Modern slavery supply chain capabilities:
The effects of Blockchain technology and employees' digital dexterity

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Abstract

Purpose – This study addresses a significant and previously unanswered question for both academics and practitioners: how do organizations learn to apply Blockchain technology to support modern slavery (MS) supply chain capabilities? Specifically, this study examines whether employees' digital dexterity (EDD) and strategic investment in Blockchain technology (SIBT) can support three MS supply chain capabilities: internal MS capability (IMSC), MS capability with customers (MSCC), and MS capability with suppliers (MSCS).

Design/methodology/approach – This study uses resource accumulation and deployment perspective to explain how EDD promotes SIBT, which then drives the development of MS supply chain capabilities. Survey data collected from the Chinese manufacturing industry were used to test the proposed theoretical framework and hypotheses through structural equation modelling and moderated regression analysis.

Findings – EDD has a positive relationship with SIBT. SIBT has a positive relationship with IMSC. IMSC fully mediates the relationships between SIBT and MS capability with customers and suppliers.

Originality/value – By conceptualizing MS supply chain capabilities as a multidimensional construct for the first time, this study discovers the significant mediating roles of IMSC. The empirical findings also clarify digital dexterity of employees that drives investment in Blockchain technology to foster MS supply chain capabilities as resource accumulation and deployment processes.

Keywords: Employees' digital dexterity; Blockchain technology; Modern slavery in supply chains; Modern slavery capabilities

Paper type: Research paper

1. Introduction

The issues of modern slavery (MS) in supply chains (i.e., human trafficking, forced labour, and child slavery) have become increasingly intricate and severe (Han *et al.*, 2022; Meehan and Pinnington, 2021; Stevenson and Cole, 2018; Szablewska and Kubacki, 2023). For example, the chocolate company Tony's Chocolonely has admitted to employing 1,700 child workers in its production and supply chain during 2021 (Eccles, 2022). Likewise, the fashion company Boohoo came under scrutiny for MS practices in 2020 after workers in Leicester garment factories received wages less than half of the minimum wage (Child, 2020). The complexity around these illegal practices makes traditional corporate social responsibility (CSR) practices, such as supplier audits and self-assessment, less effective in detecting MS and forced labour practices (New, 2015).

The operations and supply chain management literature has identified some capabilities to tackle slavery and human trafficking (Geng *et al.*, 2022), e.g., detection (Gold *et al.*, 2015; Stevenson and Cole, 2018), audit (Benstead *et al.*, 2021), supply chain mapping, supplier selection (Ishaya *et al.*, 2024), supplier engagement and tendering (e.g., Simpson *et al.*, 2021; Stevenson and Cole, 2018), and remedy/mitigation strategies including supplier development and collaboration (Gold *et al.*, 2015; Simpson *et al.*, 2021; Meehan and Pinnington, 2021). However, there is one important gap in the literature: a lack of constructs to differentiate MS capabilities for governing upstream, downstream, and internal human rights issues, which provides an integrated perspective to study MS phenomena. To address this gap, this study integrates multiple capabilities from the literature to develop three MS supply chain capability constructs: *internal MS capability* (IMSC), *MS capability with suppliers* (MSCS), and *MS capability with customers* (MSCC). IMSC is conceptualized as the importance of awareness, training, policies, and internal detection mechanisms within the organisation (Geng *et al.*, 2022; Gold *et al.*, 2015; Han *et al.*, 2022). MSCS considers capabilities for detection and remedies including collaboration with suppliers (Benstead *et al.*, 2021; Gold *et al.*, 2015). MSCC in turn focuses on collaboration and reporting with customers, given the importance of transparency and compliance with transparency regulations (Meehan and Pinnington, 2021).

To improve MS traceability and detection adopting digital technologies has been a key element (Jiang *et al.*, 2023). Digital technologies such as digital whistleblowing, work hour tracking, Blockchain, Internet monitoring, digital supplier evaluation, responsible recruitment toolkit, and digital training might help detect/prevent MS risk among multi-tier actors in a supply chain (Jiang *et al.*, 2023). Among these, Blockchain has a great potential (Han *et al.*, 2022) because of its technological qualities, e.g., immutability of data and non-repudiability (irreversibility) that ensures reliable information is stored in a decentralized database (Hald and Kinra, 2019) for improving supply chain visibility and traceability (Khan *et al.*, 2022; Kusi-Sarpong *et al.*, 2022). Such qualities in Blockchain can ensure confidentiality, integrity, and availability of traceable and trustworthy data (Xu *et al.*, 2021) to safeguard workers against abuse and forced labour practices (Boersma and Nolan, 2020; Christ and Helliar, 2021; Jiang *et al.*, 2023). Recently, several companies have started to pilot Blockchain-based technology to assure their claims of slave-free products. For example, Tony's Chocolonely has piloted a Blockchain solution and requested Barry Callebaut (its cocoa processing supplier) to input reliable data about cocoa sources into its Blockchain platform (https://www.forbes.com/). Similarly, Diginex, in collaboration with the Coca-Cola Company and Reckitt, has developed a Blockchain-based solution called diginexLUMEN. Ford has adopted IBM's Blockchain platform to trace the supply of cobalt, a vital component in electric car batteries, with the objective of combating labour exploitation (Mullan, 2020). While a few studies have recently investigated how Blockchain technology can be utilized to detect and remediate MS in supply chains (e.g., Berg et al., 2020; Christ and Helliar, 2021; Cole et al., 2019), most of these studies focused on providing conceptual discussions rather than engaging in empirical research (Szablewska and Kubacki, 2023).

Despite the apparent positive link between Blockchain and MS, the literature has not fully answered an important question: *how do organizations learn to apply Blockchain technology to support MS supply chain capabilities?* New organizational capabilities are built through resource accumulation and deployment (Maritan and Peteraf, 2011). The resource accumulation and deployment processes serve as mechanisms for generating and preserving the heterogeneity of non-tradable assets, providing an additional foundation for organizations to obtain sustainable competitive advantage (Lavie, 2012; Maritan and Peteraf, 2011). To justify strategic investment in Blockchain technology (SIBT), organizations must have accumulated enough (digital) knowledge and skills for deploying it. To effectively adopt Blockchain, one pre-requisite is employees' digital competency, e.g., digital knowledge, skills and experience and digital talent development (Ahmed *et al.*, 2022; Proksch *et al.*, 2024). The adoption of Blockchain thus requires employees who are ambitious and capable of working digitally, building digital business processes; a capability labelled as employees' digital dexterity (EDD) (Kropp *et al.*, 2021). A digitally dexterous employee is "an innovative individual with the self-efficacy to engage, without solely relying on the assistance, in the novel and sophisticated digital workplace activities towards the achievement of the organizational goals" (Ahmed *et al.*, 2022, p.639). According to Gartner (2018), dexterous employees are 3.3

times more inclined to swiftly implement digital initiatives and effectively derive value from them. As mentioned earlier, most Blockchain adoptions are at a pilot stage. To reflect readiness to shift from pilot (exploration) to the decision to invest, we introduce the new construct of EDD to precede SIBT to tackle MS.

Another important gap in the literature concerns the lack of empirical evidence to support whether SIBT improves MS supply chain capabilities beyond the above anecdotal evidence involving a few well-known companies. China serves as an intriguing context for this study, given its status as the world's second-largest digital economy. Notably, China has embraced Blockchain technology, integrating it into its national strategy and 14th Five-Year Plan (2021-2025) (Cai *et al.*, 2021; Dutta *et al.*, 2020). By 2020, the country boasted 1,309 companies providing Blockchain technical services, with industry giants like Baidu, Alibaba, and Tencent actively developing platforms and expanding their application layout (Cai *et al.*, 2021). This contrasts significantly with China's CSR practices. Despite being the world's leading global manufacturing hub, China has yet to demonstrate substantial strengths in detecting and remediating MS (e.g., forced labour and human trafficking) (VinciWorks, 2023). For instance, Apple and its biggest Chinese supplier, Foxconn, have faced criticism for issues such as prolonged overtime, the employment of underage workers, and the failure to provide legally required social and health insurance (Cadell, 2017). According to their annual CSR reports, Chinese manufacturing companies (e.g., BYD and Shein) emphasize developing their MS supply chain capabilities by identifying and eliminating MS in their supply chains; however, it remains unclear whether investing in Blockchain technology can foster such capability. This study collects evidence from the Chinese manufacturing industry to test whether EDD drives SIBT and whether SIBT contributes to MS supply chain capabilities.

