EMPIRICAL INVESTIGATION OF SUPPLY CHAIN 4.0 ADOPTION IN VIETNAM

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ABSTRACT

Purpose

The rise of Industry 4.0, also known as the 4th Industrial Revolution, has transformed traditional supply chains into Supply Chain 4.0 (SC4.0), often referred interchangeably as Digital Supply Chains (DSC). This shift is crucial for firms, especially in emerging economies like Vietnam, to maintain their global competitiveness as a manufacturing hub of the global supply chain. However, there is a lack of in-depth research on DSC adoption, with a dearth of empirical evidence and no consensus on a comprehensive framework to explain it. A wide range of papers also overlook the complexity of interorganisational relationships within supply chains and the impact of different organisational culture types on technological innovation adoption. To address these gaps, this study aims to create a theoretical framework for DSC adoption in Vietnam, with the goals of providing a comprehensive understanding and practical insights into the development of policies, strategies, and organisational changes regarding the adoption. To achieve this goal, this study uses the Technology – Organisation – Environment (TOE) framework as the core foundation, incorporating principles of interorganisational relationships into the Environmental factor. Additionally, the study employs the Competing Value Framework (CVF) model to explore the multifaceted impact of flexibility and control organisational culture values on driving digital transformation.

Research design/methodology/approach

Despite a positivist stance, the research employed a mixed-methods approach to explore DSC adoption enablers and barriers and validate its research model. This approach comprised two stages: stage 1 – quantitative stage that involved the conduct of a systematic literature review (SLR) and semi-structured interviews; and stage 2 – quantitative stage that involved the distribution of a large-scale survey. Particularly, in Stage 1, a SLR of 153 articles identifying adoption determinants, and an in-depth examination of organisational culture's role in technology adoption, informed the development of six main hypotheses and the research model. This model consists of three primary factors with their corresponding dimensions: technological factor (including perceived risks and perceived benefits), organisational factor (including organisational resources and top management's knowledge and support), environmental factor (including market pressure, market support and interorganisational relationships); as well as a moderation factor which is organisational culture (including control and flexibility types). These constructs were subsequently explored in 14 semi-structured interviews with managers from various Vietnamese companies and analysed using thematic

analysis. In Stage 2, the research model and hypotheses were empirically tested using web-based survey data of 292 responses from Vietnamese organisations and analysed through multivariate regressions.

Findings

The quantitative research findings indicate that organisational and environmental factors are crucial determinants of DSC adoption in Vietnamese firms, while the technological factor does not have significant impact on adoption. Specific dimensions of these TOE factors, including perceived benefits, top management knowledge and support, organisational resources, market pressure, and interorganisational relationships, contribute to the success of DSC adoption in Vietnam. Among these determinants, top management knowledge and support, followed by interorganisational relationships are the most influential factors in the successful implementation of DSC. Furthermore, when considering different stages of DSC adoption (adoption intention and adoption actions), perceived benefits, top management knowledge and support, market pressure, and interorganisational relationships significantly predict adoption intention, while organisational resources, top management knowledge and support, market support, and interorganisational relationships significantly determine adoption actions. The findings also highlight the coexistence of control and flexibility values within Vietnamese organisational culture. While this culture plays a positive role in DSC adoption, the interplay of these values, slightly favouring control-oriented values, negatively affects the impact of various factors on DSC adoption, with some exceptions. Despite the advantages of combining control and flexibility values in organisational culture, the study highlights the importance of prioritising flexibility values, with a focus on entrepreneurial, dynamic, and risk-taking attributes within organisations.

Implications

The empirical findings of this research provide valuable insights for managers, enhancing their understanding and informing their decisions regarding DSC adoption and implementation in Vietnam. The study highlights that Vietnamese firms adopt DSC to access real-time market data, facilitate information sharing, and respond effectively to market volatility and price competition. However, despite positive intentions, Vietnamese firms do not always take concrete actions to implement DSC. To initiate DSC adoption, top managers should acknowledge its benefits, eliminate barriers and challenges hindering adoption, and ensure that their firms are fully aware of the costs, complexities, and potential risks associated with digital transformation. The research also highlights the paramount importance of top management's support and knowledge in driving DSC implementation. This requires managers to be willing to take financial and operational risks, develop clear strategies and roadmaps for digital transformation, communicate its urgency across the organisation, allocate a sufficient and realistic budget aligned with digital transformation goals, and guide and support employees. Moreover, organisations can enhance their employees' technical proficiency through in-house digital skill training programs or by outsourcing third-party training to address the changing requirements for new roles and skills in digital technology adoption. In addition, in response to the need for rapid adaptation to market demand changes, managers should regularly reassess digital transformation strategies to align with market dynamics and customer demands. It is essential for organisations and managers to stay well-informed about and actively engage in government programs and national digital transformation policies. Exploring research and networking opportunities with external organisations can also uncover potential support programs, funding opportunities, and partnerships. Additionally, in the complex process of digital transformation, it is crucial for organisations and managers to proactively cultivate and maintain trust-based relationships with their trading partners. This involves establishing common digital objectives, promoting the exchange of information, knowledge, best practices, and insights from successful digital transformation experiences for mutual benefit.

Originality/value

This research addresses the existing gap regarding the limited attention given to the impact of Industry 4.0 in SCM and the absence of comprehensive literature review that can offer valuable insights into the development state of DSC research. It achieves this by conducting a thorough systematic literature review (SLR) of the enablers and barriers of SC 4.0, considering both Industry 4.0 and SC 4.0 perspectives which is a pioneering effort that offers valuable insights into the state of DSC research. This study is particularly significant in the context of developing economies like Vietnam, as it not only theoretically specifies and but also empirically tests a novel research model that integrates the Technology – Organisation – Environment (TOE) framework and the concept of interorganisational relationships to investigate the enablers and barriers of DSC adoption. This research also identifies the critical determinants for measuring TOE factors that are tailored to the unique context of Vietnam. Furthermore, it examines the moderating role of flexibility-control organisational culture values on the impact of these determinants on DSC adoption which had until now not been fully explored in the literature. This research also provides a comprehensive approach to DSC adoption and advances the field of technology adoption by analysing how various factors influence different stages of DSC adoption. In summary, this study lays a strong foundation for future DSC research, both in terms of its theoretical and practical implications.

Keywords: Supply chain 4.0, Industry 4.0, Enablers, Barriers, Vietnamese firms, Digital transformation, Technology adoption, Organisational culture, Flexibility culture, Control culture.

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LIST OF ABBREVIATIONS

DSC: Digital Supply Chain

SCM: Supply Chain Management

RQ: Research Question

RO: Research Objective

PUBLICATIONS DURING PHD

- **Book chapter**

Nguyen, G., Kumar, V. and Soares, A. (2022) Systematic literature review guidelines for supply chain management research. In Childe, S. and Soares, A. eds. (2022) *Handbook of Research Methods for Supply Chain Management*. Cheltenham: Edward Elgar Publishing, pp.45-70. Available at: https://doi.org/10.4337/9781788975865.00009

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“Empirical Investigation of Supply Chain 4.0 Adoption in Vietnam” at the *International 2023 PhD Academy on Innovation, Development and Policy*, Canada, 2023.

“Guidelines for the conduct of a Systematic Literature Review in Supply Chain Management” workshop for *Vietnamese Scholars in Management Network*, 2023.

“How to conduct a Systematic Literature Review” workshop for lecturers and researchers at UWE Bristol, UK, 2023.

“Empirical Investigation of Supply Chain 4.0 Adoption in Vietnam” at the *5th European Conference on Industrial Engineering and Operations Management*, Italy, 2022.

“Barriers and Enablers of Supply Chain 4.0 Implementation in Manufacturing Industry in Vietnam” at the *2nd Responsible Business Academic Symposium* at University of Birmingham: UK, 2021.

“Empirical Investigation of Supply Chain 4.0 Adoption in Vietnam” at the *Joint PhD Colloquium* organised by Taylor’s University and University of the West of England, UK, 2021.

“Supply Chain 4.0 - What Hinders and Enables Its Implementation in Vietnam and Developing Countries?” at *Showcasing Faculty of Business and Law Doctoral Research Event* at UWE

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1st Place of the Doctoral Dissertation Competition at the “4th Asia Pacific International Conference on Industrial Engineering and Operations Management”, Vietnam, 2023

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1. CHAPTER 1: INTRODUCTION

1.1. Background

In today's marketplace, individual firms no longer compete and operate in isolation but rather as an integral part of supply chain (SC) links (Carnovale, Rogers and Yeniyurt, 2019; Min and Zhou, 2002). Especially, the globalisation and liberalisation of international trade have resulted in the sourcing of production factors and consumer goods from various locations across the world, thereby increasing interdependence and interconnection among firms in international supply chains (Pananond, Gereffi and Pedersen, 2020; Aslam and Azhar, 2013; Janvier-James, 2012). For these reasons, the ultimate success and competitive advantage of a firm is reliant on its effective and efficient supply chain management (SCM) (Min, Zacharia and Smith, 2019; Lambert and Cooper, 2000). It implies the importance of supply chain competitiveness in helping firms to survive in this global competitive environment.

Over the past few years, supply chains have faced immense pressure due to a complex global network, severe market competition, cost constraints, volatile market changes caused by customers' demand for shorter time to market and personalisation of products and services (Tripathi and Gupta, 2020; Makris, Hansen and Khan, 2019). These uncertainties and volatility are further exacerbated during unexpected and uncontrollable events such as the global COVID-19 pandemic that hit the world in 2020. The pandemic caused unprecedented disruptions and economic chaos worldwide such as sudden spikes in demand for certain products and factory closure leading to supply shortages, highlighting the fragility of global supply chains (Panwar, Pinkse and De Marchi, 2022; Xu et al., 2020). However, the crisis has spurred companies to widely adopt digital technologies to enhance supply chain resilience and flexibility, aiming to mitigate such unprecedented supply chain disruptions (Cui et al., 2023; Ning et al., 2023; Frederico, 2021).

This adoption of digital technologies aligns with the broader trend toward Industry 4.0, also known as the 4th Industrial Revolution (Queiroz et al., 2020; Taliaferro, Guenette, and Ankit Agarwal, 2016) which represents *the convergence of digital technologies with physical systems and processes, representing a significant shift in the way industries operate and encompasses the integration of technologies such as the Internet of Things (IoT), Artificial intelligence, Robotics, and Data analytics*. Industry 4.0 can help organisations identify customer priorities and individual-level demand, allowing for a flexible and high-quality supply chain structure that can adapt to changing situations at a fast pace (Tripathi and Gupta, 2020).

In the face of radical and disruptive changes led by digitalisation, Industry 4.0 transformation has become a top priority on the management-level agenda for organisations, research institutes, and politicians (Bienhaus and Haddud, 2018). Therefore, different industries from a wide range of sectors have heavily invested in digitalising their supply chain to seize the opportunities brought by Industry 4.0. For instance, many production and service organisations are embracing higher technology by implementing Industry 4.0. The findings of the 2022 PwC Digital Factory Transformation Survey which gathered responses from over 700 manufacturing companies from at least 23 different countries, reveal that industrial firms are collectively investing more than $1.1 trillion annually in digital transformation solutions. According to the survey, the most successful companies, referred to as Digital Champions, are adopting a comprehensive set of factory-level digital technologies, aiming enhance manufacturing flexibility and resilience, while also lowering operational costs through automation (PWC, 2022). As a result, these companies are achieving double-digit returns by combining cost efficiencies with increased flexibility.

This digital transformation movement in supply chains has given rise to the concept of the "Supply Chain 4.0" (SC 4.0), often referred to as Digital Supply Chain (DSC) or Smart Supply Chain (Mckinsey & Company, 2017; Tjahjono et al., 2017; PWC, 2016A) - the integration of supply chain practices with Industry 4.0 technologies. Therefore, in this research SC 4.0 and DSC are used interchangeably. According to Makris, Hansen and Khan (2019), *SC 4.0 is a completely integrated, connected, smart and highly efficient supply chain ecosystem that leverages digital technologies to utilise real-time market data and foster close collaboration among different supply chain stakeholders to mitigate the impact of market changes*. Due to the ability of Industry 4.0 technologies to improve operational efficiency, increase systems management transparency, accelerate productivity, enhance interconnectivity among supply chain members; and swiftly response to the fluctuations in the markets' demands for high quality products and mass customisation, Industry 4.0 application in the supply chain is seen as a catalyst for business growth and gaining competitive advantage across various industries and countries (Vaidya, Ambad and Bhosle, 2018).

Industry 4.0 implementation in supply chain as a driver for economic growth and national competitive advantage is particularly evident in developing nations like Vietnam, where the shift towards Industry 4.0 is significantly diminishing the once-dominant competitive advantage based on low-cost labour and natural resources (Savinova et al., 2020; Calza and Fokeer, 2019; Gress and Kalafsky, 2015). However, developing economies confront numerous challenges, ranging from a lack of ICT Industry leadership capabilities to execute digital transformation strategies, to limited Internet access and connectivity, and a scarcity of digital skills required for digital transformation success (Conde and Wasiq, 2021). While adopting the digitalisation agenda of developed countries is a possibility, it is essential to acknowledge the unique nature of developing nations' supply chain and technology development.

Vietnam, a prominent emerging economy within the ASEAN region (Akbari and Hopkins, 2019) with a potential to rank among the world's top three fastest-growing economies by 2050, has positioned itself as a vital player in the global consumer goods supply chain and an attractive destination for international companies (Kearny, 2022; Hawksworth and Audino, 2017). Recently, the country has capitalised on the trend of companies relocating from China, allowing it to reap substantial benefits from this influx (Samuel and Nguyen, 2022). To harness these advantages, it is crucial for the country to improve the SCM capabilities, embrace new technologies, and optimise transport and logistics systems. These improvements are vital for achieving operational efficiency, meeting origin requirements, minimising product and service delays, increasing output, and reducing production and business costs (Blancas et al., 2014) to gain national competitiveness in the global supply chains.

Acknowledging the significance of investing in supply chain capabilities and embracing digital transformation, since 2018, Vietnam has placed Industry 4.0 at the forefront of its agenda for sustainable economic development and proactively enacted policies to encourage both private and public sectors' investment in scientific and technological research related to Industry 4.0 (Pham-Duc et al., 2021; PWC, 2018). By leveraging Industry 4.0 technologies and practices, Vietnam aims to restructure its economy and enhance supply chain productivity, efficiency, and competitiveness (Anh, 2022; Guzikova et al., 2020). The critical role of digitalisation in Vietnam's economy is underlined by its reliance on various factors. These factors include the ongoing transition of large state-owned enterprises into more market-friendly corporations, Vietnam's position as a prominent hub for assembly and manufacturing, and the intricate network of supply chains in supporting various economic activities (Walsh, Nguyen and Hoang, 2023). Thus, embracing digitalisation is crucial in harnessing the full potential of Vietnam's economy in light of these significant factors.

To facilitate the adoption of Industry 4.0 and enhance Vietnam's strategic position in global supply chains, the Ministry of Planning and Investment in Vietnam has taken proactive steps in proposing a comprehensive National Strategy for digital transformation (Ministry of Information and Communications of the Socialist Republic of Vietnam, 2021). Additionally, the Ministry of Science and Technology is actively formulating a science, technology, and innovation report for 2035, while other ministries and localities are designing action plans aligned with the principles of Industry 4.0. These initiatives aim to propel the country towards the successful adoption of Industry 4.0 and enable Vietnam to harness its numerous benefits (Ministry of Information and Communications of the Socialist Republic of Vietnam, 2021). To further support this transformation, the Vietnamese Government has introduced the National Digital Transformation Program, focusing on digital government, digital economy, and digital society (Ministry of Information and Communications of the Socialist Republic of Vietnam, 2021). Aligned with these government initiatives, leading Vietnamese businesses such as Vingroup, Viettel, FPT Software and Vinapay are actively spearheading the Industry 4.0 agenda (Akbari et al., 2023). However, despite the immense opportunities and support from Vietnamese government, there remains a notable lack of in-depth research on the understanding and implementation of Industry 4.0 in the country's supply chains (MOIT-UNDP, 2019). Additionally, according to Thanh and Quang (2020), the Vietnamese discourse surrounding the Fourth Industrial Revolution is still in its early stages, with political rhetoric outweighing concrete policy responses. This lack of government actions has hindered coordination and communication between academics and policymakers. Given that Vietnam is on the trajectory of Industry 4.0 revolution, and the effective adoption of SC 4.0 is considered as an integral element for organisational success, the government has called for influential research, practices, scientific programs and projects aimed at driving digital technology implementation in supply chain (Government News, 21).

Thus, this study aimed to conduct an in-depth research to advance the knowledge of SC 4.0, providing insights into the supporting and inhibiting conditions that ultimately contribute to the success of its adoption in Vietnamese firms. Additionally, the research also sought to contribute to the existing literature and theory development, offering actionable regulatory initiatives to managers and police makers to advance organisational and national supply chain's competitive advantages.

1.2. Research Gaps and Research Motivation

This research was driven by both academic and practical interests. While it is crucial for research studies to contribute to academic knowledge, it is also necessary to generate real-world impact (Van den Akker, Spaapen and Maes, 2017). Especially in the field of SCM where there are significant disparities between SCM theoretical ideas and the implementation of supply chain practices that pose challenges for practitioners (Sweeney, Grant and Mangan, 2015; Fawcett and Magnan, 2002). Hence, this section explores the practical gaps in terms of the urgency for firms, especially firms in emerging economies such as Vietnam to embrace digital transformation and understand the factors that hinder or facilitate firms to leverage this opportunity. Meanwhile, the academic gaps discuss the shortage of in-depth research, conceptual framework or model and use of theories that can holistically explain the development and implementation of SC 4.0 as well as the underestimation of the critical roles of organisational culture and inter-organisational supply chain relationships in the adoption of such disruptive innovation.

1.2.1. Academic interest and gaps

Firstly, despite a significant attention and acknowledgement devoted to Industry 4.0 by prominent practitioners and researchers in recent years (Oztemel and Gursev, 2020; Melnyk, Flynn and Awaysheh, 2018; Oztemel and Gursev, 2020; Pereira and Romero, 2017; Fawcett and Waller, 2014), relatively little consideration has been given to the disruption of Industry 4.0 technologies on supply chain (Frederico et al., 2019). This is a sign that DSC is still a relatively young field of inquiry where the research is still at an exploratory stage. Hence, the field can be considered conceptually immature and underdeveloped. While there has been a recent surge in studies attempting to identify factors for successful implementation of SC 4.0 or DSC in organisations (Müller and Voigt, 2018; Mittal et al., 2018; Muthusami and Srinivsan, 2018; Deloitte, 2018; Samaranayake, Ramanathan and Laosirihongthong, 2017; Dougados and Felgendreher, 2016; Pearson, et al., 2014; Lee, Kao and Yang, 2014), the number of studies in this field remains limited and there is no consensus regarding theoretical background or measurement frameworks (Queiroz et al., 2021; Frederico et al., 2019; Büyüközkan and Göçer, 2018). This highlights the need for more comprehensive research to explore the implications and implementation of Industry 4.0 technologies in supply chains.

Secondly, it is essential to emphasise that the integration of Industry 4.0 into a supply chain or SC 4.0 is not merely an implementation of digital technologies within a single organisation but a collaborative approach to digital technology adoption among all supply chain partners (Makris, Hansen and Khan, 2019; Korpela, Hallikas and Dahlberg, 2017). Despite the extensive research conducted on the external environment influencing an organisation's DSC success, a significant number of studies, such as Weerabahu et al. (2022), Attaran (2020), Wong et al. (2020), Kamble et al. (2019), Tu (2018), Lin (2014), and Low, Chen, and Wu (2011), have overlooked the importance of interorganisational relationships within external environment in the context of DSC adoption. Similarly, although existing literature on the interorganisational collaboration has predominantly emphasised supply chain information sharing and pressure from supply chain partners to adopt Industry 4.0 technologies, a notable gap remains in understanding the broader spectrum of factors and principles that shape interorganisational relationships in the context of DSC adoption. Specifically, there is a dearth of research exploring critical elements like digital readiness, trust, and incentives from supply chain partners, which play pivotal roles in facilitating successful DSC implementation. For instance, Tsai, Lee and Wu (2010) solely investigated the supply chain integration in digital technology adoption through information sharing and communication. Similarly, a study by Büyüközkan and Göçer (2018) has revealed that majority of papers in DSC only addressed the information sharing among supply chain partners. Therefore, in order to comprehensively capture the complete impact of the external environment, this research aims to integrate the insights of interorganisational relationships, thereby enriching the novelty and significance of environmental factor of the TOE framework in the context of DSC adoption. The study also seeks to investigate deeper into the complexity of interorganisational relationships within the realm of SC 4.0 adoption, thoroughly examining the aforementioned collaboration principles.

Thirdly, it is important to highlight that the majority of studies examining the disruptive effects of Industry 4.0 technologies on supply chains have predominantly concentrated on developed countries such as Germany, the United States, Japan, the United Kingdom, and China (Liao et al., 2017). However, there exists a significant research gap in understanding the implications of these technologies in emerging economies and developing nations (Frederico et al., 2019) such as Vietnam. This highlights a critical limitation in the current adoption frameworks that fail to address the distinct challenges and competitive environment inherent to developing countries. Al-Somali, Gholami and Clegg (2011) further emphasised the necessity to reevaluate the theories and study models originally developed for DSC adoption in developed countries, as they may not be directly applicable or suitable in the context of developing countries. This is because certain factors, which may be considered insignificant in developed countries, can assume critical importance in developing countries. For instance, countries like Vietnam encounter specific challenges, such as limited infrastructure, a scarcity of expertise, and restricted technology availability and accessibility (Akbari and Ha, 2020), which are not considered as crucial in developed countries. Moreover, a study conducted by Bogoviz et al. (2019) revealed that developing countries face not only financial barriers but also institutional challenges, such as the absence of state policies for the development of Industry 4.0. These challenges differ significantly from those faced by developed countries. Furthermore, upon reviewing the existing literature, it becomes evident that there is a lack of empirical evidence to validate the efficacy and applicability of current research frameworks or models regarding the adoption of DSC (Frederico et al. in 2019). Thus, there is an imperative to validate the existing theories in diverse contexts to ensure their relevance and suitability. This study, therefore, aims to propose an empirically verified research model that systematically explores the factors influencing the adoption of DSC as well as explore the contextual factors specific to developing countries like Vietnam.

Fourthly, scholars have increasingly realised that the challenges or success in adopting technologies lie in the contextual variable – organisational culture (Kagumba and Wausi, 2018; Melitski, Gavin and Gavin, 2010). The culture of an organisation is perceived as a powerful lever for technology adoption, especially in developing countries like Vietnam where employees strongly identify with and adhere to their organisation's cultural norms and values (Nguyen et al., 2019). Nonetheless, Nguyen et al (2019) argued that the relationship between organisational culture and technology adoption in developing country context such as Vietnam still remains under-researched. Similarly, Linh, Kumar and Ruan (2019) have shed light on a notable research gap in the field of DSC adoption, highlighting the limited coverage of the impact of cultural elements on such implementation within emerging economies. These studies highlight the need for further investigation into the cultural influences in shaping DSC adoption, particularly in the context of developing countries, where such investigations have been limited. Furthermore, there is no compelling evidence of the existence of a research study that incorporates different organisational culture types in influencing the SC 4.0 adoption, directly addressing how cultural differences can have different effects in a complicated interorganisational technology adoption context like SC 4.0. Additionally, although a variety of studies have investigated the different effects of organisational culture types on a technology adoption of a firm, the research findings regarding the role of these organisational culture types in technological adoption have been very contradictory. While some scholars argued that a flexibility-oriented culture is more likely to encourage organisations to adopt new technologies, and a control-oriented culture tends to resist such adoption (Naranjo-Valencia, Jiménez-Jiménez, and Sanz-Valle, 2011; McLean, 2005), others believe that both types of culture play critical roles in promoting technology adoption (Shao, Feng and Liu, 2012; and Khazanchi, Lewis and Boyer, 2007). These contradictory research findings impose a challenge on organisations to determine which culture type is the most preferable for their technology adoption, especially in inter-organisational SC 4.0 adoption. Hence, it is essential to explore which organisational culture types allow organisations to adopt SC 4.0 at higher levels.

Last but not least, there is scarce empirical research in the literature that has sought to assess the impact of determinants on different stages of technology adoption, especially with a focus on adoption intention and adoption behaviours, particularly within the context of DSC adoption. The majority of existing literature on technology adoption, particularly digital technology adoption, primarily examines the impact of determinants on overall adoption, adoption intention, or adoption actions. For example, studies like Tsai, Lee, and Wu (2010) explored the determinants of RFID adoption intention, while Low, Chen, and Wu (2011) investigated the factors influencing the adoption of cloud computing. Similarly, Tu (2018) explored the determinant factors affecting IoT adoption intention in SCM. Furthermore, while there are a few studies that have considered different stages of digital technology adoption, including both adoption intention and adoption behaviours or actions, they often do not explore how these determinants influence these different adoption stages. For instance, Martins, Oliveira, and Popovič (2014) specifically examined how determinants predict Internet banking adoption intention and how adoption intention determines Internet banking adoption behaviours. This study, therefore, aims to not only investigate the impact of different factors on the overall DSC adoption but also at its different adoption stages.

