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Effects of supply chain transparency, alignment, adaptability, and agility on blockchain adoption in supply chain among SMEs

Mohammad Iranmanesh^a, Parisa Maroufkhani^b, Shahla Asadi^c, Morteza Ghobakhloo^{d,j}, Yogesh K. Dwivedi^{e,f,*}, Ming-Lang Tseng^{g,h,i}

^a School of Business and Law, Edith Cowan University, Joondalup, WA 6027, Australia

^b The University of Waikato Joint Institute, Zhejiang University City College, Hangzhou, PR China

^c School of Computing & Engineering, University of Gloucestershire, The Park, Cheltenham GL50 2RH, UK

^d School of Economics and Business, Kaunas University of Technology, K. Donelaičio g. 73, Kaunas 44249, Lithuania

^e Digital Futures for Sustainable Business & Society Research Group, School of Management, Room #323, Swansea University, Bay Campus, Fabian Bay, Swansea SA1 8EN, Wales, UK

^f Symbiosis Institute of Business Management, Pune & Symbiosis International (Deemed University), Pune, India

^g Institute of Innovation and Circular Economy, Asia University, Taiwan

^h Department of Medical Research, China Medical University Hospital, China Medical University, Taiwan

ⁱ Ramon V. Del Rosario College of Business, De La Salle University, Manila, Philippines

^j Division of Industrial Engineering and Management, Uppsala University, PO Box 534, Uppsala, Sweden

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ABSTRACT

This study aims to investigate the extent to which the contributions of blockchain technology to supply chain parameters influence blockchain adoption among SMEs. Drawing on contingency theory, the study investigates the moderating effect of market turbulence. The data were collected from 204 SMEs in Malaysia's manufacturing sector and analysed using the partial least squares technique. The results showed that the intention of SMEs' managers to adopt blockchain is influenced by the contributions of blockchain to supply chain transparency and agility. Supply chain transparency, alignment, adaptability, and agility are interrelated. Market turbulence moderates positively the association between agility and intention to adopt blockchain. This study extends the literature by decomposing the concept of relative advantages and investigating the influences of blockchain benefits on blockchain adoption. The moderating effect of market turbulence indicates that the influence of blockchain on agility is more important for SMEs operating in a turbulent environment than the SMEs in a stable market. The findings help the policymakers and blockchain vendors in developing effective plans and strategies to speed up the adoption of blockchain among SMEs. Furthermore, the results give confidence to the managers and owners of SMEs that blockchain can be a valuable competitive advantage source.

1. Introduction

Distributed ledger technologies, particularly blockchain, are among the critical driving technologies of the fourth industrial revolution (Wamba & Queiroz, 2022). With a wide variety of powerful benefits, blockchain has the potential to transform the way various industry's function (Ali et al., 2021; Aoun et al., 2021; Hughes et al., 2019; Khanfar et al., 2021). Businesses of various sizes are clamouring to take advantage of blockchain to keep up with the digitalization race and gain a

competitive edge in the hypercompetitive and turbulent market (Morkunas et al., 2019; Ghobakhloo et al., 2021; Maroufkhani et al., 2022). Arguably, the most salient implication of blockchain involves secure financial transactions at the individual and corporate levels (Albayati et al., 2020). Nonetheless, this technology has much broader applications beyond merely offering a secure payments platform (Ehrenberg & King, 2020). Businesses, particularly small and medium-sized enterprises (SMEs), need to develop and adopt innovative business models to survive and thrive under the disruptive force of Industry 4.0,

* Corresponding author at: Digital Futures for Sustainable Business & Society Research Group, School of Management, Swansea University, Bay Campus, Fabian Bay, Swansea, UK.

E-mail addresses: m.iranmanesh@ecu.edu.au (M. Iranmanesh), parisa.maroufkhani@gmail.com (P. Maroufkhani), asadi.shahla2003@gmail.com (S. Asadi), morteza_ghobakhloo@yahoo.com (M. Ghobakhloo), y.k.dwivedi@swansea.ac.uk (Y.K. Dwivedi), tsengminglang@asia.edu.tw (M.-L. Tseng).

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globalization, and geopolitical crises (Morgan et al., 2020; Yusof et al., 2014). Industry leaders progressively move toward adopting innovative business models such as product-as-a-service or machines-as-a-service to cope with the shifting business landscape (Frank et al., 2019). Industrial reports reveal that SMEs are significantly lagging in adopting innovative business models, mostly due to the lack of technological and strategic capacities for business model success (Garzella et al., 2021). Blockchain provides SMEs with unique opportunities to leapfrog the technological requirements for adopting such business models. Blockchain mainly serves this purpose by providing SMEs with streamlining financial transactions, smart contracting, supply chain traceability, data security, and information transparency (Nuryyev et al., 2020; Wong et al., 2020). In particular, the smart contracting feature of blockchain can effectively address the cash flow issue that has long undermined SMEs' position in the supply chain relationships. The smart contracting feature allows SMEs to enforce contracts between customers and business partners autonomously, providing SMEs with frictionless and effective transaction processes (Dutta et al., 2020; Ehrenberg & King, 2020).

SMEs are the backbone of any industry, usually accounting for >90 % of total business and 50 % of employment in most economies worldwide (OECD, 2019). Thus, a healthy SME sector is vital for achieving sustainable growth and a healthy distribution of wealth. Unfortunately, many SMEs struggle with survival amid the digitalization race and the Covid-19 crisis (Juergensen et al., 2020). Consistently, policymakers and governments are attempting to increase the uptake of Industry 4.0 digital technologies, including blockchain, by SMEs to prevail over the long-lasting size-related limitations in accessing finance, reaching new markets, adopting innovative business models, and developing higher productivity and competitiveness (Ghobakhloo et al., 2022). Nonetheless, there is a significant lack of industrial and academic evidence on the commercial use of blockchain technologies among SMEs. Although a few recent studies have partially addressed the blockchain adoption intention by SMEs, little to no study has investigated blockchain technology adoption among supply chain members.

The study of blockchain adoption behaviour among SMEs is in its embryonic stages. The earliest contribution to this discipline dates back to less than two years ago when Wong et al. (2020) empirically demonstrated how a collection of organizational, technological, or environmental factors such as perceived usefulness or market dynamics could impact SMEs' decisions to adopt blockchain. Nonetheless, the somewhat low coefficient of determination values for the dependent variable of blockchain adoption within previous studies shows there is still much to learn about the driving force behind SMEs' movement toward blockchain. We believe the inefficiency in predicting SMEs' intention for blockchain adoption roots in previous studies considering blockchain as an intra-organizational digitalization project. Conversely, scholars such as Queiroz and Wamba (2019) and Saberi et al. (2019) believe that the application of blockchain should be studied at the supply chain level, as its use cases involve the collaborative use of this technology by supply partners. From this perspective, a focal firm's decision to adopt blockchain would also depend on the extent to which this technology would benefit the entire supply chain by facilitating modern collaborative business functions. The literature review reveals that the influence of supply chain-specific factors on SMEs' intention for blockchain adoption is significantly understudied. This knowledge gap is somewhat expected given that this research discipline is in its early development stages.