Another contribution of this study is to contextualize the dominant technocratic view of Blockchain application with resource accumulation perspective. MS research has recognized the roles of people in identifying and assessing MS in supply chains (e.g., Caruana *et al.*, 2021). Blockchain research has also recognized the significance of having employees with the necessary knowledge and skills to adopt blockchain technology (Clohessy and Acton, 2019). However, developing employees (dexterity) has often been left behind. By empirically testing the important role of EDD from the resource accumulation and deployment perspective (Lavie, 2012), this study emphasizes that a technical view is not the only necessary element when building MS supply chain capabilities but also that managers should consider resource accumulation as a process for developing technological capabilities.

2. Theoretical constructs

MS in supply chains is an emerging research topic due to its relevance and urgency, but with limited theoretical foundation. Our first contribution focuses on developing and testing new constructs. The first set of constructs integrate various capabilities from the literature to conceptualise and develop three dimensions of MS supply chain capabilities. The second, since there are some pilot studies using Blockchain to address MS, is a new construct specifically reflecting investment in Blockchain technology (SIBT) to increase supply chain traceability and tackle MS.

As a second contribution, we introduce to the supply chain literature the resource accumulation and deployment perspective (Maritan and Peteraf, 2011) and use it to explain how organizations learn to apply Blockchain technologies to support MS supply chain capabilities. The process of resource accumulation and deployment serves as the mechanism for generating and preserving the heterogeneity of non-tradable assets, providing an additional avenue and foundation for fostering new organizational capabilities (Lavie, 2012; Maritan and Peteraf, 2011). Based on the principles of absorptive capacity (Cohen and Levinthal, 1990) and resource relatedness (Speckbacher *et al.*, 2015), we argue the accumulation of new knowledge about Blockchain happens when employees have sufficient and relevant digital knowledge. Companies need employee with such competencies to address strategic uncertainty and to learn how to apply new technologies. Here we draw ideas from the entrepreneurship literature to define EDD.

In the following subsections, we define and explain the theoretical constructs, including the three dimensions of MS supply chain capabilities, SIBT, and EDD.

2.1. MS supply chain capabilities

A recent systematic review of the MS literature reveals that there are already many practices to detect/assess MS risks and remedies to address them (Han *et al.*, 2022). MS in supply chains is a complex problem that requires information sharing with suppliers and customers (Han *et al.*, 2022; Stevenson and Cole, 2018) and strategic collaboration with upstream suppliers (Benstead *et al.*, 2018, 2021; Bodendorf *et al.*, 2023; Simpson *et al.*, 2021). Others emphasize internal practices such as employee training and top management commitment (Simpson *et al.*, 2021; Stevenson and Cole, 2018). This study argues MS supply chain capability involves different but interrelated processes internally (intra-organizational) and externally (inter-organizational) with suppliers and customers. We conceptualize the proficiency in managing such processes as MS supply chain capabilities, which is a multidimensional construct that comprises of *IMSC*, *MSCS*, and *MSCC*. These dimensions/capabilities aim to detect, remediate, and disclose MS in supply chains through collaboration across intra- and inter-organization processes. These collaborative approaches enable firms to develop suitable interventions to tackle MS effectively (Crane, 2013).

While China has yet to demonstrate substantial strengths in detecting and remediating MS in its economy, the latest Global Slavery Index, produced by Walk Free (2023), reveals that China has shown commitment to combating MS through consistent coordination at the provincial, national, and international levels. The Ministry of Human Resources and Social Security of China enforces a national grading system with the objective of evaluating employers' adherence to labour regulations. The system aims to identify, address, and eliminate MS practices such as forced labour, excessive overtime, the hiring of underage workers, and non-compliance with legally mandated social and health insurance provisions (Walk Free, 2023). Moreover, in 2021, the General Office of the State Council released China's Action Plan against Human Trafficking (2021-2030) with the goal of enhancing the protection of human rights and upholding social harmony and stability (The State Council of China, 2021). China also takes proactive measures in participating in cooperative efforts for anti-trafficking investigations with other countries, and it consistently honours bilateral agreements to tackle MS concerns.

In compliance with national action plans and regulations, Chinese manufacturing companies issue their annual CSR reports detailing the MS supply chain practices they have implemented. For example, BYD, the world's leading manufacturer of new energy vehicles and power batteries, scrupulously monitors and comprehensively evaluates its suppliers and their downstream supply chains regarding human rights and forced labour. Internally, BYD is committed to eradicating discrimination in recruitment and strictly prohibits forced labour, labour trafficking, and child labour within its workforce (BYD CSR Report, 2023). Shein, the Chinese ultra-fast fashion giant, has a zero-tolerance policy for child labour, human trafficking, and migrant forced labour in its supply chains. It implements the SHEIN Responsible Sourcing (SRS) evaluation system, which requires regular audits of its primary suppliers to prevent and eliminate any potential risks of forced labour and human rights violations within its supply chain (Shein Sustainability and Social Impact Report, 2023).

2.1.1. Internal MS capability (IMSC)

IMSC refers to MS management practices inside of the organization to address and combat specifically MS (Simpson *et al.*, 2021; Stevenson and Cole, 2018). These following practices are included into the measurement scale for IMSC: fostering an inclusive and open organizational culture that promotes diversity and actively addresses MS issues, providing MS trainings for employees, facilitating employees' participation in external events, enhancing ethical policies, and establishing a whistleblowing hotline (Geng *et al.*, 2022; Gold *et al.*, 2015; Grimm *et al.*, 2016; Stevenson and Cole, 2018). IMSC is incomplete without a clear ethical policy that promises decent work (Soundararajan *et al.*, 2021) and protects human rights (Venkatesan, 2019). Nowadays, some companies provide comprehensive MS training sessions to employees and encourage them to attend cross-industry seminars and workshops on MS. These initiatives make employees aware of MS issues and equip them with the necessary knowledge and skills to identify and address MS. Doing so empowers employees to actively participate in fighting against MS in supply chains, facilitates knowledge sharing, and helps companies stay updated with the latest developments, best practices, and innovative approaches to combat MS (Stevenson and Cole, 2018). In addition, IMSC involves the establishment of a whistleblowing hotline to signal strong commitment and offer protection and anonymity to whistleblowers and victims. This allows employees to report any MS suspicions or concerns without fear of retaliation (Stevenson and Cole, 2018).

2.1.2. MS capability with suppliers (MSCS)

MSCS refers to the collaborative efforts between a company and its suppliers to implement effective preventive MS practices (Benstead *et al.*, 2021; Bodendorf *et al.*, 2023; Simpson *et al.*, 2021) for combating child labour, forced labour, and human trafficking. MSCS involves several key activities, including developing trusting and open relationships with suppliers, conducting supplier audits, performing detailed document analysis on suppliers, collecting supplier MS self-assessment questionnaires, suspending and terminating supply arrangements, and providing an anonymous whistleblowing hotline (Gold *et al.*, 2015; Stevenson and Cole, 2018). For instance, a focal firm might conduct regular supplier audits to assess suppliers' policies and practices regarding MS and human trafficking. These audits help evaluate the effectiveness of the suppliers' internal controls and measures in preventing and addressing MS (Benstead *et al.*, 2018, 2021; Bodendorf *et al.*, 2023). Supplier audits should involve detailed documentation to scrutinize issues related to workers' identification, right to work, age verification, payment of recruitment fees, etc. This helps verify compliance with legal and ethical standards and identify any potential signs of MS (Simpson *et al.*, 2021; Stevenson and Cole, 2018).

2.1.3. MS capability with customers (MSCC)

MSCC refers to the collaborative efforts between a company and its customers aimed at implementing and maintaining effective MS management practices (Stevenson and Cole, 2018). These practices encompass various initiatives, such as actively engaging with customers to ensure the identification and remediation of MS in supply chains. One key aspect is the publication of MS audit reports online, making them easily accessible to customers. By providing transparency and accountability, these reports enable customers to make informed decisions regarding their business relationships and contribute to broadening the fight against MS. In addition, companies with MSCC proactively disclose annual MS slavery statements to their customers to demonstrate their commitment to ethical and human rights practices and foster a sense of trust and confidence among their customers. Moreover, incentivizing customers to actively participate in detecting MS is a crucial component of MSCC. By doing so, companies and their customers can leverage their collective knowledge and expand their efforts to combat MS.

2.2. Strategic investment in Blockchain technology (SIBT)

Blockchain is considered one of the cutting-edge disruptive technologies capable of fundamentally transforming businesses and supply chains by redefining and reshaping the relationships among all supply chain members. (Fosso Wamba *et al.*, 2020; Saberi *et al.*, 2019). Blockchain records transactions into distributed ledgers in a chronological order, providing a robust and trusted approach to trace supply chain activity (Fosso Wamba *et al.*, 2020; Pedersen *et al.*, 2019).

