Global Business and Management Research: An International Journal
Vol. 16, No. 3 (2024)

From Threads to Trends: IoT's Role in Enhancing Supply Chain & Firm Performance in Pakistani Textiles

Syeda Khadija Mubeen
Graduate School of Business, Universiti Sains Malaysia, Penang, Malaysia
Syedakhadija@student.usm.my

Ali Vafaei-Zadeh*
Graduate School of Business, Universiti Sains Malaysia, Penang, Malaysia
vafaei@usm.my

Azlan Bin Amran
Graduate School of Business, Universiti Sains Malaysia, Penang, Malaysia
azlan_amran@usm.my

* *Corresponding author*

Abstract

Purpose: This study aims to investigate the influence of Technology-Organization-Environment (TOE) capability drivers on IoT adoption, analyze the effect of IoT on supply chain performance (SCP), and examine the indirect impact of TOE capability drivers on SCP through the mediating role of IoT. Additionally, the moderating role of supply chain resilience is explored. Focusing on the manufacturing sector in Pakistan, this research examines how SCP influences firm performance.

Design/methodology/approach: Twenty-one hypotheses are proposed for this study. A questionnaire has developed based on technological, organizational, and environmental perspectives. The survey will conduct within Pakistan's textile manufacturing sector using this questionnaire.

Research limitations/implications: This study will be beneficial for managers, top management, and policymakers. It identifies the areas where textile manufacturing sector need to focus in order to adopt new technologies.

Originality/value: In the literature, few articles have specifically considered IoT adoption on SCP in textile firms from a TOE framework perspective. Therefore, this study is unique in its inclusion of technological, organizational, and environmental drivers.

Keywords: TOE Framework, Supply Chain Performance, Technology adoption, Supply Chain Resilience, Firm Performance, PLS-SEM

Classification: Conceptual paper

Introduction

In the digital economy, industries face both internal and external encounters to survive in the global market, especially within the manufacturing sector (Javaid et al., 2024). Externally, companies must navigate growth, technological changes, and intense national and international competition (Abaddi et al., 2024; Azeem et al., 2021; Waqas et al., 2023). The manufacturing industry is under significant pressure to enhance supply chain performance (SCP) and gain a competitive edge (Tian, 2016). Firms need to focus on speed, quality, price, innovation, and customer responsiveness to improve their global competitiveness and achieve organizational performance through effective supply chain management (SCM). Nevertheless, the marketplace is constantly evolving, leading to short-lived advantages due to rapid product life cycles, technological progress, and globalization. Consequently, global competition compels businesses to upgrade their technology and enhance supply chain efficiency to stay competitive (Singh and Kumar, 2020).

The manufacturing sector is acknowledged as Pakistan's third-largest sector, contributing approximately 14% to 16% of the nation's annual gross domestic product (GDP), with large-scale manufacturing accounting for 80% and small-scale manufacturing for 1.8% (Bakar, 2019; Aftab et al., 2023). Research underscores that Pakistan's manufacturing industry is predominantly dominated by large enterprises, which make up approximately 80% of the sector. Manufacturing companies in Pakistan face increasing demands to enhance SCP by focusing on cost reduction, shorter delivery times, and improved customer satisfaction. In particular, the textile and apparel industries are under significant pressure from major regional competitors such as China, India, and Bangladesh, which have integrated advanced technologies into their supply chain processes (Mustafa, 2018; Owais, 2020). Consequently, key challenges for textile and apparel manufacturers in Pakistan include uncertain lead times and low productivity (Manzoor et al., 2021). Furthermore, as Lee et al. (2024) emphasize, industries with low levels of advanced technology adoption struggle to improve SCP due to insufficient organizational capabilities in the digital network. Effective SCP is crucial for enhancing industry performance by collective efficiency, dipping costs, and boosting customer gratification (Jum'a and Bushnaq, 2024). Research indicates poor SCP significantly negatively impacts overall firm performance.

This can be significantly enhanced through the adoption and implementation of IoT technology (Mukherjee et al., 2024). IoT improves the connectivity among suppliers, customers, and internal logistics processes, streamlining operations et al., 2020). It benefits manufacturers throughout the product life cycle, reducing product abandonment risks. Integrating IoT into the supply chain enhances operational procedures, lowers costs, and mitigates risks, leading to improved efficiency, reduced waste, and better product quality (Haddud et al., 2017). The global industrial IoT market reached approximately USD 326.1 billion in 2021 and is anticipated to grow to about USD 1,742 billion by 2030 (Industrial IoT Market, 2022).

The Technology-Organization-Environment (TOE) framework is recognized for its effectiveness in enhancing organizational capabilities by integrating technological, organizational, and environmental factors. This comprehensive approach underscores its significance for future research and experimentation, particularly in evaluating innovation and digital technology adoption (Abdurrahman et al., 2024). Several studies have validated the TOE model's efficacy in assessing technology adoption across various sectors (Chittipaka et al., 2022; Lutfi et al., 2023; Salah et al., 2024). Hence, this study endeavors to bridge a research gap within Pakistan's manufacturing sector by examining how TOE capability drivers influence the adoption of IoT, evaluating the impact of IoT adoption on supply chain performance (SCP), and scrutinizing how IoT adoption mediates the relationship between TOE drivers and SCP. The research aims to address the following key questions:

RQ1. What is the role of TOE capability drivers in uplifting IoT adoption and supply chain performance thereon?
RQ2. How do IoT adoption and supply chain resilience contribute to the association between TOE capability drivers and SCP?
RQ3. What impact does SCP have on firm performance (FP) in Pakistan's manufacturing industry?

This research addresses several gaps in the literature. First, while technology adoption studies have extensively explored TOE variables in the framework of big data analytics (Lutfi et al., 2023) and blockchain acceptance (Chittipaka et al., 2022), few studies (Bhatiasevi and Naglis, 2020) have applied this model within the supply chain domain. The foundation of IoT adoption and its impact on supply chain and FP has received limited attention from researchers. Second, this research examines the mediating role of IoT adoption on the relationship between TOE capability drivers and SCP. The IoT is driving a significant paradigm shift in the manufacturing industry, profoundly affecting the entire supply chain (Ehie and Chilton, 2020). Thirdly, this study explores the moderating influence of supply chain resilience on the association between IoT adoption and SCP. According to Hosseini et al. (2019), supply chain resilience empowers a system not only to recover to its pre-disruption state but also to surpass its previous capabilities.

Drawing from the resource-based perspective theory (Tukamuhabwa et al., 2015; Sheel and Nath, 2019; Alraja et al., 2022), this study proposes that TOE capability drivers, IoT adoption, and supply chain resilience play pivotal roles in safeguarding a firm's valuable resources and capabilities. According to Barney's assertion, a firm's intellectual capital encompasses assets, capacities, organizational processes, qualities, information, and knowledge that enable it to conceive and execute plans enhancing efficiency and effectiveness. This research culminates in an empirical exploration of how TOE capability drivers integrate IoT adoption and supply chain resilience to enhance both SCP and FP. This innovative conceptual framework contributes to current knowledge and suggestions industrial managers understandings to better comprehend and manage TOE capability drivers through IoT adoption and supply chain resilience, thereby bolstering supply chain and FP in developing countries. This is particularly pertinent in the context of Pakistani manufacturing industries, an area that remains underexplored in current research.