1.2.2. Practical interest and gaps

Emerging economies that rely heavily on cheap labour forces are facing a serious challenge as the rise of technology and robotics has the potential to shift manufacturing production work back to developed countries (Gress and Kalafsky, 2015; Bhasin and Bodla, 2014), which has always been the competitive advantage of developing countries such as Vietnam (Hopper, Lassou and Soobaroyen, 2017). Meanwhile, Industry 4.0 is anticipated to drive a digital transformation across global supply chains at a faster pace and shorter period than other industrial revolutions due to the rapid advancement in technology application and economic booming (Tran, Binh and Van, 2019; Deloitte, 2017). Additionally, the demand for digital transformation in supply chains is also further emphasised in the context of Covid-19 (Chuc and Anh, 2023). Thus, it is imperative for firms, especially emerging economies, to capture this trend. This requires firms in these countries to understand current and planned applications as well as the implications of these inescapable changes on the future of supply chains. Using this understanding hence, companies can identify an appropriate pathway and success factors for such transformation, ensuring their competitiveness in the global market. This imperative applies to Vietnamese firms as well, as they must actively and quickly engage in this paradigm shift to not only capitalise on the opportunities presented by Industry 4.0 but also to maintain their competitive advantage as the manufacturing hub of the global supply chain.

According to Agrawal, Narain and Ullah (2019), implementation of supply chain digitalisation can be a risky endeavour for organisations since it deliberately considers operational and financial aspects that regulate their long-term performance, making it difficult to implement. Several studies have unveiled the challenges and obstacles of digital transformation across companies, industries, and countries. Research conducted by Boston Consulting Group in 2020 and Saldanha (2019) showed that 70% of digital transformation projects fail in the implementation and scaling stage in organisations despite top management's commitment and understanding of embracing digital technologies to create digital processes and solutions. Other studies even recorded a higher rate transformation failure which is 90% (Ramesh and Delen, 2021) and 85% (Mielli and Bulanda, 2019). Similarly in Vietnam, recent research conducted by Chuc and Anh (2023) and the World Bank (Cirera et al., 2021) have revealed a concerning trend that despite Vietnam having numerous opportunities to accelerate digital transformation (as described before regarding governmental initiatives), only a small fraction of firms have fully embraced digital transformation while majority of firms are struggling to adopt digital technologies, highlighting the low level of digital readiness in Vietnam. This underutilisation of digital technologies in firms is attributed to a multitude of pitfalls, ranging from the limited capability of firms, financial constraints, to inadequate market demand, restricted access to government support, and a lack of robust technology infrastructure necessary to enable effective digitalisation initiatives (Cirera et al., 2021). It appears that digital transformation in Vietnam is exposed to multiple internal and external challenges and obstacles that create a gap between the plan or pilot studies and the implementation practices. Addressing these challenges is therefore crucial to unlocking the vast potential that digital transformation holds for Vietnamese supply chain businesses. Additionally, according to a comprehensive report published by World Bank (2017), the rate of Vietnamese corporations introducing innovative products from 2014 to 2017 stood at mere 23%, significantly lagging behind other Southeast Asian countries. For instance, Cambodia and Philippines firms claimed more than 30% of innovative products, while Thailand and Malaysia reported even higher rates of successful innovative product launches. The disparity in innovation adoption emphasises the necessity for a thorough examination of the factors influencing Vietnam's adoption of innovation practices, particularly in the realm of digital technologies, as well as the potential strategies to accelerate this digital transformation within supply chains.

Drawing on the aforementioned challenges and the need to capitalise on the opportunities presented by Industry 4.0 for Vietnamese supply chain, comprehensive research on the digital transformation in supply chain is of significant importance and interest for both Vietnamese firms and the government. As a result, the purpose of this study is to identify both enablers and challenges, as well as the fields of action to build favourable conditions while effectively addressing the barriers faced by supply chain firms for the successful implementation of digital technologies in Vietnam.

1.3. Key Research Questions

Considering both academic and practical interests, and in the light of an urgent need for Vietnamese firms to leverage digital technologies, the aim of this research is to explore the determinant factors on DSC adoption as well as the role of organisational culture. To achieve this, two research questions (RQs) are formulated:

1. What are the enablers and barriers of DSC adoption for firms in Vietnam?

2. What is the role of organisational culture in DSC adoption for firms in Vietnam?

These two RQs lead to the following objectives

Research questions	Research objectives
1. What are the enablers and barriers of SC 4.0 adoption for firms in Vietnam?	1. Synthesise the Industry 4.0 and its application in supply chain or the so-called SC 4.0. 2. Explore the main/specific enablers and barriers of SC 4.0 adoption 3. Explore Vietnamese firms' understanding of Industry 4.0 and its application in their SCM 4. Identify the current determinants that influence the adoption decision of SC 4.0 for firms in Vietnam
2. What is the role of organisational culture in SC 4.0 adoption for firms in Vietnam?	1. Investigate types of organisational culture embedded in Vietnamese firms. 2. Investigate how different types of organisational culture influence SC 4.0 decision adoption of Vietnamese firms

1.4. Research Purpose

This research is *Exploratory* and *Explanatory research*. The initial aim of the study is to gain a preliminary understanding of the current barriers and enablers of SC 4.0 application specific to Vietnamese market and conditions, which is characteristic of *exploratory research* (Forza, 2002). This is achieved through an in-depth literature review and semi-structured interviews with supply chain experts from Vietnamese firms. Moreover, a research framework of SC 4.0 adoption with well-defined constructs along with hypotheses derived from the SLR is refined and confirmed through the semi-structured interviews and finally tested through large-scale survey. This is characteristic of *explanatory research*, as the aim is to establish causal relationships between variables and seek explanatory answers through testing hypotheses and theories (Creswell and Creswell, 2017). Overall, the study is a hybrid of *exploratory and explanatory research*, as it aims to gain a preliminary understanding of the topic while also testing a theoretical framework using empirical data.

1.5. Research Methodology

To address the research questions at hand, this study adopted a *positivist research philosophy*, which acknowledges a social reality regarding the success factors and challenges of DSC. The research approach involves generation of hypotheses and development of a research model through a literature review, followed by refining these ideas through semi-structured interviews which aimed to explore critical or unaddressed factors but also confirmed the applicability of the proposed research model. This research model was later tested using a large-scale questionnaire. Therefore, the research approach of this study is deductive. In terms of methodological choice, a mixed-methods approach was employed, combining qualitative and quantitative data collection methods. This approach enhances the validity and reliability of the study, generating in-depth insights. The research design followed a sequential exploratory mixed-methods approach, with emphasis on the quantitative study and support from qualitative data collected through semi-structured interviews. The research strategy chosen was survey research, which aligns with the RQs and the examination of contemporary events beyond the researchers' control. The survey strategy is suitable considering factors such as research objectives, philosophy, approach, time and resource constraints, and data accessibility. Regarding research methods, the study conducted a systematic literature review to extract and synthesise information using thematic analysis. Semi-structured interviews were analysed using thematic analysis with the support of Nvivo software. For the questionnaire data analysis, descriptive statistics, factor analysis, correlations, and regressions were performed using SPSS Statistics 28.

Table 1-1: A summary of the research methods utilised in this study

Phase	Methods used	Type of knowledge
Research model and Hypothesis development	Literature review	Systematic literature review (SLR) associated with Industry 4.0 and SC4.0 adoption using thematic analysis to identify the determinants that inhibit or facilitate the adoption, providing a direction for the subsequent qualitative study. Literature review on significance of organisational culture in SC4.0 adoption.
	Findings of semi-structured interviews with supply chain experts and in-depth literature review	14 online semi-structured interviews with managers and supply chain experts at various leadership levels from supplying, manufacturing, and logistics/distribution firms and other relevant companies in Vietnam to refine the SLR findings and conceptualise hypotheses, conceptual research model and its constructs.
Questionnaire development	Findings of semi-structured interviews with supply chain experts and in-depth literature review	Development of measurement items for each construct through findings from literature review and interviews alongside discussions with three academics in the field of SCM. Translation of English questionnaire into a Vietnamese version under the support of one professional translator and one literature teacher.
	Pilot study	Questionnaire distribution to 12 academics and practitioners in business and SCM and amendment of the questionnaire content and design according to their feedback.
Questionnaire distribution and	Dissemination of survey and quantitative data analysis	Online survey distribution to managers of suppliers, manufacturers, logistics providers, wholesalers/ retailers in Vietnam with final results of 292 valid responses.

Hypothesis testing	Confirmation of determinants that inhibit or enable the successful adoption of SC 4.0, and the role of IOR and organisational culture in such adoption in Vietnam.

1.6. Research Scope and Limitations

This section explains the scope of the research including Unit of analysis and Geographical scope. The unit of analysis for this research is supply chain companies in Vietnam, comprising manufacturers, suppliers, distributors, logistics providers, and wholesalers/ retailers. The research aims to gather perspectives from companies of different sizes, ownership types and industries to provide a comprehensive understanding of the adoption of digital technologies in Vietnam's supply chain. Additionally, instead of examining the use of individual digital technologies in SCM which have been explored in previous studies, this study adopted a general approach, investigating a broad application of Industry 4.0 in SCM to provide a holistic picture of DSC adoption. Furthermore, while past research explored the impact of TOE factors on DSC adoption as a whole or in specific stages, such as adoption attitude, intention, or behaviours, this research investigates the impact of TOE factors not only on the overall DSC adoption but also at its different stages, including adoption intention and adoption actions.

Meanwhile, the geographical scope of this study is Vietnam, including Northern, Middle and Southern part of the country. As each region has its unique characteristics and challenges when it comes to adopting digital technologies, the study's findings provide valuable insights for supply chain companies operating in these regions.

While the research has a clear scope, it is important to acknowledge the limitations of the study. Since the research adopted a general approach to explore the adoption of Industry 4.0 holistically rather than focusing on specific Industry 4.0 technologies, the proposed research model may have potential limited application in other contexts across different Industry 4.0 technologies. Another potential limitation is the subjectivity of the participants' perspectives; diversity of respondents from different business sizes, industry types and regions; and the majority of questionnaire participants from large international firms, which can introduce potential biases into the data. To mitigate these limitations, the research used rigorous data collection and analysis methods, to ensure the validity and reliability of the study's findings.

1.7. Theoretical and Practical Contributions

Given the academic and practical interests previously described, this thesis aims to contribute to research and practice. Specifically, it seeks to advance the knowledge in SC 4.0 by investigating the influence of internal and external environmental factors on DSC adoption, along with the significance of organisational culture in facilitating such adoption. The research outcomes offer both theoretical and practical contributions, which can be outlined as follows.

1.7.1. Theoretical contribution

The objective of this study is to fill in the gaps in the current literature on SC 4.0 through several dimensions. Firstly, given the lack of consensus on the definition of SC 4.0 and a crucial need have a better understanding of SC 4.0, this study proposes a broad and inclusive understanding of SC 4.0 based on extensive prior research.

Secondly, in response to the pressing need for a more comprehensive exploration of the implications and implementation of Industry 4.0 technologies in supply chains, this research makes a significant theoretical contribution by conducting an extensive and SLR of SC 4.0 enablers and barriers from both the perspectives of Industry 4.0 and SC 4.0 as no such comprehensive review has been conducted from both perspectives to date. This SLR offers a categorisation of barriers and enablers using TOE model to provide a comprehensive picture of Industry 4.0 adoption in SCM context.

Thirdly, in light of the limited number of studies conducted in the field of SC 4.0, particularly in emerging and developing economies, and recognising the need to validate existing theories in diverse contexts to ensure their relevance and applicability, this study proposes an empirically verified research model that systematically examines the factors influencing the adoption of DSC. Additionally, the research explores contextual factors that are specific to developing countries like Vietnam. Considering the unique characteristics of the Vietnamese market, including differences in SCM and Industry 4.0 maturity levels, it was found out that the critical factors influencing DSC adoption in this context differs from those reported in existing literature, which predominantly focuses on developed country contexts.

Fourthly, taking into account the research gaps highlighted previously, which indicate the limited investigation into the impacts of different organisational culture types and various interorganisational relationship disciplines on driving technology adoption efforts, this research explores the impacts of flexibility and control organisational culture types, as well as interorganisational relationships which is incorporated into the external environment, on DSC adoption. This approach contributes to a more comprehensive multilevel understanding of a successful SC 4.0 adoption.

Lastly, given the limited research on the impact of DSC adoption determinants at its different stages as described above, this study makes a substantial contribution to DSC literature by shedding light on how various determinants influence not only overall DSC adoption but also individual adoption stages.

1.7.2. Practical contribution

As stated in practical gaps above, the actual evolution of Industry 4.0 is still progressing but evolving at a rapid pace, and as a result, the life cycle of industrial ages is getting shorter (Bienhaus and Haddud, 2018). To address this challenge, organisations and stakeholders in developing countries, especially in Vietnam must advance their capabilities for the development of DSC. Additionally, given the confusions around digital technologies and the sense of urgency towards the adoption of Industry 4.0 as stated above, this research enhances understanding of the adoption of Industry 4.0 into supply chains, the obstacles and motivators of this digital transformation as well as the role of organisational culture in such adoption. Particularly, the research unveils technological, organisational and environmental factors that firms in Vietnam encounter when implementing DSC.

From technological perspective, the research suggests that Vietnamese firms' DSC intention is influenced by their awareness of the potential advantages offered by digital transformation. Nonetheless, despite full acknowledgement of its benefits, this awareness does not translate into concrete actions. It implies the importance of Vietnamese organisations not only promoting the benefits of DSC adoption but also addressing and mitigating potential risks, obstacles, and challenges that hinder their adoption. With regards to the organisational context, the research strongly emphasises the pivotal role of top management as the primary driver of DSC adoption within Vietnamese firms. It is highly recommended that Vietnamese firms instil a sense of urgency for digital transformation across all organisational levels; actively formulate clear visions, strategies and pathways for digital transformation, along with providing guidance and sufficient support to their employees throughout the entire process. Organisations should also tackle resistance to change by providing training and education opportunities to deepen employees' understanding of digital transformation and hands-on experience in their application. Additionally, effective communication and encouragement of collaboration within the organisation are all advised. Moreover, for the successful implementation of DSC, it is critical to allocate a sufficient and realistic budget with a well-structured budgeting plan, alongside developing and investing in IT infrastructure at the early stage. This comprehensive strategy aims to enhance organisational readiness and foster a risk-taking culture for digital transformation initiatives. Finally, concerning the external business environment, the study suggests that Vietnamese firms facing significant pressure from competitors and customers are more inclined to undertake digital transformation within their SCM to adapt to market changes. Especially, the Covid 19 pandemic has been a catalyst, accelerating their digital transformation process. However, despite the strong intention to implement digital transformation, Vietnamese firms' adoption actions are not determined by the market pressure, indicating that Vietnamese organisations are still facing challenges in digital transformation process. Furthermore, the research findings also reveal that although not emerging as the critical determinant of overall DSC adoption, market support, particularly government and third-party support, still determines the actions and success of digital transformation within Vietnamese firms. Thus, it is suggested that the government policies and programs that incentivises digital transformation need to be practical and tailored to different business industries, sizes and types as well as be effectively communicated to the businesses. Additionally, firms should also explore collaboration opportunities with institutions and business associations as well as with supply chain partners to assist them in this transformative process.

Notably, this research further offers a novel insight for practitioners by highlighting the potential benefits of leverage the strengths of both flexibility and control cultures to encourage technology adoption and accelerate the digital transformation process. It is important for firms to nurture a balance, fostering flexibility values such as risk-taking, teamwork, creativity, and employee empowerment, alongside a commitment to goal-orientation, stability and procedural adherence.

In summary, the research findings provide essential information on how to build a promising condition and manage the challenges towards the digital transformation in supply chain. It also provides managers and decision-makers the practical suggestions and guidelines about governmental policies, companies' strategies and other changes for the development implementation of SC 4.0 not only in Vietnam but also for the developing countries where the 4th revolution has emerged and influenced their supply chains.

1.8. Thesis's Organisation

This dissertation is organised into 10 chapters as follows:

Chapter 1 (Introduction) introduces the background, research interest and gaps, key research questions, research purpose, brief overview of research methodology, research scope and limitations, both theoretical and practical contributions, and outline of the thesis.

Chapter 2 (Research Context) investigates the concepts of Industry 4.0, Supply Chain 4.0 and the development of Vietnam's supply chain and their Industry 4.0 application.

Chapter 3 (Theoretical Background) examines relevant technology adoption theories which serve as the foundational framework of the thesis.

Chapter 4 (Literature Review) investigates the relevant literature related to determinants of Supply Chain 4.0 adoption and the role of organisational culture in technology adoption.

Chapter 5 (Hypotheses and Research Model Development) explains the development of hypotheses and research model drawing on relevant theories and previous literature in the field.

Chapter 6 (Methodology) details the research methodology employed to address the research questions, including research purpose, philosophy, design and methods including both qualitative and quantitative research methods.

Chapter 7 (Qualitative Data Analysis and Findings) presents the validity and reliability assessment of qualitative data, qualitative data analysis technique – thematic analysis, and the qualitative results obtained from semi-structured interviews.

Chapter 8 (Quantitative Data Analysis and Findings) demonstrates the validity and reliability testing of quantitative data, regression assumption check results and hypothesis testing results obtained from multiple regression analyses.

Chapter 9 (Findings Discussion) discusses both qualitative and quantitative results that help to answer the research questions and offers plausible explanations for the findings.

Chapter 10 (Conclusion) summarises the research findings to the research questions, discusses limitations and provides suggestions for future research directions

2. CHAPTER 2: RESEARCH CONTEXT

The objective of this chapter is to provide a comprehensive overview of the research context. It begins by exploring the historical context and reviewing the definitions of industrial revolutions, with a particular focus on the fourth industrial revolution. The chapter then examines the concepts of “supply chain”, “supply chain management”, and “Supply Chain 4.0” to provide a thorough understanding of the topic. Additionally, it offers an overview of the Vietnamese supply chain and its development in Industry 4.0 which lead to the development of two research questions. In summary, this chapter aims to provide a clear and concise introduction to the research topic and set the stage for the subsequent chapters.

2.1. Industry 4.0

There are four phases of industrial development, each characterised by a distinct emphasis. These phases are:

- Industry 1.0, which focused on mechanisation and improved efficiency through the use of hydropower which increased the use of water and steam to power mechanise manufacturing processes (Kumar, Suhaib and Asjad, 2020; Gadre and Deoskar, 2020);
- Industry 2.0, which emphasised electricity, started at the late 19th century and early 20th century in Europe and USA, and brought major breakthroughs by introducing mass production of goods and replacing steam engine with an intensive use of chemical and electrical energy, synthesis of ammonia, and wireless and wired communication (Premkumar Rajagopal et al., 2018; Pereira and Romero, 2017);
- Industry 3.0 was triggered at the start of 20th century with the invention of a technological advancement which is the Integrated Circuit (microchip) which introduced computerisation. This era was characterised by the development of digital communication systems and advanced computing power, which enabled the generation, processing, and sharing of information in new ways (Premkumar Rajagopal et al., 2018). With the intensive use of electronics and information technology, automation in production was accelerated (Pereira and Romero, 2017).
- Industry 4.0 represents the current phase, emphasising the digitalisation of firms transitioning from Industry 3.0, an era of computer and Internet, to Industry 4.0, a more fully digitalised environment that allows connectivity between functional areas and tasks within and between organisations in the supply chain (CIPS, 2019)

Over the course of two centuries, three industrial revolutions have taken place, with each one building upon the technological innovations and advancements of the previous revolution (Xu, David and Kim, 2018). Rather than considering each industrial revolution as a separate event, they should be viewed as a series of events that have led to more advanced forms of production in subsequent revolutions. At the rise of data exchange and automation in the manufacturing Industry, the integration of Internet technologies and smart machines and products has ushered in a new paradigm shift in industrial production. This has resulted in products controlling their own manufacturing process and meeting the customised demands while maintaining the economic conditions of mass production. Tempted by this future expectation, the German government has initiated a concept “Industrie 4.0” or “Industry 4.0” for a planned “4th industrial revolution” to represent the German version of the Industrial Internet of Things and Cyber Physical systems (CPS) (Müller and Voigt, 2018).

Industry 4.0, initially proposed by the German government at the Hannover Messe in 2011 and often referred to as “Smart Manufacturing” or “Smart Factory”, represents a paradigm shift in production processes (Govindan et al., 2022). Despite various definitions of the term, authors have agreed that *Industry 4.0 is defined as or built upon a spectrum of advanced digital industrial technologies such as Internet of Things (IoT), Cloud Computing, Cyber Physical System (CPS), Big Data Analytics (BDA), etc. that blur the boundaries between the physical, digital, and biological realms* (Govindan et al., 2022; Xu, David and Kim, 2018; Premkumar Rajagopal et al., 2018; Pfohl, Yahsi, and Kurnaz, 2015). According to Pfohl, Yahsi and Kurnaz (2015), these disruptive technologies are strategically integrated throughout the value chain to effectively address the evolving trends of digitalisation, automisation, transparency, mobility, modularisation, network collaboration, and socialisation in both products and processes. This transformative concept enables several key capabilities, including (1) the interaction and communication between smart products and devices, as well as the interconnectedness between multiple firms in the value chain (Vaidya, Ambad and Bhosle, 2018, Zheng et al., 2018); (2) the collection and real-time evaluation of market data through the utilisation of AI, BDA, IoT and other technologies, allowing optimisation of production costs and quality, and decentralised production with real-time adaptation (Javaid et al., 2020); and (3) the automation, autonomy and increased flexibility of machines and robots thanks to the support of CPS, IoT, Cloud and Cognitive Computing, and Digital manufacturing (Vaidya, Ambad and Bhosle, 2018). These technologies help to collect, transfer and make sense of large volume of complex, variable, and high-speed data, commonly referred as Big Data (Strange and Zucchella, 2017).

In summary, the adoption of Industry 4.0 has the potential to significantly enhance a firm's operational efficiency and increase transparency in SCM. It can also accelerate productivity and interconnectivity among entities in the supply chain, especially on a global scale (Govindan et al., 2022; Rahman et al., 2022). In addition, Industry 4.0 allows organisations to take swift response to fluctuations in the markets' demands for high-quality products and mass customisation (Torn and Vaneker, 2019). Consequently, Industry 4.0 is considered a growth driver for businesses in various industries, including manufacturing (such as automotive, food, and chemicals) and service industries (such as banking and delivery), enabling them to gain a competitive advantage (Castelo-Branco, Cruz-Jesus and Oliveira, 2019; Vaidya, Ambad, and Bhosle, 2018; Tjahjono et al., 2017). According to Xu, David and Kim (2018), comparing with the previous industrial revolutions, the fourth revolution has evolved at an exponential rather than a linear pace and will be embedded within societies, disrupting almost every Industry in every country and transforming the entire systems of production, management and governance. This current industrial revolution has given birth to Supply Chain 4.0 (SC 4.0), which represents a significant opportunity and challenge for organisations to adapt and transform their supply chain operations.

2.2. Supply Chain 4.0

Supply chain (SC) and supply chain management (SCM) have been extensively researched and practiced in the fields of business management and economics. According to Min and Zhou (2002), supply chain (SC) is an integrated system where a series of interrelated business processes are synchronized in order to: (1) acquire raw materials and parts; (2) transform them into finished products and services; (3) add values to products and services; (4) distribute them to retailers or customers and (5) facilitate information sharing among business partners. Similarly, Mentzer (2004), Lambert, Stock and Ellram (1998) and La Londe and Masters (1994) defined supply chain as a network of organisations to create value through products and services that will be delivered to end customers. In a nutshell, a traditional supply chain is a set of business processes that support the physical flow of goods and services from suppliers to manufacturers, and then to customers through a network of interconnected companies (World Economic Forum, 2019; Centre for Global Enterprise, 2015).

Meanwhile, supply chain management (SCM) is a vital process for many companies as they strive to optimise their supply chain for cost efficiency and greater competitiveness (Centre for Global Enterprise, 2015). Ivanov, Tsipoulanidis and Schönberger (2019) and

Thomas and Griffin (1996) defined SCM as the management, integration and coordination of activities, materials, information and financial flows to optimise the use of supply chain resources across the entire supply chain. Meanwhile, Cooper, Lambert and Pagh (1997) defined it as an integration of key business activities into a seamless process, providing products, services and information, and adding value to customers and other stakeholders. In essence, SCM manages the flow of goods and services across the processes of planning, implementing and controlling supply chain activities, and integrating these processes to transform raw materials into value-added final products. It involves a systematic and strategic coordination within a company and across supply chain partners to optimise operational performance and meet customer demands. Therefore, to enhance operational efficiency, productivity, and gain competitive success and profitability, SCM has become a major component of a company's competitive strategy in the global competitive market with rapidly changing customer demands (Coyle et al., 2013; Verma and Seth, 2011).

In the past three decades, the field of SCM has undergone a transformational wave of challenges and changes. The traditional supply chain is outdated, inefficient and inflexible, unable to adjust to market's fluctuations, purely functioning as an operational logistics system in which the instructions flow from the supplier to the producer to the distributor to the customer and back again (Mckinsey & Company, 2017). However, with the advent of data exchange, connected technologies and automation, typically the integration of digital and physical systems which is known as Industry 4.0 or the 4th Industrial Revolution (Taliaferro, Guenette and Ankit Agarwal, 2016), supply chain has evolved tremendously towards Supply chain 4.0 (SC 4.0). This is also known as the Smart Supply Chain, or Digital Supply Chain (DSC).