When a technology is new with very few successful use cases, many companies face strategic adoption uncertainty (Yu *et al.*, 2023). While most companies shy away from such uncertainties, some companies decide to undertake new investments and adapt their activities with such new technologies hoping to create competitive advantage (Kapoor and Lee, 2013). We now see some leading companies trying to develop Blockchain solutions to trace how workers in their supply chains are treated. Thus, we define investment in Blockchain technology (SIBT) as the strategic implementation of Blockchain technology within supply chain operations aimed at enhancing transparency, security, and traceability (Khan *et al.*, 2022; Kusi-Sarpong *et al.*, 2022; Queiroz and Fosso Wamba 2019). These capabilities are consistent with identifying and reducing instances of MS.

Several recent studies have explored how Blockchain technology can assist organizations in detecting, remediating, and disclosing MS in their supply chains (e.g., Berg *et al.*, 2020;

Christ and Helliar, 2021; Cole *et al.*, 2019; Schleper *et al.*, 2022). But most of those studies focused on conducting a systematic review or developing a conceptual framework rather than empirical research (Szablewska and Kubacki, 2023). For instance, Christ and Helliar (2021) provided a conceptual discussion on how Blockchain technology can be utilized to mitigate unethical recruitment practices, with the aim of protecting migrant workers against exploitation and forced labour. Therefore, empirical research that explores how SIBT enhances the development of MS supply chain capabilities is an emerging area of inquiry, constituting a primary purpose of this study.

2.3. Employees' digital dexterity (EDD)

Originated from the entrepreneurship literature, EDD encompasses a wide range of skills, knowledge, mindset, and competencies that employees possess to effectively utilize digital technologies (Ahmed *et al.*, 2022; Gartner, 2018; Kropp *et al.*, 2021; Proksch *et al.*, 2024). These capabilities reflect an employee's proficiency in leveraging digital technologies, which is derived from their digital experience and technical know-how (Ahmed *et al.*, 2022; Frankiewicz and Chamorro-Premuzic, 2020; Kropp *et al.*, 2021; Prokesch, 2017). EDD is crucial in today's rapidly evolving technological landscape (Ahmed *et al.*, 2022). One example of such capability is the employee's ability to demonstrate proficiency in various digital tools, platforms, and technologies to drive digital transformation initiatives and contribute to the ongoing digitalization efforts within the organization (Frankiewicz and Chamorro-Premuzic, 2020; Prokesch, 2017). It also includes utilizing software applications, online platforms, and other digital tools relevant to their roles and responsibilities, such as big data analytics, Blockchain, and Artificial Intelligence (Kropp *et al.*, 2021; Proksch *et al.*, 2024). Greater facility with tools such as Blockchain can facilitate greater MS supply chain capability.

Individual digital competencies are often fostered by a culture of open discussion and learning. This culture encourages employees to actively engage in conversations about ongoing digital transformation projects and share knowledge about both successes and failures (Philip, 2021; Proksch *et al.*, 2024). To the extent these conversations include MS, employees can learn from one another, identify best practices, and collectively work towards improving digital project outcomes (Frankiewicz and Chamorro-Premuzic, 2020; Nylen and Holmström, 2015), e.g., detecting and remediating MS.

3. Theoretical model and hypothesis development

3.1. Theory and research model

This study views the development of employees' digital competencies and the investment in Blockchain for addressing MS as a resource accumulation and deployment process (Lavie, 2012; Maritan and Peteraf, 2011). Many antecedents that can support MS supply chain capabilities and technology solutions like Blockchain are valuable (Han *et al.*, 2022) when traditional CSR practices, when practiced in isolation, are ineffective (New, 2015). Blockchain's technical features such as immutability of data and non-repudiability (Hald and Kinra, 2019), decentralized database (Khan *et al.*, 2022; Kusi-Sarpong *et al.*, 2022), confidentiality, integrity, and availability (Xu *et al.*, 2021) can better combat the opacity of MS in supply chains. Tony's Chocolonely, Coca-Cola, Reckitt, Ford, and others have piloted Blockchain for ensuring supply chain traceability.

However, Blockchain is a technology, and there are other competency issues involved in implementing Blockchain and developing MS supply chain capabilities. Blockchain involves many digital competencies and most employees in manufacturing and supply chain sectors know very little about it. Not only do employees need to learn how to use it; they also need to learn to develop processes supported by Blockchain to detect and tackle MS in their supply chains. Thus, it is important to equip employees (employee's digital competence) with new knowledge and skills related to Blockchain, but also foster a culture of willingness to experiment or adopt new technologies.

Thus, we argue success in adopting a new technology begins with employees. Many companies face uncertainties about Blockchain applications and tackling MS issues. Initially, companies do not know what related resources are required to acquire Blockchain knowledge. Employees with competencies e.g., EDD, related to Blockchain would likely have sufficient absorptive capacity (Cohen and Levinthal, 1990) to learn about Blockchain. Resource relatedness makes technology transfer feasible (Speckbacher *et al.*, 2015). This involves the resource accumulation and deployment process (Maritan and Peteraf, 2011), where "resource accumulation involves transforming resource inflows into stocks, while resource deployment entails transforming stocks into outflows" (Lavie, 2012, p.318). EDD provides a fertile platform for employees to learn and explore different new digital technologies, some of which (e.g., Internet of Things, cloud computing, etc.) are related to Blockchain. They can then strategically shape and structure relevant digital resources for Blockchain applications. After acquiring sufficient digital competencies and knowledge about implementing Blockchain, the next task involves making investment decisions. Through EDD, companies feel confident to invest in Blockchain as a part of the MS supply chain capabilities. By enhancing the digital dexterity of employees, companies will be more ready to adopt Blockchain technology that traces MS issues. The investment decision kick starts the resource deployment process (Lavie, 2012; Maritan and Peteraf, 2011) whereby digital competencies and Blockchain knowledge are applied into MS supply chain processes. These new employee competencies and technical capabilities create unique MS management capabilities in supply chains. As depicted in Figure 1, we expect EDD to positively affect SIBT. We also argue SIBT supports MS with customers and suppliers through IMSC because MS capabilities in suppliers and customers depend on IMSC.

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3.2. Effects of EDD on SIBT

Blockchain technology is widely recognized for its ability to deliver essential features, including data security, authentication, traceability, and reliability (Khan *et al.*, 2022; Kusi-Sarpong *et al.*, 2022; Queiroz and Fosso Wamba 2019). However, there are limited successful use cases to show that Blockchain can be used to tackle MS in supply chains. Further, recent reports from prominent consulting firms such as McKinsey, Gartner, and KPMG suggest that over 70% of digital transformation projects fail to deliver the anticipated benefits (Gartner, 2018; Yu *et al.*, 2023). One of the major issues reported is the lack of employees' digital competency when it comes to adopting advanced digital tools and techniques. Recent research supports this perspective as successful adoption of digital technology depends more on people rather than the technology itself (Frankiewicz and Chamorro-Premuzic, 2020; Philip, 2021; Proksch *et al.*, 2024).

From the resource accumulation and deployment perspective, companies need to accumulate resources and deploy them to build new organizational capabilities (Maritan and Peteraf, 2011). They must have sufficient and related competencies to acquire new knowledge from others (Speckbacher *et al.*, 2015). This study argues that EDD, as the source for digital skills and knowledge, digital leadership, and digital talent development (Ahmed *et al.*, 2022; Frankiewicz and Chamorro-Premuzic, 2020), is required to fully leverage the technical capabilities of Blockchain. Employees with higher digital dexterity possess the digital skills, knowledge, and mindset necessary to excel in using data analytics tools to extract meaningful insights from Blockchain data (Clohessy and Acton, 2019; Gartner, 2018; Proksch *et al.*, 2024). Developing EDD reflects the process of acquiring new resources (Lavie, 2012; Maritan and Peteraf, 2011). Since EDD is highly relevant to Blockchain, their resource relatedness (Speckbacher *et al.*, 2015) may trigger innovative ideas to conceptualize the use of Blockchain for tackling MS. Investment in Blockchain reflects the beginning of a resource deployment process (Maritan and Peteraf, 2011). Its application for tackling MS must be driven by another imperative. Given the many new supply chain human right regulations, these capabilities become highly relevant when companies realize they must trace the supply chain network and identify MS more effectively. EDD, as a capability that enables companies to treat Blockchain as a strategic asset, is thus an important antecedent to SIBT.

H1: EDD is positively associated with SIBT.