Contingency theory argues that there is no best managerial method, and one technology may not fit all firms (Liang & Lu, 2013). Market turbulence is an environmental factor that causes uncertainty in the business procedure of organizations (Wang et al., 2015). In an unpredictable business environment, the agility capability of the firms plays a crucial role in maintaining their competitiveness (Lee et al., 2015). Although the previous studies have shown market turbulence moderates the influence of agility on performance (Ashrafi et al., 2019; Zhu et al., 2018), these studies have not determined whether agility plays a more

critical role in shaping managers' decisions to adopt new technology in a turbulent environment compared to a stable one. To address this gap, this study proposes market turbulence as a moderator on the relationship between supply chain agility and the intention to adopt blockchain. The study aims to answer the following two questions:

1. Do the benefits of blockchain to the supply chain influence the intention to adopt blockchain among SMEs?
2. Does supply chain agility have a higher influence on blockchain adoption among SMEs under high market turbulence than under stable market conditions?

This study contributes to the literature on blockchain in several ways. Firstly, the study reduces the scarcity of empirical evidence on the influences of blockchain benefits for the supply chains on blockchain adoption among SMEs. Secondly, this paper extends the findings of the only study on drivers of blockchain adoption among SMEs by Wong et al. (2020). They found relative advantage as one of the most important drivers of blockchain adoption at the SME level. We decomposed relative advantage to supply chain transparency, alignment, adaptability, and agility. Accordingly, the present work extends Wong et al. (2020) study by identifying the role of supply-level benefits of using blockchain in shaping the blockchain adoption intention of focal firms. Thirdly, this study also contributes to the literature by testing the moderating effect of market turbulence on the association between supply chain transparency and intention to adopt blockchain. The findings of the study help policymakers and blockchain vendors to promote the adoption of blockchain among SMEs. Furthermore, showing empirically the benefits of blockchain to the supply chain answers the SME managers' questions regarding the benefits of investing in blockchain.

2. Literature review

2.1. Blockchain technology

Blockchain has been defined as a distributed computing model with a decentralized structure that stores and corroborate chained data and employs distributed concord algorithms to produce and upgrade data (Li et al., 2020). It engages cryptology techniques to protect the access and transmission of data. It prosecutes automated transaction protocol and smart contracts to control and execute data (Li et al., 2018; Rejeb & Rejeb, 2020). The primary application of blockchain was Bitcoin, the first cryptocurrency used for secure transactions introduced by Nakamoto (2008). For this purpose, blockchain technology carries out the process of recording the transactions in an immutable, transparent, and secure manner without a trusted third party (Li et al., 2020; Wong et al., 2020). Blockchain is powerful enough to pledge the integrity, transparency, and traceability of data (Wong et al., 2020; Yu et al., 2021; Rejeb et al., 2022). It has emerged to make a significant contribution to the field of transactions in cryptocurrency (Queiroz et al., 2019). The unique implications of this technology have attracted considerable attention among scholars and practitioners (Chen et al., 2022; Di Vaio et al., 2022; Li et al., 2020; Roth et al., 2022; Salcedo & Gupta, 2021; Schlatt et al., 2022; Wong et al., 2020; Treiblmaier et al., 2022). Currently, many large organizations are practicing it to advance their operational efficiency (Yu et al., 2021).

2.2. Blockchain and supply chain

Blockchain enables organizations to leverage their supply chain capabilities for higher competitiveness (Madhwal & Panfilov, 2017; Rejeb & Rejeb, 2020; Sheel & Nath, 2019). Generally, it is "a disruptive technology for the design, organization, operations, and general management of supply chains" (Saberi et al., 2019, p. 2120). This technology generates value for the users by increasing the pace, visibility, and reliability of business practices (Sheel & Nath, 2019). There is a constant

move of data, money, and material between supply chain partners that demand transparency within processes (Dubey, Gunasekaran, et al., 2020; Zhu et al., 2018). The flow of these components in the supply chain processes should be aligned and clear among all partners to make an effective and efficient supply chain (Ammous, 2016; Subramaniam et al., 2020). In this vein, blockchain has the fundamental ability to control the flow of all substances in the process (Korpela et al., 2017) and make a transparent system for stakeholders (Dubey, Gunasekaran, et al., 2020; Zhu et al., 2018). Adopting blockchain enables all parties to access and share information with more reliability (Sheel & Nath, 2019). Blockchain consists of applications that can be applied in different settings. For example, as written rules stored in the blockchain, smart contracts enable organizations to operate credible transactions without interference from third parties (Saber et al., 2019). For example, this feature can track fraud in finance and healthcare (Dutta et al., 2020).

By applying smart contracts, users would adjust incidents such as possession of value-added services, products, locations, quantity, quality, and certifications (Abeyratne & Monfared, 2016). By adopting this technology in the supply chain process, organizations will be able to alter the whole process from purchasing the raw materials to supplying the product to the final users, considering that every step of the process can be done quickly with greater security (Dutta et al., 2020; Queiroz et al., 2019). As mentioned above, blockchain in the supply chain offers a substantial contribution to material and data flows reliably and transparently, leading to a greater degree of customization and cost reduction to serve better the final users (Liu et al., 2021; Nayak & Dhaigude, 2019). Blockchain is among emerging technologies that hold various implications for the manufacturing sector. It can be synchronized with new manufacturing technologies such as big data and the Internet of Things (Wang et al., 2022).

In a manufacturing system, the supply chain involves various components such as transactions, financial contracts, processes, knowledge, physical resources, and workforce that facilitate moving a product from supplier to customer (Abeyratne & Monfared, 2016). Therefore, it is sometimes challenging to control all transaction processes in terms of transparency and traceability within the chains (Haq et al., 2010). Blockchain technology can overcome the traceability and transparency issues within the manufacturing supply chain (Zhu et al., 2018a), primarily via the faultless and transparent record of information, distributed storage, and controlled users access (Abeyratne & Monfared, 2016; Dubey, Gunasekaran, et al., 2020; Saber et al., 2019). According to Sheel and Nath (2019) and Xu et al. (2018), some businesses have already begun integrating blockchain into manufacturing operations for a better understanding of customers' needs, while SMEs are far behind (Wong et al., 2020).

2.3. Blockchain and SMEs

The technology adoption literature among SMEs shows that smaller enterprises are not yet open to adopting emerging technologies as a viable strategy for business excellence (Maroufkhani et al., 2020; Valeri & Baggio, 2021; Wong et al., 2020). The review of the literature reveals that blockchain has been able to enhance tourism management systems (Valeri & Baggio, 2021), supply chain operation and management (Wong et al., 2020), and financial strategy in logistics (Yu et al., 2021). Although the practices of blockchain technology in the supply chain have received attention from scholars (Dubey, Gunasekaran, et al., 2020; Queiroz et al., 2019; Saber et al., 2019; Valeri & Baggio, 2021; Wong et al., 2020), research on blockchain adoption among SMEs is still emerging. According to empirical studies on disruptive technologies among SMEs by Maroufkhani et al. (2020) and Wong et al. (2020), SMEs need to look at technology adoption as an investment rather than a cost or burden. Technology adoption, blockchain in particular, will enable SMEs to become more approachable and open to customer needs (Wong et al., 2020). As discussed earlier, most transactions that might be happened by blockchain could be safer, more traceable, and transparent

(Queiroz & Wamba, 2019). In this light, blockchain can be a promising solution to challenges and frauds that may occur in SMEs' supply chains (Wong et al., 2020).