The emergence of SC 4.0 is a revolutionary development that integrates cutting-edge technologies into SCM, offering unprecedented efficiency, flexibility, and scalability in response to the dynamic demands of the market. Makris, Hansen, and Khan (2019) and Mckinsey & Company (2017) have described SC 4.0 as a highly integrated, connected, efficient and intelligent supply chain ecosystem that leverages digital technologies to achieve real-time market data insights and enables close collaboration among various stakeholders to effectively adapt to market changes. On the other hand, it is defined by Centre for Global Enterptise (2015) as a customer-centric platform model that utilises real-time data from various internal and external sources to enable demand sensing, matching and stimulation for optimising supply chain performance and meeting customer demand while alleviating risks. Although these definitions share similar insight about the use of real-time market data, the former definition emphasised SC collaboration while the latter definition concentrated on SC performance optimisation and customer demand satisfaction. Thus, both aspects (SC collaboration and optimisation) should be considered.

In essence, whilst Industry 4.0 refers to the range of technologies adopted, *SC 4.0 is the digital transformation of SCM process and operations that employs cutting-edge digital technologies and collaboration of various stakeholders across the entire supply chain, aiming to create a connected and intelligent supply chain ecosystem that can optimise and provide a flexible, customer-focused, and data-driven solution to the challenges and complexities of the contemporary business landscape.* The goal is to enable real-time data sharing, predictive analytics, demand-driven planning, optimised inventory management, efficient logistics, and customer-centricity throughout the supply chain network which eventually enhances visibility, transparency, collaboration and agility in supply chain operations.

According to Mckinsey & Company (2017) and Swanson (2017), SC 4.0 can create competitive advantage from development of new products and services, cost reduction, market share increase, positive work environments and smooth operations, such as 30% reduction on overall cost and 75% reduction in inventories and lost sales. As a result, enterprises, especially multinational corporations (MNCs) in advanced economies are transitioning towards SC 4.0 because of competitive pressure and disruption risks (World Economic Forum, 2019). However, emerging economies such as Vietnam (the focus of this study) are placed under threat of losing their competitive advantage to their developed counterparts as they are lagging in their digital supply chain transformation due to a wide range of obstacles such as lack of digital skills and acceptance of digital technologies by communities and businesses (Gonzalez et al., 2017). While it is possible to adopt the digitalisation agenda of developed countries, it is crucial to recognise that each country's supply chain and technology development is distinct and therefore requires a thorough understanding of the context to enable a tailored approach grounded in its specific characteristics to foster SC 4.0.

2.3. Vietnam's Supply Chain and Industry 4.0 Development

Emerging on the back of a strong manufacturing foundation, a strategic geographic location, substantial investments in infrastructure and a growing middle class, Vietnam has transformed itself from one of the world's poorest countries, with a history marked by decades of wars, recovery, seclusion and economic stagnation, into a highly sought-after destination for global companies seeking to shift their production facilities to Southeast Asia (DHL, 2019).

The country's remarkable economic growth has been driven largely by its thriving manufacturing Industry, and it is now widely regarded as one of the fastest growing and most promising emerging economies in the world (Akbari and Ha, 2020) and a central node in the regional and global supply chains (Goodman, Reynolds and Fittipaldi, 2022). However, supply chain development in Vietnam is still at a rudimentary stage due to its late entrance into the global supply chain (Leung, 2010) and inadequate investment in critical areas such as information technology (Tseng, Wu and Nguyen, 2011), transport infrastructure (Blancas et al., 2014), and informal relationship between firms (Luu and Ngo, 2019). Despite these challenges, Vietnam has shown a high potential for supply chain development. In recent years, Vietnam has progressively integrated comprehensively with countries in the region and other countries in the global supply chain. The years of 2018 and 2019 have welcomed many international trade agreements such as Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), EU-Vietnam Free Trade Agreement (EVFTA) which have brought in many opportunities as well as challenges for Vietnam as a part of the world market and global supply chain (Phan, Doan and Nguyen, 2020). Especially, the year 2020 has witnessed an escalating trade tension between the US and China, and Covid 19 epidemic which has led to a global backlash to China for their alleged mishandling of the crisis when many US and European firms have shifted their production facilities from China to its neighbouring countries (Samuel and Nguyen, 2022).

With continued macroeconomic stability, growing economic liberalisation and vast labour pool, Vietnam has emerged as an exceptionally attractive destination for global companies seeking to establish their presence. Recently, the country has reaped substantial benefits from its early adoption of the first-mover strategy, capitalising on the mass exodus of Industry companies from China, such as Samsung, Nike, Adidas, Apple, and other US factories relocating their manufacturing operations to Vietnam and positioning the country as a prime hub for production (Samuel, 2021). This wave of change emphasises the crucial role of SCM to Vietnam in driving operational efficiency, ensuring compliance with origin requirements, and unlocking tariff benefits. To fully harness the potential of this favourable landscape and seize the opportunities, Vietnam must prioritise the development of efficient transport and logistics networks, as well as establish robust and predictable supply chains. These essential improvements will empower manufacturers, transportation carriers, logistics service providers, and trade regulators to minimise avoidable delays, boost output, and reduce overall business costs (Blancas et al., 2014). It becomes imperative, therefore, for Vietnam to invest in enhancing its supply chain capabilities and embrace Industry 4.0 digital technologies that are responsive to the rapidly evolving global market.

In Vietnam, Industry 4.0 or the Fourth Industrial Revolution took root around 2016 (Vu and Anh, 2017). The country's awareness of this transformative era was ignited by the domestic media coverage of the World Economic Forum Annual Meeting in that year, which centered around the theme "Mastering the Fourth Industrial Revolution" (Vu and Anh, 2017). However, the momentum behind Industry 4.0 in Vietnam gained significant traction only when the country's leadership acknowledged its significance during the 4th Plenum of the 12th Central Committee on May 5th, 2016, further reinforced by the Vietnam ICT Summit, held on September 24th, 2016, with a focus on the theme "Digital Revolution: Opportunities and Challenges". At the Vietnam ICT Summit 2016, the representatives of the Ministry of Foreign Affairs emphasised that Industry 4.0 is still in its early stages, presenting a timely opportunity for Vietnam to venture into new industries and close the development gap. Furthermore, Cao Quoc Hung, Deputy Minister of Information and Communications, highlighted the significance of digital transformation as an effective solution for Vietnamese businesses to penetrate and expand export markets, especially with Vietnam's increasing integration into the global economy at the Vietnam Online Important Export Forum 2020.

The emergence of Industry 4.0 has presented a significant challenge for Vietnam and other developing countries in Asia. Historically reliant on export-oriented industries, low technology levels, abundant natural resources, and a low-cost labour force, these countries now face the urgent task of transitioning rapidly into knowledge-based economies equipped with advanced technologies (Tran, Binh and Van, 2019; Vu and Anh, 2017). The increasing prevalence of digital automation and robotics has diminished the competitive advantage of a cheap and abundant labour force in attracting foreign investment to Vietnam (Hoa, Hoa and Chau, 2019; Vu and Anh, 2017). As AI-powered control and automation are applied, robots are expected to replace human workers across various stages or even the entirety of the production line (Minh and Toan, 2018). Vu and Anh (2017) expressed concerns about the potential for low-skilled jobless growth or even outsourcing of employment from importing countries, particularly in labour-intensive industries like manufacturing, which could result in a reversal in the direction of global value chains. This trend is particularly relevant to sectors like garment, footwear, and electronics in Vietnam, employing nearly 3.5 million people and projected to experience substantial growth (Vu and Anh, 2019). According to the International Labour Organisation, up to 86% of wage workers in Vietnam's textile, clothing, and footwear manufacturing sector could potentially face job losses due to their inability to use advanced technologies. Similarly, results from a PwC survey conducted in 2020 showed that 45% of Vietnamese individuals voiced their concerns regarding automation potentially jeopardising their employment opportunities (PwC, 2021); either because they do not have required digital skill set or because they fear of being substituted by these technologies (Horváth and Szabó, 2019; Bonekamp and Sure, 2015). Vietnam's labour force is rapidly aging, further exacerbating the shortage of digitally skilled workers (Hiep, 2021). Hence, to maintain competitiveness among its neighbouring countries and address the challenge of skilled labour scarcity, Vietnam must seize the opportunity to leapfrog into Industry 4.0 and position itself as a global hub for processing and manufacturing (Diedrichs, 2019).

To successfully navigate the complexities and uncertainties of this transformation, Vietnam must leverage its strengths and build a responsive, adaptable, and resilient supply chain. Since then, the country has witnessed active engagement from academics, policymakers, businesses, and regulators in addressing various aspects of Industry 4.0 within the country (Vu and Anh, 2017). For instance, a report conducted by PwC (2018) explored that the digitisation and integration of value chains and the digitisation of business models will bring in notable transformations, including advancements in operational efficiency and better customer access for Vietnamese businesses. The report also revealed that Vietnamese corporations plan to make substantial investments in digitisation and automation within their supply chains, potentially surpassing global estimates by two to three times. Similarly, findings from a Vietnamese enterprise survey conducted by Tung and Duc (2022) revealed that digital transformation has been instrumental in increasing revenue and lowering operating costs for firms in Vietnam. Despite relatively limited current investment in digital transformation initiatives, business leaders expressed a commitment to expedite these efforts in the coming years.

Additionally, recognising the importance of preparing for the forthcoming wave of Industry 4.0 technologies that are revolutionising global production, the government has taken proactive steps. Recently, the government has developed the National Digital Transformation Programme by 2025, with an orientation towards 2030, demonstrates the government's commitment to focus on developing IT infrastructure and encouraging enterprises to invest in technological innovations to seize opportunities and minimise any negative impacts on the Industry 4.0 (Samuel, 2021). This collective engagement underlines Vietnam's unwavering commitment to embracing technological advancements and positioning itself as a key player in the unfolding Fourth Industrial Revolution. However, the benefits of digitalisation and technological advancements that drive economic prosperity are predominantly observed in advanced economies with well-developed digital infrastructure. In contrast, emerging economies like Vietnam, where technological development is still limited, face significant challenges in keeping pace with this trend. In Vietnam, despite a positive perception about the impact of Industry 4.0 on businesses, most enterprises have not fully embraced it, citing existing barriers that hinder the adoption of Industry 4.0 practices in their supply chains. It has been discussed in the Resolution No.23- NQ/TW of the Central Executive Committee on 22nd March 2018 that given Vietnam's specific circumstances and conditions, the country encounter certain challenges in its effort to participate in and adopt Industry 4.0 (Hoa, Hoa and Chau, 2019). Therefore, although there is generally a favourable view regarding the impact of Industry 4.0 on businesses, many supply chain firms in Vietnam have yet to fully embrace it (Akbari and Hopkins, 2022).

To address this issue, this study's aim is therefore to examine the effective implementation of DSC in Vietnam, given the urgent need for local firms to capitalise on digital technologies. Therefore, the research firstly aims to answer the first research question:

RQ 1: "*What are the enablers and barriers of Supply chain 4.0 (SC 4.0) adoption in Vietnam?"*

Notably, according to Kagumba and Wausi (2018) and Melitski, and Gavin and Gavin (2010), enablers or barriers of technology adoption depends largely on the organisational culture context. Especially, in developing countries, organisational culture has been considered as a crucial antecedent and key player in successful technology adoption (Dasgupta and Gupta, 2011). In Vietnam, this holds true (Nguyen et al., 2019; Tran et al., 2014), implying that successful adoption of SC 4.0 may be attributed to the influence of organisational culture. Given the research is conducted in Vietnamese context, it is essential to consider the role of Vietnamese organisational culture in SC 4.0 adoption. As discussed previously, despite an increasing number of empirical studies exploring the significant role of organisational culture as a driving force in technology adoption, there is a dearth of research studies that explore its importance specifically in the context of SC 4.0 adoption. In the light of addressing this gap, the present study aims to examine the impact of organisational culture on SC 4.0 adoption in Vietnam. This leads to the second research question which is

RQ 2: *"What is the role of organisational cultures in SC 4.0 adoption for firms in Vietnam?"*

To address these research question, it is essential to identify the appropriate theoretical frameworks that can serve as a lens through which to explore the diverse aspects and factors that impact the adoption of digital supply chains. The subsequent section of the study critically evaluates potential theoretical frameworks, considering their relevance, applicability, and ability to provide comprehensive insights into the adoption of DSC. Ultimately, the most suitable theoretical model was selected to guide the research and provide a solid theoretical foundation for investigating the enablers and barriers of DSC adoption in Vietnam.

2.4. Summary

This chapter has provided a comprehensive and clear introduction to the research topic, setting the stage for the subsequent chapters. It commenced with an exploration of the historical context and a review of four industrial revolutions, with a specific emphasis on the fourth industrial revolution. The chapter then examined the concepts of “supply chain”, “supply chain management”, and “supply chain 4.0” to provide a robust understanding of the topic. Finally, it gave an overview of the Vietnamese supply chain and its development in Industry 4.0 which necessitates an imperative to investigate the determining factors of DSC and the role of organisational culture in this context. The forthcoming chapter critically evaluates and elaborates on the theoretical frameworks that underpin this research.

3. CHAPTER 3: THEORETICAL BACKGROUND

In the exploration of Industry 4.0 adoption and SC 4.0 adoption, researchers have drawn upon a range of theories and models to deepen their understanding of the subject. These include the Resource-based view (RBV), Dynamic capabilities (DC), System theory (ST), Actor network theory (ANT), Transaction cost theory (TCT), Social capital theory (SCT), Institutional theory, Resource dependence theory (RDT), Agency theory (AT), Ecological modernisation theory (EMT), Maturity models, Critical success factors (CSF), and Technology adoption models (Wamba and Queiroz, 2022; Yang, Fu and Zhang, 2021; Oztemel and Gursev, 2020; Lai, 2017; Hazen et al., 2016).

As previously mentioned, the primary objective of this research was to propose an empirically tested research model that systematically investigates the factors that either facilitate or hinder the adoption of SC 4.0. Among these various theories and models, CSF and Technology adoption models stand out for their valuable perspectives in identifying those key factors that contribute to the success of SC 4.0 adoption. Meanwhile, other theories tend to only focus on specific aspects of technological innovation adoption instead of comprehensively and robustly defining the multifaceted nature of technology adoption like CSF and Technology adoption models. For example, the RBV only focuses on leveraging an organisation's internal resources and capabilities for successful digital innovation adoption (Silvestri et al., 2023; Dubey et al., 2019; Wu and Chiu, 2015) while Actor network theory examines the intricate network of actors and their influence on digital technology adoption (Seuwou et al., 2017; Shim and Shin, 2015). Institutional theory, on the other hand, examines the role of institutional pressures and norms in shaping digital technology adoption (Rodríguez-Espíndola et al., 2022; Lin, Luo and Luo, 2020; Lutfi, 2020). Therefore, although other theories and models have their own merits, the CSF and Technology adoption models prove particularly promising for developing a comprehensive framework to guide successful SC 4.0 adoption. By considering a broad range of factors and systematically examining their influence, these models can offer valuable insights and empirical evidence, aligning effectively with the aim of this research.

Critical success factors (CSF) play a pivotal role in identifying the crucial elements necessary for successful technological innovation adoption (Smania and Mendes, 2021; Sukathong et al., 2021; Kamal, 2006). However, to gain a comprehensive understanding of these factors and their impact on technology adoption, Technology adoption models such as the Technology Acceptance Model (TAM) or Technology – Organisation – Environment (TOE) framework offer valuable insights. These technology adoption models go beyond mere identification of critical factors for the success of innovation adoption. They provide comprehensive frameworks that allow the measurement, prediction, and understanding of the impacts and significance of these factors in driving or hindering technology acceptance and adoption (Chen, Gillenson and Sherrell, 2004). For example, For example, Ahmad et al. (2013) initially conducted literature review to identify CSFs then employed a technology adoption model which is Unified Theory of Acceptance and Use of Technology (UTAUT) to map out a roadmap to successful implementation of Information Technology and Infrastructure Library (ITIL). Similarly, recent studies by Dora et al. (2022), Zhang et al. (2020) and Mawaddah, Huang, and Chang (2020) have first identified critical success factors and subsequently utilised a technology adoption model, particularly the Technology – Organisation – Environment model, to assess and understand these factors. This suggests that technology adoption models not only build upon CSF theory but also provide insights into the likelihood and speed of innovation adoption, making them valuable for assessing the potential success and adoption rates of SC 4.0 technologies. This predictive aspect becomes particularly useful for organisations planning their SC 4.0 adoption strategies. It becomes apparent, therefore, that CSF theory alone is insufficient to fully understand the influence of these factors on the successful adoption of SC 4.0.

Based on the review and evaluation of Technology adoption models (see Appendix A), this chapter identifies TOE as the most appropriate framework that can serve as the core foundation for the study, providing a robust theoretical framework for exploring various factors that hinder or support the adoption of DSC and examining how these factors vary across different contexts. Furthermore, alongside the technology adoption perspective of TOE, this research also incorporates the interorganisational relationship (IOR) perspective. As previously discussed, the adoption of DSC requires a collaborative effort among supply chain organisations; thus, the relationships between these organisations can significantly impact the adoption process (Annosi et al., 2021; Iddris, 2018; Korpela, Hallikas, and Dahlberg, 2017). The IOR theory emphasises the significance of interorganisational collaboration and cooperation in achieving successful technology adoption (Chong et al., 2009).

By integrating these two theoretical perspectives (TOE and IOR), this research seeks to develop a deeper understanding of the factors that impact the DSC adoption which eventually help to identify best practices and develop strategies that organisations can employ to enhance DSC adoption rate. The subsequent section sheds light on the significance of TOE framework and Interorganisational relationships theory in explaining the adoption of SC 4.0 at an interorganisational level as well as filling existing gaps and addressing the challenges discussed in the Introduction chapter.

3.1. Technology Adoption Models Overview

Technology adoption models are commonly employed to investigate the users' decision-making process when adopting a specific technology (Louho, Kallioja and Oittinen, 2006). Research in technology adoption has led to a competition of many technology adoption models. The differences mainly exist in the model determinants which affect the acceptance and use of the technology. Additionally, according to Louho, Kallioja and Oittinen (2006), while some models are designed for a specific context such as a technology, a product or an industrial area, others are generic and can be applied in various contexts. In this thesis, the focus is on generic Industry 4.0 technology adoption in supply chain context.

The most common theoretical models used to examine the technology acceptance and adoption are Innovation Diffusion Theory (IDT), Theory of Reasoned Action (TRA), Theory of Planned Behaviour (TPB), Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT) and Technology – Organisation – Environment (TOE). A snapshot of these models is available in Appendix A.

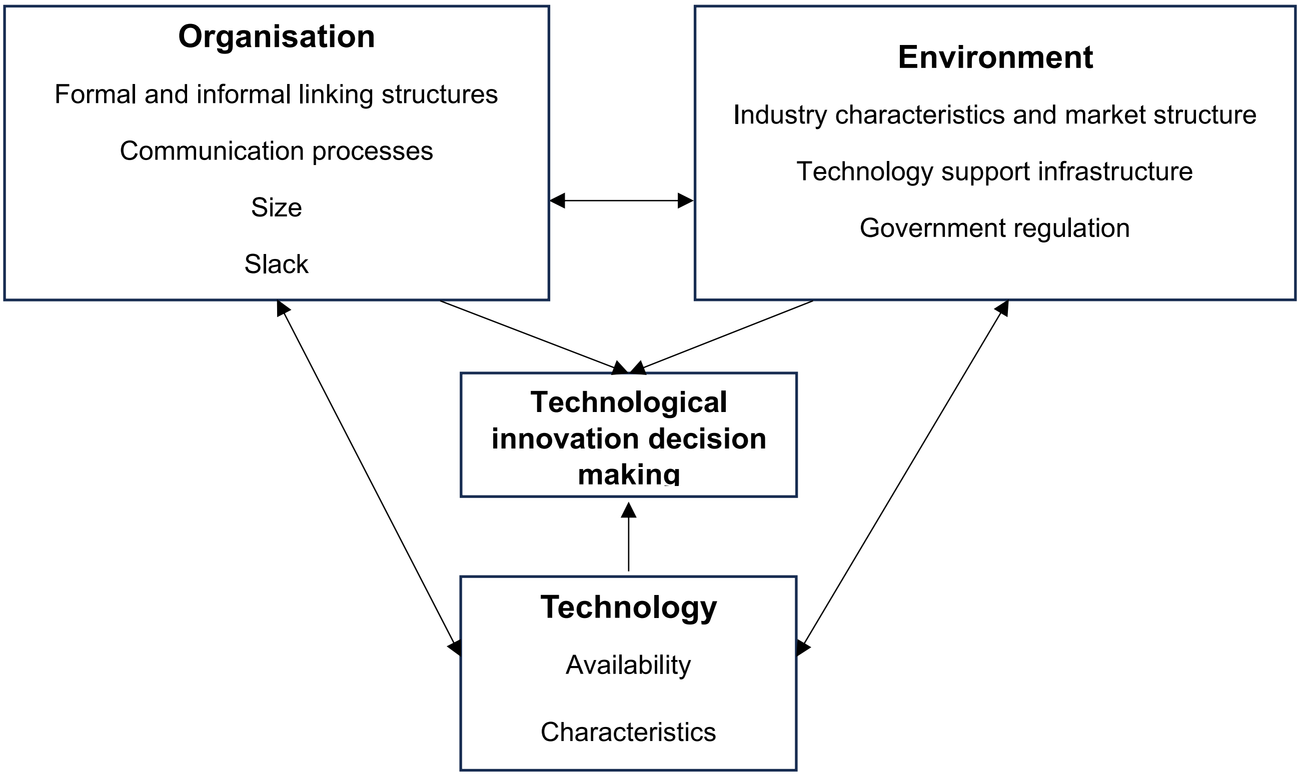
Scholars believe that TRA and TPB are predominantly applied to predict individual adoption (user level) while TAM, IDT, UTAUT and TOE study the technology adoption at organisational level (Kiwanuka, 2015; Rogers, 2003). However, despite UTAUT's widespread and valid application at an organisational level, it has been criticised for their limited consideration of environmental factor that may influence technology adoption. On the other hand, both TAM and TPB, which are routed to TRA, are accused of relying too heavily on illusion of accumulated tradition, attitudinal utilitarianism (Eze et al., 2013; Al-Natour and Benbasat, 2009) technological determinism and technology-centric predictions (Venkatesh, Davis and Morris, 2007) which indicates that the technology itself, rather than individuals, determines the organisation's structure and adoption (Awa, Baridam and Nwibere, 2015; Venkatesh, Davis and Morris, 2007). These models also neglect the influences of psychological, social and interpersonal variables on technology adoption decisions (El-Gohary, 2012; Venkatesh and Bala, 2008; Bagozzi, 2007; Davis, Bagozzi and Warshaw, 1989). Meanwhile, IDT incorporates such parameters but ignores the environmental context (Robertson and Gatignon, 1986). IDT is also mainly used to study technological adoption at the market level. In general, while IDT, TRA, TPB, TAM and UTAUT can be useful in understanding certain aspects of technology adoption, they are not designed to address the complexities of organisational-level decision-making processes. At the organisational level, the adoption of technology is influenced by various factors such as organisational culture, structure, strategy, resources, and external environment, which cannot be fully explained by these theories (Gangwar, Date and Ramaswamy, 2015).

Since the focus of this research is on firms, the organisational level is the primary parameter of analysis, and theories related to individual level and market level are not appropriate. Additionally, as the adoption of SC 4.0 involves a complex network of stakeholders and interorganisational relationships (Makris, Hansen and Khan, 2019) that are beyond the scope of these theories. The adoption of technology in organisations is also a dynamic and ongoing process (Chinedu Eze, Duan and Chen, 2014), which these theories cannot fully capture. Hence, scholars called for more integrated and holistic framework that can meet the demands for non-determinism and more social interactions as well as take into account the organisational and interorganisational factors to examine the technology adoption at the organisation level (Oliveira and Fraga, 2011). In the face of this challenge, Tornatzky, Fleischer and Chakrabarti (1990) proposed the Technology – Organisation – Environment (TOE) framework which examines the influence of technology development, organisational conditions and reconfiguration, and industry environment on the likelihood of technological adoption, which is the theoretical foundation in this research.

3.2. Technology – Organisation – Environment Framework

According to Tornatzky, Fleischer and Chakrabarti (1990), the technological context describes both internal and external technologies relevant to firms – including those currently in use and those available but not yet adopted. Technological context in the model refers to technology's characteristics, including the perceived relative advantage (gains), compatibility of technology to the technical operation and organisational system, complexity of using the technology, trialability (pilot test/ experimentation of the technology) and observability (visibility/imagination of technology benefits). On the other hand, organisational context refers to the characteristics and resources of the firm, including but not limited to the firm's scope of business, top management support, organisational culture, human resources quality, firm's size, amount of slack resources, and managerial structure measured by level of centralisation, formalisation and vertical differentiation. Environmental context considers the larger arena where the firm conducts its business, including its Industry characteristics and market structure such as competition pressure and power of firms within the market, customer-supplier relations, Industry lifecycle, and trading partners' readiness, etc. It also examines government regulations and technology support infrastructure such as skills of available labour force and access to suppliers of technology-related services. The parameters within the TOE's context have been continuously refined by other scholars with purpose of broadly strengthening the theoretical base of the model and its capability to explaining and predicting the adoption and assimilation of various types of IT innovation. Hence, the specific factors identified within the three contexts may vary across different studies (Oliveira and Fraga, 2011). The TOE framework exemplified in Figure 3-1 below was originally developed by Tornatzky, Fleischer and Chakrabarti (1990). However, it is important to note that the specific dimensions and indicators of TOE utilised in this research were derived from SLR and the interviews, and thus, differ from those originally suggested in Figure 3-1.