3.3. Effects of SIBT on MS supply chain capabilities

Companies investing in Blockchain are more likely to advance internal and external MS supply chain capabilities, addressing and eliminating MS in their supply chains (Christ and Helliar, 2021). Since forced labour practices are illegal and opaque (New, 2015), MS supply chain capabilities require multi-tier traceable data that are reliable, immutable and non-repudiable (irreversible) stored in a decentralized database (Hald and Kinra, 2019). Following the above arguments that EDD involves the accumulation of new resources to a point companies feel ready to invest in Blockchain (SIBT) specifically to address MS, they will begin to deploy digital and Blockchain knowledge to support the development of new MS supply chain capabilities. From the resource accumulation and deployment perspective, companies continue to acquire new (applied) knowledge at this deployment stage. They will learn that Blockchain technology serves as a shared ledger that documents the complete transaction history, ensuring their immutability once recorded (Schleper *et al.*, 2022). Traceability is achieved because every transaction carried out by supply chain partners is added to a block and linked with the next transaction, forming a traceable chain of transactions that is immutable within the supply chain. Any attempt to modify the data will immediately raise suspicion among supply chain participants (Khan *et al.*, 2022; Kusi-Sarpong *et al.*, 2022). These technical qualities allow secure sharing of transaction data to increase transparency and traceability while respective privacy. Companies need such transparency and integrity provided by Blockchain technology to identify, address, and eliminate MS practices in their supply chains, internally and with suppliers and customers (Han *et al.*, 2022; Schleper *et al.*, 2022).

Regarding IMSC, companies provide comprehensive training on MS, which empowers employees and make them aware of MS issues to identify and combat MS (Berg *et al.*, 2020; Cole *et al.*, 2019; Stevenson and Cole, 2018). In this regard, Blockchain allows employees to report fraud and unethical practices through a permanent (immutable) record in the Blockchain, which can deter corrupt business partners, holding them responsible for both their individual and social misconduct (Khan *et al.*, 2022; Saberi *et al.*, 2019). Given the above important technology qualities, Blockchain becomes an important tool for developing internal MS supply chain capabilities. Thus, we hypothesise:

H2a: SIBT is positively associated with IMSC.

Next, opacity in supply chains can invoke a lack of trust between suppliers and customers. MS supply chain capabilities rely on collaboration and support of first-tier suppliers to share supplier's data with customers (Cole *et al.*, 2019). The lack of trust of partners' sharing of upstream supply chain data is a major barrier for traceability but can be addressed by the integrity of Blockchain systems (Han *et al.*, 2022; Jiang *et al.*, 2023), because it is the Blockchain that is the basis for trust in the transaction data in the entire chain (linked blocks). Companies learn that audits and other existing governance structures cannot fully address trust issues related to MS because it is a crime that suppliers would deliberately hide. By investing in Blockchain, suppliers and customers may learn that the decentralized nature of Blockchain necessitates consensus among all participants in the supply chain, which may thwart unethical partners from deceiving others, i.e., engaging in hidden MS activities. By leveraging the unalterable nature of Blockchain to track employment contracts, it becomes difficult for suppliers to tamper with or manipulate records of their recruitment processes. Storing employment related information in the Blockchain can safeguard the rights and interests of workers, thereby enabling firms to build MS supply chain capabilities with customers and suppliers (Han *et al.*, 2022; Queiroz and Fosso Wamba, 2019). For instance, Diginex collaborated with the Coca-Cola Company and Reckitt to develop a Blockchain-based solution called diginexLUMEN aimed at tackling MS in agricultural supply chains by monitoring working conditions, recruiting data, and employment information in the Blockchain (Kerencheva, 2022). This approach allows companies to evaluate suppliers and customers for potential instances of MS, so they can take appropriate actions to address such risks. Given the above important technology qualities, Blockchain becomes an important tool for developing MS capabilities with supplier and customer. Thus, we posit:

H2: SIBT is positively associated with (b) MSCS and (c) MSCC.

3.4. Internal and external MS supply chain capabilities

The supply chain management literature has produced plenty of evidence showing when a focal firm has developed internal technical capabilities they will transfer and expand the best practices to its suppliers and customers (Jacobs *et al.*, 2016; Yu *et al.*, 2023). Here we expand the theoretical ideas about resource accumulation and deployment (Lavie, 2012; Maritan and

Peteraf, 2011) to a supply chain setting. We argue that a focal firm must accumulate enough knowledge to produce effective internal working procedures before they can expand the application of Blockchain to their suppliers and customers. This is highly relevant for MS supply chain capabilities because suppliers might not invest in such capabilities if their buyers do not do so. When focal firms built up strong IMSC, it also signals suppliers and customers that they are serious about tackling MS. Without first implementing MS management practices, it is difficult for companies to extend these MS practices to suppliers and customers. Focal firms with strong internal MS can only effectively tackle MS in the supply chains after their suppliers and customers also build up their own technical capabilities and begin to collaborate. Internal collaboration capability facilitates collaboration with external stakeholders (Jacobs et al., 2016).

Building internal functional capabilities within the company serves as an absorptive capacity that enables the focal company to learn from external partners (Schroeder *et al.*, 2002). While the transfer of Blockchain knowledge to suppliers and customers requires focal companies to have absorptive capacity (from EDD and SIBT), focal firms can learn from external business partners to identify, address, and reduce MS in supply chains. So, the resource accumulation and deployment processes may expand to the interfaces such that learning between the focal companies, suppliers and customers intensify. In other words, IMSC acts as a prerequisite to extending the scope of MS management practices outside the organization. As such, higher levels of IMSC can help focal firms to build a high level of external MS supply chain capabilities.

H3: IMSC is positively associated with (a) MSCS and (b) MSCC.

3.5. Mediation effect of IMSC

While Blockchain technology has garnered considerable attention for its potential to revolutionize supply chains, there are instances where its adoption may not live up to expectations and thus fail to deliver anticipated benefits (Kamble *et al.*, 2019; Sternberg *et al.*, 2021). It is important to recognize that Blockchain is a technological solution that supports the processes for identifying, addressing, and combating MS in the supply chains. That means Blockchain implementation for tackling MS must involve suppliers and customers. However, it is usually the focal firms that face higher regulatory pressures to tackle MS. While strategic investment in Blockchain (SIBT) kick starts the resource deployment process, the focal firms need to develop new capabilities to guide the supply chain-level resource accumulation and deployment processes. They must use IMSC to define the inter-organizational processes, supported by Blockchain and required to track the recruitment and treatment of workers in multi-tier supply chains, the reporting requirements, and processes that can inform customers. Thus, IMSC is not just for internal functions, it sets (governance) standards and develops MS inter-organizational processes supported by Blockchain for supporting collaboration with suppliers and customers. One can view IMSC as a bridging resource that transforms investment in Blockchain by a focal firm into inter-organization and information sharing processes for tacking MS issues (MS capabilities with suppliers and customers).

The above argument suggests SIBT can support implementation of collaborative MS supply chain practices with customers and suppliers through IMSC that leverages Blockchain technology. Moreover, IMSC allows focal firms to foster an inclusive and open organizational culture that promotes diversity and actively addresses MS issues, provides MS trainings for employees, facilitates employee participation in external events, enhances ethical policies, and establishes a whistleblowing hotline (Gold *et al.*, 2015; Grimm *et al.*, 2016; Stevenson and Cole, 2018). These norms convince suppliers and customers to participate in the Blockchain project as there is already enough preparation and commitment by the focal firm. A lack of IMSC may undermine the company's ability to implement collaborative MS management practices with supply chain partners. Building IMSC assists firms that adopt Blockchain technology together with customers and suppliers. Thus, we posit:

H4: IMSC positively mediates the relationships (a) between SIBT and MSCS and (b) between SIBT and MSCC.

3.6. Moderation effect of EDD

While SIBT can directly drive the development of IMSC (H2a), we suspect EDD plays a moderating role in this relationship. Also, while EDD was hypothesised to impact SIBT (H1), EDD, as a moderator, could have an alternative role that complements the integrated nature of our theoretical model. Because there must be an alignment between EDD and Blockchain applications, companies make a mistake if they invest in the Blockchain technology used to develop capability for tackling MS in the supply chain separately from the human resource processes that develop digital competencies. Employees may draw upon their existing knowledge and current processes and tools inside the organization to collect, sort, process, and analyse MS data from their supply chains, which often is ineffective (New, 2015). Those who do not deploy EDD into translating investment into the IMSC development might fail to use Blockchain fully because they are less open or less digitally ready to translate qualities like transparency, traceability (Fosso Wamba *et al.*, 2020; Khan *et al.*, 2022; Kusi-Sarpong *et al.*, 2022), immutability and non-repudiability (Hald and Kinra, 2019) into IMSC.

