners' incentives is a component of SC ambidexterity (Aslam et al., 2020b), we hypothesize:

H1b. SC alignment positively influences SC ambidexterity.

3.2. The relationship among SC ambidexterity, SC flexibility fit, and SC competence

3.2.1. SC flexibility fit

A company's internal manufacturing capabilities, which include volume flexibility, mix flexibility, and manufacturing conformity, are referred to as flexibility, quality, and delivery in the SC (Jin et al., 2014). The execution of operations based on efficiency (exploitation) and creativity (exploitation) through a flow of learned experience and fresh knowledge has been found to improve flexibility (Gosain et al., 2004;

Table I
Operational description of study variables.
The table below illustrates the operational definitions of key study variables, including their reference.

Variable	Description	Reference
SC adaptability	Firms' ability to sense long-term, fundamental changes in the SC and market, including economic progress, political and social change, demographic change, and radical technological advances, and to respond to such changes	Eckstein et al. (2015, p. 5)
SC alignment	SCs' ability to ensure equitable distribution of risks, costs, and gains among participants	Lee (2004)
SC ambidexterity	The manufacturer's ability to refine/extend its existing resources, develop new SC competencies, and improve performance.	Bui et al. (2021)
SC competence	Competence is often used to describe the qualities considered for managers in organizations and in certain and specific professions. SC competence is a function that integrates and coordinates with the abilities possessed by individuals involving in supply chain management	Qrunfleh & Tarafdar (2014)
SC flexibility fit	It is the gap or difference between the managerial perception of flexibility required by the environment and the real or potential flexibility of the SC. SC flexibility fit is conceptualized as a managerial ability that varies based on changes in the environment and in the manager's perception of it, as perceptions in matters of flexibility have been shown to condition the SC members' actions	Rojo et al. (2016), Stevenson & Spring (2009)

Raisch et al., 2009). According to RBV and DC, learning is a "high-order capability" crucial for improving performance (Prieto and Revilla, 2006). Through partnerships and collaboration, SC's flexibility fit encompasses individual and organizational tools to test out new practices and enhance current ones (Teece, 2007). In addition to investigating new opportunities, ambidextrous organizations can use learning to exploit their current skills (Cao et al., 2009; Raisch et al., 2009). According to Ojha et al. (2018a, 2018b), organizations require flexible strategies and expertise to build ambidexterity capabilities. According to recent research (Kazancoglu et al., 2023; Ghobakhloo et al., 2023; Ivanov and Dolgui, 2021; Rojo et al., 2016; Rojo Gallego Burin et al., 2020; Roscoe and Blome, 2019; Shukor et al., 2020), SC flexibility fit positively impacts SC adaptability.

Practices for exploiting existing knowledge and learning capabilities, simultaneously exploring and creating new competencies and knowledge, improve SC flexibility fit by constantly detecting environmental changes and accelerating reactions to them through learning (Rojo Gallego Burin et al., 2020). Hence, we hypothesize:

H2a. SC ambidexterity correlates with SC flexibility fit.

3.2.2. SC competence

From the DC perspective, competencies are prerequisites for DC development (Blome et al., 2013; Teece, 2007). Competencies generally originate from within firms, while capabilities are cultivated to address external influences (Mandal, 2017). According to Spekman et al. (2002), competence must take advantage of capabilities beyond tangible assets and explicit knowledge to include skills and assets like employee know-how, reputation, and culture that are more difficult to transfer inside SCs without appropriate learning practices. Although SC competence is considered an inter-organization competency, it must also complement intra-organizational relational competency, facilitating information sharing and collaboration among SC partners (Barnes and Liao, 2012; Youn et al., 2014). Therefore, SC competence is internal and external to firms, potentially leading to SC DCs that mitigate disruptions when effectively deployed. Learning capability is thus vital to improving SC competence because firms learn from their knowledge, processes, and experience, as well as from other firms (Tolbert and Zucker, 1983).

Ambidexterity can lead to the development of SC flexibility fit if accompanied by a high level of exploration. Exploration requires a high level of learning capability to achieve SC flexibility. Therefore, SC flexibility fit must be constantly changed through continuous exploration and learning practices to improve SC competence to mitigate disruptions (Pozzi et al., 2023; Levinthal and March, 1993; Raisch et al., 2009; Rojo et al., 2016). Hence, we hypothesize:

H2b. SC flexibility fit mediates the relationship between SC ambidexterity and SC competence.

H2c. SC flexibility fit correlates with SC competence.

3.3. The impact on firm performance (FPER)

FPER is a metric used to assess how well businesses meet their aims and objectives against those of their main rivals (Cao and Zhang, 2011). In the context of RBV, FPER is defined as the generation of more economic value than marginal competitors (Peteraf and Barney, 2003) and is attributed to assets and abilities that collect valuable, rare, inimitable, and non-substitutable (VRIN) resources (Barney, 1991). Because of the properties of VRIN resources, DCs can successfully extract competitive combinations from them to increase long-term FPER (Wang and Ahmed, 2007). DCs can serve as mediating variables between resources and performance, as demonstrated by Lin and Wu (2014). DCs are thought of as a way to transform resources into improved performance.

3.3.1. SC flexibility fit and firm performance (FPER)

From the DC perspective, firms should reconfigure resources and learn knowledge through flexibility management to improve FPER (Jiang et al., 2010), while Luo and Yu (2016) highlighted the negative influence of underfitting on FPER, leading to the notion that SC flexibility fit positively impacts FPER (Dhiaf et al., 2012; Rojo et al., 2016; Sabri, 2019). According to Vickery et al. (2003), SC flexibility fit directly affects order fulfillment lead time, warranty expenses, per-unit delivery cost, and customer return rate. Flexible business systems are also crucial in overcoming uncertainties and achieving competitive advantage during environmental uncertainties (Eisenhardt et al. (2010). Therefore, Successful firms sometimes pursue high flexibility to mitigate risks and achieve business goals (Pei et al., 2011). Hence, we hypothesize:

H3a. SC flexibility fit positively correlates with firm performance.

3.3.2. The mediation role of SC competence

Fisher (1997) first highlighted the significance of and influence of SC competency on FPER, illuminating the detrimental effects of a lack of flexibility on organizational performance. Two unique misfit configurations were described by Wagner et al. (2012): positive misfit (efficient SCs with high demand uncertainty) and negative misfit (responsive SCs with low demand uncertainty), and demonstrated that SC fit/misfit does not always result in improved FPER. The advantages of FPER from SC fit in high-uncertainty contexts may be outweighed by the costs of the resources required to maintain the fit, according to these authors' exploration of various configurations under the conditions where businesses benefit the most from fit. For instance, businesses in low-growth industrial sectors gain from SC fit the least; businesses that sell products with a low level of technological complexity, however, benefit most.