Figure 3-1: Technology – Organisation – Environment framework (Tornatzky, Fleischer and Chakrabarti, 1990)



TOE emerges as a widespread theoretical perspective that bring both human and non-human factors into technology adoption, addressing the weaknesses of other frameworks such as illusions of accumulated tradition and techno-centric predictions in TAM, TRA, and TPB (Awa, Ukoha and Emecheta, 2016). Unlike these models, TOE places more emphasis on social and behavioural constructivism while acknowledging the interplay between technology development, organisation’s conditions, and environmental issues (Hossain and Quaddus, 2011; Jacobsson and Linderoth, 2010; Barrett, Grant and Wailes, 2006).

Additionally, according to Gangwar, Date and Raoot (2014), despite having practical utility in many disciplines, IDT is not as specific as TOE. Therefore, although IDT's constructs cross-cut TOE's technology and organisation, the integration of environment parameters in TOE framework provides superior theoretical information compared to IDT in studying technology adoption (Gangwar, Date and Raoot, 2014; Hossain and Quaddus, 2011; Oliveira and Fraga, 2011). Thus, according to Gangwar, Date and Ramaswamy (2015), this holistic framework provides firms with a comprehensive understanding of the challenges and enabling factors that influence technology adoption decisions and implementation processes, as well as post-adoption diffusion among firms, enabling them to better prepare their capabilities for innovation adoption.

In recent years, the TOE framework has become the dominant theoretical perspective for studying the adoption of Industry 4.0 technologies such as studies by Ghobakhloo et al. (2022) and Lin et al. (2018) or adoption of specific Industry 4.0 technologies such as IoT (Arnold and Voigt, 2019), cloud computing (Senyo, Effah and Addae, 2016; Low, Chen and Wu, 2011), RFID (Al-Hashedi et al., 2011; Wang, Wang and Yang, 2010), business analytics (Omar, Minoufekr and Plapper, 2019), and business intelligence system (Puklavec, Oliveira and Popovič, 2018). Especially, TOE has also been extensively utilised to explore the adoption determinants of Industry 4.0 technologies in SCM context such as Blockchain (Callinan et al., 2022; Chittipaka et al., 2022; Gökalp, Gökalp and Çoban, 2022; Mittal et al., 2021; Wong et al., 2020), e-SCM (Hamadneh et al., 2023; Lin, 2018, Lin, 2014), BDA (Alaskar, Mezghani and Alsadi, 2021; Arunachalam, Kumar and Kawalek, 2018; Lai, Sun and Ren, 2017), IoT (Tu, 2018), cloud computing (Amini and Javid, 2023), mobile SCM (Chan and Chong, 2013) and AI (Nayal et al., 2022). The extensive adoption of the TOE framework in both Industry 4.0 and SC 4.0 research signifies its effectiveness in capturing the technological, organisational, and environmental factors that shape Industry 4.0 technology adoption. It provides researchers with a comprehensive lens through which they can examine the multifaceted nature of Industry 4.0 adoption in the context of SCM.

Nonetheless, like other theories and models, TOE possesses some weaknesses. For instance, TOE uses taxonomies to categorise variables into contexts and does not present a well-developed and integrated conceptual framework (Dedrick and West, 2003). Moreover, the parameters of Technology – Organisation – Environment factors are not specifically fixed, and their boundaries are not explicitly defined (Ven and Verelst, 2011). However, due to this reason, this framework gives the researchers a high flexibility of exploring and utilising various factors depending on their research context. Thus, it is viewed as a highly adaptable model to different research contexts and industries, and is found useful in studying various types of technological adoption, especially when this research does not focus on a specific Industry 4.0 technology adoption. Hence, TOE has been considered as the most prominent framework exploited in organisational-level studies of innovation adoption and has been identified as the most appropriate model to provide a more comprehensive understanding of the adoption of SC 4.0 at the organisational level.

The TOE framework was originally designed to include three factors which are Technology, Organisation and Environment (Tornatzky, Fleischer and Chakrabarti, 1990). These three aspects are seen as both enablers and barriers of a technological adoption, determining how firms perceive the necessity for, search for and adopt digital technologies in their supply chains. Therefore, they serve as the three dimensions of this study's framework. The specific dimensions used to explore the adoption of SC 4.0 in this study are further detailed in Chapter 4.

3.3. Interorganisational Relationship (IOR) Theory

Since the objective of this research is to analyse firm's implementation of Industry 4.0 in SCM context, it is necessary and indispensable to consider the supply chain characteristics, such as information sharing and communication, supply chain collaboration in resources and risks-sharing, decision making, trust and commitment. These characteristics are foundational to building inter-organisational relationships (IOR) among supply chain partners. Inter-organisational relationship (IOR) refers to the collaborative efforts and coordination between supply chain partners, such as suppliers and buyers, to achieve the mutual supply chain objectives through effective communication and information sharing, and integrated process coordination from sourcing to distribution (Lai, Sun and Ren, 2018; Chan and Chong, 2013). As claimed by Tripathi and Gupta (2020), Industry 4.0 adoption into the supply chain requires the co-adoption of more than one supply chain members; making IOR critical, as they influence the co-adoption decisions. It has been evident that many organisations are adopting technologies in their supply chain based on the strength of their interfirm collaboration (Chan and Chong, 2013), especially for emerging economies like Vietnam where business is conducted on the basis of business relationships. However, despite the popularity of TOE, Chan and Chong (2013) and Chong and Ooi (2008) stated that TOE often neglects the impact of inter-organisational relationships. As such, to provide a more complete and accurate explanation of technology adoption of firms within a supply chain context, the present research integrates the insights of IOR into the TOE model framework, expanding the environmental factor within the model, thus enriching the novelty and significance of this research.

There has been an increasing acknowledgement that organisations operate within a complex web of interconnected environmental relationships, and as such, the survival and successful performance of firms often depend critically on their linkages or interfirm relationships with other organisations (Oliver, 1990). The interfirm relationships are purposeful collaboration and cumulative efforts of organisations in the supply chain who frequently work together to exchange information and resources related to their planning, management, execution and performance management; and co-develop capabilities to mutually achieve the benefits (Wang et al., 2016A) and provide enhanced customer experience (Tripathi and Gupta, 2020). In the context of Industry 4.0, this relationship needs to be strengthened as its application in supply chain is not solely a matter of technical implementation, but also a matter of processes and the involvement of individuals within the supply chain.

With the emergence of Industry 4.0 technologies, integration and collaboration among firms will experience a new level of maturity. These digital technologies create a digital thread connecting all supply chain participants, necessitating strategic digital collaboration for efficient functioning (Dos Santos et al., 2021; Castelo-Branco, Cruz-Jesus and Oliveira, 2019). Moreover, due to process fragmentation and multi-stakeholder nature of supply chain, the efficient performance of the supply chain in the context of Industry 4.0 demands a high degree of visibility, requiring a high level of coordination and real-time and accurate data sharing among supply chain members (Tripathi and Gupta, 2020; World Economic Forum, 2019). It is also apparent that no single vendor can possess all the skills required to implement their DSC as Industry 4.0 solutions comprise diverse technologies and devices running on multiple networks (Muthusami and Srinivsan, 2018). Therefore, forming close-knit relationships with supply chain partners is truly pivotal in technology adoption to diffuse best practices and success stories, facilitate mutual learning, and overcome barriers such as lack of expertise and perceived uncertainties (Tripathi and Gupta, 2020; Zangiacomi et al., 2018).

Recent studies have proved that there is a significant relationship between supply chain collaboration and the adoption of Industry 4.0 technologies in the supply chain (Luthra et al., 2020; Frederico et al., 2019; Schneider, 2018). In the context of Industry 4.0, interorganisational collaboration is crucial for gaining competitive advantage by providing insights into the technology requirements and their impacts on the entire supply chain (PWC, 2016A; Farahani, Meier and Wilke, 2015). For these reasons, it calls for organisations' bilateral efforts to strengthen and grow the supply network on achieving the mutual digital supply chain goals that are not easily attainable alone (Oesterreich and Teuteberg, 2016). In essence, deepening the extent of inter-organisational relationships among supply chain partners can ensure the successful adoption of Industry 4.0 technologies in the supply chain ecosystem.

Thus, IOR has been an extensively used theory for better understanding the impact of interorganisational relationships on the adoption of cross-organisational technologies (Chong and Ooi, 2008). However, despite the popularity of TOE, Chan and Chong (2013) and Chong and Ooi (2008) stated that TOE often neglects the impact of inter-organisational relationships. Since DSC is an organisational-level decision made within an interorganisational context, it is crucial to incorporate IOR principles to offer a comprehensive and precise understanding of technology adoption among firms within a supply chain context. Thus, the present research integrates the insights of IOR into the environmental factor within TOE model, aiming to enrich the novelty and significance of this research. While TOE serves as an inclusive and fundamental theoretical model to examine DSC adoption within firms, IOR extends this traditional framework to investigate the impact of relationships between supply chain stakeholders on the adoption of DSC. Several studies (e.g. Khadivar, Nazarian and Salemi, 2023; Chan and Chong, 2013) have integrated TOE and IOR in exploring the adoption of digital technologies within supply chains. These studies suggested that the use of TOE and IOR can provide a more comprehensive explanation for technology adoption within the context of SCM.

Prior studies have investigated interorganisational relationships (IOR) in various ways, encompassing factors such as collaboration, leadership, knowledge, culture and justice, information sharing, communication, trust, power and pressure. For example, Chan and Chong (2013) claimed that IOR works on the principles of trust, collaboration and information sharing. Whereas Chong et al., (2009) highlighted trust, communication, collaboration, information sharing and trading partners' power as critical factors influencing the implementation of digital supply chain. Wang et al. (2018)'s study, on the other hand, examined three constructs which are strategic collaboration, information sharing and process coordination with trust, commitment, and power as the mediating factors that facilitate supply chain integration and collaboration. Meanwhile, a study by Kavin and Narasimhan (2018) indicated that trust, power and communication, in addition to strategic collaboration and information sharing, are among the three most influential dimensions that influence the interorganisational collaboration in the supply chain. Overall, there is a range of scholarly views on the degree to which IOR dimensions impact technology adoption. These perspectives are later considered when integrating IOR principles with TOE in this research.

3.4. Summary

To explain the foundation for the study, this chapter has provided an overview of technology adoption and interorganisational relationships theory as the basis to investigate the previously identified gaps. To ensure relevance and accuracy, the selection of theories drew upon on a range of several studies that investigated the adoption of technologies, specifically the application of Industry 4.0 in SCM context (Osei et al., 2023; Wong et al., 2020; Supranee and Rotchanakitumnuai, 2017; Cao et al., 2015; Lin, 2014; Chae, Yen and Sheu, 2005). The research examined technology adoption models with a purpose of identifying the appropriate core framework for the research. Through a thorough review of technology adoption models and given the weaknesses of other models in addressing the comprehensive aspects of technology adoption at organisational and interorganisational level, Technology – Organisation – Environment (TOE) was found to be the most appropriate framework, serving as a dominant model explaining the key factors that can influence the adoption of SC 4.0. Additionally, the chapter also reviewed the Interorganisational Relationship (IOR) theory to explore the principles of inter-firm collaboration. These theories were considered as fundamental in the development of a robust research framework for this study, enabling the identification of critical factors influencing the adoption of SC 4.0.

4. CHAPTER 4: LITERATURE REVIEW

In today's rapidly changing business landscape, digital technologies have disrupted several industries, including logistics, manufacturing, and transportation (Zekhnini et al., 2020). This has given rise to the concept of SC 4.0, which refers to the integration of advanced technologies like AI, Blockchain, and IoT into supply chain operations. The potential benefits of SC 4.0 have garnered significant attention from both academics and practitioners as it promises to improve efficiency, reduce costs, and enhance customer satisfaction (Zekhnini et al., 2020; Da Silva, Kovaleski and Pagani, 2019; Büyüközkan and Göçer, 2018).

Nonetheless, despite the increasing interest in SC 4.0, there is a lack of academic studies that provide a comprehensive framework for its adoption, considering the critical role of organisational culture. Since the organisational culture of a company can significantly impact its ability to adopt new technologies and adapt to change (Shuaib and He, 2022; Fiordelisi et al., 2019), it is essential to understand how different organisational cultures can influence the adoption of SC 4.0. In response to this gap, this chapter aims to provide a systematic literature review of existing literature associated with SC 4.0 adoption barriers and enablers, followed by a literature review on the type of different organisational cultures on such adoption. The review draws on a range of sources, including academic journals, conference proceedings, and Industry reports, to provide a comprehensive overview of the topic.

4.1. Supply Chain 4.0 Determinants

Undoubtedly, SC 4.0 or DSC has quickly emerged as an evolving concept that has gained increased interests from both practitioners and researchers across various disciplines (Makris, Hansen and Khan, 2019; Swanson, 2017; Wu et al., 2016), leading to a significant number of publications (Zekhnini et al., 2020). However, it is believed that this research field has been quite fragmented and divergent (Wu et al., 2016) because it has the deep roots in many traditional fields such as engineering, data analysis and information system, etc. Additionally, despite wealth of publications on SC 4.0, only a handful of studies have attempted to evaluate its implementation through systematic literature reviews, such as Frederico et al. (2019), Novais, Maqueira and Ortiz-Bas (2019), Büyüközkan and Göçer (2018) and Wu et al. (2016). Moreover, most SLRs in this field revealed an absence of quality assessment as an inclusion criteria and transparency in the reviewing process. In addition, many previous SLRs also failed to distinguish between Industry 4.0 papers and SC 4.0 papers, making it challenging to identify development trends and the growing attention of researchers and practitioners towards SC 4.0 compared to other fields (Nguyen, Kumar and Soares, 2022). To fill the gaps in the academic literature review, this research aims to conduct a systematic literature review (SLR) that synthesises the key SC 4.0 research findings pertaining to implementation factors, following strict and explicit guidelines. These guidelines are informed by both best practices and the unique attributes of SCM, intended to enhance the quality of selected studies and mitigate the frequently discussed gaps in SCM papers. Through this approach, this research aims to contribute to a more comprehensive understanding of SC 4.0 implementation and provide valuable insights for both researchers and practitioners.

According to Denyer and Tranfield (2009), SLR is a well-established and proven method for examining the bibliographic sources for a specific topic with the aim of producing organised and classified outcome based on the current accumulation of research regarding the research questions. An SLR involves systematically retrieving, selecting, and carefully reviewing relevant papers using strictly predefined selection criteria and explicit methods of data extraction and synthesis (Ferrari, 2015). Because of its well-defined steps, SLR can be easily verified or replicated by other researchers (Denyer and Tranfield, 2009). In addition, by conducting a critical analysis of research articles through an SLR, potential researcher bias can be mitigated, resulting in more objective answers to research questions. Moreover, such an analysis can uncover systematic patterns, synthesise knowledge, and expose any research gaps or trends in the literature that may have gone unnoticed, ultimately strengthening the field of study and contributing to theory development (Wu et al., 2016). Therefore, when compared to traditional literature review methods, an SLR can provide a more well-organised structure with defined steps and a deeper, more rigorous, transparent, and replicable review process (Novais, Maqueira and Ortiz-Bas, 2019; Mallett et al., 2012).

Building on the established research methodology proposed by Tranfield, Denyer, and Smart (2003), and successfully implemented in previous literature reviews focused on supply chain and its application of Industry 4.0 technologies (Novais, Maqueira and Ortiz-Bas, 2019; Frederico et al., 2019; Awwad et al., 2018; Govindan et al., 2018), this study employs the same SLR design to identify, evaluate, and interpret prior conceptual and empirical research publications in the field of enablers and barriers/challenges of adopting SC 4.0, DSC, or Smart Supply Chain.

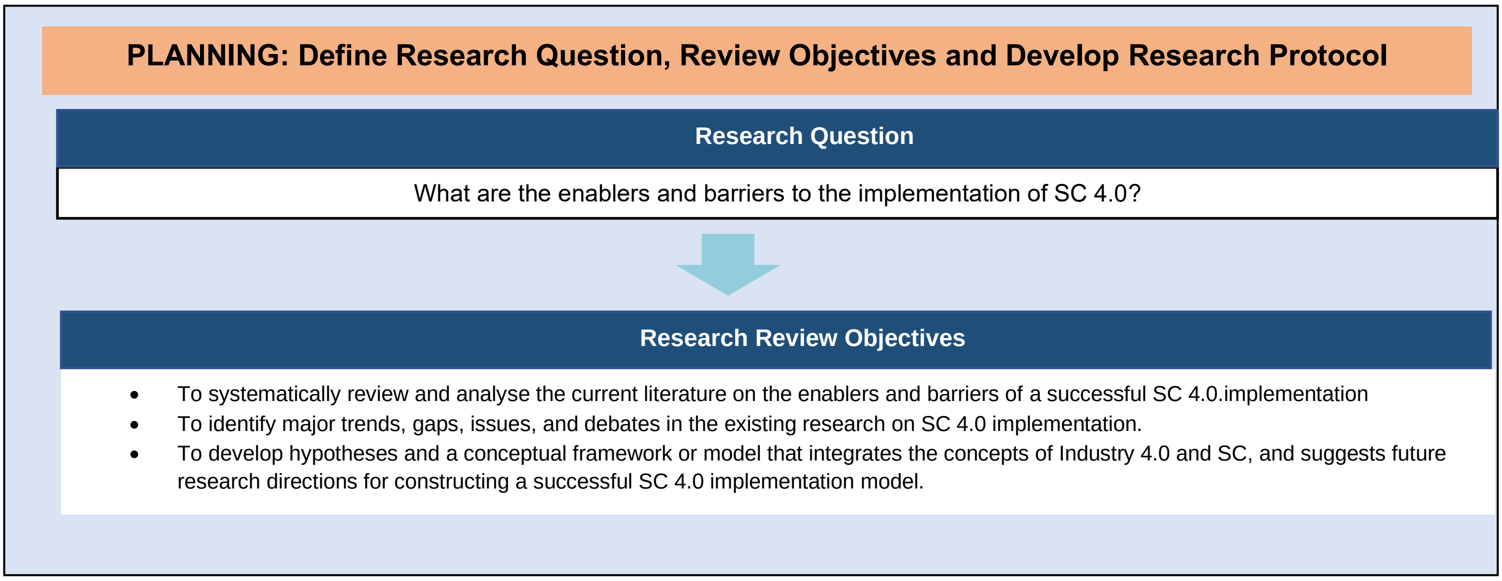
To address the first research question which is "*Which are the enablers and barriers of SC 4.0 adoption in Vietnam?*", this study conducts a systematic literature review from two perspectives: (1) the adoption of Industry 4.0 in a general context and (2) the adoption of Industry 4.0 in the field of SCM. The reason for this dual approach is to integrate two independent concepts, namely SCM in the domain of business management and Industry 4.0 in the domain of information technology. Additionally, the research aims to explore the general factors influencing the application of Industry 4.0 in a country, and then conduct a thorough and in-depth analysis of these factors specifically in the context of SCM (Nguyen, Kumar and Soares, 2022). The SLR is organised into three phases, following the methodology proposed by Tranfield, Denyer and Smart (2003) which are Planning, Conducting and Reporting.

During the planning phase, the research area is delimited, and a protocol is established to identify, select, review, and synthesise relevant literature (Seuring and Müller, 2008). It consists of research review objectives, inclusion and exclusion criteria that are developed around three research review objectives as outlined in SLR procedure to limit the systematic error and bias in the screening of papers for review. The search strategy was first developed by determining the relevant data sources. To have access to a wide range of academic and conference publications sources, databases including Science Direct, Business Source Complete, SCOPUS, Emerald, Taylor and Francis, Google Scholar. Besides, considering the relative infancy of the topic, it is not deemed appropriate to exclude unpublished studies and reports. As such, non-academic sources including the practitioner journals and industrial reports from global companies and organisations' official websites such as Deloitte, KPMG, PWC, McKinsey & Company or World Economic Forum's website were also searched to collect the most recent smart SC applications in practice. In addition to identifying the relevant data sources, it is also crucial to determine the keywords for paper search. In this SLR, the keywords were not predetermined before the search but gradually emerged during the extensive reading and searching process. The main four keywords identified from the research question include: (1) "Industry 4.0", (2) "Supply Chain", (3) "enablers", (4) "barriers" (5) "organisation". To extend the identification of relevant articles, it is important for the researchers to identify the breadth and scope of the search keywords by searching for synonyms in the thesaurus or alternative terms used by different authors to express similar implications (Nguyen, Kumar and Soares, 2022). In this SLR, it was found that the term "enablers" and "barriers" in Industry 4.0 context have deep roots in different terminologies such as "factors, success factors, drivers, challenges, determinants, readiness, and maturity". Similarly, "Industry 4.0 and Supply Chain" was initially as the search term on databases, the researcher discovered alternative terms "Supply Chain 4.0", "Smart Supply Chain", "Digital Supply Chain" and "Intelligent Supply Chain" used by different authors in the articles. These keywords are frequently used in the recent smart SC and Industry 4.0 literature. Hence, all these alternative terms were applied interchangeably to search for further articles. Since the focus of this study is barriers and enablers of implementation of Industry 4.0 in the SC context, the researcher combined the above keywords specifically to constitute a series of strings - the combination of search keywords. The strings were then applied in the search on the databases to select relevant papers. It was determined that the keywords should appear in the papers' titles, abstracts, or keywords in relevant refereed journals. The literature was obtained from relevant journals in the areas of Operations and Production Management, Operation Research, Business and Management, Logistics, Distribution and Transportation, Information Management and Information Technology, Computers, and Industrial Engineering. Furthermore, in the planning stage, the papers would be either selected or rejected after performing a content check based on delimitating the inclusion and exclusion conditions (detailed in Figure 4-1). According to Durach, Kembro and Wieland (2017), these criteria reflect various aspects of research purpose, research questions and quality of the selected literature. Exclusion criteria were first applied to remove irrelevant studies and subsequently inclusion criteria are applied. The exclusion criteria were also simultaneously applied during the process. List of exclusion and inclusion criteria were mentioned in Figure 4-1.

The conducting phase involves screening research articles to identify, select, evaluate, analyse, and synthesise pertinent information. Initially, potential papers were searched and identified using the predetermined keywords on the selected databases. Next, the duplicated papers, theses, dissertations, and other irrelevant papers were removed. Furthermore, any papers, which do not focus on implementation factors/ actors/ components/ constructs / model/ conceptual model/ framework of Industry 4.0 concepts and applications in supply chain, either throughout the entire paper or in their specific sections, were also excluded. Specifically, articles which heavily view from technical perspective of Industry 4.0 such as data mining or technological function barriers were considered out of scope of this review. After the removal of the paper duplication among databases and irrelevant papers, the selected papers were then analysed to decide whether they can address the research topic. It involves the scrutiny of selected papers' titles, abstracts, and keywords. However, if the title, keywords, and abstract were vague, the entire text was examined through an in-depth reading of methodologies, main discussion, and results. Additionally, in order to select a paper for the review, the paper underwent a quality assessment. While several sets of quality assessment have been proposed such as Cohen and Crabtree (2008) and Briner and Denyer (2012), the standard criteria for SLRs established by Nguyen, Kumar and Soares (2022) emerged to be particularly beneficial for SCM papers. This SLR quality assessment criteria evaluates various aspects of a paper, including the contribution, literature review, methodology, analysis, and conclusion. In order for the paper to be selected, the paper must meet the defined high-quality criteria in at least one of these aspects. Finally, 153 articles that have a clear focus on discussing the implementation of industry 4.0 and/or within supply chain context were chosen for review.

Finally, in the reporting and dissemination phase, the content of the selected papers was systematically reviewed and classified into relevant categories using structured descriptive and thematic analysis methods. This process aimed to identify patterns, research directions, and similarities or differences in research findings among authors within the sampled articles. Figure 4-1 provides a visual representation of the three phases of the SLR and the corresponding outputs for each phase. The comprehensive insights into the details of SLR process can be found in the published book chapter (Nguyen, Kumar and Soares, 2022).

Figure 4-1: Systematic literature review procedure adapted from Tranfield, Denyer and Smart (2003).