The investment in Blockchain (SIBT) from a pure technical perspective means focal firms may ignore promising digital competencies (and rely on outsider technologists). Technology alone is inadequate if employees lack essential digital skills, knowledge, mindset, and leadership qualities (Ahmed *et al.*, 2022; Kropp *et al.*, 2021; Proksch *et al.*, 2024). IMSC is not a pure technological capability, as focal firms need employees to monitor, develop and govern the Blockchain systems. Focal firms do not just deploy financial means (to invest), they must also mobilize digital competencies from within their organizations. To fully adopt the Blockchain's technical capabilities into internal MS processes, it is important to utilize digital competencies of employees, e.g., digital skills and knowledge, digital leadership, and digital talent development (Ahmed *et al.*, 2022; Frankiewicz and Chamorro-Premuzic, 2020). This study argues that a resource accumulation and deployment perspective is required to develop technology-mediated capability, e.g., IMSC. It is dexterous employees who learn how to expand the application of the technical qualities of Blockchain to new processes that boost the effects of SIBT on IMSC. The higher the EDD, the more effective the integration of technical qualities from Blockchain into internal MS processes becomes. Thus, we hypothesize:

H5: EDD positively moderates the relationship SIBT and IMSC.

4. Research methodology

4.1. Survey data collection

We collected primary data by conducting a large-scale survey among manufacturers in China. We sampled from China because it has a nation-wide strategy to implement Blockchain applications in industries (Dutta et al., 2020). Initially, we made efforts to directly contact potential participants to gauge their interest in taking part in this research project. Unfortunately, many of them declined to participate as they were primarily focused on recovering from and surviving the COVID-19 pandemic. To improve the response rate and the quality of data collection, we decided to partner with a professional survey marketing company. The survey marketing company provided a directory of 800 manufacturing firms, which were randomly selected and contacted, ultimately resulting in 210 usable responses (response rate of 26.25%)

------------------------------ Insert Table 1 -------------------------------

Table 1 provides a summary of the sample companies' profiles. Therein can be seen that the responding companies represent a diverse range of businesses in terms of manufacturing industries, firm size, age, and geographical locations. For instance, the companies operate in various manufacturing industries, including electronics and electrical, industrial machinery and equipment, chemicals and petrochemicals, and many others. The data also reveal that a significant portion of the companies have been in operation for more than 20 years. Furthermore, the companies are situated in various economic development regions and provinces, encompassing the south, east, north, central, and west of China, each representing different phases of industrial development in the country.

The questionnaire was completed by informants holding executive roles within their respective organizations, including CEOs, directors, and managers, most of whom had over 10 years of experience. In addition, when reaching out to key informants, we requested that knowledgeable respondents complete various sections of the questionnaire. For instance, we suggested that HR managers, responsible for overseeing employee recruitment, training, and personnel development, should complete the EDD section, while chief supply chain or logistics officers were recommended to handle the MS supply chain capabilities section. The SIBT section is intended for completion by chief technology officers or technology managers responsible for digital technology project management, particularly in the adoption of Blockchain technology. If necessary, they were also encouraged to seek input from senior managers in the relevant functional departments. Thus, we believe that the respondents possessed extensive knowledge and ability to effectively respond to the questionnaire.

4.2. Bias and endogeneity assessment

The t-test was utilized to assess non-response bias (Hair *et al.*, 2018), and the results indicated no significant statistical differences between the groups regarding the number of employees and annual sales in relation to early and late responses. This finding suggests that non-response bias is not likely to be a concern in this study.

To assess common method bias (CMB), two statistical approaches were employed. Firstly, Harman's single-factor test was performed using confirmatory factor analysis (CFA). The results indicated unsatisfactory model fits (χ^2 / df = 4.176; CFI = .755; IFI = .757; TLI = .735; RMSEA = .123; and SRMR = .124). Secondly, to further explore the possibility of CMB, the marker variable technique was employed (Lindell and Whitney, 2001). Respondents' job tenure was considered as a marker variable, which is theoretically unrelated to at least one scale examined in this study. As presented in Table 3, the lowest positive correlation (r = .010) between the marker variable and other variables was used to adjust the inter-construct correlations and assess their statistical significance (Lindell and Whitney, 2001). The findings indicate that, even after the adjustment, the previously significant correlations remained significant. Thus, the results above demonstrate that CMB is not a significant concern in this study.

The CMB evaluation reported above also serves to mitigate potential endogeneity concerns. Researchers suggest that CMB is a significant source of measurement error, which could result in endogeneity (Ketokivi and McIntosh, 2017). As mentioned earlier, we have taken steps to reduce this risk, thereby minimizing the potential threat of endogeneity resulting from measurement error. Furthermore, there is the potential for endogeneity arising from a reverse causality relationship between the independent and dependent variable (Ketokivi and McIntosh, 2017). From the resource accumulation and deployment perspective, we postulate the impacts of EDD and SIBT on operational performance, and these viewpoints do not support the notion that operational performance influences EDD or SIBT. Therefore, it is unlikely that our data analysis results are significantly affected by endogeneity. Nonetheless, we acknowledge that eliminating endogeneity is improbable, which we recognize as a limitation of our cross-sectional research design.

4.3. Measures and controls

The measurement items utilized in this study are presented in Table 2. Content validity was established prior to data collection through a comprehensive analysis of relevant literature and a pilot test conducted with academics and practitioners. Initially developed in English, the original measurement scales were then translated into Chinese and subsequently back translated to enhance the reliability of the questionnaire (Yu *et al.*, 2023). In the translation process, certain items were slightly modified to improve accuracy and ensure their relevance to digital and MS supply chain practices implemented by companies in China. To further assess the relevance and clarity of the measurement items, academic experts and industrial executives were consulted during the pilot test. Based on the feedback received, redundant and ambiguous items were eliminated or modified to enhance the content validity of the measurement scales.

------------------------------- Insert Table 2 -------------------------------

The measures for the three dimensions of the MS supply chain capabilities were developed mainly based on the work of Stevenson and Cole (2018) and others (e.g., Benstead *et al.*, 2021; Geng *et al.*, 2022; Gold *et al.*, 2015; Han *et al.*, 2022; Meehan and Pinnington, 2021), in addition to reports from consulting companies and organizational MS statements and reports. IMSC focuses on implementing MS management practices within the organization at the organizational level, while MSCC and MSCS focused on detecting and remediating MS in the SC operations and implementing collaborative MS management practices with suppliers and customers. The measures for SIBT were adapted from Fosso Wamba *et al.* (2020) and Kusi-Sarpong *et al.* (2022), who focused on adopting Blockchain technology in the SC process to integrate different SC partners. The measures for EDD were adapted from Ahmed *et al.* (2022) and Proksch *et al.* (2024), who focused on assessing employees' capacity to utilize digital technologies, encompassing digital skills, knowledge, experience, and technical know-how.

The theoretical model incorporated three control variables: firm age (measured by the number of years since the firm's foundation), firm size (measured by the number of employees), and the manufacturing industry (represented by a dummy variable). We controlled for firm size and age in the research model because larger or older firms might possess more necessary organizational resources to invest in Blockchain technology for building MS supply chain capabilities compared to smaller or younger firms (Han *et al.*, 2022; Yu *et al.*, 2023). In addition, firms operating in different manufacturing industries might conduct varying levels of investment in Blockchain technology and harness the benefits of SIBT for developing MS supply chain capabilities (Han *et al.*, 2022; Jiang *et al.*, 2023).

5. Analysis and results

5.1. Reliability and validity analysis

We conducted a CFA to evaluate the reliability and validity of the theoretical constructs. The outcomes are presented in Tables 2 and 3. According to the findings in Table 2, the measurement model exhibits a favourable fit (χ^2 / df = 1.746; CFI = .944; IFI = .945; TLI = .930; RMSEA = .060; SRMR = .053), indicating that the constructs possess unidimensionality (Hair et al., 2018). As depicted in Table 3, the Cronbach's alpha values (ranging from .827 to .936) and composite reliability (ranging from .827 to .936) of all constructs exceed the threshold of .70, which affirms the high reliability of all scales employed in this study (Hair *et al.*, 2018).

---------------------------------- Insert Table 3 ----------------------------------

According to Table 2, the CFA results demonstrate that all indicators within their respective constructs exhibit statistically significant factor loadings exceeding .60. This finding strongly supports the convergent validity of the constructs (Hair *et al.*, 2018). Table 3 illustrates that the average variance extracted (AVE) for each construct surpasses the recommended minimum value of .50, ranging from .545 to .699. This observation suggests a robust convergent validity (Fornell and Larcker, 1981).