3. Theoretical framework and hypothesis development

3.1. Resource-based view theory

According to the Resource-based View (RBV) theory, un-substitutable, valuable, and rare resources enable firms to be competitive. The RBV theory, initially introduced by Wernerfelt (1984) and specified as concepts regarding the role of an organization's capabilities and resources, are the primary basis for its policy and the principal source of profitability. RBV has emphasized the importance of resource allocation, autonomy, utilization imitability, and heterogeneity in producing capabilities to achieve a competitive advantage in supply chain and operations management research (Dubey, Bryde, et al., 2020; Hitt et al., 2016; Ketokivi, 2016). If we only consider the firms' internal resources as sources of competitiveness, then competitive advantages generated through the shared capabilities of partners in the supply chain are neglected (Sheel & Nath, 2019). The researchers added dynamic and relational terms to consider supply-chain-related resources and capabilities and overcome the limitations of the RBV (Fawcett et al., 2011; Lavie, 2006). The dynamic extension emphasizes integrating external and internal competencies in rapidly changing markets to maintain competitiveness (Teece, 2007). The emphasis of the relational extension is on the relationships among supply chain partners (Lavie, 2006). According to Eckstein et al. (2015), agility and adaptability are dynamic capabilities triggered by supply chain partners' ability to integrate their processes (alignment). Dynamic capabilities provide competitive advantages for the firm by enabling them to surpass its competitors (Blome et al., 2013). Transparency is an invisible resource that may lead to supply chain alignment, adaptability, and agility. In summary, drawing on RBV, this study proposed associations between supply chain transparency, alignment, adaptability, and agility.

3.2. Contingency theory

Contingency theory originates in organizational theory and emphasizes developing the most appropriate management approach to respond appropriately to different situations (Liang & Lu, 2013). According to this theory: (i), there is no best organizational structure or managerial method that fit all firms, and (ii) the effectiveness of any managerial methods or organizational structures depends on internal and external business environments and processes (Galbraith, 1973). Contingency theory has been used frequently to explain decision-making and organizational management in the context of information systems (IS) (Liang & Lu, 2013; Reinking, 2012). According to this theory, the fit between benefits deriving from technology and the organization's business environment is one of the critical factors managers should consider in adopting technology (Araral, 2020). Blockchain provides various benefits, including transparency, agility, trust, authenticity, security, cost reduction, and efficiency (Dutta et al., 2020; Wong et al., 2020). However, these benefits are not equally crucial for all firms and depend on the internal and external environments of the organization. For instance, supply chain agility and rapidly responding to the changes in the market and customer needs are more crucial in a turbulent market than in a stable one (Ashrafi et al., 2019; Chen, 2019). Accordingly, based on the contingency theory, this study proposes that the influence of supply chain agility on the intention to adopt blockchain depends on market turbulence. It means market turbulence moderates the associations between agility and blockchain adoption. Transparency is another attribute of blockchain, which can be a valuable source of competitive advantage depending on the supply chain situation and complexity in which the firm operates (Dubey, Gunasekaran, et al., 2020; Zhu et al., 2018). Therefore, this study proposes transparency as another driver of

the intention to adopt blockchain.

3.3. Operational supply chain transparency

Dubey, Gunasekaran, et al. (2020, p. 3384) described operational supply chain transparency as “an ‘organization’s capability to proactively communicate with stakeholders to create visibility and traceability into upstream and downstream supply chain operations.” These authors defined supply chain transparency as the degree to which supply chain members can track existing and past activities of products in the whole chain. Transparency enhances the visibility of downstream and upstream procedures and reduces the complexity of the supply chain processes (Brandon-Jones et al., 2014). Whitten et al. (2012) remarked that business procedures, including purchasing, production, retailing, and logistics, must be aligned externally and internally throughout the supply chain to achieve a competitive advantage. The previous studies proposed trust, information integration, and visibility as the antecedents of alignment, adaptability, and agility (Feizabadi et al., 2019; Handfield et al., 2015). It means a lack of trust among supply chain partners, lack of information integration, and lack of visibility are the main barriers to business procedure integration and alignment. Dubey, Altay, Gunasekaran, Blome, Papadopoulos, and Childe (2018) also confirmed the significant influence of visibility on supply chain alignment. By growing supply chain transparency, firms can create trust and gain greater supply chain visibility (Duckworth, 2018). Dubey, Bryde, et al. (2020) found transparency to drive trust, information integration, and visibility. From the above arguments, we can conclude that operational supply chain visibility causes alignment among chain partners. According to Wong et al. (2012), the absence of transparency along chain is the principal barrier of internal as well as external alignment. Therefore, we propose:

H1. Operational supply chain transparency positively influences supply chain alignment.

According to the market changes, supply chain adaptability refers to the firm’s ability to change in terms of technologies, products, and strategies (Kaurić et al., 2014). Adaptability focuses on fundamental changes, and agility emphasizes the speed of responses (Eckstein et al., 2015). As such, adaptability is more needed in coping with fundamental and long-term changes, and agility is required to respond quickly to short-term and temporary changes. Liang et al. (2007) revealed that building adaptability in the supply chain would produce notable marketing advantages for the organization. To adapt to diversity, organizations should have the capability to see their supply chains up and down (Dobrzykowski et al., 2015). Feizabadi et al. (2019) suggested flexibility, process integration, and visibility as the key antecedents for supply chain adaptability. Patel et al. (2012) stated that flexibility enables organizations to adapt appropriately to differences, adjust operational sources, and utilize possibilities in unstable situations. Kortmann et al. (2014) distinguished flexibility as a significant driver of adapting to business developments. Dobrzykowski et al. (2015) applied a multi-regional examination of the manufacturer to confirm absorptive capability as an antecedent to a flexible supply chain strategy.

Additionally, Wong et al. (2011) explained that process integration enables organizations to adapt to variations by concentrating on reliability and delivery sufficiently. As one of the key features of blockchain, transparency increases the level of trust, information integration, and visibility across chain members (Dubey, Bryde, et al., 2020). Furthermore, Walsh (2007) specified that more transparency accordingly improves flexibility. Accordingly, a positive association between supply chain transparency and adaptability is expectable. Therefore, we propose:

H2. Operational supply chain transparency positively influences supply chain adaptability.

The ability to capture changes and quickly respond to them is called supply chain agility (Eckstein et al., 2015; Wilding et al., 2012). Previous studies on agility have found that supply chain flexibility, process integration, and visibility are key enablers of agility (Feizabadi et al.,

2019; Gligor et al., 2015). Flexibility is the “foundation of the house of agility” (Tatham, Pettit, Charles, et al., 2010). In line with this perspective, (Eckstein et al., 2015; Li et al., 2009) recognized flexibility as a core dimension of supply chain agility.