In uncertain environments, firms should enable high SC flexibility to accumulate SC competence capabilities to enhance performance (Hughes et al., 2022; Fatorachian and Kazemi, 2021; Merschmann and Thonemann, 2011; Rojo et al., 2016; Sreedevi and Saranga, 2017). To balance flexibility fit/misfit in SCs, we argue that firms should acquire higher SC competence to improve FPER. Hence, we hypothesize:

H3b. SC competence mediates the relationship between SC flexibility fit and firm performance.

H3c. SC competence positively correlates with firm performance.

3.3.3. SC ambidexterity and firm performance (FPER)

In order to sustain their competitive edge, ambidextrous organizations use their existing competencies while looking into new prospects (Cao et al., 2009). In order to improve exploration and exploitation practices and raise FPER, this calls for learning capability based on the creation/dispersion capacity to find methods of distributing relevant learning resources. Additionally, this enables the creation of fresh SC skills that raise FPER (Bui et al., 2021). According to numerous earlier research (Aslam et al., 2018; Bravo et al., 2018; Gualandris et al., 2018; Kariuki, 2018; Pertheban and Arokiasamy, 2019; Kayikci et al., 2022a; Kayikci et al., 2022b), ambidexterity's mix of exploration and exploitation has a beneficial impact on FPER. Hence, we hypothesize:

H4a. SC ambidexterity positively correlates with firm performance.

3.3.4. SC adaptability and firm performance (FPER)

SC adaptability measures a company's capacity to identify long-term, fundamental shifts in the market and SC and to alter the SC accordingly. This enables the SC to shift the market during any disturbance by increasing product innovation rates, launching innovative products, and breaking into new markets to remain competitive/maintain FPER (Lee, 2004; Li and Mathiyazhagan, 2018). Hence, we hypothesize:

H4b. SC adaptability positively correlates with firm performance.

3.4. The moderating role of blockchain technology (BCT) adoption

According to the DC framework, businesses can add "value" by altering SC procedures and assets to boost output. The assets of a company that enables the creation and distribution of goods and services include both tangible (such as IT infrastructure) and intangible (such as information or process expertise) assets (Barratt and Oke, 2007). Previous research (Prajogo and Olhager, 2012; Qrunfleh and Tarafdar, 2015; Samadi and Kassou, 2016; Vickery et al., 2010; Wu et al., 2006) has demonstrated the importance of using IT in SC processes to strengthen SC capabilities and enhance business performance. BCT, an innovative internet-based IT program, can make it possible for SC members to share documents and transactions quickly, accurately, and reliably, enhancing SC performance in general (Sheel and Nath, 2019).

3.4.1. Blockchain adoption's influence on SC ambidexterity and SC flexibility fit

The role of BCT in SC ambidexterity has yet to be explored extensively. In the present study, we hypothesize that BCT-enabled capabilities can help firms to enhance SC ambidexterity by improving SC adaptability and SC alignment, as well as by exploiting SCs' current competencies and exploring new opportunities to respond effectively to crises (Bui et al., 2021; Hald and Kinra, 2019; Sheel and Nath, 2019). BCT facilitates adaptability by allowing SC practitioners, in collaboration with other organizations, to improve demand forecasts, inventory management, and back-ups as the market situation changes (Angelis and da Silva, 2019; Ivanov et al., 2019), aligning the entire SC toward a common goal. BCT can enhance SC flexibility fit more cheaply than conventional transactions by improving document exchange between two or more organizations and implementing smart contracts (Korpela et al., 2017; Nandi et al., 2020). BCT can help organizations navigate through disruptive environments by improving SC flexibility fit by adopting and adjusting existing practices via partnerships, collaboration, and data-sharing among partners, thus helping to eliminate trust-related issues, identify market shifts, and take corrective actions (Davidson et al., 2016; Dubey et al., 2020; Ketchen Jr et al., 2007). Therefore, we hypothesize:

H5a. The intention to adopt blockchain moderates the relationship between SC ambidexterity and SC flexibility fit; when there is a high intention to adopt blockchain, the relationship between SC ambidexterity and SC flexibility fit will be stronger.

3.4.2. Blockchain adoption's influence on SC competence

The role of BCT in improving SC competence needs to be clarified in the literature (Wamba and Queiroz, 2020a, 2020b, 2020c). In this study, we view SC competence as internal and external organizational, managerial, technical, and strategic capabilities and skills enabling SCs to overcome disruptions (Barney and Hesterly, 2010; Teece, 2007). Hence, BCT adoption should improve competencies through fast, effective information sharing or the digitization of flows and products to be managed across organizations in a multi-tier approach (Nandi et al., 2021). New digital technologies, such as BCT, can help firms to change business models and internal processes in areas including awareness, resources, commitment, and governance (Kamble et al., 2021a, 2021b), to align themselves with the new situation, and to adjust to the demand for new competencies (Mavlutova et al., 2021). Hence, we hypothesize:

H5b. The intention to adopt blockchain moderates the relationship between SC flexibility fit and SC competence; when there is a high intention to adopt blockchain, the relationship between SC flexibility fit and SC competence will be stronger.

3.4.3. Blockchain adoption's influence on SC competence

BCT enables the creation of decentralized digital infrastructures that can be applied to various domains (banking, contract management), complementing or substituting traditional, centralized institutions (Vial, 2019). Deploying BCT significantly improves FPER (Rehman Khan et al., 2021), specifically regarding profit and return on investment (Stranieri et al., 2021). BCT can also improve SC transparency, immutability, privacy, reliability, and trustworthiness (Kamble et al., 2021a, 2021b). Emerging BCT capabilities are expected to add value to SC networks through competitive advantage in terms of reduced transaction-based costs, delineating organizational boundaries, automation, adding new products and services, and decentralizing SC decision-making and FPER (Angelis and da Silva, 2019; Nandi et al., 2020; Yadav and Singh, 2020). Hence, we hypothesize:

H5c. The intention to adopt blockchain moderates the relationship between SC competence and firm performance; when there is a high intention to adopt blockchain, the relationship between SC competence and firm performance will be stronger.

4. Methodology

4.1. Data collection

An electronic questionnaire survey was sent to manufacturing companies in the US and the UK to empirically evaluate the assumptions and validate the overall conceptual model. A five-point Likert scale was used to evaluate the constructs (1 being “strongly disagree,” and five being “strongly agree”). The survey was developed and administered via Prolific in English, and after discarding ten incomplete responses, 283 valid responses (230 UK; 53 US) were considered for analysis. Tables II and III provide participants' and firms' demographic details.