The structure of this paper is organized as follows: Section 2 will provide an inclusive past literature review, detailing the development of hypotheses. Section 3 will outline the contributions of this study and present the conclusions drawn from the research.

Literature review and hypotheses development

Definitions and dimensions

Supply chain performance (SCP)

Supply chain performance refers to the operational metrics and indicators that enhance the overall supply chain through collaborative connections among its participants (Odongo et al., 2016). It differs from FP, which represents the tangible outcomes or results achieved through collaboration among both inter-organizational and intra-organizational entities (Huisman and Smits, 2007). Improved SCP holds strategic importance, potentially leading to swift financial returns, increased productivity, profitability, and enhancements in overall competitiveness (Jensen and Whitfield, 2022). Research by Green et al. (2019) underscores that higher levels of SCM application correlate positively and significantly with competitive advantages. Consequently, many companies prioritize optimizing SCP as a strategic tool to enhance organizational performance (Sutduean et al., 2019).

Firm performance (FP)

Firm performance denotes the overall success or effectiveness of a corporation or organization (Li et al., 2006). It is assessed through various metrics, both financial and non-financial (Tan et al., 1998). Financial metrics, such as revenue, profit margins, return on investment, and market share, provide quantitative insights into the financial health of a firm. In contrast, non-financial metrics, comprising customer gratification, employee engagement, innovation, and sustainability, offer qualitative assessments of other aspects of FP (Chen and Paulraj, 2004). Furthermore, several factors influence firm performance, including strategy, resources, capabilities, and the external environment (Abeysekara et al., 2019). For instance, firms with clear strategies, effective leadership, engaged employees, and robust relationships with stakeholders are more likely to perform strongly. Strategies that align with organizational goals, investments in resources and capabilities, and adaptability to external changes are crucial for improving FP (Singh et al., 2021). This may involve initiatives such as product innovation, process optimization, talent management, and strategic partnerships (Lin et al., 2020). Ultimately, FP is pivotal for long-term success and sustainability. By continually measuring, monitoring, and enhancing performance, firms can bolster their competitiveness, achieve sustainable growth, and generate value for stakeholders (Di Vaio et al., 2023)

Internet of Things (IoT)

Technology adoption refers to the deliberate decision by individuals, organizations, or societies to integrate new innovations into their existing practices or systems, recognizing it as the most suitable path forward (Rogers, 2003). Within an organizational context, adoption involves accepting and ultimately implementing innovation (Deering et al., 2012). IoT, or the Internet of Things, encompasses the interconnectedness of devices through improvised infrastructure, ensuring continuous access to generated data by management personnel (Qader et al., 2023). Key IoT technologies within the supply chain include radio frequency identification (RFID), cloud computing, wireless sensor networks (WSN), middleware, and IoT application software, all of

which facilitate enhanced performance and environmentally sustainable practices (Ali et al., 2023). SCM stands as a critical business priority embedded within the strategic plans of nearly all manufacturing companies, particularly as the digital era advances towards interconnectedness via the Internet (Farahani et al., 2017). However, the adoption of IoT also introduces security challenges such as data breaches, identity theft, and hacking concerns (Qader et al., 2023). Therefore, in the competitive corporate landscape of modern times, manufacturing businesses encounter substantial challenges in developing new products or services with distinctive features crucial for survival and maintaining a competitive edge (Yang et al., 2019).

Supply chain resilience (SCR)

Supply chain resilience may be described that the supply chain's ability to be prepared for any unanticipated event, react to continuing disturbances, and recover from distractions (Brusset et al., 2017). SCR is a requirement with several dimensions. Consequently, it is essential to grasp and comprehend the notion appropriately. The supply chain can react to the situation by planning for unanticipated occurrences, responding to disruptions as they occur, and then recovering operational capabilities for connections, procedures, and additional regulatory framework (Qader et al., 2022; Heredia et al., 2022). SCR comprises three key phases: anticipation, resistance, and recovery/response. Hosseini et al. (2019) suggest that the greater the complexity and limitations of the external environment, the higher the probability of experiencing disruptions, unforeseen occurrences, and unforeseeable events. Instances such as natural calamities, military conflicts, labor strikes, and economic downturns are examples of disturbances that can considerably influence supply chain operations (Chopra and Sodhi 2004; Negri et al. 2021, Butt, 2021). However, the current situation can be improved through digitalization and government support, which are seen as promising solutions. Moreover, supply chain resilience has the potential not only to recover to its initial state before the disruption but also to become more advanced than before (Hosseini et al., 2019). Chowdhury and Quaddus (2017) demonstrated that SC resilience can provide more accurate predictions of SCP. Based on the findings of Altay et al. (2018), SCR is a dynamic competence that has a substantial influence on SC performance.

Theoretical underpinning

The study is rooted in Resource-Based View (RBV) theory, focusing on how a organization's resources and capabilities influence its long-term performance. RBV highlights the importance of aligning and efficiently using these elements to achieve desired outcomes (Grant, 1991; Barratt and Oke, 2007; Queiroz et al., 2022). The theory emerged as a response to a move from a product-centric view to a resource-centric perspective (Wernerfelt, 1984). RBV underscores that coordinated deployment of resources and capabilities is pivotal for generating performance and achieving competitive advantages (Alraja et al., 2022). Eniola and Ektebong (2016) proposed that supply chains maintain their performance through distinct resources. RBV's relevance stems from its widespread use in FP studies. It guides the optimal use of scarce and unique resources, aiding in achieving performance goals (Barney, 1991). Additionally, RBV is established to promote value through resource commitment, enabling firms to create and grow by controlling resources (Hunt and Davis, 2012; Carter et al., 2017). The theory's focus on internal resources and external capabilities helps in strategy formulation for achieving targets (Alraja et al., 2022). RBV similarly addresses the strategic practice of IT applications like IoT, which can provide a competitive edge through unique capabilities (Sheel and Nath, 2019; Eisenhardt and Martin, 2000). Although the impact of IoT on SCP remains uncertain, strategic implementation and reconfiguration are

suggested. Resilience is explored through various theories, including RBV, dynamic capabilities, and more. Therefore, RBV has been utilized to elucidate how resources and capabilities contribute to resilience and performance (Tukamuhabwa et al., 2015; Wu and Chiu, 2015). SCR, viewed as a higher-level capability, involves adapting to disruptions and effectively utilizing resources for competitive advantage (Wang et al., 2010). RBV's framework helps understand how SCP influences FP.

Hypotheses development

TOE capability drivers and IoT adoption

Technological capability drivers

In the context of hypothesis development, the increasing digitization and rapid innovation driven by the internet and globalization have significantly shortened product life cycles, compelling businesses across various sectors and sizes to continually upgrade their technologies (Qader et al., 2022). Technology plays a pivotal role not only in fostering economic development but also in delivering significant economic benefits to businesses. Compatibility stands out as a critical driver influencing technology adoption, as demonstrated in studies such as Kapoor et al. (2015) and Chen et al. (2020), which found that compatibility, particularly in areas like artificial intelligence, strongly influences adoption rates. Moreover, the cost associated with adopting new technologies is another pivotal factor influencing adoption decisions (Tan et al., 2009; Ramayah et al., 2016). Despite the initial high costs often associated with IoT adoption, many firms are motivated by the potential for significant returns on investment (Arendt, 2008). However, cost remains a barrier, as evidenced in research on electronic commerce adoption among manufacturing firms (Sila, 2013; Mohtaramzadeh et al., 2018). Despite its potential benefits, IoT deployment faces barriers such as privacy and security concerns (Whitmore et al., 2014; Haddud et al., 2017). Issues like cybersecurity breaches in supply chains underscore the importance of robust security measures across both hardware and software layers (Boyes, 2015; He et al., 2022). Given the insights from studies such as Lutfi et al. (2022), which underscore a notable negative correlation between security and the adoption rates of technologies such as big data, this study proposes that security and privacy concerns exert a negative influence on IoT adoption. Therefore, the following hypothesis is posited:

H01: Compatibility has a positive impact on IoT adoption.