Discriminant validity was assessed using two approaches. Firstly, previous research (Hair *et al.*, 2018; Kline, 2005) suggests that it is unlikely for items assigned to one construct to significantly load on others unless the correlations between theoretical constructs are exceptionally high (r > .90). Evaluating discriminant validity, this criterion has been commonly employed by previous empirical studies (e.g., Cheung *et al.*, 2010; Singh *et al.*, 2011). Table 3 shows inter-construct correlations are below the commonly accepted threshold of .90 (Hair *et al.*, 2018; Kline, 2005), which demonstrates that there is unlikely to be an issue related to discriminant validity. Secondly, the Heterotrait-Monotrait (HTMT) approach was utilized to evaluate the discriminant validity (Henseler *et al.*, 2015). Researchers have not reached a consensus on the precise threshold level for HTMT (Franke and Sarstedt, 2019). Some researchers suggest that HTMT values should be lower than .85 (e.g., Henseler *et al.*, 2015, who propose a stricter threshold) or .90 (e.g., Grewal *et al.*, 2004; Hair *et al.*, 2019, who advocate for a more lenient threshold), while others (e.g., Franke and Sarstedt, 2019; Voorhees *et al.*, 2016) propose that an HTMT value below 1 confirms discriminant validity among theoretical constructs. The findings presented in Table 4 indicate that all the constructs have HTMT ratios below the accepted threshold of .90, thereby confirming the reasonable levels of discriminant validity for the constructs.

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5.2. Hypothesis testing

We utilized structural equation modelling to examine the hypothesized relationships, and the findings are presented in Table 5. The results indicate that the overall model fit indices are deemed acceptable (χ^2 / df = 1.708; CFI = .925; IFI = .926; TLI = .914; RMSEA = .058; SRMR = .068). Although three control variables, namely firm size, firm age, and industry type, were incorporated into the structural models, none of them exhibited a significant positive effect on either MSCS or MSCC.

--------------------------------- Insert Table 5 ---------------------------------

According to the findings presented in Table 5, the structural model indicates a significant association between EDD and SIBT (β = .687, $p < .001$), providing support for H1. While SIBT is positively associated with IMSC (β = .536, $p < .001$), there is no statistically significant relationships between SIBT and MSCS (β = -.018, *n.s.*) or MSCC (β = -.054, *n.s.*). Consequently, H2a is supported, while H2b and H2c are rejected. Additionally, IMSC is positively associated with MSCS (β = .968, $p < 0.001$) and MSCC (β = .991, $p < 0.001$). Thus, H3a and H3b receive support.

We employed a bias-corrected bootstrapping approach with 2,000 resamples to examine the mediating effect of IMSC (H4a and H4b). The results, as presented in Table 6, indicate that there is no significant direct relationship between SIBT on MSCS (β = -.018 *n.s.*). However, there is a positive association between SIBT and MSCS through IMSC (β = .519, $p < .001$; 95% CI [.362–.696]), providing evidence for the mediating role of IMSC. The Sobel test (z = 5.309, $p < .001$) further confirms the presence of this mediating effect, supporting H4a. Table 6 also demonstrates similar results for the relationship between SIBT and MSCC, providing further support for H4b, which suggests that IMSC fully mediates the relationship between SIBT and MSCC.

------------------------------ Insert Table 6 -------------------------------

We utilized moderated regression analysis to examine the moderating effect of EDD. The results, presented in Table 7, indicate that the variance inflation factors (VIF) values in all models are below 2, suggesting the absence of significant multicollinearity issues in this study (Hair et al., 2018). Model 1 in Table 7 incorporates control variables (i.e., firm age, size, and industry type). However, no significant positive effect on IMSC was observed, except for firm size. Model 3 reveals that the interaction between SIBT and EDD is not statistically associated with IMSC (β = .009, *n.s.*). Consequently, H5 is rejected.

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6. Discussion and implications

6.1. Theoretical implications

This study makes significant contributions to the literature on MS and Blockchain by revealing the resource accumulation processes to develop Blockchain applications for tackling MS (Christ and Helliar, 2021; Jiang *et al.*, 2023). The resource accumulation process relies on employee's digital dexterity (EDD) because it is a resource related to Blockchain. We show that firms with EDD are more likely to strategically invest in Blockchain technology (SIBT) for developing MS supply chain capabilities. That means firms do not just invest in a yet-to-be proven technologies like Blockchain. They need sufficient related knowledge (absorptive capacity) to learn it, and they also need sufficient skills to clarify uncertainties facing the investment decision. We also show the resource accumulation process starts from the focal firm developing internal MS capabilities based on strategic investment in Blockchain, before expanding to suppliers and customers. That means resource accumulation processes are path dependent. One can imagine a pyramid where EDD is the base supporting the technology investment decision, then internal MS capabilities become the next level supporting the development of the next level, MS capabilities with suppliers and customers.

One significant theoretical contribution of this study is that, for the first time, we conceptualize MS in supply chains as a multidimensional construct from the upstream, internal, and downstream perspectives of the supply chain. This construct consists of three main dimensions, namely IMSC, MSCS, and MSCC. This comprehensive and integrated conceptualization significantly extends the existing MS research (e.g., Stevenson and Cole, 2018) by teasing out the scope of the practices and validating the measurement scales for future studies. Moreover, we show combating MS in supply chains requires a strategic collaboration with suppliers and customers (Benstead *et al.*, 2021; Bodendorf *et al.*, 2023; Stevenson and Cole, 2018) that is fundamentally supported by IMSC, thus revealing that internal MS capabilities serve as the basis or foundation for deploying external MS supply chain capabilities.

Another important theoretical implication is that we demonstrate the mediating role of IMSC. The finding advances past studies that argue for the need to collaborate to tackle MS (Benstead *et al.*, 2021; Bodendorf *et al.*, 2023; Simpson *et al.*, 2021). We add to the existing MS research by showing internal MS capabilities must be developed to drive external (suppliers and customers) development (Gold *et al.*, 2015; Grimm *et al.*, 2016; Stevenson and Cole, 2018). This contributes to understand how SIBT improves MS supply chain capabilities beyond pilot testing and anecdotal evidence (e.g., Christ and Helliar, 2021; Mullan, 2020). The mediation role of IMSC implies, however, no direct significant effects of IMSC on MSCS (H2b) and MSCC (H2c). An interpretation of this result suggests a potential lack of trust between some customers and suppliers. While one school of thought suggests that Blockchain removes the need of trust, the other suggests that Blockchain without previous trust makes no sense (Cole *et al.*, 2019). High levels of trust lend themselves to Blockchain implementation, and firms in our sample may not necessarily have strong and trusting relationship with all their suppliers and customers. In contrast, internally, trust levels are expected to be higher than externally, which shows how Blockchain seems to have a stronger effect internally on MS in our sample.

We argue our findings serve as a platform for advancing a cumulative capability perspective of MS supply chain capability. We show IMSC serves as the base for integrating suppliers' and customers' processes for training, detecting and mitigating MS risk. IMSC is fundamental to fostering an inclusive and open organizational culture and enhancing ethical policies, provides fundamental foundations for companies to implement collaborative MS practices with supply chain partners. This capability is required to fully transfer and integrate Blockchain applications into suppliers and customers because traceability and trust is key to strengthening collaboration dedicated to tackle MS issues with customers and suppliers (Han *et al.*, 2022).

This study enriches the MS literature by showing Blockchain technology and employee digital competence are related resources. As opposed to using typical digital competency constructs, we demonstrate that EDD, borrowed from the entrepreneurship literature (e.g., Ahmed *et al.*, 2022; Proksch *et al.*, 2024), is valuable as it emphasizes HR practices such as selecting employees with digital competency and cultural elements like emphasizing the review of digital projects. We find that Chinese manufacturers developed EDD as a resource accumulation process to support Blockchain investment decisions. They are related resources because they both focus on increasing transparency and traceability. Employee's digital competencies are important for clarifying uncertainty in investing in Blockchain application (Ahmed *et al.*, 2022). Here we show steps or pathways for accumulating enough resources to develop MS capabilities. We show developing MS supply chain capabilities relies heavily on strategic investments in Blockchain (SIBT). This shows, among many pathways manufacturers could consider, employees' digital competencies and investment in Blockchain are the main driver in China.

Our initial arguments suggest companies with employees with high levels of EDD (such as digital knowledge, mindset, and skills) are more likely to obtain the full value of Blockchain technology for detecting and remediating MS in global supply chains. Surprisingly, we found no moderation effect of EDD on the relationship between SIBT and IMSC (H5). The findings show EDD can drive investment in Blockchain technology and it is other pathways (other than digital competencies) that affect the effectiveness of SIBT. Perhaps the effectiveness of EDD depends on other technical, people and social elements not accounted by the EDD conceptualization (Ahmed *et al.*, 2022; Kropp *et al.*, 2021). From the resource accumulation and deployment perspective, EDD functions as a process for accumulating resources, assisting organizations in identifying uncertainties in Blockchain technology investments and supporting strategic decisions related to Blockchain investments.