To accurately model our theoretical concepts, we represented all the constructs as first-order models. For example, the broad concept of SC Adaptability is comprised of three specific dimensions: structural sensing, structural flexibility, and structural innovativeness. It is crucial to distinguish how these constructs are measured. Changes in the concept cause changes in the items. We developed SC adaptability, SC alignment, and SC flexibility fit as reflective first-order constructs (Becker et al., 2012). This approach simplifies the model estimation process and reduces potential collinearity issues among the many individual survey items.

Table II
Participants' profile ($n = 283$).
The table below displays demographic information of study participants, including age, gender, education, and experience levels with corresponding percentages.

	n	%
Gender		
Female	103	36.40%
Male	180	63.60%
Age (years)		
Below 20 years	2	0.71%
21–25 years	27	9.54%
26–30 years	43	15.19%
30–35 years	55	19.43%
36–40 years	39	13.78%
41–45 years	44	15.55%
46–50 years	21	7.42%
51 years or above	52	18.37%
Education		
Less than high school	5	1.77%
High school graduate	67	23.67%
Bachelor's (College) degree	169	59.72%
Master	35	12.37%
Professional degree	6	2.12%
Doctorate	1	
Manufacturing experience (years)		
Upto 2 years	24	8.48%
2–4 years	41	14.49%
4–6 years	32	11.31%
6–8 years	35	12.37%
8–10 years	26	9.19%
More than 10 years	125	44.17%

Table III
Firms' profile ($n = 283$)
The table below displays a percentage-wise categorization of firms along with the number of employees being studied for this study.

	n	%
Location		
UK	230	81.27%
US	53	18.73%
Number of employees		
0–9	19	6.71%
10–50	33	11.66%
51–100	34	12.01%
100–150	13	4.59%
150–200	24	8.48%
200–250	17	6.01%
250–500	13	4.59%
500–1000	17	6.01%
More than 1000	113	39.93%

4.2. Data analysis

We analyzed the measurement tool and conceptual model simultaneously using SmartPLS 4.1.1.6, a PLS-SEM tool. The choice of the data-analysis methodology is supported by the fact that PLS-SEM manages model complexity with fewer constraints than other methods (Ringle et al., 2012) and offers reliable results even for small sample sizes (Chin, 1998). SmartPLS 4.1.1.6 also allows higher-order models to be tested. We developed SC adaptability, SC alignment, SC flexibility fit and FPER as reflective first-order constructs (Dubey et al., 2019; Mikalef et al., 2019). This approach can reduce collinearity among indicators by using alternative concrete sub-dimensions of the more abstract construct to reorganize the indicators and constructs (Hair et al., 2019). A two-stage procedure was used to develop and estimate the route model (Becker et al., 2012; Ringle et al., 2012). Using the conventional repeated indicators approach in step one, we examined only the outer loadings without taking the consistency or dependability of the model into account (Sarstedt et al., 2019).

Recognizing that endogeneity—arising from omitted variables, measurement error, or reverse causality—can severely bias parameter estimates and threaten the validity of causal inferences (Antonakis and House, 2014; Sarstedt et al., 2020), we employed a few steps to mitigate this issue at the research design and data analysis stages: (a) we conducted a thorough literature review to identify and include the key antecedent and mediating variables (e.g., SC adaptability, alignment, ambidexterity) theorized to influence firm performance. This reduces the risk of omitted variable bias by capturing the core constructs of the nomological network; (b) the survey items for the independent variables (e.g., SC capabilities) and the moderating variable (BCT intention) were framed in a present-tense or general capability context, while the items for the dependent variable (firm performance) were explicitly worded to reflect outcomes over a recent period (e.g., "even when the whole industry/sector has faced supply chain disruptions"). This framing helps strengthen the theoretical implication of causation.

The data analysis followed a two-step process: first, the measurement model was assessed for reliability and validity, and second, the structural model was tested to evaluate the hypothesized relationships. The reliability and internal consistency of the survey items were rigorously evaluated using established metrics, including Cronbach's alpha (α), composite reliability (CR), and indicator loadings. Validity was assessed through convergent validity (Average Variance Extracted - AVE) and discriminant validity (Fornell and Larcker, 1981).

5. Results

5.1. Common method bias (CMB)

Since our data for both predictor and criterion variables were collected from the same respondents via a single questionnaire, the results could be influenced by Common Method Bias (CMB). CMB is a potential threat to validity that arises from the measurement method itself, rather than from the constructs the measures represent. It can artificially inflate (or occasionally deflate) the observed relationships between variables. To address this, we employed both procedural and statistical remedies. As a procedural remedy, we ensured respondent anonymity, used clear and concise scale items, and separated scale items for different constructs within the questionnaire to reduce evaluation apprehension and minimize the chances of respondents guessing the hypothesized relationships (Podsakoff et al., 2003). SRMR value is 0.096 which is well below the threshold value of 0.10 that displays the model as a good fit.

For a statistical test, we used the full collinearity assessment approach (Kock, 2015). This method involves calculating the Variance Inflation Factor (VIF) for each construct in the model by specifying them as outcomes of a common latent variable. This differs from typical collinearity testing, which checks for correlations between independent variables. The full collinearity test for CMB checks if a single underlying factor (the 'method' factor) can explain all variables in the model.

A VIF value less than 5.0 which is under acceptable limit (Table IV). We therefore proceeded with testing the measurement and structural models.

5.2. Measurement model

The internal consistency reliability of the measures was evaluated using Cronbach's alpha (α) and composite reliability (CR). As shown in Table V, all values for both α and CR exceeded the recommended threshold of 0.70 (Nunnally & Bernstein, 1994), indicating satisfactory reliability.

Convergent validity was assessed using the average variance extracted (AVE) and indicator loadings. All standardized indicator loadings were significant ($p < 0.001$) and exceeded 0.708, confirming that each item shared more variance with its construct than with error variance. The AVE values for all constructs were above the threshold of 0.50 (Fornell and Larcker, 1981). This demonstrates adequate convergent validity, meaning the items effectively capture their intended constructs (Hair et al., 2019).

Finally, discriminant validity was established using the Fornell-Larcker criterion. As presented in Table V, the square root of the AVE for each construct (diagonal values) is greater than its highest correlation with any other construct (off-diagonal values in the same row and column). Fornell-Lacker values are displayed in the lower half of the diagonal of Table V and the upper half has HTMT values. Table V shows that discriminant validity was achieved as HTMT values were below 0.85 and the diagonal value (square root of AVE) was more than the correlation values between the construct. This confirms that each construct is distinct and captures a phenomenon not represented by other constructs in the model.