H02: Cost has negative impact on IoT adoption.

H03: Security & privacy has negative impact on IoT adoption.

Organizational capability drivers

According to the TOE framework, organizational context significantly influences the adoption of new technologies. Organizational capabilities, including resources and managerial support, play a crucial role in facilitating technology adoption. The ability of employees to effectively learn and utilize new technologies, supported by managerial encouragement, is essential for successful adoption (Sivathanu, 2019). Top management support is pivotal in securing resources for technology adoption and realizing the benefits and future performance improvements associated

with its implementation (Kumar et al., 2022). Previous studies have primarily highlighted top management's role in shaping organizational norms, values, and culture to foster technology adoption (Khan and Ali, 2018; Ahmad et al., 2019). Organizational readiness, encompassing technical IT skills and the capacity to manage and invest in new technologies, is critical (Yoon and George, 2013). Larger organizations typically possess greater resources to explore new technologies and achieve economies of scale (Horváth and Szabó, 2019). Research underscores that an organization's readiness level significantly correlates with its adoption rate of emerging technologies (Nguyen et al., 2022; Lutfi et al., 2022). Similarly, organizational readiness has been identified as pivotal in the adoption of cloud computing (Gui et al., 2020). Moreover, organizational innovativeness is a key determinant in technology adoption decisions. Companies with a culture of innovation are more inclined to embrace inter-organizational systems (Venkatesh and Bala, 2012). The willingness and ability of organizations to absorb and implement innovations are closely tied to their innovativeness (Lin et al., 2020), which in turn positively influences the adoption of new technologies. This propensity for innovation has been shown to significantly enhance the adoption of blockchain technology (Nuryyev et al., 2020). Based on these insights, the following hypotheses are proposed:

H04: Top management support has positive impact on IoT adoption.
H05: Organization readiness has a positive impact on IoT adoption.
H06: Organization innovativeness has a positive impact on IoT adoption.

Environmental capability drivers

Environmental consequences refer to the structural impacts on industries, while external environmental drivers stem from the broader economic climate. Understanding a firm's external environmental drivers requires a comprehensive grasp of its environmental consequences (Godina et al., 2020; Qalati et al., 2021). Businesses typically contend with competitive pressures from suppliers, customers, and industry rivals. Research indicates a positive correlation between mobile commerce adoption and competitive pressure (Chau et al., 2020). Similarly, Rawashdeh and Rawashdeh (2023) identified a statistically significant relationship between competitive pressure and digital vision. High market competitiveness has been widely acknowledged to influence firms' adoption of emerging technologies (Farahbakhsh et al., 2023). Additionally, Tajudeen et al. (2018) found a positive correlation between increased competition levels and social media usage. Adopting advanced technologies is a common strategy for maintaining competitiveness in today's business environment (Asiaei and Rahim, 2019). Furthermore, trade partner engagement refers to collaborative business relationships involving two or more firms (Lin et al., 2011). In supply chain contexts, these relationships become increasingly complex due to the growing number of network nodes (Fernie, 2023). Organizations may adopt technologies at the behest of their trading partners to maintain connectivity (Cegielski et al., 2012). Recent studies highlight that pressure from business partners significantly influences the adoption of new technologies (Low et al., 2011). Wamba et al. (2020) underscored trading partner pressure as pivotal in cloud computing adoption, while Alam et al. (2021) emphasized its impact on AR technology adoption. Thus, trading partner pressure may positively influence IoT adoption. Moreover, government support can either facilitate or impede technology deployment within organizations. Many governments provide administrative and financial support for adopting and training on emerging technologies, benefiting businesses lacking internal resources to enhance their competitiveness (Lee and Yoon,

2022). Conversely, stringent regulations mandating robust control and testing equipment for industrial safety can hinder technology adoption (Gwala and Mashau, 2023). Rodríguez-Espíndola et al. (2022) assessed the significance of governmental support in digital platform adoption in developing countries. This study aligns with assumptions regarding IoT adoption and recognizes the role of government support in encouraging and encouraging IoT technology adoption. Therefore, the following hypothesis is posited:

H07: Competitive pressure has a positive impact on IoT adoption.
H08: Trading partner pressure has a positive impact on IoT adoption.
H09: Government support has a positive impact on IoT adoption

IoT adoption and supply chain performance

The adoption of IoT is on a trajectory of continuous growth and is poised to significantly impact consumers, businesses, and society as a whole, particularly within the manufacturing sectors (Lund et al., 2014). IoT adoption allows manufacturers to monitor and track their products' activities, providing valuable insights that enhance technical support (Rymaszewska et al., 2017). By offering real-time remote monitoring of product usage, status, and location throughout the product life cycle, IoT enhances SCP (Spring and Araujo, 2017). In contemporary business environments, IoT enables supply chain managers to dynamically address challenges, developing tactical and strategic procedures to improve SCP (Li and Li, 2017). IoT-driven supply chains boost productivity and competitiveness by optimizing shipments, responding faster to market changes, and ensuring complete deliveries (Affia et al., 2019; Robinson, 2015). Consequently, the following hypothesis is proposed:

H10: IoT adoption has a positive impact on SCP.

IoT adoption as a mediator

Previous research has established that technology adoption is significantly influenced by TOE (Technological, Organizational, and Environmental) factors (Bhattacharya and Wamba, 2018; Ali Abbasi et al., 2022). Empirical evidence has also confirmed a strong relationship between technology adoption and SCP (Lee et al., 2022; Qader et al., 2022). Therefore, the existing literature supports the mediating role of IoT adoption in the relationships between these three TOE factors: technology (compatibility, cost, security & privacy), organization (top management support, organizational readiness, and organizational innovativeness), and environment (competitive pressure, trading partner pressure, and government support), and SCP. Prior studies have similarly tested the mediating role of various technologies such as cloud computing (Abu-Darwish et al., 2022), digital innovation (Khin and Ho, 2018), and blockchain (Sun et al., 2022). For instance, Philsoophian and Akhavan (2021) explored blockchain adoption as a mediator in knowledge sharing for supply chain management, while Hussain et al. (2020) found that e-commerce mediates the relationship between FP and TOE factors. Based on these findings, it is anticipated that technology (compatibility, cost, security & privacy), organization (top management support, organizational readiness, and organizational innovativeness), and

environment (competitive pressure, trading partner pressure, and government support) indirectly influence SCP through IoT adoption. Therefore, the following hypotheses are proposed:

H12: IoT adoption positively mediates the relationship between compatibility and SCP.
H13: IoT adoption negatively mediates the relationship between cost SCP.
H14: IoT adoption negatively mediates the relationship between security & privacy and SCP.
H15: IoT adoption positively mediates the relationship between top management support and SCP.
H16: IoT adoption positively mediates the relationship between organization readiness and SCP.
H17: IoT adoption positively mediates the relationship between organization innovativeness and SCP.
H18: IoT adoption positively mediates the relationship between competitive pressure and SCP.
H19: IoT adoption positively mediates the relationship between trading partner pressure and SCP.
H20: IoT adoption positively mediates the relationship between government support and SCP.