As another antecedent of agility, visibility reflects the readiness to identify transitions, possibilities, and threats immediately. Organizations eventually require excellent visibility up and down the supply chain (Gligor et al., 2015). Tatham, Pettit, Charles, et al. (2010) proposed a maturity model for supply chain agility and emphasized the significance of flexibility and visibility in accomplishing agility. Another two concepts inherent to supply chain agility description and enablers are information and process integration (Tatham, Pettit, Scholten, et al., 2010) and firms must adapt if they are supposed to remain in the global marketplace. Therefore, companies and their supply chains must be agile and flexible to reduce disruptions and ensure a continuous flow of services and goods to their global customers (Khan et al., 2019). Transparency, as one of the key characteristics of blockchain, increases the level of trust, information integration, and visibility across chain members (Dubey, Bryde, et al., 2020; Sheel & Nath, 2019). Moreover, Selmosson and Hagström (2015) stated that transparency leads to flexibility. Urschinger (2018) stated that agility originates from transparency and trust. Hence, this study proposed supply chain transparency as an antecedent of supply chain agility. Consequently, the subsequent hypothesis is developed:

H3. Operational supply chain transparency positively influences supply chain agility.

Kashmanian (2017) stated that the supply chain has become longer, more extensive, dispersed, and complicated. Consequently, there is a necessity for transparency in the supply chain. Transparency provides members of the supply chain to trace products to confirm accuracy. Zhu et al. (2018) revealed that applying possible technologies such as blockchain and RFID can enhance the capability to do supply analytics, which provides improvements in transparency. With low transparency within the supply chain, a firm is not capable of knowing the risks and achieving sustainability purposes (The Sustainability Consortium, 2016). The absence of transparency is a critical obstacle to promoting the supply chain’s sustainability (Laurell, 2014). Moreover, Casey and Wong (2017) discussed that the scarcity of transparency is one of the causes of the lack of trust in sharing knowledge among supply chain members. Therefore, developing transparency can significantly improve trust among the supply chain partners. In an empirical study, Dubey et al. (2019) showed that blockchain technology offers transparency to a chain and consequently enhances trust among partners.

Sheel and Nath (2019) illustrated that managers agreed that blockchain technology adoption aids in enhancing the reliability of transactions as well as transparency. Moreover, blockchain provides a tamper-proof source of data retrieval and recording. Chod et al. (2020) demonstrated that blockchain technology facilitates supply chain transparency more efficiently than outdated monitoring mechanisms. Additionally, Shin et al. (2020) revealed that blockchain enhances transparency, and non-profit firms are applying blockchain technology to increase donations and improve transparency. Previous studies have found relative advantage as a key driver of technology adoption among SMEs (Maroufkhani et al., 2020; Maduku et al., 2016). Wong et al. (2020) confirmed the significant influence of relative advantage on blockchain adoption among SMEs. Accordingly, this study proposed the transparency benefit of using blockchain as a driver of adopting blockchain. Consequently, we posit:

H4. Operational supply chain transparency positively influences the intention to adopt blockchain.

3.4. Supply chain alignment

Supply chain alignment refers to integrating the processes of supply chain partners aiming to achieve better performance (Sheel & Nath, 2019). Aligning strategies and processes of supply chain partners is

essential (Gattorna & Jones, 1998). Several studies revealed the importance of supply chain alignment in developing customer value and gaining competitive advantage, which causes a higher performance (Sheel & Nath, 2019; Wong et al., 2012). Tuominen et al. (2004) declared that in a challenging and complicated company environment, adaptability resembles one of the essential requirements for sustainable competitive advantage and high performance. The probable relationship between the Triple-A supply chain variables, namely alignment, adaptability, and agility, was explored in the study by Dubey and Gunasekaran (2016). Dubey and Gunasekaran (2016) found that humanitarian supply chain adaptability is positively influenced by alignment. Supply chain alignment leads to adaptability due to process enhancement, information integration, flexibility, visibility, and data quality. Moreover, Alfalla-Luque et al. (2018) stated that supply chain adaptability is positively influenced by supply chain alignment. Therefore, we propose:

H5. Supply chain alignment positively influences supply chain adaptability.

The capability of adjusting supply chain configuration to align supply chain members in terms of objectives such as information integration, visibility, and collaboration is called (Dubey and Gunasekaran (2016). In another study, Feizabadi et al. (2019) proposed information integration, visibility, and collaboration as the antecedents of agility. Accordingly, a positive association between supply chain alignment and agility is expected. Tallon and Pinsonneault (2011) empirically found a significant and positive relationship between alignment and agility. Moreover, Aslam et al. (2020) stated that supply chain alignment positively influences supply chain agility. Imgharene et al. (2017) revealed that the alignment between information technology and business strategy could stimulate agility. Thus, we propose:

H6. Supply chain alignment positively influences supply chain agility.

3.5. Supply chain adaptability

The ability to adjust supply chain design and modify the supply network concerning products, technologies and strategies to face structural changes in the market is called supply chain adaptability (Aslam et al., 2020). Stevenson and Spring (2007) remarked that adaptability enables the supply chain partners to cope with the supply chain dynamics. Therefore, adaptability allows supply chain partners to quickly adjust the configuration of the supply chain in response to market changes and consequently obtain a favourable competitive advantage. The role of adaptability in saving costs and improving supply chain performance has been extensively supported by prior studies (Croom et al., 2007; Lee, 2004; Tatham & Christopher, 2018). According to Eckstein et al. (2015), agility is the reason that adaptability causes better supply chain performance. It means adaptability causes agility, which is one of the main sources of competitive advantage and high performance. The ability to adjust the supply chain configuration and develop new markets and new supply chains creates the basis for the chain partners to develop agile capabilities (Eckstein et al., 2015). Moreover, supply chain adaptability and agility are highly correlated as the sources of agility and adaptability (e.g., flexibility, visibility, and information integrity) are connected. Dubey and Gunasekaran (2016) found that humanitarian supply chain adaptability positively influences humanitarian supply chain agility. Therefore, we posit:

H7. Supply chain adaptability positively influences supply chain agility.

3.6. Supply chain agility

Supply chain agility refers to “the supply chain’s ability to adjust its tactics and operations quickly. This ability can manifest itself proactively or reactively” (Gligor & Holcomb, 2012). Agility relates to how rapidly a firm responds to short-term variations in the business. Supply

chain agility is the capability to encounter unanticipated variations in the business requirements and transform them into market opportunities (Swofford et al., 2008). Agility empowers an organization to obtain a competitive advantage in unpredictable functioning market environments (Brusset, 2016). Agility enables firms to respond to the shifting demands in the marketplace (Gligor & Holcomb, 2012). According to Lee (2004), the principal purposes of supply chain agility are to respond quickly to short-term changes in supply or demand and smoothly manage external disorders. (Collin & Lorenzin, 2006; Lee, 2004) encouraged firms to give deeper consideration to supply chain agility, as supply disruptions and demand fluctuations happen more quickly and extensively in the current market compared to the past.