We assessed the implications of this on the model structure in two ways. (a) by testing their conceptual integrity – each removed item was evaluated for its conceptual contribution to its respective construct. The conceptual domain of each construct remained intact and well-represented by the final set of indicators. (b) by testing their measurement performance – the primary goal of item removal was to improve the psychometric properties of the measurement model. As confirmed by the results in Table V, the refined constructs all demonstrate strong reliability (CR > 0.70) and convergent validity (AVE > 0.50 for reflective constructs). This indicates that the purified scales are more robust and provide a clearer, more precise measurement of their underlying theoretical concepts.

5.3. Goodness of fit

Finally, SmartPLS calculated the normed fit index (NFI) and standard

Table IV
Collinearity measures.

Constructs	Items	Item description	Outer loadings	VIF
Supply Chain Ambidexterity	SCAM1	Our supply chain managers proactively pursue new supply chain solutions	0.816	2.517
	SCAM2	Our supply chain managers continually experiment to find new solutions that will improve our supply chain	0.801	2.860
	SCAM3	To improve our supply chain, our supply chain managers continually explore for new opportunities	0.809	3.212
	SCAM4	Our supply chain managers are constantly seeking novel approaches in order to solve supply chain problems	0.815	2.566
	SCAM5	To stay competitive, our supply chain managers focus on reducing operational redundancies in our existing processes	0.643	1.641
	SCAM6	Our supply chain managers consider that leveraging of the current supply chain technologies is important to our firm's strategy	0.756	1.935
	SCAM7	To stay competitive, our supply chain managers focus on improving our existing technologies	0.788	2.245
	SCAM8	Our supply chain managers focus on developing stronger competencies in our existing supply chain processes	0.808	2.474
Supply Chain Adaptability	SCAD1	Our organization has ability to flexibly respond to long term fundamental changes in the “technology” brought by supply chain disruption	0.704	1.842
	SCAD 2	Our organization has ability to flexibly respond to long term fundamental changes in the “competition” brought by supply chain disruption	0.713	2.212
	SCAD3	Our organization has ability to flexibly respond to long term fundamental changes in the “supply” brought by supply chain disruption	0.645	2.084
	SCAD4	Our organization has ability to flexibly respond to long term fundamental changes in the “demand” brought by supply chain disruption	0.644	2.007
	SCAD5	Our organization has ability to engage in long-term innovations (e.g., introduced a greater number of new products and services to markets) in comparison with our competitors even during supply chain disruption	0.661	2.260
	SCAD6	Our organization has ability to engage in long-term innovations (e.g., period from product development to final customer delivery is considerable shorter) in comparison with our competitors even during supply chain disruption	0.792	2.834
	SCAD7	Our organization has ability to engage in long-term innovations (e.g., our supply chain demonstrates a higher degree of product innovativeness) in comparison with our competitors even during supply chain disruption	0.782	2.938
	SCAD8	Our organization has ability to engage in long-term innovations (e.g., our supply chain changes production methods at a greater speed) in comparison with our competitors even during supply chain disruption	0.821	3.470
	SCAD9	Our organization has ability to engage in long-term innovations (e.g., our supply chain is constantly improving its manufacturing processes) in comparison with our competitors even during supply chain disruption	0.760	2.653
	SCAD10	Our organization has ability to sense long-term fundamental changes in the technology (e.g., technological advances) brought by supply chain disruption	0.730	2.219
	SCAD11	Our organization has ability to sense long-term fundamental changes in the competition (e.g., fundamental changes in the competitive landscape) brought by supply chain disruption	0.700	2.064
	SCAD12	Our organization has ability to sense long-term fundamental changes in the supply (e.g., new emerging supply markets) brought by supply chain disruption	0.716	2.310
	SCAD13	Our organization has ability to sense long-term fundamental changes in the demand (e.g., fundamental changes in consumer preferences) brought by supply chain disruption	0.674	2.028
Supply Chain Alignment	SCAL1	Business strategy of our organization is consistent with customer needs	0.599	1.310
	SCAL2	When the supply chain cannot fulfill customer needs, your organization initiates necessary changes in processes and organizations	0.686	1.464
	SCAL3	The business strategy of our organization is consistent with the objectives of the shareholders/owners	0.735	1.675
	SCAL4	The operations/supply chain strategy of our organization is consistent with the business strategy	0.761	1.761
	SCAL5	The employees of our organization share the same vision as the shareholders/ owners	0.714	1.576
	SCAL6	When the supply chain cannot deliver shareholder/	0.787	1.788

(continued on next page)

Table IV (*continued*)

Constructs	Items	Item description	Outer loadings	VIF
		owner objectives, our organization initiates necessary changes to the organization and related processes		
Blockchain Adoption	IUB1	Our organization predict I would use blockchain technologies in the following months.	0.964	4.404
	IUB1	Our organization plan to use blockchain technologies in the following months	0.974	4.404
Supply Chain Competence	SCC1	Our supply chain is able to handle non-standard orders	0.667	2.212
	SCC2	Our supply chain is able to meet special customer specification requirements	0.699	2.354
	SCC3	Our supply chain is able to produce products characterized by numerous features, options, sizes and colors	0.688	1.947
	SCC4	Our supply chain is able to rapidly adjust capacity so as to accelerate or decelerate production in response to changes in customer demands	0.795	2.368
	SCC5	Our supply chain is able to rapidly introduce large numbers of product improvements/variation	0.785	2.993
	SCC6	Our supply chain is able to handle rapid introduction of new products	0.768	2.566
	SCC7	Our supply chain has fast customer response time	0.764	2.144
	SCC8	Our supply chain is characterized by a great amount of cross-over of the activities of our firm and our trading partners	0.726	2.008
	SCC9	Our supply chain is characterized by a high level of integration of information systems in our firm	0.673	1.794
	SCC10	Our supply chain has a short-order-to-delivery cycle time	0.643	1.623
Supply Chain Flexibility Fit	SFFF1	Our organization has successfully managed to attract the sufficient number of suppliers to meet the customer demands	0.702	2.324
	SFFF2	Our organization has successfully managed to obtain a range of products and services provided by major suppliers to meet the customer demands	0.777	3.002
	SFFF3	Our organization has successfully managed to attract the sufficient number of suppliers to obtain a range of major materials/ components/products to meet the customer demands	0.749	2.660
	SFFF4	Our organization has ability to support information systems in transportation and distribution management to meet the customer demands	0.725	2.190
	SFFF5	Our organization has ability to support information systems in firm inventory management to meet the customer demands	0.753	2.532
	SFFF6	Our organization has ability to support information systems in sales and operations management to meet the customer demands	0.771	2.761
	SFFF7	Our organization has ability to support information systems in product planning to meet the customer demands	0.751	2.695
	SFFF8	Our organization has successfully developed a range of new products or services to meet the customer demands	0.669	1.571
	SFFF9	Our organization has ability to "change products and services mix" to meet the customer demands	0.693	1.852
	SFFF10	Our organization has ability to "adjust manufacturing facilities and processes" to meet the customer demands	0.608	1.512
Firm Performance	FPER1	Our organization has improved or maintained 'return on investment (ROI)' even when the whole industry/sector has faced supply chain disruptions	0.808	3.002
	FPER2	Our organization has improved or maintained 'ROI growth' even when the whole industry/sector has faced supply chain disruptions	0.825	3.266
	FPER3	Our organization has improved or maintained 'market share' even when the whole industry/sector has faced supply chain disruptions	0.819	2.936
	FPER4	Our organization has improved or maintained 'market share growth' even when the whole industry/ sector has faced supply chain disruptions	0.804	2.697
	FPER5	Our organization has improved or maintained 'return on sales (ROS)' even when the whole industry/ sector has faced supply chain disruptions	0.900	3.717
	FPER6	Our organization has improved or maintained 'ROS growth' even when the whole industry/sector has faced supply chain disruptions	0.888	3.358