Supply chain resilience as a moderator

Resilience serves as an internal resource enabling organizations to navigate external crises and opportunities, potentially enhancing FP (Liu et al., 2018). It facilitates adaptive responses in crisis scenarios, aiding survival, recovery, growth, and competitive advantage (Torres et al., 2019). In times of volatility and uncertainty, resilience capabilities are crucial for organizations to recover swiftly from disruptions and adapt to future challenges (Duchek, 2020). Conversely, organizations lacking resilience are more vulnerable to disruptions and struggle to restore operations quickly (Piprani et al., 2020). While prior research has explored the relationship between technology adoption and SCP (Qader et al., 2022; Wamba et al., 2022), there is limited investigation into SCR as a moderator between IoT adoption and SCP. IoT adoption enhances supply chain resilience by providing real-time visibility, thereby improving overall SCP (Ivanov et al., 2019). Existing literature also highlights resilience's significant impact on organizational performance (Siagian et al., 2021). Hence, it is hypothesized that the resilience capability of manufacturing firms in handling disruptions will moderate the relationship between IoT adoption and SCP. Therefore, this study proposes the following hypotheses:

H21: The positive relationship between IoT adoption and SCP will be stronger when SCR is high.

Firm Performance as an outcome

Due to the fiercely competitive business environment, FP has become a focal point for numerous scholars and researchers. In the realm of textile manufacturing companies, the agility and resilience of the supply network significantly influence SCP. The linkage between SCP and FP has been widely affirmed (Qrunfleh et al., 2014). An effective supply chain can substantially lower costs, boost productivity, enhance quality, and improve customer satisfaction, thereby bolstering financial performance through better responsiveness to customer needs, reduced inventory levels, and streamlined operations. Furthermore, coordinated supply chain activities within and beyond

organizational boundaries are pivotal in meeting customer delivery expectations promptly and efficiently, while also trimming inventory and logistics costs, factors crucially tied to FP (Kocoglu et al., 2022). Numerous studies underscore that a supply chain's ability to manufacture and deliver products in alignment with customer demands significantly contributes to enhanced FP (Vickery et al., 2003; Chen et al., 2004). Scholars have extensively explored the impact of SCM practices on firm performance, with findings indicating that supply chain process integration indirectly influences performance (Farivar et al., 2022), and that superior SCP positively correlates with organizational performance (Loon Lee et al., 2022). Therefore, based on these insights, the following hypothesis is proposed:

H11: SCP has a positive impact on FP.

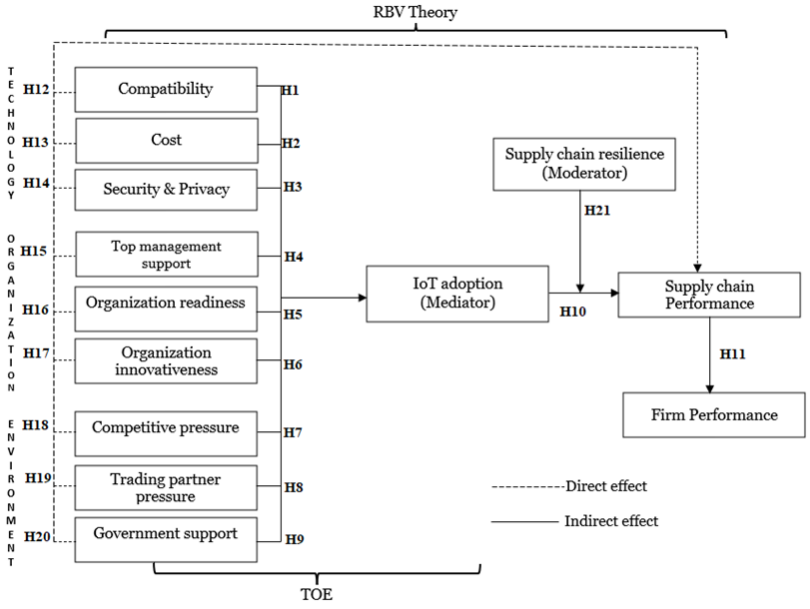

Figure 1. The research framework
Source: (Author)

Contributions and conclusions

The digital era introduces new corporate ideals and challenges, fostering deeper connections among people/consumers, governments, and enterprises, albeit with associated costs. When industrial firms deploy IoT systems to navigate global market challenges and unforeseen events, they gain a competitive edge. This study aligns closely with the philosophy and practice of business research. Previous research on technology adoption has predominantly focused on specific performance metrics within the manufacturing sector, such as export, economic, environmental, and sustainable performance (Umar et al., 2021; Khan et al., 2022; Alraja et al., 2022; AL-Khatib, 2023). However, less attention has been given to measuring the impact of IoT on SCP compared to theorizing about the broader impacts of technology adoption. Existing literature has largely theorized the positive effects of technology adoption on SCP (Qader et al., 2022). Therefore,

achieving enhanced supply chain efficiency through adoption drivers is pivotal for many businesses.

This study aims to explore the role of IoT adoption as a moderating variable in the relationship between adoption capability drivers (TOE drivers) and SCP. Specifically, the research will investigate the influence of nine variables on IoT adoption within the industrial sector. Previous studies employing TOE drivers have typically used conventional drivers to assess innovation adoption. However, this study will uniquely incorporate cost, security and privacy, trade partner pressure, and organizational innovativeness, which have been underutilized in previous research. Additionally, the study will examine the moderating impact of supply chain resilience on the relationship between SCP and firm performance, drawing data from industrial managers in Pakistan's manufacturing sector.

This expanded framework offers practical implications, particularly by suggesting that attitudes are shaped through deliberate evaluation of constructs/factors, potentially leading to action, given the high-involvement nature of IoT adoption. While the constructs of this proposed model are not exhaustive, further research is encouraged for refinement and enhancement. Nevertheless, current research indicates that integrating TOE and RBV is uncommon in the context of IoT adoption, SCP, and firm performance. Despite attempts by scholars to integrate various theories and models to study adoption and performance (Oliveira et al., 2019; Hussain et al., 2022), the delayed adoption of IoT in industrial settings often stems from insufficient knowledge and awareness about IT infrastructure capabilities. RBV and TOE offer valuable insights into how businesses can enhance FP (Abdurrahman et al., 2024). This paper provides a stronger theoretical foundation for understanding adoption behavior. However, the proposed integration of RBV and TOE capability drivers on a broader scale could offer more comprehensive explanatory and predictive frameworks for IT adoption. The connection between adoption drivers and constructs is not mutually exclusive; rather, their interaction is complementary, with each element exerting varying degrees of influence at different decision-making junctures.

Operational implications

This research holds important implications for industry professionals, government entities, and academia. Future researchers are encouraged to further refine the models proposed herein. It is imperative for governments, their agencies, and non-governmental organizations to support the manufacturing sector in adopting IT infrastructures by disseminating information on cost reduction and improved decision-making capabilities. Governments also bear the responsibility of enhancing governance through transparency, accountability, inclusivity, and adherence to the rule of law, thereby promoting economic development and industrial growth in the digital age, especially in countries like Pakistan facing resource constraints but pivotal in economic development.