Inclusion Criteria for paper selection

Sources/Databases	Keywords		Period
	Sample A: INDUSTRY 4.0 (I.4)	**Sample B: SUPPLY CHAIN 4.0 (SC4.0)**	
• Science Direct • Business Source Complete • SCOPUS • Emerald • Taylor and Francis • Google Scholar • Organisations' official website	"Industry 4.0 Application/ Adoption/ Implementation/ Factors", "Industry 4.0 Challenges/ Barriers/ Obstacles", "Industry 4.0 Enablers/ Success Factors/ Determinants/ Drivers/ Readiness/ Maturity	"SC(M) 4.0/ Digital SC(M)/ Smart SC(M)/ Intelligent SC(M)", "Enablers/ Determinants/ Success Factors/ Drivers/ Maturity/ Factors of SC(M) 4.0/ Digital SC/ Smart SC/ Intelligent SC", "Barriers/ Challenges of SC(M) 4.0/ Digital SC(M)/ Smart SC(M)/ Intelligent SC(M)"	From 2011 till August 2020

- Papers which contain at least Industry 4.0, Industry 4.0-related technologies, or the fourth industrial revolution in their title or abstract, to ensure substantive relevance.
- Papers published in reliable and high-quality sources in English, such as peer-reviewed journals, policy reports, conference, proceedings.
- Papers that provide access to the full text.
- Papers addressing the research questions.
- Papers focusing on management and business sides

Exclusion Criteria

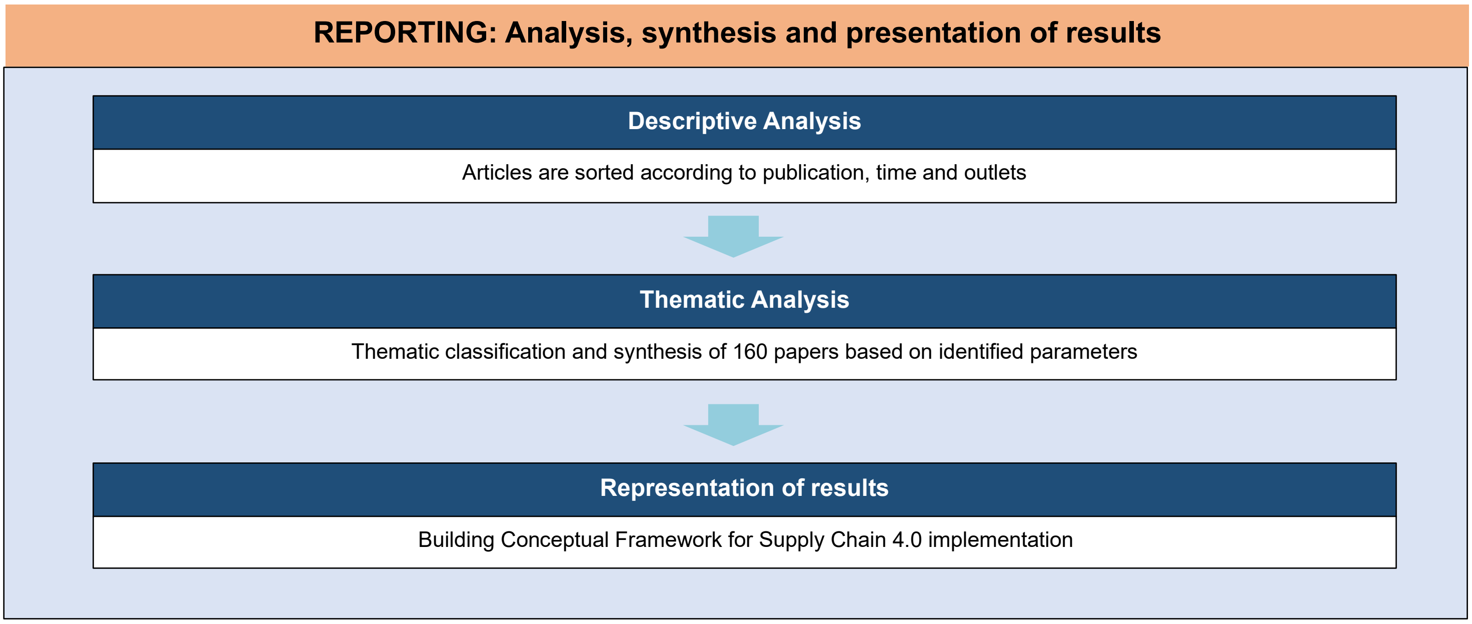
- Non-English
- Do not address the research questions
- Heavy focus on technical views
- Lack of in-depth explanation
- Theses, dissertations and duplicate papers

CONDUCTING

	Sample A: I.4	Sample B: SC 4.0
Identification of research studies Keywords search on databases	621 papers	334 papers
Evaluation and selection of relevant studies Removal of duplication among databases and irrelevant papers	417 papers	153 papers
Analysis of titles, abstracts and keywords	251 papers	113 papers
Reason-based elimination upon reading full text of each extracted paper thoroughly and in-depth and examination of main results, conclusions and main discussion	117 papers	60 papers

SLR Sample after duplication

153 papers



After an extensive SLR where the selected papers were thoroughly scrutinised, evaluated, and categorised using the methods of descriptive and thematic analyses. While the descriptive analysis outcomes can be found in Appendix B, the thematic research findings are presented below. In these sections, research directions, similarities, and differences within the sampled articles are discussed, provide valuable insights into the current state of knowledge and the prevailing trend in the field, which in turn contribute to the identification of research gaps that justify further investigation.

As stated above, for conducting a comprehensive literature review, this research employs thematic analysis technique as a rigorous and transparent method. According to Lerigo-Sampson (2022), Clarke and Braun (2017), Maguire and Delahunt (2017), Alhojailan and Ibrahim (2012), and Tranfield, Denyer, and Smart (2003), thematic analysis is a well-established quality research method that consolidate research findings on specific themes to present established knowledge. To identify the most prominent themes and subthemes in the literature, thematic analysis examines the results, findings, discussions, conclusions, and recommendations of the selected papers, which are then used to develop the conceptual framework for the study. The value of thematic analysis lies in its ability to extract and synthesise information from a large body of literature, providing a comprehensive overview of the research field and ensuring the dependability, credibility, and trustworthiness of their findings (Alhojailan and Ibrahim, 2012). This approach also allows for the exploration of diverse perspectives, highlighting similarities and differences, and uncovering unexpected insights (Durach, Kembro, and Wieland, 2017; Nowell et al., 2017; Pittaway, Holt, and Broad, 2014).

During the thematic analysis, the SC 4.0 conceptual framework and its associated barrier and enabler dimensions evolve in this research. The data analysis reveals a total of 24 factors, which include: (1) Perceived technological risks; (2) Perceived technological benefits; (3) Perceived technological cost; (4) Technological complexity, (5) Technological compatibility, (6) Data privacy and security, (7) Interconnection standards or technical standards, (8) Unclear return on investment, (9) Human resources (including Skills and knowledge and Training and education), (10) Technological infrastructure, (11) Digital/innovative culture, (12) Financial resources, (13) Top management's knowledge and support, (14) Strategy and strategic roadmap, (15) Decentralised organisational structure, (16) Inter-department coordination, (17) Government regulations and support, (18) Competitive pressure, (19) Customers' individualisation demand, (2) Market uncertainties, (21) Collaboration with supply chain partners, (22) Information sharing and Trust with supply chain partners, (23) Trading partners' power, (24) Third parties' support.

To eliminate duplication and simplify the number of factors, it is necessary to group and classify them into relevant themes and subthemes. This process, known as "coding" (Given, 2008), involves constant comparisons among factors within and between studies to ensure data consistency (Nguyen, Kumar and Soares, 2022). It is suggested by Nguyen, Kumar and Soares (2022), reviewers may need to recode data by combining existing codes to encompass a broader perspective or reduce a large dataset.

In this analysis, the 24 factors identified from the data can be coded into eight main themes. *Data privacy and security, Interconnection standards, Perceived technological cost, Technological complexity, Technological compatibility,* and *Unclear return on investments* are classified as **Perceived technological risks.** This is because perceived technological risks refer to technology-related problems and uncertainties that firms encounter when adopting new technology (Hsu, Ray, and Li-Hsieh, 2014), which can decrease the technology's reliability and trustworthiness. Whereas, **Perceived technological benefits** are classified separately due to its distinctive nature from other factors. While *Human resources, Technological infrastructure, and Financial resources* are grouped under **Organisational resources;** *Strategy and strategic roadmap* is considered as a part of **Top management knowledge and support**. *Competitive pressure, Customers' individualisation demand,* and *Market uncertainties,* on the other hand, are categorised as **Market uncertainty and pressure.** *Information sharing and Trust with supply chain partners, Trading partners' readiness, and Trading partners' power* fall under the umbrella term of **Collaboration with supply chain partners***.* Additionally, Decentralised organisational structure, and Inter-department coordination are a part of **Digital/ innovative culture**. Finally, *Third-party support and Government regulations and support* fall under the category of **Environment Support.**

Therefore, following the categorisation of factors into themes and subthemes as described above, this thematic analysis presents the following findings: **Perceived technological risks, Perceived technological benefits, Organisational resources, Top management knowledge and support, Market support, Market pressure, and Interorganisational relationships with supply chain partners.** It is worth noting that this research focuses on exploring various types of organisational culture. Therefore, while the thematic results do not cover the **Digital/Innovative culture** theme, it will be discussed in a separate section that follows.

As discussed in the theoretical review chapter, the Technology – Organisation – Environment (TOE) framework integrated with the Interorganisational relationship (IOR) theory are identified as providing a structured and comprehensive approach to understanding the factors that influence the implementation of SC 4.0. By utilising these frameworks, the researchers can enhance the clarity and coherence of their findings. Therefore, in this research, these frameworks are employed to present the thematic findings which classify the above themes into three broad dimensions: Technology, Organisation, and an extended Environment by incorporating Inter-organisational relationships. The *Technological factor* comprises of Perceived technological risks and Perceived technological benefits. Meanwhile, *Organisational factor* consists of Organisational resources and Top management knowledge and support. On the other hand, *Environmental factor* encompasses Market support, and Market pressure, and Inter-organisational relationships.

By classifying the factors into relevant themes and subthemes, the data can be simplified and interpreted more easily, providing valuable insights into the determinants of SC 4.0 adoption. SLR findings, categorised according to Technology – Organisation – Environment framework, are summarised in the Table 4-1 below. This table presents a comprehensive overview of SC4.0 adoption factors, their corresponding dimensions, and related indicators.

Table 4-1: Summary of SC4.0 adoption factors, dimensions and indicators

Factors	Dimension	Indicators
Technological factor	Perceived benefits	
	Perceived risks	SC data privacy and security risk
		Absence of industrial interconnection standards
		Perceived costs and unclear return on investment (ROI) risk
		Technological complexity risk
		Technological compatibility issue
Organisational factor	Organisational resources	Human resource's competence and willingness for change
		Infrastructure and internet-based networks
		Financial competence
	Top management knowledge and support	
Environmental factor	Market pressure (Customers and competitors' pressure)	
	Market support	Governmental regulations and support
		Third-party support
	Interorganisational relationships	Trading partner's power
		Trading partner's readiness
		Trust-based information sharing with supply chain partners

These findings have the potential to inform and guide organisations in the planning and execution of SC 4.0 initiatives, as they highlight critical areas that need to be addressed for its successful implementation. Further elaboration on these themes and subthemes is provided below.

4.1.1. Technological factor

Technology factor refers to the characteristics related to the technology that can negatively or positively influence on the decision-making process regarding its adoption (Lai, Sun and Ren, 2017; Maduku, Mpinganjira and Duh, 2016; Tornatzky, Fleischer and Chakrabarti, 1990). This dimension consists of two critical aspects which are perceived benefits and perceived risks associated with digital technology adoption. This factor consists of two critical dimensions which are perceived benefits and perceived risks associated with digital technology adoption.

4.1.1.1. Perceived benefits

The literature suggests that various authors have identified *perceived benefits* which refers to users' perceptions of the benefits of new technology, as a key factor in technology adoption (Yacob and Peter, 2022). Industry 4.0 technologies have the potential to offer numerous benefits to SCM, including increased resource efficiency by minimising waste; greater flexibility and customisation; improved information sharing within the firm and among trading partners, leading to better supply chain visibility and stronger partnerships; inventory and labour cost savings; more precise prediction and management of supply chain risks; and faster response rates to environmental changes (Lai, Sun and Ren, 2018; Tu, 2018; Lin, 2014; Wang, Wang and Yang, 2010). These advantages ultimately translate into better product and service delivery and a competitive edge.

In general, perceived benefit of Industry 4.0 into their supply chains is considered as technology driver as firms only implement new technologies if decision makers perceive clear organisational benefits that outweigh potential negative effects. Nonetheless, numerous studies have found an absence of awareness on potential benefits of Industry 4.0, as many organisations remain uncertain about the technicalities, functions, and economic advantages of investing in the innovation (Ali and Aboelmaged, 2022; Vern, Miftah and Panghal, 2022; Haddud et al., 2017). Hofmann and Rüsch (2017) found a significant proportion of the respondents (80%) reported a lack of awareness regarding the practical advantages of digital technologies in SC 4.0, which has made them hesitant to participate in related initiatives. Many of them also expressed concerns about the unclear cost-benefit ratio of these technologies and the risks involved in substantial digital supply chain transformation investments. This highlights the need to have a comprehensive understanding of the benefits associated with digital technology adoption in SCM.

4.1.1.2. Perceived risks

On the other hand, *perceived risks* associated with the adoption of a technology refers to the potential problems and uncertainties that a firm may face while integrating the technology into their operations (Hsu, Ray and Li-Hsieh, 2014). As previously mentioned, perceived risks of technology can be measured by various dimensions, including (1) Data privacy and security, (2) Interconnection standards, (3) Perceived technological costs associated with ambiguity regarding the expected return on investment, (4) Technological complexity, and (5) Technological compatibility. Each of these factors is discussed in more detail below.

(1) Supply chain data privacy and security risk

Data security concerns are related to various security threats, including identity fabrication, industrial espionage, data theft, unauthorised access to intellectual property, sabotage of critical infrastructure, and denial of service, which are further intensified by the proliferation of embedded and connected devices and underlying network heterogeneity (Carcary et al., 2018; McKinsey & Company, 2015). Meanwhile, *data privacy concerns* pose challenges related to data ownership, such as the challenges of uncontrolled data generation and diffusion, inadequate authentication, anonymity preservation, and risks pertaining to sensitive data which are driven by the widespread use of Internet of Things (IoT) devices (Carcary et al., 2018). One crucial issue in this regard is unauthorised surveillance, which allows for large-scale data collection without individuals' consent, leading to tracking and inference of individual behaviours (Carcary *et al.*, 2018). Data privacy is a crucial aspect of proper data handling, including data collection, usage, and compliance maintenance. It governs how data is collected, shared, and used and is a branch of data security, which encompasses policies, methods, and means to protect data confidentiality, integrity, and availability from unauthorised internal and external users. In other words, data security is essential for ensuring data privacy; without data security, data privacy cannot be guaranteed.

Within the context of SCM, one of the key features of Industry 4.0 is its ability to connect different organisations within the supply chain to enhance its efficiency. However, Wang et al. (2016B) have pointed out that supply chain systems are inherently vulnerable to security breaches. Cybercriminals can exploit these vulnerabilities through tactics such as phishing attacks and stolen privileged credentials, leading to the exposure of sensitive data related to customers, suppliers, commercial strategies, and trade secrets. These vulnerabilities arise from a wide range of factors such as insecure web interfaces, software and firmware vulnerabilities, privacy concerns, and inadequate encryption and authentication/authorisation protocols (Carcary et al.,2018). The most significant vulnerability is often found at the top of the supply chain and can spread throughout the organisational processes through dependent actors. Organisations that aim to successfully integrate Industry 4.0 into their operations while safeguarding the confidentiality, integrity, and availability of their data must address these data privacy and security concerns. For this reason, cybersecurity has become a crucial element of organisational culture and a central component of corporate strategy (Ghobakhloo, 2020A; McKinsey & Company, 2015), particularly in the face of the growing threat of cyberattacks.

(2) Absence of industrial interconnection standards

The rise of Industry 4.0 technologies for cross-organisational and even cross-national communication has created an indispensable requirement that these new technologies must adhere to widely accepted data standards and data sharing protocols in supply chain operations to avoid data variation (Kamble et al., 2019; Nagy et al., 2018). Moreover, the transformation towards SC 4.0 needs to be approached systematically and necessitates a high level of collaboration among stakeholders (Weerabahu et al., 2022). Misalignment of stakeholder efforts to drive this transformation can cause coordination failures, which can be addressed through public policy interventions. Mechanisms such as data standards for connectivity and information sharing endorsed by all stakeholders, both public and private, can be implemented to align stakeholders (World Economic Forum, 2019).

Standardising data enables a shift from isolated data to an integrated structural format (Omar, Minoufekr and Plapper, 2019). Achieving a seamless integration of technology and business processes in supply chain operations requires firms to overcome barriers between objects, services, actors, machines, manufacturers, and users, as well as the physical and virtual worlds (KPMG, 2016A). Additionally, given the complexity and sheer volume of unstructured dynamic data that require effective data cleansing methods, as well as concerns around data safety and intellectual property protection, it is critical to establish common interconnection standards (Ding, 2018). It is believed that these standards can ensure the shared understanding of terminology, information sharing, data interpretation, and communication quality and protection between devices and their digital counterparts in the virtual cloud (Omar, Minoufekr and Plapper, 2019; Kamble et al., 2019; Zhong et al., 2016). As such, the interoperability, information transparency, efficient integration between vendors, data security, and product tracking can be achieved (Kamble et al., 2019; Zelbst et al., 2019).

(3) Perceived costs and unclear return on investment (ROI) risk

The costs associated with the implementation of technology in firms, referred to as *perceived costs*, can inhibit the adoption of Industry 4.0. Previous studies claimed that smooth adoption of digital technologies in supply chain requires substantial implementation and running cost, such as costs of operating, setup, training, hardware, software, and system integration (Lian, Yen, Wang, 2014; Lin, 2014; and Lumsden, Gutierrez, 2013). Due to the extensive and varied nature of these costs, firms perceive the expenses of technology adoption to be enormous. According to Agrawal, Narain, and Ullah (2019), this perception is compounded by the challenge of capturing the return on investment (ROI) of transformation, which can be unknown and uncertain, posing high risks for organisations.

Therefore, the ROI of Industry 4.0 applications may take longer to materialise than anticipated, leading to increased payback periods and adoption costs (Kamble et al., 2019; Luthra et al., 2018). Firms that perceive these costs to be excessively high or are unable to invest due to unclear ROI may hesitate to adopt Industry 4.0 in their supply chains. Thus, the cost aspect remains a significant deterrent to technology adoption (Puklavec, Oliveira and Popovič, 2018). However, if firms perceive that the benefits of implementing Industry 4.0 technologies outweigh the costs, they are more likely to adopt these innovations in their supply chains.

(4) Technological complexity risk

Technological complexity refers to the level of difficulty associated with understanding and using new technology within an organisation (Lai et al., 2018). Research has shown that organisations may be less inclined to adopt new technologies if they perceive them as complex or challenging (Lumsden and Gutierrez, 2013). This is primarily because companies may believe that the integration of new technology could cause disruptions to their current business systems and processes (Lumsden and Gutierrez, 2013). For instance, in the case of cloud computing adoption, complexity can be measured by factors such as task duration, integration with existing information systems, specialised cloud infrastructure construction, data transfer efficiency, and system functionality (Wang et al., 2019A). The complexity associated with implementing Industry 4.0 in the supply chain is further compounded by the absence of common standards and protocols for data collection and sharing in the Internet of Things (IoT) (Machadoa et al., 2019; Türkeș et al., 2019; Ajmera and Jain, 2019). In fact, the absence of data standardisation and protocols for information sharing among supply chain partners (Kamble et al., 2019; Luthra and Mangla, 2018; Oliveira, Thomas and Espadanal, 2014) leads to implementation complexities, such as fragmented solutions and interoperability challenges among non-standard protocols and devices (Carcary et al., 2018; Haddud et al., 2017). These issues make it challenging for organisations to adopt new technological innovations.

(5) Technological compatibility issue

Technological compatibility refers to the degree to which an innovation is perceived as consistent with the existing values, past experiences and the needs of potential adopters (Bhardwaj, Garg and Gajpal, 2021; Doolin and Ali, 2008). While system compatibility has improved over the years, the ability of new technologies to seamlessly integrate with existing systems remains a crucial attribute in the technical dimension (Arnold and Voigt, 2019; Senyo, Effah and Addae, 2016). A study of Lumsden and Gutierrez (2013) revealed that firms are more likely to adopt new technologies that are compatible with their existing work application systems and the organisational values. Similarly, Kamble et al. (2019) suggest that compatibility with current industrial automation, including software, hardware, and other machinery, is crucial for smooth integration between systems. Hence, it is argued that firms are more likely to implement new technologies into the supply chain if they can fit into existing processes.

4.1.2. Organisational factor

Organisational factor refers to the conditions that reflect a firm's readiness to provide support or act as a barrier, as perceived by managers (Yeh and Chen, 2018). These conditions are used to assess whether a company has the necessary technical, human and financial resources to make investments in new technologies (Sealy, 2012). As previously mentioned, organisational factor highlights the significance of organisational resources and top management's knowledge and support which are further elaborated below.

4.1.2.1. Organisational resources

Organisational resources refer to both tangible (physical assets) and intangible (human resources, skills, and experience) resources that a firm possesses to implement innovations (Lai, Sun and Ren, 2017). Prior literature has empirically supported a positive relationship between organisational resources and technology adoption (Maduku, Mpinganjira and Duh, 2016; Hsu, Ray and Li-Hsieh, 2014). According to Lai, Sun and Ren (2017), well-developed organisational resources serve as a crucial foundation for successful digital transformation. As discussed above, organisational resources encompass (1) human resource's IT competence and willingness for change, (2) financial resource and (3) IT infrastructures which are discussed further below.

(1) Human resource's competence and willingness for change

Human resources' competence refers to necessary technological and management skills, knowledge, expertise, and experience required for firms to embrace the digital transformation, as well as training and education provided to enhance these skills and knowledge. The emergence of Industry 4.0 is expected to witness a significant transformation in the nature of supply chains, including changes to the profiles of human resources in the industry (Osmundsen, 2020; Varshney, 2020; Vial, 2019). The past has taught us that automation technologies will not completely replace the need for manpower but creates new roles, functions, and challenges. As a result, it is essential for companies to prioritise the development of their workforce to ensure they have the necessary skills and knowledge to adapt to the evolving landscape of Industry 4.0. As stated by Lamba and Singh (2018), Kiel et al. (2017) and Richey et al. (2016), successful implementation of Industry 4.0 technologies demands a profound knowledge incorporated with strong computational and analytical skills to comprehend and process a massive amount of data generated in operation and SCM in order to make business-driven decisions, as well as to plan, monitor and supervise the manufacturing process. Similarly, a report by KPMG (2016A) also further emphasised the importance of professional staff in industrial enterprises who possess extensive knowledge in IT and a deep understanding of supply chain. Hence, highly trained and qualified professionals such as data scientists and consultants with data-related skills are the key to the success of the adoption of Industry 4.0 (Bienhaus and Haddud, 2018; Schoenherr and Speier-Pero, 2015). In addition to the technical skills, Omar, Minoufekr and Plapper (2019) and Frederico et al. (2019) also have highlighted the importance of managerial skills in supporting technological transformation and ensuring its successful implementation within an organisation.

It is obvious that the profound impact of digital technologies on supply chain advancement is undeniable, but their benefits cannot be realised without addressing human resource factors (Agrawal, Narain and Ullah, 2019). The advent of digitalisation has given rise to new job opportunities, such as IT experts, designers, engineers, and logistics experts. However, it has been observed that there exists a significant deficit of digital skills among the workforce which is a major hindrance that can retard or delay the progress towards Industry 4.0 across entire supply chain (Luthra et al., 2020). The scarcity of specialists from the STEM subjects, including science, technology, mathematics, and engineering poses a huge challenge to many industrial companies (KPMG, 2016A). Likewise, a study conducted by Schoenherr and Speier-Pero (2015) indicated that one of the potential barriers to using predictive analytics in SCM is inexperienced workers who lack the ability to effectively utilise suitable data to improve organisational performance.

The shift towards a digital smart supply chain polarises the labour market by increasing the demand for highly qualified workers, while reducing the need for those with lower educational levels (Sony and Naik, 2020). In the DSC, technology and people are interdependent; therefore, and a successful implementation process should prioritise building a harmonious relationship between humans and technology (Büyüközkan and Göçer, 2018). Hence, educational and training systems must ensure the employees are able to work with highly complicated technologies. This is especially crucial in the context of increasing cybersecurity risks. A report by KPMG (2016A) revealed that the most important protective measure against the vulnerabilities of intelligent production systems to hacking attacks, system errors, and other risks is to provide further training and education to IT personnel and the workforce to prevent misuse and unauthorised access. The use of novel technological means can be counterproductive if workers are not fully prepared to operate and take control of them. Employees without adapting their skills will have a tough time to remain in employment; therefore, firms are prioritising their tremendous investment into the training and continuous education of workers to upgrade their skill sets to meet Industry 4.0 requirements and develop competence for specialised jobs (Luthra et al., 2020; Luthra and Mangla, 2018).

(2) Infrastructure and internet-based networks

Data plays a crucial role in SC 4.0, and as such, a high level of proficiency is required for its acquisition, transmission, visualisation, and storage. Firms that aspire to adopt SC 4.0 effectively will need to undergo a significant overhaul of their IT infrastructure, necessitating the replacement or redesign of existing systems and contextualised data delivery methods for the exploitation of data (Moeuf et al., 2020; Gürdür, El-khoury and Törngren, 2019). The technological infrastructure, as described by Senyo, Effah, and Addae (2016), comprises hardware, software, network resources, and necessary services to support the operation and management of technologies in an organisation. Whereas, IT infrastructure, as defined by Raj et al. (2020), Lumsden and Gutierrez (2013), and Low, Chen, and Wu (2011), encompasses a wide range of broadband infrastructure, information technology-based facilities, and installed enterprise systems and network technologies. These infrastructure and facilities not only help to capture but also store a large amount of data from diverse sources. However, to capture only meaningful data, IT infrastructure and facilities such as smart filters must be robust and intuitive in capturing relevant information while ignoring those with inaccuracies (Lamba and Singh, 2018). In addition, storing massive amounts of data necessitates data warehouses or cloud-based storage solutions. Therefore, establishing adequate mechanisms and facilities for capturing, storing, and retrieving meaningful data plays a pivotal role in the implementation of SC 4.0.