This study reveals there might be many resource accumulation pathways in which Blockchain technology is deployed to support MS capabilities for detecting and remedying MS in global supply chains. (Han *et al.*, 2022; Jiang *et al.*, 2023). While we show the roles of EDD and SIBT from the resource accumulation perspective, our findings show more research gaps in understanding the role of digital technologies in detecting and eliminating MS in supply chains (Han *et al.*, 2022; Szablewska and Kubacki, 2023). Alongside recent empirical studies that have examined the role Blockchain technology plays in improving supply chain sustainability (Khan *et al.*, 2022) and sustainable production (Kusi-Sarpong *et al.*, 2022), this study provides crucial evidence for a deeper understanding of the roles of Blockchain technology in combating MS (Christ and Helliar, 2021; Jiang *et al.*, 2023).

6.2. Managerial implications

The empirical findings discussed above provide timely and meaningful practical guidance to managers who seek to detect and combat MS in their global supply chains in today's digital era. Firstly, over the years, an increasing number of MS scandals have come to light. MS is currently garnering significant attention from various stakeholder groups, including governments, NGOs, the media, and other interested parties (Child, 2020; Eccles, 2022). Our study reminds managers that more comprehensive and integrated MS supply chain capabilities should be developed, which cross the entire supply chain process from the supplier, internal, and customer perspectives. Implementing collaborative MS management practices with suppliers is important, but it is also necessary to implement MS supply chain practices with customers and within the organization as well. Building both internal and external MS supply chain capabilities is crucial for companies to effectively address and remediate MS in their supply chains.

Secondly, among the three main dimensions of MS supply chain capabilities, our study indicates that managers should prioritize the implementation of internal MS practices, as it provides a fundamental internal foundation for creating external MS supply chain capabilities and acts as a basis for using Blockchain when collaborating with suppliers and customers. Internal MS practices encompass fostering an inclusive and open organizational culture that promotes diversity and actively addresses MS issues, providing MS trainings for employees, encouraging employees to take part in external MS events, enhancing ethical policies, and establishing a whistleblowing hotline.

Thirdly, our study also reminds managers that not only a technical view is needed when building new MS supply chain capabilities. Managers should consider resource accumulation as a process for developing new MS supply chain capabilities. There is a need for complementary strategic investments in technologies that aid in tracing the use of labour in the supply chain, which involve uncertainties. Having and recruiting digitally competent employees is a way to address such uncertainties. That means the starting point is HR policy to recruit digitally competent employees, who demonstrate proficiency in various digital tools, platforms, and techniques to drive digital transformation initiatives. However, managers should also promote a culture that encourages employees to be innovative and proactive to actively engage in conversations about ongoing digital transformation projects. We suggest that managers develop strategies and processes to develop digital dexterity of employees and investment in Blockchain technology as the basis for effectively developing new MS supply chain capabilities.

Finally, this study also indicates that fully harnessing the benefits of Blockchain technology requires companies enhance the digital dexterity of their employees through a resource accumulation lens. It is important to balance between technology and people, as the technology itself is not autonomous enough to detect and tackle complex MS issues. To more effectively identify and address MS in supply chains, companies need to strengthen their employees' digital competencies as well as experience, mindset, skills, and talent related to traceability in the supply chains.

6.3. Research limitations

Although this study generates significant theoretical and practical contributions, it also has certain limitations that provide directions for future research. Firstly, this study focuses on how companies can build MS supply chain capabilities by strategically shaping and structuring their employees' digital competencies and investment in Blockchain. This study has not investigated the outcomes and benefits of the new MS supply chain capabilities (Han *et al.*, 2022). Future studies can examine how the three dimensions of MS capabilities affect performance outcomes such as financial, environmental, social, or operational performance.

Secondly, this study relies on a resource accumulation perspective, which provides some, but perhaps incomplete, explanation for the different resource pathways. There may be other social elements that cover a culture to increase traceability and ethical value that treat MS violations as unethical rather than just a risk to mitigate. In other words, the positive impact of Blockchain adoption on MS capability may be attributed to socially positive externalities, such as organizational learning, organizational culture, reputation, information and knowledge sharing, and infrastructure and technologies (e.g., big data analytics) that can support the detection of MS (Jiang *et al.*, 2023). Thus, future research might examine these factors and how companies bundle these resources to address, identify, and combat MS in supply chains.

Thirdly, in this study, we incorporated three control variables (firm age, firm size, and the manufacturing industry types) that have been commonly used in previous research within the supply chain management field. We suggest that future research explore additional potential control variables at the corporate governance level (e.g., regulatory environment and top management team characteristics) to investigate the effect of Blockchain technology on the development of MS supply chain capabilities.

Finally, in this study, we gathered survey data from manufacturers in China. Other countries may have different contexts that might change the results. Although we made efforts to eliminate the potential CMB, and the statistical tests also demonstrated that CMB is not a serious issue in this study, we recognize that eliminating endogeneity is unlikely. Therefore, we encourage future research to employ other research approaches, such as in-depth case study interviews and collecting secondary data using the company's MS statements.

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Table 1: Sample characteristics (n = 210)

	%		%
Industry type		**Firm location**	
Automobile	6.2	Pearl River Delta	11.0
Building materials	7.6	Yangtze River Delta	2.9
Chemicals and petrochemicals	11.4	Bohai Sea Economic Area	26.2
Electronics and electrical	14.8	Northeast China	24.3
Fabricated metal products	7.6	Central China	31.9
Food, beverage and alcohol	9.5	Southwest China	3.3
Industrial machinery and equipment	13.3	Northwest China	.5
Pharmaceutical and medical	5.2	**Firm age (years)**	
Publishing and printing	1.9	≤ 20	60.0
Rubber and plastics	8.1	21 – 40	36.7
Textiles and apparel	8.1	41 – 60	2.9
Toys	2.4	> 60	.5
Wood and furniture	1.4	**Job title**	
Others	2.4	President/CEO	11.9
Number of employees		Vice President	9.5
≤ 100	40.5	Director	13.3
101 – 500	37.1	Manager	57.6
501 – 1000	15.2	Other senior executive	7.6
> 1000	7.1		
Job tenure			
≤ 10	65.7		
11-20	29.0		
> 20	5.2		

Source(s): Authors' own creation

Table 2: Descriptive statistics: loadings, mean, and S.D.

Survey questions	Factor loadings	Mean	S.D.
1. Employees' digital dexterity (EDD)			
Digital skills are an important selection criterion in recruiting new employees	.717	5.538	1.242
Our employees use all digital services and products we offer	.729	5.619	1.205
Our employees have the necessary skills to further digitalize our company	.756	5.581	1.262
We actively discuss our digital projects within our company including failures and best practices	.750	5.605	1.257
2. Strategic investment in Blockchain technology (SIBT)			
Our company invests resources in blockchain-enabled supply chain applications	.809	5.286	1.378
Our company would be willing to make further investment in blockchain technology to facilitate communication with supply chain partners	.711	5.500	1.339
Business activities in our company require the use of blockchain technology	.802	5.171	1.461
Functional areas in our company require the use of blockchain technology	.693	5.290	1.437
Blockchain technology is highly applicable to our company and may be considered to replace the current contractual relationship with supply chain partners	.754	5.252	1.493
Our company can count on trading partners to be sincere based on blockchain-enabled supply chain applications	.728	5.305	1.356
3. Internal MS capability (IMSC)			
We create the right inclusive, open culture within the firm, including around diversity and modern slavery	.650	4.819	1.735
We provide trainings for employees on modern slavery	.767	3.900	1.890
Our employees attend cross-industry seminars and workshops to network and improve knowledge on modern slavery	.799	4.186	1.779
We augment existing internal ethical policies to incorporate modern slavery concerns with widespread dissemination within the firm	.772	4.390	1.879
We provide whistle blowing hotline within the firm with protection and anonymity for whistle blowers	.829	4.362	1.979
4. MS capability with suppliers (MSCS)			
We develop trusting, open relationships with suppliers with an open dialogue on detection and remediation of modern slavery (e.g., child labour, forced labour and human trafficking)	.827	4.548	1.882
We conduct supplier audits to assess their policies for modern slavery and human trafficking	.846	4.443	1.904
We conduct detailed document analysis in suppliers (e.g., worker identification cards, right to work, age, payment of recruitment fees, etc.)	.661	4.710	1.798
We conduct supplier modern slavery self-assessment questionnaires	.844	4.143	1.936
We suspend supply arrangements until modern slavery concerns have been addressed	.878	4.224	2.005
We terminate supply arrangements if the remediation plan of modern slavery is not met on time	.832	4.190	1.869
We provide anonymous whistle blowing hotline for suppliers with follow-up detection activities of modern slavery	.854	4.167	2.006
5. MS capability with customers (MSCC)			
We collaborate with customers to ensure remediation of modern slavery	.862	4.114	1.893
We publish modern slavery audit reports online, so they are available to customers	.895	4.133	1.993
We disclose annual modern slavery statements to customers	.864	4.167	1.987
We incentivise customers to detect modern slavery concerns	.856	4.138	1.948