Our study identifies a critical pathway for promoting IoT adoption. In developing nations, notably Pakistan, there is anecdotal evidence suggesting that businesses often overlook the potential of technology in decision-making processes. Our findings underscore the significance of IoT adoption and supply chain resilience in enhancing overall performance. Hence, businesses should prioritize the adoption of innovative technologies and bolster the resilience of their supply chains accordingly.

References

Abaddi, S., & AL-Shboul, M. D. A. (2024). "Revealing the hidden"–challenges facing early digital entrepreneurs in Jordan. *Management & Sustainability: An Arab Review*, *3*(1), 69-88.

Abdurrahman, A., Gustomo, A., & Prasetio, E. A. (2024). Impact of dynamic capabilities on digital transformation and innovation to improve banking performance: A TOE framework study. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1), 100215.

Abeysekara, N., Wang, H., & Kuruppuarachchi, D. (2019). Effect of supply-chain resilience on firm performance and competitive advantage: A study of the Sri Lankan apparel industry. *Business Process Management Journal*, 25(7), 1673-1695.

Affia, I., Yani, L. P. E., & Aamer, A. M. (2019, December). Factors affecting IoT adoption in food supply chain management. In *9th International Conference on Operations and Supply Chain Management* (pp. 19-24).

Aftab, J., Abid, N., Cucari, N., & Savastano, M. (2023). Green human resource management and environmental performance: The role of green innovation and environmental strategy in a developing country. *Business Strategy and the Environment*, 32(4), 1782-1798.

Ahmad, S. Z., Abu Bakar, A. R., & Ahmad, N. (2019). Social media adoption and its impact on firm performance: the case of the UAE. *International Journal of Entrepreneurial Behavior & Research*, *25*(1), 84-111.

Ahmetoglu, S., Che Cob, Z., & Ali, N. A. (2022). A systematic review of Internet of Things adoption in organizations: taxonomy, benefits, challenges and critical factors. *Applied Sciences*, *12*(9), 4117.

Al Kurdi, B., Alshurideh, M., Nuseir, M., Aburayya, A., & Salloum, S. A. (2021). The Effects of Subjective Norm on the Intention to Use Social Media Networks: An Exploratory Study Using PLS-SEM and Machine Learning. Approach. In *Advances in Intelligent Systems and Computing1339.* https://doi.org/10.1007/978-3-030-69717 4_55.

Alharbi, F., Atkins, A., & Stanier, C. (2016). Understanding the determinants of Cloud Computing adoption in Saudi healthcare organisations. *Complex & Intelligent Systems*, *2*, 155-171.

Ali Abbasi, G., Abdul Rahim, N. F., Wu, H., Iranmanesh, M., & Keong, B. N. C. (2022). Determinants of SME's social media marketing adoption: competitive industry as a moderator. *Sage Open*, *12*(1), 21582440211067220.

Ali, S. M., Ashraf, M. A., Taqi, H. M. M., Ahmed, S., Rob, S. A., Kabir, G., & Paul, S. K. (2023). Drivers for Internet of Things (IoT) Adoption in Supply Chains: Implications for Sustainability in the Post-pandemic Era. *Computers & Industrial Engineering*, 109515.

Alraja, M. N., Imran, R., Khashab, B. M., & Shah, M. (2022). Technological Innovation, Sustainable Green Practices and SMEs Sustainable Performance in Times of Crisis

(COVID-19 pandemic). *Information Systems Frontiers*. https://doi.org/10.1007/s10796-022-10250-z

Altay, N., Gunasekaran, A., Dubey, R., & Childe, S. J. (2018). Agility and resilience as antecedents of supply chain performance under moderating effects of organizational culture within the humanitarian setting: a dynamic capability view. *Production Planning & Control*, 29(14), 1158-1174.

Anaam, E. A., Magableh, M. N. Y., & Ridha, A. (2022). Key Factors Influence on Decision Making to IoT Adoption in Telecommunication Companies: A Review. International *Journal of Engineering & Technology*, 11(1), 14-19.

Arendt, L. (2008). Barriers to ICT adoption in SMEs: How to bridge the digital divide? *Journal of Systems and Information Technology, 10*(2), 93 –108. doi:10.1108/13287260810897738.

Asadi, S., Nilashi, M., Iranmanesh, M., Hyun, S. S., & Rezvani, A. (2022). Effect of internet of things on manufacturing performance: A hybrid multi-criteria decision-making and neuro-fuzzy approach. *Technovation*, *118*, 102426.

Asiaei, A. and Ab. Rahim, N.Z. (2019), "A multifaceted framework for adoption of cloud computing in Malaysian SMEs", J*ournal of Science and Technology Policy Management, 10* (3), 708-750. https://doi.org/10.1108/JSTPM-05-2018-0053

Ayoade, J. (2007). Roadmap to solving security and privacy concerns in RFID systems. *Computer Law & Security Review*, *23*(6), 555-561.

Azeem, M., Ahmed, M., Haider, S., & Sajjad, M. (2021). Expanding competitive advantage through organizational culture, knowledge sharing and organizational innovation. *Technology in Society, 66*, 101635.

Baig, H., Ahmed, W., & Najmi, A. (2021). Understanding influence of supply chain collaboration on innovation-based market performance. *International Journal of Innovation Science*, *14*(2), 376-395.

Bakar, A. (2019). Manufacturing sector in Pakistan: a comprehensive review for the future growth and development. *Pakistan Journal of Humanities and Social Sciences, 7*(1), 77 – 91.

Barratt, M., & Oke, A. (2007). Antecedents of supply chain visibility in retail supply chains: a resource-based theory perspective. *Journal of operations management*, *25*(6), 1217-1233.

Beamon, B. M. (1998). Supply chain design and analysis: Models and methods. *International journal of production economics*, 55(3), 281-294.

Bhatiasevi, V., & Naglis, M. (2020). Elucidating the determinants of business intelligence adoption and organizational performance. *Information development*, 36(1), 78-96.

Bhattacharya, M., & Wamba, S. F. (2018). A conceptual framework of RFID adoption in retail using TOE framework. In *Technology adoption and social issues: Concepts, methodologies, tools, and applications*, 69-102. IGI global.

Brusset, X., & Teller, C. (2017). Supply chain capabilities, risks, and resilience. International *Journal of Production Economics*, 184, 59-68.

Butt, A. S. (2021). Strategies to mitigate the impact of COVID-19 on supply chain disruptions: a multiple case analysis of buyers and distributors. *The International Journal of Logistics Management.*

Caro, F., & Sadr, R. (2019). The Internet of Things (IoT) in retail*: Bridging supply and demand. Business Horizons*, 62(1), 47-54.

Carter, C. R., Kosmol, T., & Kaufmann, L. (2017). Toward a supply chain practice view. *Journal of Supply Chain Management*, *53*(1), 114-122.

Cegielski, C. G., Jones-Farmer, L. A., Wu, Y., & Hazen, B. T. (2012). Adoption of cloud computing technologies in supply chains: An organizational information processing theory approach. *The international journal of logistics Management*, *23*(2), 184-211.

Chen, I. J., & Paulraj, A. (2004). Towards a theory of supply chain management: the constructs and measurements. *Journal of operations management*, 22(2), 119-150.