root mean square residual (SRMR) to assess the fit quality. NFI findings range from 0 to 1, with scores closer to 1 suggesting a higher fit (Lohmöller, 1989); SRMR values less than 0.08 indicate that the data fit the model (Henseler et al., 2014; Hu and Bentler, 1999). Thus, we can test the structural model because it fits predictions well.

5.4. *Structural model testing: direct and indirect results*

We tested the proposed hypotheses using SmartPLS 4.1.1.6 (see Fig. II and Table VI). The direct effect results supported H1a ($\beta = 0.404$;

Table V
Validity and Reliability of constructs
The table below illustrates the assessment and relationships between first-order in the research model, including indicators, factor loadings, and hierarchical relationships.

	CA	CR	AVE	IUB	FPER	SCAD	SCAL	SCAM	SCC	SCF
IUB	0.936	0.969	0.939	0.969	0.282	0.342	0.260	0.307	0.300	0.307
FPER	0.917	0.936	0.708	0.263	0.842	0.493	0.546	0.450	0.536	0.598
SCAD	0.922	0.933	0.519	0.321	0.459	0.721	0.698	0.704	0.699	0.744
SCAL	0.809	0.863	0.513	0.233	0.477	0.608	0.716	0.756	0.687	0.843
SCAM	0.908	0.926	0.610	0.285	0.418	0.655	0.658	0.781	0.609	0.702
SCC	0.898	0.916	0.522	0.291	0.498	0.650	0.597	0.567	0.723	0.793
SCF	0.897	0.915	0.520	0.284	0.547	0.681	0.721	0.639	0.722	0.721

Note: CA: Cronbach Alpha, CR: Composite Reliability, AVE: Average Variance Explained, SC: Supply Chain; IUB: Intention to Adopt BCT, SCAD: SC Adaptability, SCAM: SC Ambidexterity, SCC: SC Competence, SCFF: SC Flexibility Fit, FPER = Firm Performance.

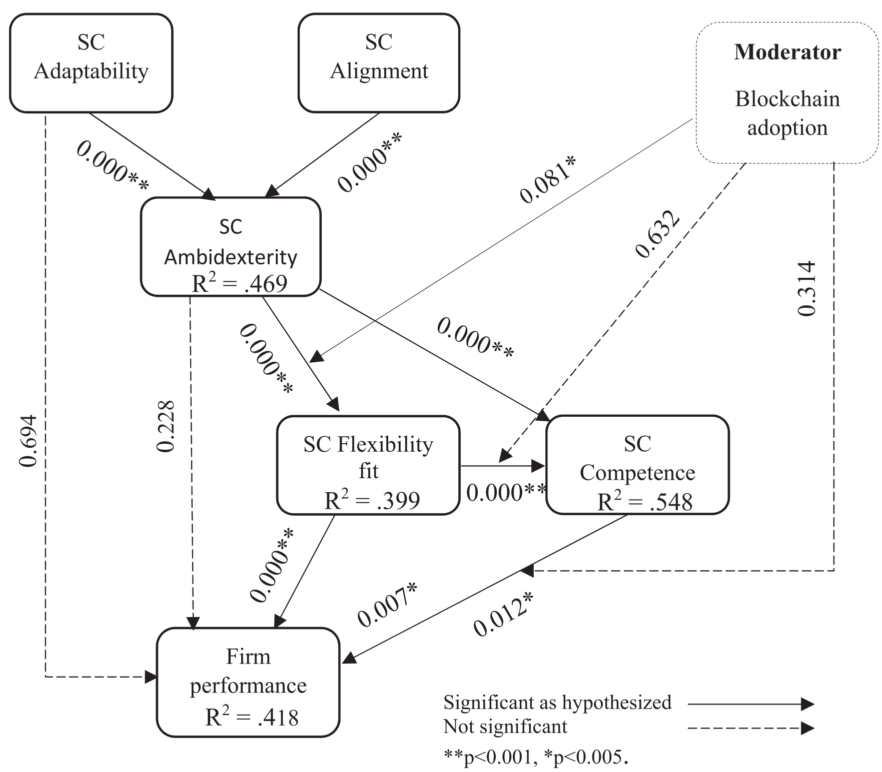

Fig. II. Results of hypotheses testing
The below figure is a visual representation summarizing the results of hypotheses testing, including statistical tests, p-values, effect sizes, and conclusions related to research hypotheses.
Note: SC: Supply Chain.

$p < 0.001$), H1b ($\beta = 0.412$; $p < 0.001$) demonstrating that SC adaptability and SC alignment have a positive impact on SC ambidexterity. H2a was also supported ($\beta = 0.621$; $p < 0.001$), indicating the positive relationship between SC ambidexterity and SC flexibility fit. Similarly, H2c ($\beta = 0.597$; $p < 0.001$) and *H3a* ($\beta = 0.328$; $p = 0.01$) were supported, demonstrating the positive influence of SC flexibility fit on SC competence and FPER. H3c was also supported ($\beta = 0.175$; $p < 0.05$), signifying a positive relationship between SC competence and FPER. However, H4a ($\beta = 0.038$; $p = 0.318$) and H4b ($\beta = 0.076$; $p = 0.164$) were rejected; neither SC ambidexterity nor SC adaptability positively influenced FPER. Regarding mediation, H2b was supported ($\beta = 0.371$; $p < 0.001$), indicating a full mediation effect of SC flexibility fit between SC ambidexterity and SC competence. Similarly, H3b was supported ($\beta = 0.105$; $p = 0.043$), demonstrating a significant indirect effect of SC competence between SC flexibility fit and FPER (Tables VI and VII).