(3) Financial competence

As reported by various industrial studies, manufacturers are investing significantly in digitalising their operations (Kamble, Gunasekaran and Sharma, 2018). As stated by Lai, Sun, and Ren (2018) and Deloitte (2018), organisational investment in technological innovation adoption depends significantly on *financial competence* or *financial readiness* which refers to the availability of financial resources to pay for digitalisation expenses. These expenses can range from the costs of dismantling previous physical infrastructure to building high-end technical infrastructure, implementing new digital hardware systems and software applications, employee training on new systems, integration and maintenance, cybersecurity measures, licensing, and consultation from external experts (Ghobakhloo, 2020A; Lamba and Singh, 2018). Lai, Sun and Ren (2018) claimed that the importance of financial support cannot be underestimated, given by the fact that without sufficient financial resources, neither IT equipment nor IT professionals can be affordable.

4.1.2.2. Top management knowledge and support

Top management knowledge and support can be defined as the degree to which top managers comprehend the importance of digital transformation and actively participate in the process of digital transformation. It is crucial that decision makers or frontline executors must possess visionary and innovative qualities, as well as a deep understanding and knowledge of the potentials and strategic implications of SC 4.0 to effectively navigate the changing landscape of SCM. Literature has also underlined the crucial role of top management commitment in the successful application of Industry 4.0 in both organisational and SCM context (Ghobakhloo, 2020B; Lamba and Singh, 2018; Mittal et al., 2018; Chan and Chong, 2013; Al-Hashedi et al., 2011). According to a study by Lamba and Singh (2018), this commitment creates a shared vision that becomes deeply embedded in the organisational culture and ethics, which in turn, serves as the primary driving force behind the strategic and operational plans of 4.0 initiatives and their successful execution.

Top management plays a crucial role in supporting digitalisation in various areas. Firstly, top management can create a supportive environment (Lumsden and Gutierrez 2013) by promoting a culture of experimentation, risk-taking, and collaboration, and initiating these cultural changes from the top-down. By serving as role models, top management can lead by example and establish a clear vision for adopting digital SCM, formulate strategies, and define approaches for change management and management control to govern and coordinate the overall process of transformation (Veile et al., 2020; Schneider, 2018; Chan and Chong, 2013; Lumsden and Gutierrez 2013). Secondly, top management's commitment plays a vital role in building firm capabilities through the acquisition and orchestration of resources, ultimately leading to a competitive advantage for the organisation (Gunasekaran et al, 2017; Lin, 2014; Lumsden and Gutierrez 2013).

In addition, during the transition to Industry 4.0, top management can strengthen employees' sense of ownership in daily tasks and foster acceptance of the transformation by providing clear role and rule clarity, and promoting interpersonal trust and connectedness among employees (Ghobakhloo, 2020B; Al-Isma'ili et al., 2016; Lin, 2014; Lumsden and Gutierrez 2013). Lastly, top management's involvement helps to coordinate and operationalise interdisciplinary communication between departments and stakeholders, enabling effective integration of digital SCM (Kiel et al., 2017). For that reason, the commitment of managers at all levels is indispensable for the successful supply chain transformation of an organisation. This entails providing necessary resources, embracing knowledge-based learning paradigms with enthusiasm, and contributing to the development of collaborative virtual networks among supply chain partners (Ghobakhloo, 2020B; Arunachalam, Kumar and Kawalek, 2018; Puklavec, Oliveira and Popovič, 2018; Lin, 2014).

4.1.3. Environmental factor

Environmental factor pertains to the external environment in which the organisation conducts its business activities (Maduku, Mpinganjira and Duh, 2016). In the context of technology adoption, environmental factor can either facilitate or inhibit a firm's adoption behaviours when facing the dilemma whether to embrace new technologies or not (Lai, Sun and Ren, 2017). The environmental factor includes three critical dimensions which are market pressure from customers, competitors and uncertain events; market support from government and external organisations; and the interorganisational collaboration.

4.1.3.1. Market pressure

Market pressure is the combination of competitive and customer pressures, along with market uncertainties. *Competitive pressure* can be defined as the degree of perceived pressure felt by firms from their industry competitors, which triggers the need to implement new technology to maintain competitiveness and gain an advantage (Lammers, Tomidei and Trianni, 2019; Tu, 2018; Hsu, Ray and Li-Hsieh, 2014; Zailani, Fernando and Zakaria, 2010). This is because adopting new technologies in the supply chain can bring a multitude of benefits for firms such as better inventory visibility, improved operational efficiency, enhanced coordination effectiveness, and more accurate and real-time data collection, all of which contribute to better supply chain and market performance compared to their competitors (Lin, 2014). As a result, many organisations have outsourced their IT infrastructure and human resources to keep up with competitors and gain a competitive advantage, enabling them to alter the rules of competition and outperform rivals (Arnold and Voigt, 2019).

According to recent studies by Kraus et al, (2021), Agrawal, Narain and Ullah (2019), KPMG (2016A), in addition to competitive pressure, the transformation towards digitalisation is driven primarily by growing *customer pressure*, which refers to the pressure exerted by customers on firms to quickly meet their individualised and dynamic requirements for products and services. The shift from a seller's market into a buyer's market has become apparent, indicating the power of buyers in defining the conditions of trade (Strandhagen et al., 2017; Lasi et al., 2014). This trend leads to an increasing individualisation requirement for products and, in extreme cases, to individual products, known as "batch size one" (Lasi et al., 2014). A report by Accenture (2017) also confirms this trend, stating that customers today seek unique buying experiences with personalised product options, including omni-channel customer service and delivery, and the ability to purchase, collect, and return products anywhere. The report also believed that the continuous need of customers towards new, unique and customised products is driving faster product development, giving most products a short life span and therefore requires firms to digitalise their supply chain to address this challenge. This belief is supported by Zailani, Fernando and Zakaria (2010) who also agreed that pressures or requirements imposed by customers, who are purchasing firms or individuals, act as an enabler for technology adoption by firms.

Additionally, firms' digital technology adoption and digital transformation is driven by the unpredictable changes they encounter in the market, which is also referred to as *market volatility*. The uncertainties and volatility can be attributed to the intense competition, more stringent regulatory requirements, constantly changing geopolitical factors, volatile price fluctuations, unpredictable competitor actions, rapid shifts in production processes, volatile levels of demand, or unreliability of inbound supplies, and other unforeseeable and uncontrollable events (Arnold and Voigt, 2019; Arnold, Veile and Voigt, 2018; Accenture, 2017). For example, according to Kutnjak (2021) and Deloitte (2020), Covid-19, as regarded as a black swan event, caused significant disruption to global firms and exposed the vulnerabilities of traditional supply chain models, forcing many firms and the entire industries to rethink and transform their global supply chain models to digital ones. The unpredictability of such scenarios demands a planned execution of new technologies such as 5G, since communication will be critical to implement economic stimulus.

In accordance with the prevailing view, Patterson, Grimm and Corsi (2003) claimed that uncertainties exist because firms do not obtain perfect information to make decisions; therefore, more frequent exchange of information between business partners is required to meet delivery expectations when changes occur. To enable a fast and reliable share of demand data, sales projections, and production with business partners, firms need to adopt advanced, value chain-spanning information technologies. Consequently, firms improve information and data exchange to respond more quickly and accurately to market uncertainties. Contrary to that, research by Wei, Lowry and Seedorf (2015) revealed a significant negative relationship between a market uncertainty and the adoption of RFID technology in Chinese companies, which could be explained by the fact that Chinese companies are more risk-averse than Western companies and therefore try to avoid high investments. However, most research demonstrated a positive relationship between high levels of market volatility and a need for advanced information technology implementation and faster adoption rates.

4.1.3.2. Market support

Market support refers to the support that firms receive from various sources, including the government and external organisations such as research institutes, banks and universities, in their pursuit of digital transformation (Rahayu and Day, 2015). This support can come in various forms, such as favourable policies, legal guidelines, financial incentives, and access to Industry networks and funding programs. In the following section, the importance of market support and its impact on the successful implementation of digital transformation is explained further.

(1) Governmental regulations and support

Research has shown that government policies and regulations are crucial for the development of SC 4.0, and have the highest influence on the other drivers of this transformation (Luthra et al., 2020; Lammers, Tomidei and Trianni, 2019). The laws and policies put in place by regulatory authorities can encourage more businesses to participate in the transition to the factory of the future and overcome the challenges associated with Industry 4.0 in the early stages (Luthra et al., 2020; Lai, Sun and Ren, 2018). Additionally, governmental regulations can provide guidance for saving resources and developing a digital culture in manufacturing industries. However, businesses may hesitate to adopt new technologies if they lack confidence in the government's ability to protect their data privacy and security. Therefore, Lai, Sun and Ren (2018) believed that the diffusion and adoption of information technology is dependent on government support. In addition, firms are more willing to adopt new technologies if governments provide regulatory support to ensure compliance with standards and protocols, as noted by Oliveira, Thomas and Espadanal (2014).

Government policies and incentives are crucial in fostering a supportive environment and encouraging firms to develop the necessary competences for the adoption and diffusion of SC 4.0 technologies. Studies have shown that the government support and incentives can take various forms, including subsidies, tax rebates, funding for research and development, investment in national infrastructure such as broadband networks, technical support, training, and the creation of an “Industry 4.0” industry and research cluster (Ajmera and Jain, 2019; Lai, Sun and Ren, 2018; PWC, 2014; Zailani, Fernando and Zakaria, 2010). Meanwhile, governmental policies and regulations deal with the business issues related to Industry 4.0, such as labour regulations and work safety, technological standards, intellectual property, liability for artificial intelligence, data security and privacy, competitive data protection law, and compliance process (Veile et al., 2020; Anggrahini et al., 2018; Schumacher, Erol and Sihn, 2016; PWC, 2016B; PWC, 2014).

However, studies by Agrawal, Narain and Ullah (2019), Luthra and Mangla (2018) and Lai, Sun and Ren (2018) even discovered the restrictive government incentives and policies as the most significant hindrance IT adoption as they directly or indirectly impact every other barriers. Due to the uncertain legal environment, policy analysts and regulatory bodies have not developed a roadmap for transforming the traditional supply chains into a smarter ones (PWC, 2014). The absence of guidelines for firms also obstructs the adoption of SC 4.0 since firms lack a clear vision of which areas to prioritise transformation, whether it is international operations, customer relationships, or business models (Agrawal, Narain and Ullah, 2019).

Therefore, it is crucial for governments to conduct comprehensive case studies and research across various industrial sectors to provide a clear roadmap and guidelines for the successful implementation of SC 4.0.

(2) Third-party support

The successful implementation of SC 4.0 is heavily dependent on the firm's direct environment. As believed by Oesterreich and Teuteberg (2016), firms that benefit from their innovation ecosystems that include industry networks, funding programs, research institutes or universities have a far greater chance of successfully mastering the digital transformation. Indeed, intensive cooperation between companies and leading innovators in technologies such as Google, IBM, Cisco, GE, Siemens, start-ups, scientific institutes, regional networks, and business associations can facilitate the exchange of best practices, foster the collaborative projects, and provide legal aid and technological solutions (Tripathi and Gupta, 2020; PWC, 2016B; Kannabiran and Dharmalingam, 2012). Additionally, a close partnership with universities and schools can help ensure the future employees acquire relevant skills, promote skills development, and provide human resource training and transfer. Such knowledge transfer and awareness creation can help organisations minimise the risks and chances of Industry 4.0 failure in supply chain networks (Tripathi and Gupta, 2020).

However, a survey conducted by Kannabiran and Dharmalingam (2012) pinpointed that firms face an obstacle in their digitalisation efforts due to inadequate collaboration with education and research institutes, as well as a lack of relevant industrial clusters to learn from best practices in the field. This can be problematic as without coordination and alliances with universities and research institutions, organisations may miss out on shared knowledge and updates on ongoing cutting-edge research, thereby limiting their access to valuable information (Mittal et al., 2018). To overcome this challenge, it is crucial for companies to establish strong partnerships with universities, research institutions, and industrial clusters to foster collaboration, knowledge sharing, and access to the latest research and practices. By doing so, companies can stay ahead of the curve and remain competitive in the ever-evolving digital landscape.

4.1.3.3. Interorganisational relationships

A study by PWC (2016A) indicated that collaborative supply chain ecosystems can be carried out in multiple methods, particularly aligning participating companies' joint business objectives and action plans, enforced common processes and data sharing, agreed monitored performance metrics and transparency guarantee throughout the supply chain. The inter-organisational collaboration can be in forms of alliances, strategic partnerships and cooperation in communities (McKinsey & Company, 2015) that involves mutual contact and interaction through the overlapping boards and councils, joint programs and projects or written agreements between trading partners. As discussed above, an effective collaboration among supply chain partners in DSC adoption is highly influenced by various factors, including (1) the trading partners' power, (2) supply chain partners' digital readiness and (3) information sharing. These factors will be explored in greater detail below.

(1) Trading partners' power

Chan and Chong (2013) suggested that trading partners have the power to influence the adoption of technology in two ways: through *convincing power*, where partners provide rewards, benefits, and support towards technology implementation, or through *compulsory power*, where partners exert pressure to adopt technology with the threat of abandoning the partner in case of rejection.

In fact, past research empirically supports the notion that innovation adoption is facilitated by the firms' perceived availability of trading partners' support and incentives (Oettmeier and Hofmann, 2017; Gangwar, Date and Ramaswamy, 2015; Gutierrez, Boukrami and Lumsden, 2015). This phenomenon can be explained by the fact that innovation diffusion is an uncertainty minimisation process where individuals and organisations collect information and data throughout the innovation decision process to diminish the technological uncertainty or risks. During this process, partner support in minimising risks and uncertainties about Industry 4.0 in supply chain can be achieved through information sharing, best implementation practices, cost-benefit analyses, employee training support, and support in implementation and operation processes (Oettmeier and Hofmann, 2017). Thus, partners support can positively affect the diffusion process of a particular innovation, as firms can develop innovation-related capabilities by tapping into the experiential learning of their partners, which can help reduce perceived risks towards the technology (Mittal et al., 2018). Additionally, according to Low, Chen and Wu (2011), digital technology adoption of firms are dependent on by the convincing power of their supply chain partners, such as financial incentives. In essence, partners' support and incentives play a crucial role in encouraging firms' adoption of SC 4.0.

On the other hand, empirical studies have consistently shown that trading partners can place pressure on firms to adopt new technologies (Alam et al., 2021; Lammers, Tomidei and Trianni, 2019). This refers to the pressure exerted by both upstream and downstream partners. Given that most firms rely on inputs and collaboration from partners to satisfy their customers, it is not surprising that powerful partners who generate a large proportion of a firm's profits or provide scarce resources can greatly influence the firm's decision to adopt an innovation (Senyo, Effah and Addae, 2016). In such cases, the firm is under significant pressure to adopt the innovation in order to demonstrate its fitness as a business partner and to align with its partners to track physical goods across the supply chain. For instance, a study conducted by Wang, Wang and Yang (2010) found that trading partner pressure was a significant driver for the adoption of RFID technology in the manufacturing Industry. This suggests that firms are more likely to adopt RFID technology when there is increased pressure from powerful trading partners to do so. In recent times, major companies such as Wal-Mart, Metro, and Tesco have been known to exert strong pressure on their suppliers to adopt RFID technology.

(2) Trading partners' readiness

Partners' readiness is defined as the degree of willingness and ability of trading partners to embrace and utilise digital technologies (Kosmol, Reimann and Kaufmann, 2019). Previous studies have shown that firms expect their partners to have similar or comparable levels of innovation readiness when adopting technological advancements to leverage the innovation and achieve digital complementarity at an interorganisational level (Kamble et al., 2021; Kosmol, Reimann and Kaufmann, 2019; Sun et al., 2018; Awa and Ojiabo, 2016). Nonetheless, several studies have identified an absence of digital readiness among partners as a major obstacle to successful digital transformation for firms, considering that organisations have varying levels of financial, human, and IT resources organisations. For example, in a developing countries, some supply chain partners may not be ready to invest in high-cost advanced technologies such as Blockchain (Khan et al., 2023). As such, trading partners with lower levels of digital readiness may hinder a firm's ability to adopt digital technologies effectively. In fact, small businesses may not have sufficient resources to fully digitalize their supply chain activities, thereby hampering technological adoption by other firms (Awa, Nwibere and Inyang, 2010). Therefore, Kosmol, Reimann and Kaufmann (2019) noted that high levels of digitalisation among partners allow firms to use digital practices across boundaries, while low levels can hinder efforts to implement interorganisational digital solutions. It is crucial for firms to take into account the readiness of their trading partners prior to implementing digital technologies, as this could have a significant impact on the overall success of their digital transformation efforts. Additionally, since the adoption of digital technologies in SCM largely depends on collaboration with existing supply chain partners (Weerabahu et al., 2022; Werner et al., 2021; Srai and Lorentz, 2019; Queiroz and Wamba, 2019), firms seeking to implement digital technologies are significantly influenced by, if not reliant on, their trading partners' readiness to adopt such technologies (Malik et al., 2021; Bruque-Cámara, Moyano-Fuentes and Maqueira-Marín, 2016). For example, a study by Kamble et al. (2021) found that the blockchain adoption is highly subjected to the externally uncontrollable factors, such as the readiness of the supply chain partners to adopt technologies.

(3) Trust-based information sharing with supply chain partners

According to Lai, Sun and Ren (2018), sharing information is considered as a critical aspect of successful supply chain collaboration. Supply chain collaboration requires the exchange of actual or planned information and events with industry partners to coordinate the production activities. This exchange of information encompasses various operational issues, such as market demand forecasts, production and delivery schedules, order status, logistics, and inventory status (Singh, Kumar and Chand, 2019; Golini, Mazzoleni and Kalchschmidt, 2018).

Singh, Kumar and Chand (2019) argued that in the era of Industry 4.0, the smooth flow of information in the supply chain is critical for the survival of any organisation. However, the exposure of firm’s internal information to business partners is considered as unwise; therefore, many organisations are hesitant to share valuable and critical information with their supply chain partners (Saberi et al., 2019). The reluctance to disclose information from partners can limit the full benefits of adopting technologies, which may subsequently impede the successful implementation of SC 4.0. Additionally, there are also various privacy and security policies related to supply chain data and information usage that can hinder effective communication and data sharing between partners (Oncioiu et al., 2019). This can result in issues such as information transparency, security breaches, and data integrity problems, which can impede the flow of information across the supply chain. Consequently, building trust between supply chain partners is critical for successful information sharing. In the context of implementing a DSC, organisations must commit to sharing critical information, making it critical to build long-term relationships based on trust and the assurance that partners will not act opportunistically or violate relationship norms (Chan and Chong, 2013). Thus, by fostering trustful collaborative relationships, supply chain actors can enable the transfer of knowledge, access to proprietary technologies, and access to distinctive complementary capabilities, ultimately leading to unparalleled process and product innovation (Patnayakuni, Patnayakuni and Rai, 2002). It is proven by the research of Francisco and Swanson (2018) that identified the significance of trust in enhancing the willingness to share information within the supply chain network. Therefore, in the era of Industry 4.0, it is imperative for firms to recognise that effective information sharing is a critical success factor in supply chain collaboration and that building collaborative relationships based on trust and mutual benefit is essential for realising the full potential of SC 4.0 technologies.

In conclusion, a SLR of 153 studies have resulted in the development of 8 main themes, including: (1) Perceived benefits, (2) Perceived risks, (3) Organisational resources, (4) Top management knowledge and support, (5) Market pressure (Customers and competitors' pressure), (6) Market support, (7) Interorganisational relationships, and (8) Digital/innovative culture. Drawing from the reviewed literature, it is evident that among these factors, organisational culture stands out as a critical factor that can greatly influence the effectiveness and success of digital technology implementation within a firm (Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz, 2020; Kagumba and Wausi, 2018). It can either facilitate or hinder such technology adoption process. Especially, according to Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz (2020), the impact of organisational culture on technology and innovation implementation is even greater in developing countries. Thus, successful digital transformation requires firms to develop digital culture capable of facilitating this disruptive change – an organisational culture that is suitable for digitally transforming organisations (Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz, 2020). This highlights the importance of understanding the impact of organisational culture on the adoption of DSC and its implications for organisations seeking to implement DSC. Therefore, this research aims to examine the role of organisational culture in SC 4.0 adoption. The following section explains the significance of cultural values in digital transformation.

4.2. Organisational Culture in Technology Adoption

Introducing digital technologies alone is insufficient without addressing corporate culture, which plays a critical role in determining an organisation's ability to adapt to changing circumstances (Schuh et al., 2017). Therefore, organisational culture is seen as one of the key determinants for successful technology adoption in various studies (Panuwatwanich and Nguyen, 2017). It denotes a set of values, beliefs and assumptions shared by organisational members and reinforced by the organisational goals and practices (Hales, 1998) that help individuals to understand organisational functioning and provide them with the norms for organisational behaviours (Deshpande and Webster Jr, 1989). It was suggested that organisational culture has a significant impact on the effectiveness and efficiency of both innovation and supply chain strategies (Hartnell, Ou and Kinicki, 2011) and the perception and reaction of organisational members towards the international and external environments (White, Varadarajan and Dacin, 2003). Therefore, organisational culture has been extensively studied as a crucial factor in firms' successful implementation of strategic technology adoption plans (Shao, 2019; Dubey et al., 2019; Lepore et al., 2018; Naranjo-Valencia, Jiménez-Jiménez and Sanz-Valle, 2011; Liu et al., 2010).

In the case of DSC, the widespread implementation of digital technology has required the transformation in corporate culture to align with digital goals of firms, so that firms can leverage the full potential of digital technologies and minimise the obstacles of digital transformation (Ghadge et al., 2020). It is notable that the features of Industry 4.0 implementation may benefit from different types of organisational culture (Tortorella et al., 2023). For example, Industry 4.0 requires high levels of process standardisation (Yin, Stecke, and Li, 2018) that can be facilitated by organisational cultures that prioritise the establishment of clear behavioural protocols and procedures (Mohelska and Sokolova, 2018). In other words, an organisational culture that emphasises a structured and systematic approach can facilitate the implementation of Industry 4.0 technology. Similarly, as asserted by Mohtaramzadeh, Ramayah and Jun-Hwa (2018), different types of organisational cultures can either weaken or strengthen the influence of antecedent variables on technology adoption, as they are associated with different underlying values, assumptions, and expectations that can directly or indirectly affect technology adoption of firms. Poku and Vlosky (2002) also claimed that the technological adoption is tremendously influenced by the cultural orientation of an organisation, which can either create strong or weak relationships among the determinant factors that lead to technological adoption.

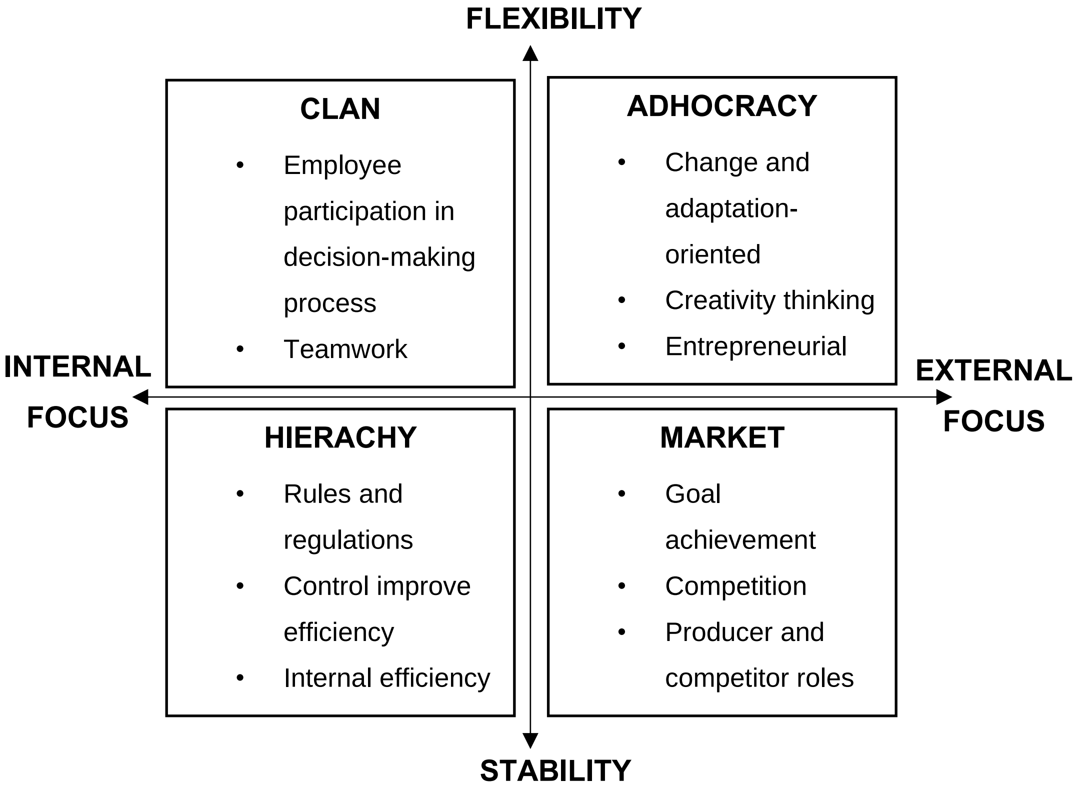
Drawing from the reviewed literature on organisational culture values, it is evident that organisational culture plays a crucial role in the adoption of DSC. Organisational culture can either facilitate or hinder the adoption process. This highlights the importance of understanding the impact of organisational culture on the adoption of DSC and its implications for organisations seeking to implement DSC. Therefore, this research aims to examine the role of organisational culture in SC 4.0 adoption.