Chen, X., & Siau, K. (2020). Business analytics/business intelligence and IT infrastructure: impact on organizational agility. *Journal of Organizational and End User Computing (JOEUC)*, *32*(4), 138-161.

Chittipaka, V., Kumar, S., Sivarajah, U., Bowden, J. L. H., & Baral, M. M. (2022). Blockchain Technology for Supply Chains operating in emerging markets: an empirical examination of technology-organization-environment (TOE) framework. *Annals of Operations Research*, 1-28.

Chopra, S., & Sodhi, M. S. (2004). Managing risk to avoid supply-chain breakdown. *MIT Sloan management review.*

Chowdhury, M. M. H., & Quaddus, M. (2017). Supply chain resilience: Conceptualization and scale development using dynamic capability theory. *International Journal of Production Economics*, 188, 185-204.

Cohen, C., & Cohen, P. (2005). West, & Aiken (2003). *Applied multiple regression/correlation analysis for the behavioral sciences*, 545.

Curtin, J., Kauffman, R. J., & Riggins, F. J. (2007). Making the 'MOST'out of RFID technology: a research agenda for the study of the adoption, usage and impact of RFID. *Information Technology and Management*, *8*, 87-110.

Das, S. D., & Bala, P. K. (2023). What drives MLOps adoption? An analysis using the TOE framework. *Journal of Decision Systems*, 1-37.

Dearing, J. W., Kee, K. F., & Peng, T. Q. (2012). Historical roots of dissemination and implementation science. Dissemination and implementation research in health: *Translating science to practice*, 55, 71.

Dewi, M. A. A., Hidayanto, A. N., Purwandari, B., Kosandi, M., & Budi, N. F. A. (2018). Smart city readiness model using technology-organization-environment (TOE) framework and its effect on adoption decision. PACIS 2018 *Proceedings*. 268. https://aisel.aisnet.org/pacis2018/268.

Di Vaio, A., Hassan, R., & Palladino, R. (2023). Blockchain technology and gender equality: A systematic literature review. *International Journal of Information Management*, 68, 102517.

Ehie, I. C., & Chilton, M. A. (2020). Understanding the influence of IT/OT Convergence on the adoption of Internet of Things (IoT) in manufacturing organizations: An empirical investigation. *Computers in Industry*, 115, 103166.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: what are they?. *Strategic management journal*, *21*(10-11), 1105-1121.

Eniola, A. A.& Entebang, H. (2016). Financial literacy and SME firm performance. *International Journal of Research Studies in Management, 5*(1), 31-43.

Eutsler, J., & Lang, B. (2015). Rating scales in accounting research: The impact of scale points and labels. *Behavioral Research in Accounting*, 27(2), 35-51.

Farahani, P., Meier, C., & Wilke, J. (2017). Digital supply chain management agenda for the automotive supplier industry. Shaping the digital enterprise: Trends and use cases in digital innovation and transformation, 157-172.

Farahbakhsh, S., Snellinx, S., Mertens, A., Belderbos, E., Bourgeois, L., & Van Meensel, J. (2023). What's stopping the waste-treatment industry from adopting emerging circular technologies? An agent-based model revealing drivers and barriers. *Resources, Conservation and Recycling, 190*, 106792.

Farivar, S., Golmohammadi, A., & Ramirez, A. (2022). Analytics Capability and Firm Performance in Supply Chain Organizations: The Role of Employees' *Analytics Skills. Analytics*, 1(1), 1-14.

Fiksel, J. (2006). Sustainability and resilience: toward a systems approach. *Sustainability: Science, Practice and Policy*, 2(2), 14-21.

Finstad, K. (2010). Response interpolation and scale sensitivity: Evidence against 5-point scales. *Journal of Usability Studies*, 5(3), 104-110.

Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological science*, *18*(3), 233-239.

Glabenewswire new Industrial-IoT-Market-Size-to-Worth-Around-USD-1742-8-Bn-by-2030.html.

Godina, R., Ribeiro, I., Matos, F., Ferreira, B. T., Carvalho, H., & Peças, P. (2020). Impact assessment of additive manufacturing on sustainable business models in industry 4.0 context. *Sustainability (Switzerland)*, *12*(17). https://doi.org/10.3390/su12177066.

Green, K. W., Inman, R. A., Sower, V. E., & Zelbst, P. J. (2019). Comprehensive supply chain management model. Supply Chain Management: *An International Journal*, 24(5), 590-603.

Gwala, R. S., & Mashau, P. (2023). COVID-19, Social Media Adoption, and the Future of Digital Diplomacy in Africa. In *The COVID-19 Pandemic and the Digitalization of Diplomacy* (pp. 46-73). IGI Global.

Haddud, A., DeSouza, A., Khare, A., & Lee, H. (2017). Examining potential benefits and challenges associated with the Internet of Things integration in supply chains. *Journal of Manufacturing Technology Management*.

Heredia, J., Rubiños, C., Vega, W., Heredia, W., & Flores, A. (2022). New strategies to explain organizational resilience on the firms: A cross-countries configurations Approach. Sustainability, 14(3), 1612.

Horváth, D., & Szabó, R. Z. (2019). Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities?. *Technological forecasting and social change*, *146*, 119-132.

Hosseini, S., Ivanov, D., & Dolgui, A. (2019). Review of quantitative methods for supply chain resilience analysis. Transportation research part E: *logistics and transportation review*, 125, 285-307.

Hsu, C. W., & Yeh, C. C. (2017). Understanding the factors affecting the adoption of the Inte Alharbi, F., Atkins, A., & Stanier, C. (2016). Understanding the determinants of Cloud Computing adoption in Saudi healthcare organisations. *Complex & Intelligent Systems*, *2*, 155-171.

Huisman, W., & Smits, M. (2007, January). Investing in Networkability to Improve Supply Chain Peformance. In 2007 40th Annual *Hawaii International Conference on System Sciences (*HICSS-7) 207-207. IEEE.

Hunt, S. D., & Davis, D. F. (2012). Grounding supply chain management in resource-advantage theory: In defense of a resource-based view of the firm. *Journal of Supply Chain Management*, *48*(2), 14-20.

Hussain, S., Song, X., & Niu, B. (2020). Consumers' motivational involvement in eWOM for information adoption: The mediating role of organizational motives. *Frontiers in psychology, 10, 3055.*

Javaid, M., Haleem, A., Singh, R. P., & Sinha, A. K. (2024). Digital economy to improve the culture of industry 4.0: A study on features, implementation and challenges. *Green Technologies and Sustainability*, 100083.

Jensen, F., & Whitfield, L. (2022). Leveraging participation in apparel global supply chains through green industrialization strategies: Implications for low-income countries. *Ecological Economics, 194*, 107331. https://doi.org/10.1016/j.ecolecon.2021.107331.

Jum'a, L., & Bushnaq, M. (2024). Investigating the role of flexibility as a moderator between supply chain integration and firm performance: the case of manufacturing sector. *Journal of Advances in Management Research*, *21*(2), 203-227.

Kapoor, K. K., Dwivedi, Y. K., & Williams, M. D. (2015). Examining the role of three sets of innovation attributes for determining adoption of the interbank mobile payment service. *Information Systems Frontiers*, *17*, 1039-1056.

Khan, A. N., & Ali, A. (2018). Factors affecting retailer's adopti on of mobile payment systems: A SEM-neural network modeling approach. *Wireless Personal Communications*, *103*, 2529-2551.