The supply chain typically involves associated activities, including designing products, manufacturing, and delivery between channel partners. The organization must cooperate with partners to accomplish these associated activities efficiently and simultaneously control the volatility of the marketplace to gain a competitive advantage (Liu et al., 2013; Van Hoek et al., 2001). Under this situation, supply chain agility, which entirely concerns consumer responsiveness in unpredictable business, is crucial in assuring the organization’s competitiveness (Swofford et al., 2006). Due to the advanced business volatility, agility has been developed as a crucial competitive element and a primary determinant of survival (Matawale, Datta, & Mahapatra, 2016). Agility enables firms to change cycles and modify to reflect changing circumstances (Swofford et al., 2006). Sheel and Nath (2019) explained how blockchain technology could improve agility and consequently create a competitive advantage and enhance performance. Considering the importance of relative advantage in adopting blockchain (Wong et al., 2020), the study proposed supply chain agility as a driver of intention to adopt blockchain, and the following hypothesis is formulated:

H8. Supply chain agility positively influences the intention to adopt blockchain.

3.7. Market turbulence

Market turbulence refers to “the rate of changes in the composition of customers and their preferences” (Ashrafi et al., 2019, p. 3). Market turbulence causes vagueness and uncertainty in the business procedure of organizations (Wang et al., 2015). The rapid changes in customer needs make the business environment unpredictable and turbulent (Ashrafi et al., 2019; Pavlou & Sawy, 2010). The supply chain should be agile to provide uninterrupted service to customers and deal with market turbulence (Chen, 2019). Although removing sources of uncertainty is impossible, the firms should have the ability to respond fast to the market changes and unpredictable demands to gain a competitive advantage over competitors (Ashrafi et al., 2019; Lee et al., 2015). In a stable market with low uncertainty, firms may achieve an acceptable level of performance with an outdated structure and strategy, which the same firms will lose competitive advantage and will encounter significant difficulties in a turbulent environment (Trkman & McCormack, 2009). Thus, quick response to unexpected and short-term changes in the market is more crucial for firms in a turbulent market environment compared to a stable market. Bhatt et al. (2010), the firms with low supply chain agility respond slowly to changes in customer needs may lag behind competitors and lose opportunities. Phuong et al. (2012) also asserted that as uncertainty is high in a turbulent market, the firms should process information quickly to respond rapidly to the changes and remain competitive advantages. Supply chain agility plays a more crucial role in generating a competitive advantage for the firms operating in a market with high turbulence and uncertainty than those within a stable market. Accordingly, it is expectable that the agility benefit of using blockchain is more important for managers of SMEs within a turbulent market, and consequently, supply chain agility has a higher effect on the intention to adopt blockchain among these SMEs. As such, we propose:

H9. Market turbulence positively moderates the relationship

between agility and intention to adopt blockchain.

3.8. Model overview

Drawing on RBV and contingency theories and the literature on the blockchain, supply chain, and SME, the study proposes that operational supply chain transparency positively influences supply chain alignment, supply chain adaptability, supply chain agility, and blockchain intention to adopt (Fig. 1). Supply chain alignment is considered a driver of supply chain adaptability and supply chain agility. Moreover, the study proposes that supply chain adaptability is a driver of supply chain agility, which in turn influences the adoption of blockchain. Furthermore, the study hypothesized that market turbulence moderates the relationship between supply chain agility and blockchain adoption among SMEs.

4. Methods

4.1. Measurements

The validated items from the previous studies were used to measure the constructs of the study (the measurement items have been provided in the appendix). The items of operational supply chain transparency, market turbulence, and blockchain adoption intention were adapted from Zhu et al. (2018), Ashrafi et al. (2019), and Wong et al. (2020), respectively. The measures of supply chain alignment, supply chain adaptability, and supply chain agility were adapted from Sheel and Nath (2019). The items were measured using a 5-point Likert scale ranging from “1 = Strongly Disagree” to “5 = Strongly Agree”. Although validated items from the literature were adapted and modified to fit into the context of the study, still, the content validity and face validity of the measurements were evaluated through a pretest with two blockchain experts and three academicians. The items were modified following their inputs. The revised questionnaire was piloted with 36 managers/owners of SMEs to evaluate the reliability of the constructs and to ensure the items are understandable (Maroufkhani et al., 2020). The Cronbach's alpha values of all the constructs were above the proposed threshold (0.7) by Hair (2019), indicating reliable measurements.

4.2. Sampling and data collection

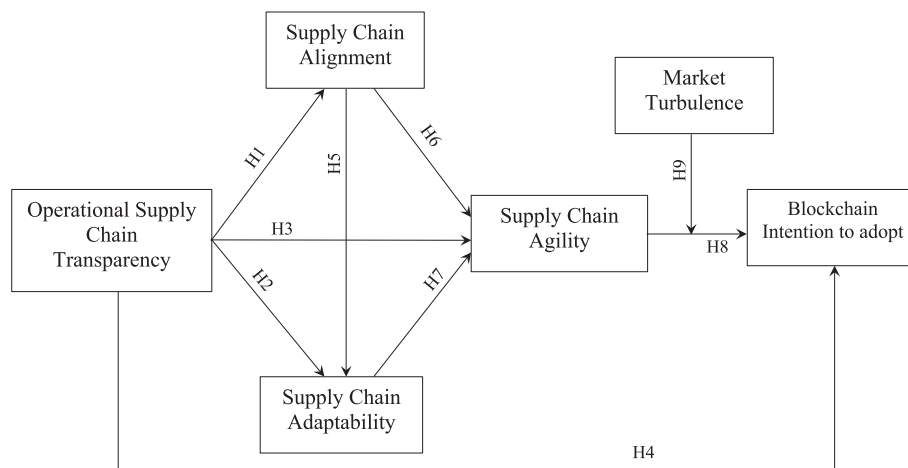
SMEs in the manufacturing sector form the population of the study. In Malaysia, SMEs in the manufacturing sector refer to firms with <200 full-time employees (Leitch & Volery, 2017). The sampling frame was taken from the Federation of Malaysian Manufacturers (FMM) directory. The data were collected from the managers/owners of SMEs as they have the power to decide to adopt blockchain. We contacted the firms by

phone to explain the purpose of the study and to confirm their willingness to participate in the study. A total of 850 questionnaires were mailed to the corresponding respondents with returned envelopes. Out of 850 potential respondents, 204 usable responses were received after two times follow-up phone calls, resulting in a response rate of 24.0 %. The demographic profile of the sample is presented in Table 1.

The response rate is comparable to the studies on manufacturing firms in Malaysia using the mail questionnaire (e.g., Abdullah et al., 2016; Shaharudin et al., 2017). However, due to the low response rate, the data were subjected to non-response bias. Using a *t*-test, early and late responses were compared to assess non-response rate bias (King & He, 2005). No significant differences indicated that non-response bias is not a concern. Furthermore, as a single respondent responded to both

Table 1
Demographic profile of the sample.