It is notable that extant literature has proposed several alternative methods to categorise organisational culture. For example, Wallach (1983) categorised organisational cultures into bureaucratic, innovative and supportive cultures. Denison and Mishra (1995), on the other hand, based on the culture traits, divided organisational cultures into four functional dimensions which are adaptability, consistency, involvement and missions to explore the relationships among the organisational culture, structure, strategy and organisational effectiveness. Alternatively, McAfee, Glassman and Honeycutt Jr (2002) developed the relation-and-transaction-oriented cultures, while the Competing Values Model (CVM) was proposed by Quinn and Rohrbaugh (1983). CVM conceptualises different value orientations that underline the organisational culture and allows the comparison of these value orientations within and between firms (Lewis and Boyer, 2002).

Among organisational culture models, the Competing Values Model (CVM) has been extensively used for assessing organisational culture for several decades (Ferreira and Hill, 2008). The model is extremely useful for organising and understanding a wide range of organisational and individual phenomena. The robustness of the framework has been proven across a variety of phenomena and it explains the core approaches to thinking, behaving and organising that are associated with human activity. The contrasting values captured by CVM also explain the rationale for choosing this model over other organisational culture models such as Hofstede's (1980) or O'Reilly, Chatman and Caldwell (1991). Furthermore, Lamond (2003) and Howard (1998) have validated this model as an accurate representation of organisational culture. Notably, several scholars have also endorsed CVM as an appropriate model for organisational culture research studies in developing countries (Shao, 2019; Chen et al., 2018; Dai, Chan and Yee, 2018; Liu et al., 2010) and SCM contexts (Chu, Wang and Lai, 2019; Braunscheidel, Suresh and Boisnier, 2010). Therefore, according to Panuwatwanich and Nguyen (2017), this approach has been adopted in numerous studies investigating the role of organisational culture in innovation and adoption and has proven to be a reliable tool for classifying and evaluating different types of organisational culture. Thus, the current research adopts CVM model as it has been well-established and extensively used in a number of operations management research (Hardcopf, Liu and Shah, 2021).

CVM identifies two major dimensions that distinguish between different types of organisational culture. The first dimension is *flexibility – control* axis which emphasises the firm's desire for change or stability while the second dimension is *internal – external* axis that describes firms' focus on internal or external activities (McDermott and Stock, 1999). Flexibility orientation focuses on creativity, spontaneity and risk-taking, whereas the control orientation values order, predictability and efficiency (Cameron, 2009). For example, some organisations are viewed as effective if they are adaptable and transformational whereas some organisations are seen as effective if they are predictable, stable and consistent. On the other hand, internal orientation emphasises integration, collaboration and unity, whereas external orientation focuses the competition, differentiation and rivalry (Cameron, 2009). For instance, some organisations believe they are effective if they maintain harmonious internal relationships and processes, whereas others believe they are successful if they compete against others and create a market niche. The combination of these dimensions results in the identification of four distinctive culture types – hierarchical, group, national and developmental. Figure 4-2 provides an illustration of these culture types.

Figure 4-2: Competing values framework (Quinn and Rohrbaugh, 1983).



In the model, the *hierarchical culture* focuses on stability and internal integration, reflecting many layers of management and supervision to achieve control, security and stability. Hence, this type of culture values bureaucracy such as control, coordination, and internal efficiency (Hardcopf, Liu and Shah, 2021; Naor et al., 2014). The *group culture* – the clan culture, on the other hand, emphasises flexibility and internal focus, with a focus on the employee (Cameron and Quinn, 2011). In group culture, shared values, participation, collaboration, teamwork, employee involvement and empowerment, and corporate commitment to workers are the focus of firms. Meanwhile, *developmental culture* – entrepreneurial culture focuses on high flexibility and external environment. Firms adopting this type of culture aim to encourage creativity, individualism, risk-taking to cope with uncertainty and ambiguity (Cameron and Quinn, 2011). Hence, developmental culture is more likely to support new technological development, adoption and implementation. Finally, *rational culture* is primarily based on the concepts of control and external focus with core values of competitiveness, outcome excellence, productivity, and goal fulfilment. This type of culture's core values helps leverage a firm's capabilities in building products flexibly, fast, at lower costs, with high quality which therefore results in high profitability (Pakdil and Leonard, 2015; Naor et al., 2014).

Previous studies have suggested that organisational culture can significantly influence the ability of managers to effectively perceive and interpret information, rationalise, and exercise their discretion during their decision-making processes (Liu et al., 2010; Berthon, Pitt and Ewing, 2001). This is because organisational culture shapes the values, norms and beliefs which eventually guides the behaviours of organisational members. Thus, it is suggested that different types of organisational cultures can have a significant impact on technology adoption (Shao, 2019; Dubey et al., 2019; Lepore et al., 2018). Cameron and Quinn (2011) proposed that organisations can cultivate either a flexibility orientation culture, which emphasises change, empowerment, and creativity, or a control orientation culture, which prioritises stability, efficiency, and formalisation. These distinct cultural types can lead to divergent environments within firms and offer varying levels of guidance and support for employees, affecting their ability to generate and implement new ideas and innovations (Khazanchi et al., 2007). As a result, organisations with flexibility-oriented and control-oriented cultures may respond differently to technological, organisational and environmental factors when adopting DSC practices. In line with previous literature (Cai, Gu and Wu, 2021; Shao, 2019; Lepore et al., 2018; Liu et al., 2010), this study adopts the typology of flexibility and control-oriented culture in the research model.

Several studies have identified that flexibility-oriented cultures (i.e. clan and adhocracy culture) and control-oriented cultures (i.e. hierarchy and market culture) can act as moderating factors in the achievement of technology adoption and organisational outcomes (Mohtaramzadeh, Ramayah and Jun-Hwa, 2018; Liu et al., 2010). For example, Liu et al. (2010) investigated the effects of flexibility and control-oriented organisational culture on the relationship between organisations' perceived pressures and e-SCM adoption intention. Meanwhile, Long et al. (2023) explored the moderating role of these two types of culture on the relationship of Blockchain technology adoption and supply chain trust. It was found that these cultures not only shape managers' responses to environmental changes and strategic decision-making but also enhance employees' skills and knowledge, their willingness to change and perception of risks and benefits associated with technology adoption (Martín-de Castro et al., 2013; Hynes, 2009; Hsu and Fang, 2009; Prajogo and Ahmed, 2006). This can ultimately influence the implementation and assimilation of technology (Liu et al., 2010; Berthon, Pitt and Ewing, 2001).

4.3. Critiques

Regarding existing literature on technology adoption, scholars have studied the adoption from diverse theoretical lenses. Despite the wealth of research in this area, the findings regarding both barriers and enablers of adoption have been inconsistent. Factors that one scholar has found to be significant may not have the same impact in other studies. For example, the perceived benefits of technology, which is a technological factor, have been studied repeatedly, yet its impact has been found to be inconsistent across research studies. While it was found to be a crucial factor in several studies, such as Henao-Ramírez and Lopez-Zapata (2022), Horváth and Szabó (2019), Lai, Sun and Ren (2017), Gangwar, Date and Ramaswamy (2015), and Low, Chen and Wu (2011), it was found to be insignificant in Kurnia et al. (2015). Thus, it is plausible that the determinants of SC 4.0 adoption in Vietnam might be different from the existing studies. Additionally, it has been observed that the majority of research studies predominantly focus on the context of developed countries (Liao et al., 2017). However, developing countries like Vietnam encounter specific challenges, such as limited infrastructure, a scarcity of expertise, and restricted technology availability and accessibility (Akbari and Ha, 2020), or even the absence of state policies for the development of Industry 4.0, which differ significantly from those faced by developed countries (Bogoviz et al., 2019). This indicates a critical gap and limitation in the current adoption frameworks that fail to address the distinct challenges and competitive environment inherent to developing countries (Frederico et al., 2019). Moreover, although there has been a recent increase in number of studies aiming to identify determinants of SC 4.0 or DSC in organisations (Müller and Voigt, 2018; Samaranayake, Ramanathan, and Laosirihongthong, 2017; Dougados and Felgendreher, 2016; Pearson et al., 2014), the number of studies in this field is still scarce, and there is no consensus regarding the theoretical background or measurement frameworks. Therefore, Al-Somali, Gholami and Clegg (2011) suggested future research to reassess the theories and study models initially formulated for DSC adoption in developed countries, as they may not be directly applicable to the context of developing countries. To address the identified gaps, the research primarily aims to empirically identify the enablers and barriers of SC 4.0 while also seeking to validate the existing theories within the specific context of Vietnam.

However, as stated by Kagumba and Wausi (2018) and Melitski, Gavin and Gavin (2010), enablers or barriers of technology adoption largely depend on the contextual factor which is organisational culture. It suggests that the inconsistencies in the findings of previous studies may be attributed to the influence of organisational culture. Therefore, Liu et al. (2010) and Hewett, Money and Sharma (2002) suggested that investigating the moderating effect of organisational culture could potentially help to address these inconsistencies. Organisational culture and its impact on business strategies and firms' competitive advantage have been widely studied in literature (Anning-Dorson, 2021; Khazanchi et al., 2007; McLean, 2005). Despite a growing body of empirical studies exploring the role of organisational culture as a crucial driver in technology adoption, there is a lack of compelling evidence of existing research studies that incorporates the organisational culture types in SC 4.0 adoption, addressing the impact of different culture directions on such transformative decision. Nguyen et al. (2019) also further highlighted the under-researched nature of the relationship between organisational culture and technology adoption in developing countries like Vietnam. Similarly, Linh, Kumar, and Ruan (2019) shed light on a notable research gap in the field of DSC adoption, specifically regarding the limited coverage of cultural influences on implementation within emerging economies. These studies underscored the imperative for further investigation into the role of culture in shaping DSC adoption, particularly in the context of developing countries where such investigations have been limited. This therefore presents a substantial gap between theoretical and empirical research, hindering the progress and ability of both academics and practitioners to effectively understand and implement technology adoption strategies in a real-world context. Especially in developing countries, organisational culture has been considered as an antecedent of technology adoption (Dasgupta and Gupta, 2011). In particular, in Vietnam, business culture is one of the key players in successful innovation adoption (Nguyen et al., 2019; Tran et al., 2014). To address this gap, the present study aims to examine the impact of organisational culture on such adoption in Vietnam.

Additionally, although a variety of studies have investigated the different effects of organisational culture types on an innovation adoption of a firm, the research findings regarding the role of these organisational culture types in technological adoption have been very contradictory. On the one hand, majority of scholars suggested that since flexibility-oriented culture is more adaptable to changes and open to novel ideas and technological advancements, it leads to greater likelihood for organisations to adopt new technologies. Meanwhile, control-oriented culture that emphasises stability, hierarchy, rules and uniformity may resist change and be more hesitant to adopt new technologies (Naranjo-Valencia, Jiménez-Jiménez and Sanz-Valle, 2011; McLean, 2005). This highlights the importance of having an organisational culture that is characterised by openness, flexibility, supportiveness, and a data-driven approach for companies to achieve agility in the market (Arunachalam, Kumar and Kawalek, 2018; Schuh et al., 2017; Schumacher, Erol and Sihn, 2016). Therefore, cultivating a flexibility-oriented culture can be a key driver in a successful digital transformation, enabling firms to gain a competitive edge and position themselves for long-term success.

On the other hand, Liu et al. (2010) conducted a research study that yielded contrasting results regarding the moderating impact of flexibility-oriented cultures on firms' responses to external events and environmental pressures, such as those from suppliers, customers, and the government, in the context of adopting e-SCM. Their findings diverged from previous studies, suggesting that flexibility cultures weaken the influence of pressures from suppliers, customers, and competitors. This is attributed to the inherent nature of a flexibility-oriented culture, which places a strong emphasis on fostering creativity and embracing change while emphasising independent evaluation and adoption of innovations rather than being pressurised by the expectations and requirements of its powerful partners (Khazanchi et al., 2007; Stock, McFadden and Gowen III, 2007). Thus, Liu et al. (2010) believed that firms with flexibility attributes would not value what may be gained from the environmental pressures but prefer to develop unique practices to differentiate themselves from industry competitors. Following this logic, the authors proposed that a firm with flexibility orientation may weaken the impact of external environment pressures on technology adoption of the firm. These contradictory research findings impose a challenge on organisations to determine which culture type is the most preferable for their innovation adoption, especially in interorganisational SC 4.0 adoption. Hence, it is essential to explore which organisational culture types allow organisations to adopt SC 4.0 at higher levels. Building on prior research, the present study proposes that these two types of organisational culture may have distinct moderating effects on firms' adoption of SC4.0 in response to technological, organisational, environmental (TOE) factors.

Therefore, to address the identified gaps in existing literature and the necessity of identifying the enablers and barriers of SC 4.0 in Vietnamese context, and the role of different organisational culture types in such adoption, this research aims not only to explore the determinants of SC 4.0 but also to explore specific moderating impacts of both flexibility and control-oriented cultures on the relationship between TOE factors and the adoption of SC 4.0. Therefore, the subsequent chapter proposes a research model and hypotheses to address these research aims.

4.4. Summary

This chapter first provided a comprehensive systematic review of 153 existing research studies on SC 4.0 adoption determinants/ factors. Through this review, three main themes and seven subthemes were identified, aligning with the extended TOE framework integrated with the IOR theory. The findings of the SLR highlight inconsistencies and the dominance of research studies focusing on developed countries in existing literature. It also revealed a significant research gap in understanding the influence of different organisational culture types on SC 4.0 adoption, highlighting the necessity for further investigation in this area. Additionally, the review shed light on the under-researched relationship between organisational culture and innovation adoption in developing countries, such as Vietnam. This contributes to the development of the research model and hypotheses, which are discussed in the subsequent chapter.

5. CHAPTER 5: HYPOTHESES AND RESEARCH MODEL DEVELOPMENT

After considering the theoretical gaps in chapters 3 and literature gaps in chapter 4, it is clear that there is a compelling need to develop an empirically validated research model that systematically examines the determinants of DSC adoption in Vietnam. Addressing these gaps, this study aims to uncover the enablers and barriers of DSC adoption by empirically investigating how the TOE with the extension of IOR factors can impact the adoption of SC 4.0 in addition to the moderating role of organisational culture in such adoption, specifically in Vietnamese firms.

To achieve this objective, this chapter begins with the development of the research framework presenting a comprehensive rationale and justification for the research framework and hypotheses by drawing upon the reviewed literature and incorporating theoretical perspectives, including the TOE model, IOR theory, and Flexibility and Control-oriented culture theory. This framework guides the empirical investigation, enabling the data collection and analysis of the determinants of DSC adoption in Vietnam. The chapter later provides an examination of relationship between independent variables, dependent variables and moderator variable of the study which serve as the basis for hypothesis development.

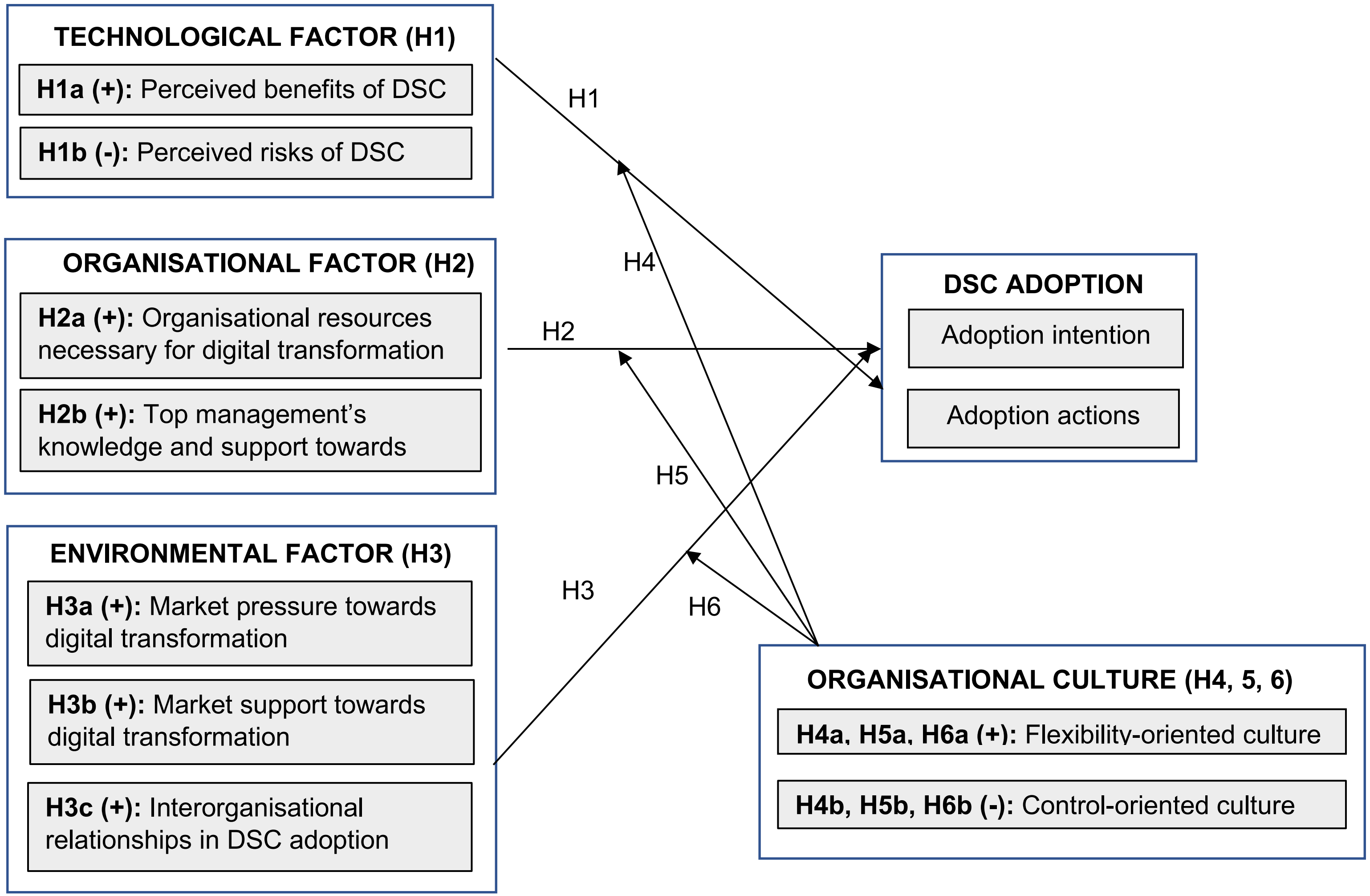
5.1. Research Model of This Study

The review of the existing literature and relevant theories suggests that the adoption of SC 4.0 is influenced by technology, organisation, and environment (TOE) factors, which are extended with interorganisational relationship (IOR) attributes. Additionally, organisational culture plays a moderating role in systematically modifying the strength and/or form of the relationship between TOE factors and the adoption of SC 4.0.

As discussed in Chapter 4, this research identifies three key factors that affect the adoption of DSC. The *Technological factor* refers to the characteristics related to the technologies, which include two main dimensions: (1) Perceived benefits and (2) Perceived risks. Perceived benefits focus on the relative advantages that technology adoption can bring to the organisation. On the other hand, perceived risks encompass costs and uncertainties related to cybersecurity, technical incompatibility, technical complexity, and missing data sharing standards. The *Organisational factor* refers to the organisational setting that supports digital transformation, which comprises two dimensions: (1) The availability of organisational resources and (2) Top management's knowledge and support. The availability of organisational resources refers to the availability of competent employees with the necessary skills, training, and willingness to change, as well as financial and infrastructure resources. Top management knowledge and support, on the other hand, relates to the support of the organisation's leaders towards digital transformation and their level of understanding of its potential benefits and adoption urgency. Finally, the *Environmental factor* relates to an organisation’s external environment, which influences its business activities. It consists of three dimensions: (1) Market pressure from competitors, customers, and uncertain events; (2) Market support from governmental policies, incentives, and other external organisations; and (3) Interorganisational relationships involving information sharing based on trust, trading partners’ pressure and support, and trading partners' readiness in their digital transformation.

These factors can ultimately have either a positive impact as an enabler or a negative impact as a barrier to the adoption of DSC. In addition to these factors, the organisational culture types refer to the cultural values that the organisation possesses, which include flexibility orientation and control orientation. These cultural values can either facilitate or hinder the adoption of DSC, depending on how well they align with the other factors of the proposed model. Based on the findings from the literature review and theoretical review, the research model and hypotheses can be illustrated in the Figure 5-1 below.

Figure 5-1: Research Model.



5.2. Hypothesis Development

5.2.1. Technological factor's impact on DSC adoption

Technological factor reflects the specific attributes and characteristics of the technologies in use. These attributes play a crucial role in shaping how the benefits, costs, and associated risks of technology adoption are perceived (Beier and Früh, 2020; Khoumbati, Themistocleous, and Irani, 2006), which therefore influence firms' technology adoption decisions (Lin, 2014).

Numerous studies have consistently recognised the significant impact of Technological factor, such as relative advantages or benefits, compatibility, and complexity of technologies, on the adoption process (Gangwar, Date, and Ramaswamy, 2015; Oliveira, Thomas, and Espadanal, 2014; Low, Chen, and Wu, 2011). Notably, Lai, Sun, and Ren (2018) and Lin (2014) highlighted that technological context factors emerge as the foremost determinants strongly influencing firms' decisions and the extent to which they embrace technology and innovation. Based on these insights, the following hypothesis can be formulated:

H1: Technological factor has a significant impact on DSC adoption.

As identified in Chapter 4, Technological factor includes the perception of companies towards (a) the benefits and (b) the risks associated with digital technology adoption and the broader digital transformation within their supply chains. Therefore, two hypotheses including H1a and H1b can be proposed as follows:

5.2.1.1. Perceived benefits' impact on DSC adoption

Perceived benefits refer to the operational and strategic advantages a firm anticipates gaining through the adoption of digital technologies or the broader digital transformation within their supply chains. Numerous studies have considered perceived benefits to be a crucial indicator of innovation and technology adoption (Shamout et al., 2022; Vern, Miftah and Panghal, 2022; Yacob and Peter, 2022; Lai, Sun and Ren, 2018; Supranee and Rotchanakitumnuai, 2017; Gunasekaran et al., 2017; Zhong et al., 2016; Gangwar, Date, and Ramaswamy, 2015; Lin, 2014; Rai, Patnayakuni, and Seth, 2006). For example, a study conducted by Lai, Sun and Ren (2018) which investigated the determinants of BDA on SCM, highlights that the perception of the benefits of employing BDA stands out as the most influential predictor. This aligns with the beliefs of Gunasekaran et al. (2017) and Rai, Patnayakuni, and Seth (2006), who asserted that the application of BDA in SCM yields numerous advantages which therefore prompted firms to implement such technology. These include enhanced responsiveness to environmental changes, more accurate prediction and management of supply chain risks, strengthened partnerships, and a reduction in supply chain waste. Furthermore, research conducted by Lai, Sun, and Ren (2018) as well as Zhong et al. (2016) highlighted that BDA provided firms with a robust tool to address the challenges posed by information asymmetry since firms can effectively leverage various data sources to evaluate changes and trends in the competitive landscape. In the same line, a study by Gangwar, Date and Ramaswamy (2015) observed a similarly significant and positive impact of the perceived benefits of Cloud computing on its adoption. It is witnessed that firms' cloud computing adoption largely depends on several strategically significant advantages such as scalability and mobility. These advantages, in turn, lead to a multitude of positive outcomes, such as increased internal process efficiency, improved employee productivity, greater customer service, reduced inventory costs, and enhanced collaboration with trading partners.

The aforementioned studies have consistently revealed that strong perception of the benefits associated with technology adoption significantly increases the likelihood and willingness of firms to embrace and integrate new technologies into their operations. Thus, it can be argued that when firms perceive the benefits of Industry 4.0 technologies on their supply chain operations, they are more likely to adopt these technologies to improve their supply chain performance. Put simply, there is a positive relationship between the perceived benefits of Industry 4.0 technologies and the decision to adopt them (Stentoft et al., 2021; Lumsden and Gutierrez, 2013).

Additional studies also further highlighted the critical need of fostering a more comprehensive understanding and awareness of the potential benefits offered by digital technologies to facilitate such adoption as the lack of awareness poses a challenge to the widespread adoption of Industry 4.0 within supply chains and hinders organisations from fully embracing its transformative potential. Notably, research conducted by Ali and Aboelmaged (2022), Vern, Miftah, and Panghal (2022), and Haddud et al., (2017) have revealed that despite the increasing prominence of Industry 4.0, many organisations lack the necessary awareness of its potential benefits, ultimately inhibiting its widespread adoption within these organisations. Specifically, it was witnessed that many businesses remain uncertain about the technicalities, functionalities, and economic advantages associated with investing in this innovative paradigm. The plausible explanation is that the technology is still in its infancy, and companies believe that many problems can still be easily solved by traditional databases and information systems (Wang et al., 2019B). Similarly, a study of Raj et al. (2020) found that one of the significant barriers to Industry 4.0 technology adoption is lack of clarity regarding the productivity gains and economic benefits of investment in technology. Thus, there is a need for increased awareness and understanding of the transformative potential of Industry 4.0 to foster its adoption in supply chains and enable organisations to fully capitalise on its benefits. Drawing upon the discussion, it can be hypothesised that:

H1a: Perceived benefits have a positive influence on DSC adoption.