Note: Model fits: χ^2 = 486.006; df = 289; χ^2 / df = 1.682; CFI = .951; IFI = .952; TLI = .945; RMSEA = .057; SRMR = .053; Source(s): Authors' own creation

Table 3: Construct-level correlation matrix and reliability and validity analysis

Variables	Mean	S.D.	EDD	SIBT	IMSC	MSCS	MSCC	Cronbach's alpha	Composite reliability	AVE
EDD	5.586	1.007		.576**	.339**	.315**	.276**	.827	.827	.545
SIBT	5.301	1.125	.580**		.439**	.475**	.429**	.885	.885	.564
IMSC	4.331	1.511	.346**	.445**		.809**	.807**	.874	.876	.586
MSCS	4.346	1.627	.322**	.480**	.811**		.898**	.936	.936	.678
MSCC	4.138	1.766	.283**	.435**	.809**	.899**		.925	.925	.756
MK	1.400	.588	.147*	.214**	.061	.010	.016	–	–	–

Note: Marker variable (MK) is respondents' job tenure; the unadjusted correlations are located below the diagonal, while the adjusted correlations for potential common method variance can be found above the diagonal.; ** $p < 0.01$; * $p < 0.05$; Source(s): Authors' own creation

Table 4: HTMT ratio

Constructs	EDD	SIBT	IMSC	MSCS	MSCC
Employees' digital dexterity (EDD)					
Strategic investment in Blockchain technology (SIBT)	.580				
Internal MS capability (IMSC)	.346	.448			
MS capability with suppliers (MSCS)	.323	.484	.810		
MS capability with customers (MSCC)	.282	.438	.808	.898	

Source(s): Authors' own creation

Table 5: Results of direct effect test

Pathways in the model	Unstandardized coefficient	t-value	Hypothesis testing result
EDD → SIBT	.687***	7.824	H1: Supported
SIBT → IMSC	.536***	6.298	H2a: Supported
SIBT → MSCS	-.018	-.383	H2b: Not supported
SIBT → MSCC	-.054	-1.084	H2c: Not supported
IMSC → MSCS	.968***	9.960	H3a: Supported
IMSC → MSCC	.991***	10.183	H3b: Supported
Control variables			
Firm age → MSCS	.057	1.514	
Firm size → MSCS	.051	1.272	
Electronics and electrical → MSCS	-.008	-.221	
Industrial machinery and equipment → MSCS	-.001	-.035	
Chemicals and petrochemicals → MSCS	-.036	-.959	
Food, beverage and alcohol → MSCS	-.032	-.905	
Firm age → MSCC	.028	.706	
Firm size → MSCC	.057	1.380	
Electronics and electrical → MSCC	-.012	-.304	
Industrial machinery and equipment → MSCC	-.024	-.637	
Chemicals and petrochemicals → MSCC	.001	.021	
Food, beverage and alcohol → MSCC	.0001	.002	
Variance explained	R^2		
SIBT	.472		
IMSC	.287		
MSCS	.944		
MSCC	.945		

Model fits: χ^2 = 714.096; df = 431; χ^2 / df = 1.657; CFI = .932; IFI = .933; TLI = .922; RMSEA = .056; SRMR = .067; *** $p < 0.001$; Source(s): Authors' own creation

Table 6: Results of mediation test

Structural paths	Direct effect	Indirect effect	95% CI for indirect effect	Sobel test	Meditation test result
SIBT→IMSC→MSCS	-.018	.519***	.362–.696	z = 5.309***	H4a: Supported (full mediation)
SIBT→IMSC→MSCC	-.054	.531***	.374–.719	z = 5.345***	H4b: Supported (full mediation)

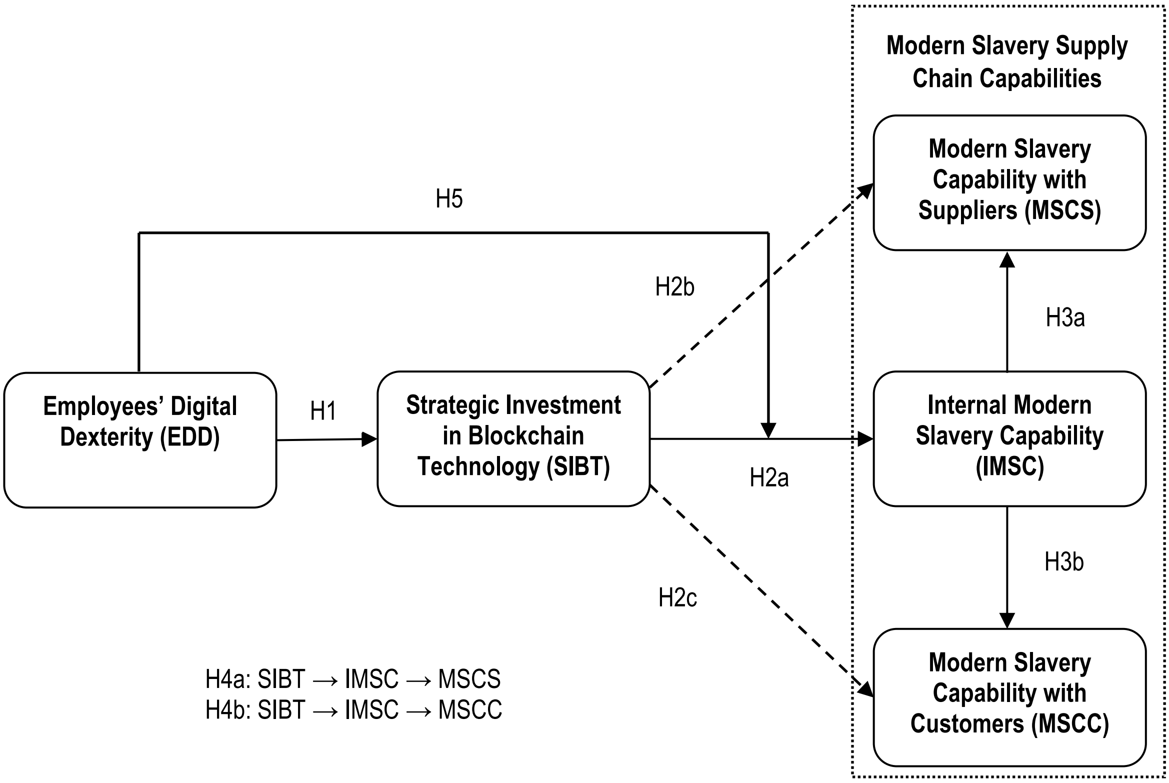
Note: CI: bootstrap confidence interval; Standardized effects; 2,000 bootstrap samples; *** $p < 0.001$; Source(s): Authors' own creation

Table 7: Results of moderation test

	Model 1	Model 2	Model 3
Control variables			
Firm age	-.003 (-.038)	-.042 (-.641)	-.041 (-.631)
Firm size	.394 (5.345)***	.316 (4.611)***	.315 (4.566)***
Electronics and electrical	.012 (.178)	.004 (.060)	.003 (.047)
Industrial machinery and equipment	-.059 (-.858)	-.061 (-.975)	-.061 (-.958)
Chemicals and petrochemicals	-.037 (-.523)	.000 (.002)	.000 (.007)
Food, beverage and alcohol	-.095 (-1.416)	-.093 (-1.515)	-.093 (-1.512)
Independent variable			
SIBT		.335 (4.594)***	.335 (4.583)***
Moderator			
EDD		.097 (1.327)	.097 (1.325)
Interaction effect			
SIBT × EDD			.009 (.147)
R^2	.156	.306	.306
Adjust R^2	.131	.278	.274
F-value	6.271***	11.056***	9.782***
Max VIF	1.309	1.556	1.556

Note: Standardized coefficients and t-values are reported; Dependent variable is IMSC; *** $p < 0.001$; Source(s): Authors' own creation

Figure 1: Proposed research model



Source(s): Authors' own creation