Demographic Factors	Category	Frequency	Percentage
Operation Years	5 years and below	40	19.6 %
	6–10 years	32	15.7 %
	11–15 years	33	16.2 %
	15 years and above	109	53.4 %
Number of employees	30–75	71	34.8 %
	75–200	133	65.2 %
Gender	Male	148	72.5 %
	Female	56	27.5 %
Manufacturing type	Electric and electronic	39	19.1 %
	Food, furniture, and paper	16	7.8 %
	Basic and fabricated metal	12	5.9 %
	Textile and apparel	10	4.9 %
	Food and beverage	8	3.9 %
	Others	119	58.4 %
Supply chain position	Upstream supplier (supplier to other businesses)	144	70.6 %
	Downstream supplier (supplier to end customer)	60	29.4 %
Age	<25 years	6	2.9 %
	25–34 years	77	37.7 %
	35–44 years	100	49.0 %
	45 years and above	21	10.3 %
Education level	Bellow high school diploma	6	2.9 %
	High school diploma	15	7.4 %
	Bachelor	118	57.8 %
	Master and above	65	31.9 %



the endogenous and exogenous construct, common method bias (CMB) may influence the validity and reliability of the measured constructs and tested relationship in the model (Fuller et al., 2016). To evaluate the CMB, we evaluate the correlation between the main constructs of the study and a marker variable (i.e., “attitude toward buying green products”). The correlation values were not significant, indicating that CMB is not a concern in the study (Lindell & Whitney, 2001).

4.3. Data analysis

The partial least squares (PLS) technique was employed to test the proposed relationships. PLS is a multivariate analysis approach suitable for exploratory studies (Hair et al., 2019). Considering the predictive nature of the study, the PLS approach was selected. As recommended by Hair et al. (2019), the validity and reliability of the constructs were evaluated in the first stage, followed by testing the hypotheses using non-parametric bootstrapping in the second stage.

5. Results

5.1. Assessment of measurement model

Following the direction proposed by Hair et al. (2019), the validity and reliability of the constructs were assessed based on four coefficients, namely factor loading, average variance extracted (AVE), composite reliability (CR), and Heterotrait–Monotrait (HTMT). Loadings of all the items were above 0.7 (Table 2), indicating that indicators are reliable. The AVE and CR values of the constructs were above 0.5 and 0.7, respectively, indicating acceptable reliability and convergent validity (Hair et al., 2019).

To test the discriminant validity, the HTMT ratio was evaluated. All the HTMT values were less than the critical value of 0.85 (Table 3), indicating acceptable discriminant validity (Henseler et al., 2015).

Table 2
Measurement model assessment.

Constructs	Items	Factor loadings	Composite reliability	Average variance extracted
Operational Supply Chain Transparency (TRA)	TRA1	0.845	0.912	0.722
	TRA2	0.833		
	TRA3	0.843		
	TRA4	0.879		
Supply Chain Alignment (ALG)	ALG1	0.913	0.941	0.800
	ALG2	0.914		
	ALG3	0.901		
	ALG4	0.849		
Supply Chain Adaptability (ADP)	ADP1	0.904	0.919	0.792
	ADP2	0.916		
	ADP3	0.847		
Supply Chain Agility (AGL)	AGL1	0.875	0.946	0.687
	AGL2	0.897		
	AGL3	0.780		
	AGL4	0.850		
	AGL5	0.832		
	AGL6	0.793		
	AGL7	0.836		
	AGL8	0.760		
Market Turbulence (MT)	MT1	0.903	0.945	0.850
	MT2	0.932		
	MT3	0.931		
Blockchain Adoption Intention (BAI)	BAI1	0.936	0.948	0.858
	BAI2	0.930		
	BAI3	0.913		

Table 3
Discriminant validity (HTMT_{.85}).

	TRA	ALG	ADP	AGL	MT	BAI
TRA						
ALG	0.579					
ADP	0.747	0.639				
AGL	0.457	0.374	0.628			
MT	0.309	0.246	0.495	0.465		
BAI	0.513	0.320	0.628	0.648	0.803	

5.2. Assessment of structural model

The proposed model explained 27.2 %, 49.9 %, 33.3 %, and 67.8 % of the variance (R^2) in supply chain alignment, adaptability, agility, and intention to adopt blockchain. The Stone-Geisser (Q^2) values of all endogenous constructs were above zero, demonstrating the predictive capability of the model. To test the hypotheses, this study applied non-parametric bootstrapping (Hair et al., 2019). According to the results (Table 4), supply chain transparency significantly influences alignment ($\beta = 0.520$; $p < 0.001$), adaptability ($\beta = 0.486$; $p < 0.001$), and blockchain adoption ($\beta = 0.181$; $p < 0.001$). The association between transparency and agility was not supported ($\beta = 0.076$; $p > 0.05$). Although alignment has a positive significant effect on adaptability ($\beta = 0.318$; $p < 0.001$), it has no direct effect on agility ($\beta = 0.013$; $p > 0.05$). The positive influence of adaptability on agility was supported ($\beta = 0.517$; $p < 0.001$). The results confirm the positive relationship between agility and intention to adopt blockchain ($\beta = 0.277$; $p < 0.001$). The moderating effect of market turbulence was tested using the orthogonalization approach (Little et al., 2006). According to the result, market turbulence moderates positively the association between supply chain agility and intention to adopt blockchain ($\beta = 0.093$; $p < 0.05$). It means that the influence of agility on blockchain adoption is higher among the SMEs operating in the high turbulent market in comparison to the ones in the low turbulent market. As such, all the hypotheses were accepted except H3 and H6.

6. Discussion

This study demonstrates the relationships between supply chain transparency, alignment, adaptability, and agility and their influences on the intention to adopt blockchain among SMEs by considering market turbulence as a moderator. The results revealed that although supply chain transparency significantly influences supply chain alignment and adaptability, it has no direct effect on supply chain agility. The insignificant direct effect of transparency on agility should not be interpreted as a lack of relationship between these concepts, as transparency

Table 4
Hypotheses testing results.

Hypotheses	Relationships	Path Coefficients	T Values	P Values	Decisions
Main Model					
H1	TRA → ALG	0.520	5.834***	0.000	Supported
H2	TRA → ADP	0.486	5.371***	0.000	Supported
H3	TRA → AGL	0.076	0.832	0.203	Not Supported
H4	TRA → BAI	0.181	3.319***	0.000	Supported
H5	ALG → ADP	0.318	3.295***	0.001	Supported
H6	ALG → AGL	0.013	0.158	0.437	Not Supported
H7	ADP → AGL	0.517	6.797***	0.000	Supported
H8	AGL → BAI	0.277	4.741***	0.000	Supported
Moderating Effect of Market Turbulence					
–	MT → BAI	0.567	11.536	0.000	Supported
H9	MT*AGL → BAI	0.093	1.928*	0.027	Supported

Note. * $p < 0.05$; *** $p < 0.001$ (one-tail).

profoundly affects adaptability as a critical driver of agility. It means adaptability takes the power of the direct influence of transparency on agility and explains the associations between these two concepts. The previous studies proposed trust, information and process integration, and visibility as the antecedents of alignment, adaptability, and agility (Feizabadi et al., 2019; Handfield et al., 2015). As one of the main attributes of blockchain, transparency enhances the level of trust, information integration, and visibility across chain members (Dubey, Gunasekaran, et al., 2020; Gurtu & Johny, 2019; Sheel & Nath, 2019). Therefore, supply chain transparency leads directly to supply chain alignment and adaptability and indirectly causes supply chain agility.