To test the moderation hypotheses, we introduced a categorical moderator variable, “intention to adopt blockchain” (IUB): “0” (1 standard deviation below the mean) for low IUB and “1” (1 standard deviation above the mean) for high IUB. The moderating effect can be analyzed by examining the impact of interaction terms formed by the IUB construct with SC ambidexterity and SC flexibility fit, SC flexibility fit and SC competence, and SC competence and FPER, respectively. According to Baron and Kenny (1986), moderator hypotheses are supported when the path coefficients between the interaction term and the dependent variable are substantial. Table VIII reveals that the moderating effect of IUB is significant in SC ambidexterity–SC flexibility fit interaction ($\beta = 0.075$; $p = 0.032$; CILL = 0.010, CIUL = 0.143), supporting H5a. Fig. III shows that firms with high IUB and SC ambidexterity have higher SC flexibility fit than firms with low levels of IUB. The moderating effect of IUB was insignificant for SC competence or FPER, rejecting H5b and H5c.

Table VI
Hypothesis testing
The table below displays the results of hypothesis testing, including statistical tests, *p*-values, and conclusions related to research hypotheses.

Hypothesis	Relationship	β	Std dev.	*t*-statistic	*p*-value	Result
H1a	SCAD → SCAM	0.404	0.057	7.086	0.000	Supported***
H1b	SCAL → SCAM	0.412	0.054	7.575	0.000	Supported***
H2a	SCAM → SCFF	0.621	0.045	13.780	0.000	Supported***
H2b	SCAM → SCFF → SCC	0.371	0.051	7.253	0.000	Supported***
H2c	SCFF → SCC	0.597	0.063	9.426	0.000	Supported***
H3a	SCFF → FPER	0.328	0.104	3.142	0.001	Supported**
H3b	SCFF → SCC → FPER	0.105	0.061	1.718	0.043	Supported*
H3c	SCC → FPER	0.175	0.093	1.884	0.030	Supported*y
H4a	SCAM → FPER	0.038	0.081	0.473	0.318	Rejected
H4b	SCAD → FPER	0.076	0.077	0.979	0.164	Rejected

Note.
SCAD=SC Adaptability, SCAL = SC Alignment, SCAM = SC Ambidexterity, SCC=SC Competence, SCFF=SC Flexibility Fit, FPER = Firm Performance.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table VII
Mediation analysis.

Hypothesis	Relationship	β	Std dev.	*t*-statistic	*p*-value	LL CI	UL CI	Result**
H2b	SCAM → SCFF → SCC	0.371	0.051	7.253	0.000	0.291	0.455	Supported***
H3b	SCFF → SCC → FPER	0.105	0.061	1.718	0.043	0.011	0.209	Supported*

Note.
SCAM = SC Ambidexterity, SCC=SC Competence, SCFF=SC Flexibility Fit, FPER = Firm Performance.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table VIII
Moderation testing
The table below illustrates the moderation testing results, including interaction effects, significance levels, and interpretations of how one variable moderates the relationship between two others.

Hypothesis	Relationship	β	Std dev.	*t*-statistic	*p*-value	5% CILL	95% CIUL	Result
H5a	IUB*SCAM**SCFF	0.075	0.040	1.848	0.032	0.010	0.143	Supported
H5b	IUB*SCFF**SCC	0.009	0.053	0.174	0.431	−0.076	0.096	Rejected
H5c	IUB*SCC → FPER	0.073	0.059	1.240	0.108	−0.026	0.168	Rejected

Note. IUB = intention to adopt BCT, SCAM = SC ambidexterity, SCC=SC competence, SCFF=SC flexibility fit, FPER = firm performance.

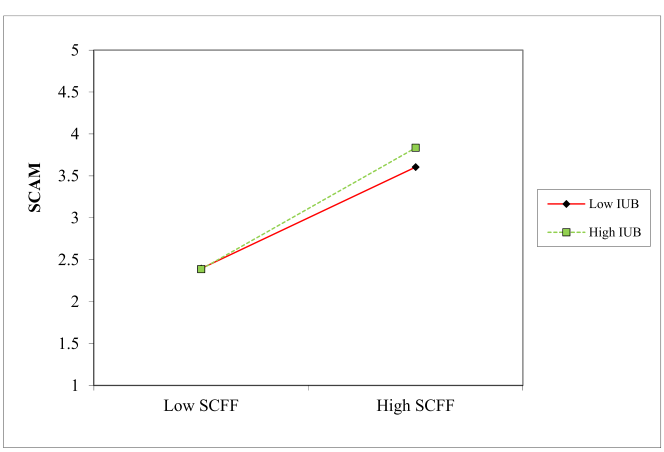

Fig. III. Moderation effect of intention to adopt BCT (IUB) on SC flexibility fit (SCFF) with SC ambidexterity (SCAM)
The below figure is a graphical representation illustrating Moderation effect of intention to adopt BCT (IUB) on SC flexibility fit (SCFF) with SC ambidexterity (SCAM).

6. Discussion

The current study focuses on the conceptual model for some SC skills and variables—namely, SC adaptability, SC alignment, SC ambidexterity, SC flexibility fit, and SC competence—and how they relate to FPER under the regulating influence of BCT adoption. We submitted three study questions and constructed the linkages between the detected variables using the DC framework.

RQ1 questioned the relationship between SC ambidexterity and SC adaptability and alignment. To answer this question, we looked at the connections between SC adaptability and SC ambidexterity (H1a) and the connections between SC alignment and SC ambidexterity (H1b). The findings supported both hypotheses, according to Lee (2004), who discovered that alignment and adaptability are the fundamental components of a strong SC, and Gibson and Birkinshaw (2004), who saw ambidexterity as a behavioral capacity to simultaneously demonstrate alignment and adaptability across an entire business unit. Aslam et al. (2020b) also conceptualized SC ambidexterity as a combination of SC adaptability and SC alignment, suggesting that organizations pursue ambidextrous strategies, including adaptability and alignment, by maintaining a balance between them to reduce the effects of SC disruptions. Checking SC adaptability and SC alignment sub-constructs effect size (f2) revealed them all to be significant. However, structural innovation (SI) had a greater effect on SC adaptability, suggesting the significant role of innovation in driving SC adaptability and SC ambidexterity, supporting Güemes-Castorena and Ruiz-Monroy (2020).