Kocoglu, I., Keskin, H., Cemberci, M., & Civelek, M. E. (2022). Effect of Supply Chain Coordination on Performance: A Serial Mediation Model of Trust, Agility, and Collaboration. *International Journal of Information Systems and Supply Chain Management (I*JISSCM), 15(1), 1-15.

Kumar, V., Vrat, P., & Shankar, R. (2022). Factors influencing the implementation of industry 4.0 for sustainability in manufacturing. *Global Journal of Flexible Systems Management*, *23*(4), 453-478.

Lee, I., & Lee, K. (2015). The Internet of Things (IoT): Applications, investments, and challenges for enterprises. *Business horizons, 58*(4), 431-440.

Lee, K. L., Teong, C. X., Alzoubi, H. M., Alshurideh, M. T., Khatib, M. E., & Al-Gharaibeh, S. M. (2024). Digital supply chain transformation: The role of smart technologies on operational performance in manufacturing industry. *International Journal of Engineering Business Management*, *16*, 18479790241234986.

Li, E. Y., Chen, J. S., & Huang, Y. H. (2006). A framework for investigating the impact of IT capability and organisational capability on firm performance in the late industrialising context. *International Journal of Technology Management, 36*(1-3), 209-229.

Lin, J., Luo, Z., & Luo, X. (2020). Understanding the roles of institutional pressures and organizational innovativeness in contextualized transformation toward e-business:

Evidence from agricultural firms. *International Journal of Information Management*, *51*, 102025.

Lokuge, S., Sedera, D., Grover, V., & Dongming, X. (2019). Organizational readiness for digital innovation: Development and empirical calibration of a construct. *Information & management*, *56*(3), 445-461.

Lutfi, A., Al-Okaily, M., Alsyouf, A., Alsaad, A., & Taamneh, A. (2020). The impact of AIS usage on AIS effectiveness among Jordanian SMEs: A multi-group analysis of the role of firm size. *Global Business Review*, 0972150920965079.

Mahmood, T., & Mubarik, M. S. (2020). Balancing innovation and exploitation in the fourth industrial revolution: Role of intellectual capital and technology absorptive capacity. Technological Forecasting and Social Change, 160,1-28. https://doi.org/10.1016/j.techfore.2020.120248.

Malik, S., Chadhar, M., Vatanasakdakul, S., & Chetty, M. (2021). Factors affecting the organizational adoption of blockchain technology: Extending the technology–organization–environment (TOE) framework in the Australian context. *Sustainability*, *13*(16), 9404.

Manzoor, U., Baig, S. A., Hashim, M., Sami, A., Rehman, H. U., & Sajjad, I. (2022). The effect of supply chain agility and lean practices on operational performance: a resource-based view and dynamic capabilities perspective. *The TQM Journal*, *34*(5), 1273-1297.

Mohtaramzadeh, M., Ramayah, T., & Jun-Hwa, C. (2018). B2B e-commerce adoption in Iranian manufacturing companies: Analyzing the moderating role of organizational culture. *International Journal of Human–Computer Interaction*, 34(7), 621-639.

Mukherjee, S., Baral, M. M., Chittipaka, V., Nagariya, R., & Patel, B. S. (2024). Achieving organizational performance by integrating industrial Internet of things in the SMEs: a developing country perspective. *The TQM Journal*, *36*(1), 265-287.

Mustafa, M. B., Saleem, I., & Dost, M. (2021). A strategic entrepreneurship framework for an emerging economy: reconciling dynamic capabilities and entrepreneurial orientation. *Journal of Entrepreneurship in Emerging Economies*, *14*(6), 1244-1264.

Narwane, V. S., Gunasekaran, A., & Gardas, B. B. (2022). Unlocking adoption challenges of IoT in Indian agricultural and food supply chain. Smart Agricultural *Technology*, 2, 100035.

Negri, M., Cagno, E., Colicchia, C., & Sarkis, J. (2021). Integrating sustainability and resilience in the supply chain: A systematic literature review and a research agenda. *Business Strategy and the environment*, 30(7), 2858-2886.

Newby, M., H. Nguyen, T., & S. Waring, T. (2014). Understanding customer relationship management technology adoption in small and medium-sized enterprises: An empirical study in the USA. *Journal of Enterprise Information Management*, *27*(5), 541-560.

Ng, I. C., & Wakenshaw, S. Y. (2017). The Internet-of-Things: Review and research directions. *International Journal of Research in Marketing,* 34(1), 3-21.

Nguyen, T. H., Le, X. C., & Vu, T. H. L. (2022). An Extended Technology-Organization-Environment (TOE) Framework for Online Retailing Utilization in Digital Transformation: Empirical Evidence from Vietnam. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(4), 200.

Nwosu, A. U., Goyal, S. B., & Bedi, P. (2021). Blockchain transforming cyber-attacks: healthcare industry. In Innovations in Bio-Inspired Computing and Applications: Proceedings of the 11th International Conference on Innovations in Bio-Inspired Computing and Applications (IBICA 2020) held during December 16-18, 2020 11 (pp. 258-266). *Springer International Publishing.*

Nyaga, K.M. (2013), "The impact of mobile money services on the performance of small and medium enterprises in an urban town in Kenya'', Doctoral Dissertation.

Odongo, W., Dora, M., Molnar, A., Ongeng, D., & Gellynck, X. (2016). Performance perceptions among food supply chain members: a triadic assessment of the influence of supply chain relationship quality on supply chain performance. *British Food Journal.*

Omoyiola, B. O. (2020). The evolution of information security measurement and testing. IOSR *Journal of Computer Engineering,* 22(3), 50-54.

Pettit, T. J., Croxton, K. L., & Fiksel, J. (2019). The evolution of resilience in supply chain management: a retrospective on ensuring supply chain resilience. Journal of Business Logistics, 40(1), 56-65. https://doi.org/10.1111/jbl.12202.

Phillips, T., Karygiannis, T., & Kuhn, R. (2005). Security standards for the RFID market. *IEEE Security & Privacy*, *3*(6), 85-89.

Piprani, A. Z., Jaafar, N. I., & Mohezar Ali, S. (2020). Prioritizing resilient capability factors of dealing with supply chain disruptions: an analytical hierarchy process (AHP) application in the textile industry. *Benchmarking: An International Journal*, *27*(9), 2537-2563.

Qalati, Sikandar Ali, Li, W., Ahmed, N., Mirani, M. A., & Khan, A. (2021). Examining the factors affecting sme performance: the mediating role of social media adoption. *Sustainability (Switzerland)*, *13*(1), 1–24. https://doi.org/10.3390/su13010075

Qrunfleh, S., & Tarafdar, M. (2014). Supply chain information systems strategy: Impacts on supply chain performance and firm performance. *International journal of production economics,* 147, 340-350.

Rad, F. F., Oghazi, P., Palmié, M., Chirumalla, K., Pashkevich, N., Patel, P. C., & Sattari, S. (2022). Industry 4.0 and supply chain performance: A systematic literature review of the benefits, challenges, and critical success factors of 11 core technologies. Industrial Marketing Management, 105, 268-293.

Ramayah, T., Ling, N. S., Taghizadeh, S. K., & Rahman, S. A. (2016). Factors influencing SMEs website continuance intention in Malaysia. *Telematics and Informatics*, *33*(1), 150-164.