Although alignment was a significant antecedent of adaptability, its direct influence on agility was not supported. The association between adaptability and agility was confirmed. These findings, to some extent, are consistent with the findings of Dubey and Gunasekaran (2016), who found significant relationships between these three concepts in the context of the humanitarian supply chain. The insignificant direct effect of alignment on agility can also be justified through adaptability. As alignment is highly correlated with adaptability, as a key driver of agility, the insignificant direct effect of alignment is due to its indirect effect on agility through adaptability. It means that the integration of the processes of supply chain members (alignment) using blockchain enables firms to quickly change the design and adjust supply chain, production, quality, and quantity (adaptability) due to the reason that chain members can easily share the documents and information related to design, sourcing, production, and logistics and consequently react fast the demand changes (Ivanov et al., 2019; Sheel & Nath, 2019). Furthermore, in addition to the flexibility and ability to react fast to unpredictable changes, the ability to predict the potential changes before they occur plays a vital role in the extent of adaptability (Dobrzykowski et al., 2015; Feizabadi et al., 2019). Supply chain alignment enables chain members to see up and down the supply chain and consequently predict the potential changes faster and more precisely (Azadegan, 2011). Data quality is one of the main barriers to firms' ability to predict precisely (Côte-Real et al., 2020). Information and process integration through blockchain can enable chain members to access trustable information and consequently do the prediction using quality data.

In summary, supply chain alignment leads to adaptability due to enhanced process and information integration, flexibility, visibility, and data quality. Supply chain adaptability and agility are highly correlated as the sources of agility and adaptability are connected. Both supply chain adaptability and agility depend on the prediction capability and flexibility in coping with changes (Eckstein et al., 2015).

The findings confirmed the influences of supply chain transparency and agility on the intention to adopt blockchain. These results align with Wong et al.'s (2020) findings, which found relative advantage as an antecedent of blockchain adoption among SMEs. In the current uncertain market, where demand fluctuations and supply disruptions happen frequently, agility is a crucial competitive element (Matawale, Datta, & Mahapatra, 2016; Swafford, Ghosh, & Murthy, 2006). Supply chain agility enables firms to respond rapidly to market changes (Gligor & Holcomb, 2012). Furthermore, lack of trust, information integration, and visibility in the current complex supply chain networks can influence supply chain performance and efficiency (Longo et al., 2019). Supply chain transparency can eliminate trust, information integration, and visibility issues (Duckworth, 2018). Therefore, as the benefits of using blockchain, supply chain transparency and agility assure the firm's competitiveness and motivate SMEs to adopt blockchain.

Finally, market turbulence moderates positively the association between supply chain agility and intention to adopt blockchain. This result is consistent with the contingency view regarding one technology that does not fit all (Reinking, 2012). The moderating effect of market turbulence indicates that as agility and quick response to market changes are more crucial for the firms operating in a turbulent environment, the contribution of blockchain to agility is more important for SMEs

operating in a turbulent environment and has a higher effect on their decision to adopt blockchain. As such, policymakers and blockchain vendors should target SMEs in the turbulent market and promote blockchain technology among them. The contribution of SMEs to supply chain agility should be communicated to the managers/ owners of SMEs.

6.1. Contributions to the literature

This study contributes to the literature by answering the questions regarding the benefits of blockchain technologies for SMEs and the extent to which benefits trigger the intention adoption of SMEs' managers. Although blockchain adoption has received growing attention from scholars, the focus of these studies has been on the adoption of blockchain at the individual level (Queiroz et al., 2019; Walsh et al., 2020) or among large firms (Ullah et al., 2021; Wamba & Queiroz, 2022). At the time of the study, only one article investigated the drivers of blockchain among SMEs at the firm level (Wong et al., 2020). This study found relative advantage as the driver of top management support and blockchain adoption. The importance of relative advantage in emerging technology adoption among SMEs has been confirmed in previous studies (Khayer et al., 2020; Maroufkhan et al., 2020). To the best of our knowledge, this study is among the first that decomposed relative advantage and investigated the interrelationship among dimensions of relative advantage and their influence on intention to adopt blockchain among SMEs. The findings of the study showed that supply chain transparency and agility have a positive effect on blockchain adoption.

Furthermore, the study confirmed that supply chain transparency, alignment, adaptability, and agility are interrelated. Supply chain adaptability is triggered by transparency and alignment, leading to supply chain agility. Ours is the first study that empirically tests the influence of supply chain transparency on supply chain alignment, adaptability, and agility. Supply chain transparency and alignment are positively associated. Furthermore, although the influence of market turbulence on technology adoption has been proven in the literature, there is a lack of study on the interaction of market turbulence and agility on technology adoption. The findings of this study illustrate that market turbulence moderates positively the influence of agility on blockchain adoption. This means that when SMEs operate in a competitive and unexpected market, they have a higher intention to adopt blockchain due to the positive influence of blockchain on agility capability.

6.2. Implications for practice

Considering the benefits of blockchain and the critical role of SMEs in economics, policymakers seek to promote blockchain usage among SMEs. The previous studies on the drivers and barriers of adopting blockchain unanimously agreed that understanding the benefits of using blockchain has a significant influence on the decision of SME managers to invest in blockchain (Wong et al., 2020). Hence, this study aims to answer some questions of SME managers engaged in adopting blockchain, such as: How does blockchain contribute to the supply chain? Does blockchain contribute to all industries? The studies that have attempted to answer these questions in the literature have limitations such as lacking theory and lacking empirical evidence. By developing a model which is grounded in theory and testing it empirically, this study suggests interesting directions for SME managers, policymakers, and blockchain service providers. As we understand, supply chain agility, adaptability, and alignment are three pillars of competitive advantage in the current competitive market (Dubey et al., 2018; Feizabadi et al., 2019). Hence, SMEs' dilemma is to what extent blockchain helps achieve alignment, adaptability, and agility. Existing literature has found a lack of trust, visibility, and information integration as the main barriers to supply chain agility, adaptability, and alignment (Dobrzykowski et al., 2015; Feizabadi et al., 2019). Transparency, as the main attribute

of blockchain, has the potential to increase visibility and information integration and consequently build trust among supply chain partners (Dubey, Gunasekaran, et al., 2020; Duckworth, 2018; Morgan et al., 2020). Accordingly, we tested the influence of transparency on supply chain alignment, adaptability, and agility. The empirical results offer immense guidance to SME managers, showing that investment in blockchain provides transparency among partners and further improves supply chain alignment, adaptability, and agility. Thus, we can argue that blockchain enables supply chain partners to better integrate processes including sourcing, transport, and service, quickly chain the design as per market requirement, and introduce new products.