RQ2 inquired about how SC ambidexterity, SC flexibility fit, and SC competence can help in improving FPER. To address this question, we examined the direct relationship between SC ambidexterity and SC flexibility fit (H2a), the mediation influence of SC flexibility fit on the relationship between SC ambidexterity and SC competence (H2b), and the direct relationship between SC flexibility fit and SC competence (H2c). The results suggested significant support for H2a, H2b, and H2c. As expected, SC ambidexterity had a positive and significant effect on SC flexibility fit, meaning high levels of exploration and exploitation can contribute to a higher level of SC flexibility fit required by the environment, as Rojo et al. (2016) suggested. In addition, the findings demonstrate empirically that SC flexibility fit significantly impacted SC competence, indicating the importance of finding the proper SC flexibility fit to the environment to improve SC competence, especially in larger organizations, as suggested by Ngai et al. (2011). SC flexibility fit was found to mediate the SC ambidexterity–SC competence relationship, meaning that ambidexterity capability through exploration/exploitation by achieving a higher level of learning capability to achieve SC flexibility fit and improve SC competence (Rojo et al., 2016). These results signify the importance of SC flexibility fit in managing SC disturbances; pursuing high SC flexibility fit in high environmental uncertainty results in higher SC flexibility fit and SC competence, leading to higher SC performance (Kristal et al., 2010; Luo and Yu, 2016; Sabri, 2019). The effect size comparison revealed that among SC flexibility fit's subconstructs, information system flexibility fit (ISFT) had the most influence on SC flexibility fit, indicating that sourcing proper IT capabilities is a significant element in improving SC flexibility fit in an uncertain environment due to its ability to store and share accumulated experience and new knowledge (Gosling et al., 2010; Rojo et al., 2016).

In addition, to address **RQ2**, we also explored the relationship between SC flexibility fit and FPER (H3a), the mediation influence of SC competence on the relationship between SC flexibility fit and FPER (H3b), and the direct relationship between SC competence and FPER (H3c). The results revealed that both hypotheses were supported. SC flexibility fit positively influenced FPER by improving efficiency and operational performance, supporting the previous literature (Blome et al., 2013), (Rojo et al., 2016; Sabri, 2019). This is also in line with Wagner et al. (2012) argument that under high-uncertainty environmental conditions, firms can benefit most from fit and gain higher FPER by offsetting the costs of the resources needed to maintain the fit. Like Rojo et al. (2016) claimed that higher competence in an SC will improve results for the company by lowering costs, improving quality, and speeding up delivery, SC competency also had a favourable impact on FPER. SC competence also mediated the SC flexibility fit–FPER relationship, aligning with previous literature in which SC competence influenced SC agility and performance in uncertain environments (Al-Zabidi et al., 2021). SC competence can also help avoid SC disturbance by combining competencies with modern technologies (W.-H. Weng, 2020a).

Furthermore, we examined the direct relationship between SC ambidexterity and FPER (H4a) and the influence of SC ambidexterity on FPER (H4b) to address the last part of **RQ2**. The results failed to support both hypotheses. Surprisingly, neither SC ambidexterity nor SC adaptability significantly affected FPER. These findings contrast with prior studies (Jermsittiparsert and Pithuk, 2019; Lee and Rha, 2016; Perthe-ban and Arokiasamy, 2019) suggesting that SC ambidexterity is an essential capability for firms in mitigating SC disruptions' negative impacts and enhancing FPER, as well as studies indicating SC adaptability's positive influence on FPER (Eckstein et al., 2015; Jermsittiparsert and Pithuk, 2019). These findings imply that more than having the ability to adapt to changes and the skills to explore and exploit new opportunities in the SC is needed to achieve higher FPER in disruptive environments. Firms, therefore, should combine SC ambidexterity with other elements, including having advanced IT capabilities (Gu et al., 2021; Wamba et al., 2020; W.-H. Weng, 2020a), practicing SC risk management (El Baz and Ruel, 2021), improving SC competences (Al-Zabidi et al., 2021), and having the right SC flexibility fit (Rojo-Gallego-Burin et al., 2020). By acquiring these abilities and practicing SC ambidexterity, firms can attain firm performance, competitive advantage, and combinative capability and produce new products.

RQ3 questioned whether BCT adoption would have a positive moderation effect on SC flexibility fit, SC competence, and FPER. To answer this question, we examined the moderating effect of BCT on the relationship between SC ambidexterity and SC flexibility fit (H5a), the moderating effect of BCT on the relationship between SC flexibility fit and SC competence (H5b), and the moderating effect on BCT on the relationship between SC competence and FPER (H5c). The moderation tests revealed that H5b and H5c were not supported. BCT adoption moderated the SC ambidexterity–SC flexibility fit relationship (high BCT adoption strengthens the SC ambidexterity–SC flexibility fit relationship), supporting prior literature (Davidson et al., 2016; Dubey et al., 2020; Treiblmaier, 2018) and proving that BCT can be an added value in SCs to improve SC flexibility fit given its ability to enhance transparency and information exchange among organizations through smart contracts. Blockchain automates routine transactions (via smart contracts), reduces errors, and ensures data integrity, which enhances reliability, efficiency, and coordination in daily operations. These improvements bolster the firm's core supply chain competencies. We predicted that implementing BCT can indirectly help generate new competencies in SCs by changing processes, resources, and governance, thus leading to improved SC performance. However, BCT adoption was found to moderate neither the SC flexibility fit–SC competence nor the SC competence–FPER relationship. This could be because organizations are still experimenting with digital technologies such as BCT, attempting to use its potential and evaluate its impact on their businesses regarding value creation and competitive advantage (Anthony Jnr and Abbas Petersen, 2021). However, they lack a digital strategy to guide this change, evaluate the processes, skills, and competencies, and make the proper adjustments (Nandi et al., 2021; Saleh and Awny, 2020). A digital strategy also helps make real-time sense of how suppliers, channel partners, and competitors respond to crises in their smart contracts (Blackburn et al., 2020; Wamba et al., 2020).

Our study highlights blockchain's role not merely as a technological tool but as a capability-enhancing mechanism within the dynamic capability framework, reinforcing the idea that digital technologies can shape how firms sense, seize, and reconfigure in pursuit of ambidexterity. Further, managers should view blockchain adoption as part of a **strategic digital roadmap**, rather than a stand-alone investment. Its greatest value lies in enabling supply chains to be both efficient and adaptable, ensuring that flexibility is not ad hoc but aligned with organizational objectives.