Rawashdeh, A., & Rawashdeh, B. (2023). The effect cloud accounting adoption on organizational performance in SMEs. *International Journal of Data and Network Science*, *7*(1), 411-424.

Rodríguez-Espíndola, O., Chowdhury, S., Dey, P. K., Albores, P., & Emrouznejad, A. (2022). Analysis of the adoption of emergent technologies for risk management in the era of digital manufacturing. *Technological Forecasting and Social Change*, *178*, 121562.

Rogers, Patricia L., ed. Designing instruction for technology-enhanced learning. *IGI Global*, 2003.

Rymaszewska, A., Helo, P., & Gunasekaran, A. (2017). IoT powered servitization of manufacturing–an exploratory case study. *International journal of production economics*, *192*, 92-105.

Salah, O. H., & Ayyash, M. M. (2024). E-commerce adoption by SMEs and its effect on marketing performance: An extended of TOE framework with ai integration, innovation culture, and customer tech-savviness. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1), 100183.

Sanchez-Torres, J. A., & Juarez-Acosta, F. (2019). Modelling SME e-commerce with IMAES. *Journal of Business & Industrial Marketing*, *34*(1), 137-149.

Sayginer, C., & Ercan, T. (2020). Understanding determinants of cloud computing adoption using an integrated diffusion of innovation (doi)-technological, organizational and environmental (toe) model. *Humanities & Social Sciences Reviews*, *8*(1), 91-102.

Shahadat, M. H., Chowdhury, A. H. M. Y., Nathan, R. J., & Fekete-Farkas, M. (2023). Digital Technologies for Firms' Competitive Advantage and Improved Supply Chain Performance. *Journal of Risk and Financial Management*, 16(2), 94.

Sheel, A., & Nath, V. (2019). Effect of blockchain technology adoption on supply chain adaptability, agility, alignment and performance. *Management Research Review*.

Siagian, H., Tarigan, Z. J. H., & Jie, F. (2021). Supply chain integration enables resilience, flexibility, and innovation to improve business performance in COVID-19era. *Sustainability*, *13*(9),1-19 https://doi.org/10.3390/su13094669.

Sila, I. (2013). Factors affecting the adoption of B2B e-commerce technologies. *Electronic commerce research*, *13*, 199-236.

Singh, R. K., & Kumar, R. (2020). Strategic issues in supply chain management of Indian SMEs due to globalization: an empirical study. *Benchmarking: An International Journal*, *27*(3), 913-932.

Singh, R. P., Javaid, M., Haleem, A., & Suman, R. (2020). Internet of things (IoT) applications to fight against COVID-19 pandemic. Diabetes & Metabolic Syndrome: *Clinical Research & Reviews*, 14(4), 521-524.

Singh, S., Sharma, M., & Dhir, S. (2021). Modeling the effects of digital transformation in Lin, J., Luo, Z., & Luo, X. (2020). Understanding the roles of institutional pressures and organizational innovativeness in contextualized transformation toward e-business: Evidence from agricultural firms. *International Journal of Information Management*, *51*, 102025.

Sivathanu, B. (2019). Adoption of industrial IoT (IIoT) in auto-component manufacturing SMEs in India. *Information Resources Management Journal (IRMJ)*, *32*(2), 52-75.

Spring, M., & Araujo, L. (2017). Product biographies in servitization and the circular economy. *Industrial Marketing Management*, *60*, 126-137.

Sun, B., & Liu, Y. (2021). Business model designs, big data analytics capabilities and new product development performance: Evidence from China. *European Journal of Innovation Management*, *24*(4), 1162-1183.

Sutduean, J., Singsa, A., Sriyakul, T., & Jermsittiparsert, K. (2019). Supply chain integration, enterprise resource planning, and organizational performance: The enterprise resource planning implementation approach. *Journal of Computational and Theoretical Nanoscience*, 16(7), 2975-2981.

Tajudeen, F. P., Jaafar, N. I., & Ainin, S. (2018). Understanding the impact of social media usage among organizations. *Information & management*, *55*(3), 308-321.

Tan, K. C., Kannan, V. R., & Handfield, R. B. (1998). Supply chain management: supplier performance and firm performance. *International Journal of Purchasing & Materials Management*, 34(3).

Tian, F. (2016, June). An agri-food supply chain traceability system for China based on RFID & blockchain technology. In *2016 13th international conference on service systems and service management (ICSSSM)* (pp. 1-6). IEEE.

Tornatzky, L. G., Eveland, J. D., Boylan, M. G., Hetzner, W. A., Johnson, E. C., Roitman, D., & Schneider, J. (1983). The Process of Technological Innovation: Reviewing the Literature. *National Science Foundation*, *May*, x, 264. http://www.csa.com/partners/viewrecord.php?requester=gs&collection=TRD&recid=N8426466AH.

Tukamuhabwa, B. R., Stevenson, M., Busby, J., & Zorzini, M. (2015). Supply chain resilience: definition, review and theoretical foundations for further study. *International journal of production research*, *53*(18), 5592-5623.

Venkatesh, V., & Bala, H. (2012). Adoption and impacts of interorganizational business process standards: Role of partnering synergy. *Information systems research*, *23*(4), 1131-1157.

Venkatesh, V., & Bala, H. (2012). Adoption and impacts of interorganizational business process standards: Role of partnering synergy. *Information systems research*, *23*(4), 1131-1157.

Wang, C.L., and Ahmed, P.K. (2004). The development and validation of the organisational innovativeness construct using confirmatory factor analysis. *European Journal of Innovation Management*, 7(4), 303-313.

Wang, Y. M., Wang, Y. S., & Yang, Y. F. (2010). Understanding the determinants of RFID adoption in the manufacturing industry. *Technological forecasting and social change*, 77(5), 803-815.

Waqas, U., Abd Rahman, A., Ismail, N. W., Kamal Basha, N., & Umair, S. (2023). Influence of supply chain risk management and its mediating role on supply chain performance: perspectives from an agri-fresh produce. *Annals of Operations Research*, 324(1-2), 1399-1427.

Wernerfelt, B. (1984). A Resource-based View of the Firm. 5(June 1982), 171–180.

Whitmore, A., Agarwal, A. and Da Xu, L. (2015), "The Internet of Things a survey of topics and trends", *Information Systems Frontiers, 17* (2), 261-274.

Wong, L. W., Leong, L. Y., Hew, J. J., Tan, G. W. H., & Ooi, K. B. (2020). Time to seize the digital evolution: Adoption of blockchain in operations and supply chain management among Malaysian SMEs. *International Journal of Information Management*, *52*, 101997. https://doi.org/10.1016/j.ijinfomgt.2019.08.005.

Wu, L., & Chiu, M. L. (2015). Organizational applications of IT innovation and firm's competitive performance: A resource-based view and the innovation diffusion approach. *Journal of Engineering and Technology Management*, *35*, 25-44.

Wu, L., & Chuang, C. H. (2009). Analyzing contextual antecedents for the stage-based diffusion of electronic supply chain management. *Electronic Commerce Research and Applications*, 8(6), 302-314.

Yang, Y., Zheng, X., Guo, W., Liu, X., & Chang, V. (2019). Privacy-preserving smart IoT-based healthcare big data storage and self-adaptive access control system. *Information Sciences*, 479, 567-592.

Yoon, T. E., & George, J. F. (2013). Why aren't organizations adopting virtual worlds?. *Computers in Human Behavior*, *29*(3), 772-790.