The findings also enable the policymakers and blockchain service providers to design appropriate plans and prioritize the actions to boost blockchain adoption among SMEs. The significant influence of transparency and agility on blockchain adoption suggests that government and service providers should formulate awareness programs for managers of SMEs. Furthermore, blockchain service providers should share and communicate the success stories of using blockchain by SMEs (Maroufkhani et al., 2020). The contribution of blockchain to supply chain adaptability and alignment can be emphasized in the awareness programs as well. As the blockchain diffusion among SMEs is in the early stage, the government and vendors should target SMEs in industries with high market turbulence. The ability of the chain to react fast to unexpected market changes plays a more critical role in the success of SMEs in the competitive market compared to those that perform in less competitive markets.

6.3. Limitations and future research direction

Although the findings answer the two research questions of the study, there are some limitations that offer directions for future studies. Firstly, as the diffusion rate of blockchain among SMEs is low in Malaysia, we investigated the drivers of blockchain adoption. Future studies in developed countries can empirically test the contribution of blockchain capabilities to supply chain competitiveness. Secondly, the sample of the study is limited to SMEs, which have different power in integrating resources, information, and service compared to large firms. Future studies may test the model of the study among large firms. Thirdly, future studies can extend the findings of this study by testing the mediating effect of trust, visibility, and information integration on the associations between supply chain transparency, adaptability, alignment, and agility (Feizabadi et al., 2019).

Furthermore, market turbulence is an environmental factor. Future studies can enrich the proposed model by testing the moderating effect of organizational factors such as organizational readiness, financial resource, and employee capability (Maroufkhani et al., 2020; Toufaily et al., 2021). Alternatively, the existence of a direct effect between supply chain transparency and blockchain adoption indicates that alignment, adaptability, and agility are not the only explanation for the association between transparency and blockchain adoption. Future studies can test the mediating effects of other factors such as security and performance efficiency (Dutta et al., 2020; Gurtu & Johny, 2019). Finally, yet importantly, the enablers of blockchain assessed in this study, such as the operational transparency or agility of supply chains, imply that the scope of blockchain adoption expands well beyond the boundaries of focal firms. As one of the fundamental technological constituents of Industry 4.0, the institutionalization of blockchain entails the horizontal integration of value network partners and their functions. This means the scope of blockchain adoption expands beyond the focal implementing SMEs. The successful adoption of blockchain for a given SME would significantly rely on the readiness of its upstream suppliers and downstream distributors and customers to engage in the blockchain-driven business interactions collaboratively. Indeed the literature widely acknowledges that the adoption of business-to-business digital technologies should be studied at the supply chain analysis levels (Ghobakhloo et al., 2014). Ghobakhloo et al. (2022)

recently revealed that the integrative technologies of Industry 4.0, such as blockchain, require the implementing firm and its business partners and customers to have technical competencies (e.g., infrastructure or positive attitude) to jointly adopt and accept such technologies. We studied the determinants of blockchain adoption intention from the focal firm perspective. Future research is invited to explore how key determinants such as transparency or supply chain agility can affect supply partners' collective blockchain adoption decisions."

7. Conclusions

The huge expansion of outsourcing, production facilities relocation, and globalization make modern supply chains complex (Eckstein et al., 2015; Saberi et al., 2019). Blockchain is one of the most cutting-edge, transformation, and promising technologies (Kouhizadeh et al., 2020; Wamba & Queiroz, 2022) that has the potential to transform supply chain management by embedding transparency, security, authenticity, trust, and efficiency into the chain (Dutta et al., 2020; Wong et al., 2020). In this study, drawing on RBV and contingency theories, we evaluated the associations between supply chain transparency, alignment, adaptability, agility, and intention to adopt blockchain among SMEs. The results confirmed that the blockchain's ability to enhance supply chain transparency and agility influences SMEs' intention to adopt blockchain. In industries with turbulence and unpredictable markets, the contribution of the blockchain to agility plays a more significant role in motivating firms to adopt blockchain. Although results show that agility is influenced by supply chain adaptability, it should be considered that supply chain transparency and alignment are determinants of adaptability. Given the benefits of blockchain and the low level of adoption among SMEs, this study made substantial contributions to the literature and practice by illustrating the roles of blockchain benefits to the supply chain in motivating SMEs to adopt this disruptive technology.

CRedit authorship contribution statement

Mohammad Iranmanesh: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Parisa Maroufkhani:** Methodology, Writing – original draft. **Shahla Asadi:** Methodology, Writing – original draft. **Morteza Ghobakhloo:** Methodology, Writing – original draft, Writing – review & editing. **Yogesh K. Dwivedi:** Writing – original draft, Writing – review & editing. **Ming-Lang Tseng:** Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgement

None.

Appendix

Measurement instrument

Operational Supply Chain Transparency (TRA)

1. Blockchain is helpful in sharing operational plans (e.g., distribution plans, production plans) regarding product design information among supply chain partners.

- Blockchain is helpful in sharing operations information (e.g., batch size, run quality, transfer quality, buffer stock, available machines, machine breakdown time) among supply chain partners.
- Blockchain is helpful in sharing planning and design information (e.g., current planning and design performance, operations performance, resource utilization, rework and scrap level, level of work progress) among supply chain partners.
- Blockchain is helpful in sharing strategic information (e.g., new orders, product demand, internal and external expertise, teachability, culture, government regulations) among supply chain partners.

Supply Chain Alignment (ALG)

- My firm's capability for process integration will improve by using blockchain.
- My firm's capability to integrate sourcing, transport, service process, and other internal areas will be improved by using blockchain.
- My firm's capability to integrate sourcing, transport, service process, and other areas with suppliers will improve by using blockchain.
- My firm's capability to integrate sourcing, transport, service process, and other areas with customers will improve by using blockchain.

Supply Chain Adaptability (ADP)

- My firm can quickly change the design as per market requirements by using blockchain.
- My firm can quickly adjust our production mix by using blockchain.
- My firm can change the quantity and quality mix of purchasing by using blockchain.

Supply Chain Agility (AGL)

- Blockchain is helpful in reducing manufacturing lead time.
- Blockchain is helpful in reducing the development cycle time.
- Blockchain is helpful in improving the frequency of introducing new products.
- Blockchain is helpful in increasing product customization.
- Blockchain is helpful in increasing delivery capabilities.
- Blockchain is helpful in increasing customer service.
- Blockchain is helpful in delivery reliability.
- Blockchain is helpful in adjusting to changing market needs.

Market Turbulence (MT)

- In our kind of business, customers' product preferences change a lot over time.
- Marketing practices in our product area are constantly changing.
- New product introductions are very frequent in this market.

Blockchain Adoption Intention (BAI)

- My firm will adopt blockchain in supply chain management in the future.
- My firm will use blockchain in supply chain management in the future.
- My firm intends to digitally transform supply chain management through blockchain.

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