7. Conclusions

7.1. Summary

SCs are considered the primary mechanism through which businesses create impact in all aspects of our daily needs; however, the challenges present an opportunity to integrate BCT, which could fundamentally alter the future of SCs (Hewett, 2020; Stranieri et al., 2021). The present study attempted to augment research on SC capabilities and BCT to understand their interactions and contribution to SC performance. Based on the literature review, we developed a model and hypotheses by utilizing the DC framework that ties BCT with SC adaptability, SC alignment, SC ambidexterity, SC flexibility fit, SC competence, and FPER. We collected data via a self-reported survey from 287 participants in UK and US manufacturing firms to test the model and hypotheses. Findings revealed that SC adaptability and SC alignment have a positive association with SC ambidexterity. We further identified innovation as a critical driver in this construct. SC ambidexterity was found to have a significant positive impact on SC flexibility fit, and SC flexibility fit has a significant relationship with SC competence. SC flexibility fit had a full mediation effect between SC ambidexterity and SC competence, and the firm's IT capability was the most significant contributor to this relationship. Findings also revealed a positive relationship between SC flexibility fit and FPER and between SC competence and FPER, as well as the full mediation influence of SC competence between SC flexibility fit and FPER. Regarding the relationship between SC ambidexterity and SC adaptability with FPER, neither SC ambidexterity nor SC adaptability significantly affected FPER, suggesting other capabilities that could influence this relationship. We also examined the moderation effect of adopting BCT (IUB) with SC flexibility fit, SC competence, and FPER; IUB significantly moderated the SC ambidexterity–SC flexibility fit relationship but not the SC competence–FPER relationship.

7.2. Theoretical implications

This study has several theoretical implications. First, it is among the first studies to assess SC capabilities' influence on firm performance in a simple first-order framework (Fig. I) and evaluate the moderation impact of BCT. Despite much literature on SC capabilities, research integrating all these constructs with BCT is rare. Second, this study extends research on BCT's impact on SCs in disruptive environments to examine BCT's possible benefits, showing that implementing BCT alone may not be as beneficial as prior literature suggests (Kamble et al., 2021a, 2021b; Nandi et al., 2021); it is also necessary to improve IT and innovation capabilities, refine SC competencies, and develop a strategy to ensure the proper flexibility fit in a digital environment (Blackburn et al., 2020). Hence, this study complements the growing body of knowledge regarding digital transformation and SCs, proposing potential new directions by refocusing on competencies and strategy (Nandi et al., 2021; Saleh and Awny, 2020). Finally, prior literature has primarily focused on utilizing the DC framework in investigating the impact of digital transformation in SCs (Dubey et al., 2015; Lee and Rha, 2016; Shashi et al., 2020; Wamba et al., 2020). However, this may not be well suited to perceive SC capabilities and digital technologies in a disruptive environment as independent DCs. The combined disruptive effects of digital technologies require SC capabilities to complement each other to transform the whole organization and ensure success and survival. Therefore, other theories, such as resource orchestration theory (ROT) (Hitt et al., 2011; Sirmon et al., 2011) and the technology enactment framework (TEF) (Fountain, 2004; Schellong, 2007), might be better suited to investigating this phenomenon.

7.3. Practical implications

Many organizations seek ways to strengthen their SC adaptability, ambidexterity, and collaborations by deploying BCT; this study provides decision-makers and managers with meaningful, cost-saving benefits. First, SC adaptability and alignment can improve SC ambidexterity. Therefore, managers should focus on fostering innovation capability by implementing innovation and idea-sharing strategies as a priority adjusting processes to improve ambidexterity. Second, IT capability and its flexibility fit (internally and externally) can improve SC ambidexterity, competencies, and flexibility fit. Hence, managers should not focus solely on acquiring the best IT systems and bombarding employees with training to develop their competencies; they need to think holistically and collaboratively. The systems chosen must be aligned and fit with other IT systems and competencies internally and with other partners. Finally, deploying BCT could lead to superior SC performance; nevertheless, other conditions should be met before making such an expensive investment. A solid digital strategy guiding this change by continuously re-evaluating processes, skills, and competencies and making the proper adjustments could help managers obtain optimal results from emerging BCT capabilities. Manufacturing firms should leverage blockchain-enabled traceability to co-develop solutions with supply chain partners, and how IT-driven smart contracts can streamline supplier coordination to balance efficiency with flexibility.

7.4. Limitations and future research

Although this paper contains several positive findings, its shortcomings should be acknowledged. First, the sample size is small (283); future studies might use a bigger sample size. Second, since this paper only looked at a select few SC capabilities, researching other variables, such as SC agility, data-driven culture, and SC innovation, as well as looking at the same contexts from various theoretical stances, like ROT and TEF, could help SCs perform better in disruptive environments. Third, just two Western nations were where the data were gathered; future research could gather data from more nations while considering cultural characteristics (such as language, Eastern vs. Western, developed vs. emerging, etc.). Fourth, a cross-sectional study design was used in this paper to gather data. Employing a case study or longitudinal research should allay any worries about CMB or endogeneity and guarantee consistency throughout time or places. Fifth, this study did not examine if or how effectively BCT was adopted; instead, it examined firms' intentions to adopt BCT. Therefore, studies that use actual BCT data and examine the perspectives of many stakeholders would be helpful. Further, interoperability with legacy systems, data standardization issues, and uneven adoption among supply chain partners often prevent seamless implementation. Hence, many blockchain solutions are still in developmental or pilot phases, with limited large-scale, proven applications in supply chains. BCT adoption requires significant investment, technical expertise, and coordination across multiple actors, which many organizations may lack. Hence, the value of blockchain is contingent on network-wide participation, but fragmented adoption limits its transformative potential which demands attention.

CRediT authorship contribution statement

Mahak Sharma: Conceptualization, Writing – original draft, Writing – review & editing, Visualization, Supervision. **Bader K. AlNuaimi:** Conceptualization, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Mehmood Khan:** Writing – original draft, Writing – review & editing, Resources, Software, Methodology, Investigation, Formal analysis, Data curation, Investigation. **Rsha Alghafes:** Writing – review & editing, Resources, Visualization, Methodology, Investigation, Project administration. **Rudresh Pandey:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis, Data curation.

Acknowledgements

Princess Nourah bint Abdulrahman University Researchers supporting project number (PNURSP2026R541), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.

Data availability

Data will be made available on request.

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