5.2.1.2. Perceived risks' impact on DSC adoption

Previous studies have highlighted the significance of perceived technological risks in shaping a firm's decision to adopt new technologies (Malik et al., 2021; Falcone, Steelman and Aloysius, 2021; Biucky, Abdolvand and Harandi, 2017; Martins, Oliveira and Popovič, 2014; Hsu, Ray and Li-Hsieh, 2014; Im, Kim and Han, 2008). These studies emphasised that organisations carefully evaluate the potential risks associated with the adoption of new technologies before making adoption decisions. For example, a study conducted by Hsu, Ray and Li-Hsieh (2014) observed a significant negative impact of perceived risks on the adoption of cloud computing. The authors explained that some firms exercise caution due to the perceived risks associated with the relatively immature cloud computing market. Consequently, in these early stages of cloud computing, concerns regarding confidentiality, service disruptions, and vendor lock-in act as inhibitors, impeding firms from embracing innovative cloud services. Similarly, research by Malik et al. (2021) unveiled that risks linked to Blockchain adoption, such as scalability issues, privacy concerns, and sluggish transaction processing speeds, exerted a negative influence on its adoption among Australian firms.

Essentially, the perceived risks associated with technology adoption can significantly influence a firm's confidence in the reliability and trustworthiness of the technology, thereby shaping its decision to adopt it. When a firm has a higher perception of risks, it may hesitate to fully trust the technology and become less confident in its potential benefits (Xie et al., 2021; Khayer et al., 2020). Conversely, when perceived risks are lower, the firm is more likely to have greater confidence in the technology's reliability, leading to a higher likelihood of adoption (Laskurain-Iturbe et al., 2023).

As mentioned previously in Chapter 4, the perceived risks encompass various risks and problems associated with technology adoption, including (1) data privacy and security concerns, (2) interconnection standards, (3) uncertainties regarding the costs and expected return on investment (ROI), (4) technological complexity, and (5) compatibility with existing systems. Each of these factors contributes to the overall perception of risks, influencing the organisation's confidence in the reliability and trustworthiness of the technology.

(1) **Data privacy:** The successful implementation of Industry 4.0 within organisations and their supply chains faces significant challenges related to cybersecurity threats and data privacy and security concerns. These challenges have been widely recognised in the existing literature as major obstacles that need to be addressed (Ahamad et al., 2022; Demirkesen and Tezel, 2022; Kumar, Bhamu and Sangwan, 2021; Majumdar, Garg and Jain, 2021; Stentoft et al., 2021). The authors argued that to effectively integrate Industry 4.0 technologies while ensuring the confidentiality, integrity, and availability of data, organisations must prioritise addressing data privacy and security concerns. This entails adopting cybersecurity measures and making it an integral part of their organisational culture and corporate strategy (Ghobakhloo, 2020A; McKinsey & Company, 2015).

(2) **Interconnection standards**: The absence of common standards and standardised protocols for data collection and sharing has emerged as a significant impediment to the widespread adoption of Industry 4.0, limiting supply chain cooperation between different systems and actors (Machadoa et al., 2019; Ajmera and Jain, 2019; Nagy et al., 2018). This is supported by Industry reports, such as PWC's (2016B), which revealed that 423 surveyed executives from 26 countries identified the lack of digital standards, norms, and certifications as a prominent barrier facing companies, particularly those in the industrial manufacturing sector.

(3) **Uncertainties regarding the costs and expected return on investment** (ROI): Numerous studies have highlighted the risks of substantial costs associated with adopting digital technologies in supply chains, including operating costs, setup costs, training expenses, hardware and software investments, and system integration costs (Lian, Yen, Wang, 2014; Lin, 2014; and Lumsden, Gutierrez, 2013). Due to the extensive and varied nature of these costs, firms perceive the expenses of technology adoption to be enormous. De Alwis, De Silva and Samaranayake (2023), Sayem et al (2022), Tripathi and Gupta (2020), and Orzes et al. (2018) further emphasised the challenge of quantifying the return on investment (ROI) for such transformative initiatives, which introduces further uncertainty and risk. It implies that unclear ROI and perceived high costs can lead to hesitation and reluctance in adopting Industry 4.0 in supply chains. Consequently, the cost factor remains a prominent deterrent to technology adoption, limiting the widespread embrace of Industry 4.0 initiatives (Puklavec, Oliveira, and Popovič, 2018).

(4) **Technological complexity**: Extensive research has consistently indicated that organisations exhibit hesitancy towards technology adoption when they perceive it as complex or challenging (Ghobakhloo et al., 2022; Tortorella et al., 2021; Raj et al., 2020; Halse and Jæger, 2019; Lumsden and Gutierrez, 2013). For example, Ali et al. (2021) and van Lopik et al. (2020) identified the significant influence of technological complexity on the adoption of Blockchain and AR respectively. These studies emphasised the challenges

that organisations face in grappling with the intricacies and complexities associated with these technologies, which can significantly hinder their widespread adoption. This implies the necessity to address concerns regarding technological complexity and provide adequate support and guidance to employees to foster successful DSC adoption.

(5) **Compatibility with existing systems**: Previous literature has highlighted the importance of technological compatibility as an essential factor in the successful adoption of new innovations. Companies often evaluate how to integrate their current IT systems and applications with new technologies before deciding to adopt them (Lian, Yen and Wang, 2014). However, the adoption of heterogeneous technologies has led to compatibility issues during the implementation of technological innovations (Kamble et al., 2019). For example, a study on cloud computing adoption by Lian, Yen and Wang (2014) found that cloud service providers often utilise proprietary software that may not be fully compatible with existing systems of firms, thus necessitating the need for companies to modify their current systems to accommodate the new cloud systems. Hence, compatibility issues arising from the differences in technology adoption can pose a significant challenge for firms looking to adopt digital technologies (Kumar, Mangla and Kumar, 2022; Tamvada et al., 2022; Chauhan and Singh, 2021; Kamble, Gunasekaran and Sharma, 2018).

In general, cybersecurity risks, technological complexity, compatibility issues, substantial investment costs and unclear ROI have all been proven to decrease the probability of successful adoption of digital technologies in SCM. Therefore, based on a literature review examining the impact of perceived risks on the implementation of DSC, it is possible to hypothesise that:

H1b: Perceived risks have a negative influence on the DSC adoption.

5.2.2. Organisational factor’s impact on DSC adoption

Organisational context refers to the descriptive aspects or characteristics of an organisation, such as its size, scope, managerial structure, and available resources, which reflect the readiness of firms that can facilitate or constrain the adoption and implementation of new technologies and innovations (Yeh and Chen, 2018; Oliveira, Thomas and Espadanal, 2014; Sealy, 2012). According to Senyo, Effah and Addae (2016), for technology to be effectively utilised, it must align with the organisational setting.

In numerous studies focusing on technology and innovation adoption (Henao-Ramírez and Lopez-Zapata, 2022; Gangwar, Date, and Ramaswamy, 2015), organisational context factors consistently emerge as a primary focus, exerting the most influential impact on companies as they embrace digital technologies. Therefore, it can be hypothesised that:

H2: Organisational factor has a significant impact on DSC adoption.

As discussed in Chapter 4, this study examines two Organisational factor's dimensions which are (a) organisational resources and (b) top management knowledge and support. Thus, two sub-hypotheses are proposed.

5.2.2.1. Organisational resources' impact on DSC adoption

The existing body of research consistently supports the positive relationship between organisational resources and technology adoption (Samaranayake et al., 2022; Maduku, Mpinganjira and Duh, 2016; Hsu, Ray and Li-Hsieh, 2014). In line with these findings, Lai, Sun, and Ren (2017) emphasised the significant role of well-developed organisational resources as a foundation for successful digital transformation. Samaranayake et al. (2022) further emphasised that organisations that can excel in acquiring and effectively utilising resources and capabilities are more likely to achieve successful implementation of digital technologies. The finding is not surprising, given the resource-intensive nature of the Industry 4.0 transition and the implementation of its technological components (Hoyer, Gunawan and Reaiche, 2020). As discussed above, organisational resources encompass various factors, including the competence and willingness of human resources to embrace change, the availability of financial resources, and the adequacy of IT infrastructures.

There is a stream of literature demonstrating a strong correlation between proficiency of human resources and their utilisation of IT (Varshney, 2020; Carroll and Wagar, 2010). The willingness of employees to embrace innovative changes is also considered crucial for firms' successful digital transformation. It is believed that both employees and top managers need to take a leading role in the digital transformation of their company (Berman, 2012). As without a properly prepared workforce that is willing to engage in transformation efforts, the benefits associated with digitalisation cannot be fully realised (Imran et al., 2022; Agrawal, Narain and Ullah, 2019). This is particularly important as Industry 4.0 technologies require new skill sets and on-going skill development.

However, a significant obstacle that hinders the widespread adoption of Industry 4.0 throughout the supply chain is the substantial shortage of digital skills and knowledge within the workforce (Ali and Aboelmaged, 2022; Luthra et al., 2020; Ingaldi and Ulewicz, 2019; Huang, Talla Chicoma and Huang, 2019). Similarly, a global Industry 4.0 survey conducted by PWC (2016B) indicated that one of the challenges to firms' digital transformation is not the technologies but the lack of digital skills. The survey findings suggest that the focus should not solely be on the technologies themselves but also on equipping employees with the necessary digital skills to effectively work with complex technologies. Recognising the importance of a skilled workforce, organisations are placing a strong emphasis on investing in extensive training and continuous education programs to upgrade employees' skill sets, align them with the requirements of Industry 4.0, and prepare them for specialised jobs (Luthra et al., 2020; Luthra and Mangla, 2018).

Additionally, various studies have highlighted the crucial role of high infrastructure, information technology based facilities in effective adoption of Industry 4.0 (Luthra and Mangla, 2018). For example, Frederico et al. (2019) stated that adequate IT infrastructure is essential for the effective utilisation of technologies and should be accessible not only during the initial development and implementation stages but also for the continuous management and evolution of these technologies. However, as rated by the experts in prior studies, significant pitfalls to the adoption of technological innovation at the corporate level rated is the absence of robust IT infrastructure, poor internet connectivity and electricity issues (Attiany et al., 2023; Sharma et al., 2021; Kamble et al., 2019; Luthra and Mangla, 2018). This necessitates the need for efficient communication networks with strong signal strength to ensure high-speed data transfer without compromising data quality, as well as adequate facilities for data capture and storage (Müller and Voigt, 2018; Shinohara et al., 2017; Deloitte, 2015). Without addressing these challenges, companies may struggle to fully embrace and benefit from technological advancements.

On the other hand, the adoption of Industry 4.0 solutions also requires considerable financial investments to establish a robust and secure network and upgrade legacy systems (Omar, Minoufekr and Plapper, 2019; Puklavec, Oliveira and Popovič, 2018; Kiel et al., 2017; Schröder, 2016). Availability of strong capital can also support firms to endure the technical disruptions during the adoption and implementation of new technologies. Thus, a dedicated financial support from the organisation is imperative for the success of Industry 4.0 integration in operations and SCM (Lamba and Singh, 2018). On the contrary, Machadoa et al. (2019), Schroeder et al. (2019) Banerjee (2018) believed that financial resources pose a significant obstacle for organisations when firms lack financial support or funding or are unable to divert significant amounts of budgets into nascent innovation. In such cases, slack financial resources can limit the organisations' development opportunities and serve as a major drawback to the adoption of new technological advancements.

In summary, the existing literature has highlighted the crucial role of human resources' competence and willingness for change, IT infrastructure and financial competence in driving the adoption of firms' digital transformation. Therefore, it can be hypothesised that:

H2a: Availability of organisational resources has a positive influence on DSC adoption.

5.2.2.2. Top Management knowledge and support

Top management plays a pivotal role in driving and supporting digitalisation efforts across multiple domains. As the field of SCM undergoes significant digital transformation (Tay and Loh, 2021), top managers must have the foresight to anticipate and embrace the possibilities brought about by SC 4.0. Therefore, their knowledge and understanding of digital transformation as well as leadership and strategic decisions have a profound impact on the successful adoption of DSC within organisations. Numerous studies have revealed that the level of knowledge, innovativeness, experience, and education of managers is a crucial factor that determines the extent of IT implementation in an organisation, as it influences the proactive or reactive approaches taken towards rapid technological changes (Elbeltagi et al., 2013; Kannabiran and Dharmalingam, 2012). For instance, Elbeltagi et al. (2013) found that the educational level of top management, such as the chief executive officer (CEO), plays a critical role in enabling the adoption of technological innovation. It implies that top managers should be well-versed in the principles, emerging technologies, and strategic implications of SC 4.0 as well as latest trends and best practices in DSC management. Lamba and Singh (2018) also further noted that top management willingness and support can influence all other enablers, making it the most critical factor in executing Industry 4.0 strategies and action plans. Top management can support digital transformation in several ways, from fostering a culture of experimentation, risk-taking, and collaboration (Lumsden and Gutierrez 2013) to establishing a clear vision for DSC adoption (Veile et al., 2020; Schneider, 2018). Top management can also facilitate employee engagement and acceptance of the digital transformation (Lin, 2014) and inter-firm and intra-firm communication for successful DSC implementation (Kiel et al., 2017). This highlights the significance of top management engagement in ensuring the successful adoption of DSC.

Clearly, the digitalisation of supply chains presents numerous opportunities for businesses, but these benefits are often left untapped due to a lack of leadership and relevant experience in top management (Agrawal, Narain and Ullah, 2019). In some cases, managers may not have the long-term commitment and support necessary for digital transformation (Saberi et al., 2019). Without the clear vision, values, and guidance of top management, employees may resist change, especially older employees who are unfamiliar with emerging technologies. Raj et al. (2020) believed a lack of buy-in from top management can make it potentially challenging to develop a digital roadmap for the adoption of Industry 4.0 initiatives into the supply chain. Additionally, another tremendous challenge faced by companies is that top management might not possess sufficient knowledge of Industry 4.0 and may not fully understand the possible ROI (Richey et al., 2016) and its specific consequences and implications (Luthra and Mangla, 2018) which makes them hesitant to adopt these sophisticated technologies. Thus, Bag et al. (2018) suggested that firms should prioritise developing leaders with essential skills for the digital era. Such management initiatives would foster greater adoption of Industry 4.0 and facilitate its integration within the supply chain network. This highlights the importance of top managers' understanding and capabilities in recognising the potential of Industry 4.0 and leveraging its insights for business decisions, (Gupta and George, 2016). The authors also emphasised the significant role of top management in collaborating with other functional managers to enhance organisation's digital skills that are difficult to replicate, giving companies a competitive advantage in the market. Therefore, it can be concluded that:

H2b: Top management's knowledge and support have a positive influence on the DSC adoption.

5.2.3. Environmental factor' impact on DSC adoption

Businesses do not exist in isolation; they operate within an environment characterised by various factors that can either facilitate or hinder their business operations. Within the domain of technology adoption, Environmental factor can play a pivotal role, either enabling or constraining a firm's decisions when confronted with the choice of embracing new technologies or not (Lai, Sun, and Ren, 2018). Thus, considering Environmental factor in an organisation's decisions regarding technological adoption is crucial due to its significant impact on the organisation's overall success (Senyo, Effah, and Addae, 2016).

The environmental context refers to the setting in which a company conducts its operations, influenced by industry-specific characteristics and structures, such as the extent of competitive pressure, accessibility to externally provided resources, and regulatory frameworks, which serve as crucial determinants in shaping the adoption of innovative technologies within a particular Industry (Oliveira, Thomas and Espadanal, 2014). According to Henao-Ramírez and Lopez-Zapata (2022) and Lin (2014), an organisation's inclination to innovate and embrace IT innovations is contingent upon the opportunities and threats presented by its external environment. Existing literature consistently acknowledges the Environmental factor's influence on the adoption of new technology (Aboelmaged, 2014; Chan, Chong and Zhou, 2012; Henderson, Sheetz and Trinkle, 2012). Therefore, it can be hypothesised that:

H3: Environmental factor has a significant impact on DSC adoption.

As outlined in Chapter 4, Environmental factor considered in this study includes (a) market pressure, (b) market support and (c) interorganisational relationships among supply chain partners. Therefore, the three sub hypotheses are proposed.

5.2.3.1. Market pressure's impact on DSC adoption

Market pressure encompasses competitive and customer pressures as well as market uncertainties. Many studies have shown that the increasing competitive pressure on firms, particularly in a global economy, has been identified as a significant incentive and enabler for the adoption of information and communication technologies (ICT) in the supply chain, such as RFID adoption (Wang, Wang and Yang, 2010), cloud computing (Hsu, Ray and Li-Hsieh, 2014; Lumsden and Gutierrez, 2013), and e-SCM (Lin, 2014). Industries are often characterised by rapid changes, placing firms under constant pressure to keep up with their competitors' adoption of new technologies. Thus, as stated by Wang, Wang and Yang (2010), as market competition intensifies, firms are more motivated to seek competitive advantages through innovation. Therefore, in a study by Lin (2014), competitive pressure was observed to have significant and positive influence on the extent of digital technology adoption, indicating that firms tend to adopt innovations more aggressively when facing strong competition to avoid falling behind. In addition to competitive pressure, Kraus et al, (2021), Agrawal, Narain and Ullah (2019) also believed that the growing customer demand for customised products and services has exerted pressure on firms to adopt digital solutions to meet that need. Furthermore, this transformation has also been significantly accelerated by the market uncertainties and volatility such as the Covid-19 pandemic which has caused global supply chain disruptions, forcing multiple companies to digital transform their supply chain operations (Kutnjak, 2021; Gabryelczyk, 2020; Wade and Shan, 2020). In summary, market pressure from customers, competitors and unpredictable events have proven to drive firms to implement digital technologies in their supply chains to improve operational efficiency and obtain competitive advantage. Thus, it can be hypothesised that:

H3a: Market pressure has a positive influence on the DSC adoption.

5.2.3.2. Market support's impact on DSC adoption

According to Lai, Sun, and Ren (2018) and Ghobakhloo et al. (2012), the adoption and diffusion of new technologies are heavily reliant on the support received from government and external organisations. Therefore, the impact of this support on digital transformation initiatives cannot be underestimated. While a significant number of studies have revealed the importance of government policies and regulations (e.g. data privacy and security, labour and work safety laws) as a critical factor for the development of SC 4.0, having the highest influence on the other drivers of this transformation (Luthra et al., 2020; Lammers, Tomidei and Trianni, 2019), a considerable amount of literature have condemned the lack of clear governmental regulations and support as a major barrier to the adoption of Industry 4.0 in the supply chain context (Saberi et al., 2019; Nair, Chellasamy and Singh, 2019; Türkeș et al., 2019). This highlights the important role of government in accelerating the digital transformation within the country and businesses.

Furthermore, research has consistently highlighted the significance of third-party support in facilitating the adoption of digital technologies. Notably, Oesterreich and Teuteberg (2016) asserted that companies can effectively navigate the digital transformation by harnessing innovation ecosystems that encompass industry networks, funding programs, research institutes, and universities. These ecosystems offer invaluable resources, opportunities for knowledge exchange, and collaborative support, enabling organisations to adapt to the evolving digital landscape and achieve successful transformation outcomes. As companies transition to smart supply chains, the acquisition of digital supplies and services, such as software, developers, digital platforms, and specialized competencies, becomes indispensable (Tripathi and Gupta, 2020). Consequently, fostering interdisciplinary collaboration with digital leaders beyond organisational boundaries becomes increasingly vital (Oesterreich and Teuteberg, 2016; Kannabiran and Dharmalingam, 2012).

In summary, having sufficient market support from government and external firms is undoubtedly a key determinant of success for firms embarking on digital transformation. Firms that receive such support are better positioned to effectively adopt and implement digital transformation. Conversely, those without adequate support may face a challenge of keeping up with the fast pace of technological advancements in their Industry. Therefore, it can be concluded that:

H3b: Market support has a positive influence on the DSC adoption.

5.2.3.3. Interorganisational relationships' impact on DSC adoption

Previous studies have emphasised the significance of cooperative relationships among supply chain stakeholders in the adoption of DSC practices, highlighting the importance of exploring Interorganisational relationships (IOR) between these partners (Lin and Lin, 2014). Similarly, Chan, Chong and Zhou (2012) also claimed that the formation of strong interorganisational relationships has been identified as a key determinant of successful collaborative technology implementations. Several previous studies such as Pu, Wang and Chan (2020), Lin (2014), Zaffar, Kumar and Zhao (2013), Chong et al. (2009) and Huang, Janz and Frolick (2008) also provided evidence revealing the importance of nurturing strong interorganisational relationships as a crucial factor for the successful adoption of digital technologies. However, a number of studies have shown that interorganisational collaboration with the entire supply chain ecosystem has been one of the highest challenges for firms (Raj et al., 2020; Khan, 2019; Ding, 2018; Farahani, Meier and Wilke, 2015). Research carried out by Lammers, Tomidei and Trianni (2019), Mittal et al., 2018 ans Kache and Seuring (2017) have revealed that lack of cross-disciplinary network such as a limited number of particular suppliers/vendors or parties' reluctance to collaborate and integrate with partners has been cited as the key challenge for DSC adoption. This ineffective and insufficient collaboration across the supply chains lies in the problem that the immediate benefits of collaborative efforts are not instantly visible. Whereas Ding (2018) found that this key issue is primarily caused by the scarcity of information among supply chain partners and the lack of willingness of firms to participate in the digital transformation. The issue necessitates a deeper comprehension of the nature of relationships between organisations to promote the acceptance of business collaboration within the supply chain (Supranee and Rotchanakitumnuai, 2017). Thus, business partners can focus on enhancing their interorganisational relationships by fostering long-term collaboration, willingness to share information, and improving mutual communication (Chong et al., 2013).

As previously discussed in the SLR, successful collaboration among supply chain partners in the adoption of DSC technologies is influenced by several key factors, including the power dynamics among trading partners, the extent of information sharing, and the digital readiness of supply chain partners. Previous research has suggested that supply chain partners can exert power on firms, compelling them to make substantial investments to sustain business relationships, and in turn, keep pace with their partners in terms of technological development (Chan and Chong, 2013). Therefore, the power of trading partners is a crucial element for the successful implementation of DSC (Zeng, Chan and Pawar, 2020). For instance, Lin (2014) found that trading partner power is positively related not only to the likelihood of DSC 4.0 adoption but also to the extent of adoption, as the author believed that DSC differs from stand-alone technologies and must be co-adopted by multiple organisations. Similarly, a study by Low, Chen and Wu (2011) revealed that trading partner power has positively significant impact on cloud computing adoption in the high-tech Industry. Meanwhile, a study of Tan and Ludwig (2016) showed that companies in China that experience higher levels of power dependence have greater tendency to adopt technologies. It could be argued that greater dependence on external partners often compels organisations to comply with or adopt their partners' technologies to sustain business relationships.

Additionally, since the adoption of digital technologies in SCM largely depends on collaboration with existing supply chain partners (Weerabahu et al., 2022; Werner et al., 2021; Srai and Lorentz, 2019; Queiroz and Wamba, 2019), firms seeking to implement digital technologies are significantly influenced by, if not reliant on, their trading partners' readiness to adopt such technologies (Malik et al., 2021; Bruque-Cámara, Moyano-Fuentes and Maqueira-Marín, 2016). For example, a study by Kamble et al. (2021) found that the Blockchain adoption is highly subjected to the externally uncontrollable factors, such as the readiness of the supply chain partners to adopt technologies. Therefore, successful DSC adoption necessitates synchronisation among partners, with a shared commitment to embracing technological innovations.

Furthermore, Korpela, Hallikas, and Dahlberg (2017) highlighted the significance of strategic and operative information exchange for successful adoption of DSC, emphasising its role in fostering supply chain collaboration (Lotfi et al., 2013). Similarly, Singh, Kumar, and Chand (2019) stressed the criticality of seamless information flow within the supply chain for the survival and competitiveness of organisations in the era of Industry 4.0. Information sharing is also widely acknowledged as a significant antecedent of eSCM adoption (Chong and Bai, 2014; Chong et al., 2013). This is because SC 4.0 relies heavily on digital technologies and interconnected systems, which require a seamless flow of information to foster integrated planning and coordination of the activities across the entire supply chain network (Shao et al., 2021; Scholz et al., 2018). By sharing information such as demand forecasts, order status, product planning, and production schedule, organisations can achieve real-time visibility, transparency, coordination and agility throughout the entire supply chain network (Chong and Bai, 2014). This, in turn, facilitates timely decision-making, enhances operational efficiency, and enables organisations' supply chains to adapt to dynamic market conditions. Therefore, establishing a robust information flow is a crucial factor for success in SC 4.0 adoption. However, information sharing can be a challenge in inter-firm relationships as information is often viewed as a source of competitive advantage. As highlighted by Moktadir et al. (2019) and Oncioiu et al. (2019), a major challenge associated with SC 4.0 adoption is the absence of information sharing due to concerns over information disclosure policies. Some information remains disclosed to protect an organisation's solvency such as financial reasons or even a matter of principles (Richey et al., 2016). Therefore, according to Chan and Chong (2013), it is critical to build long-term relationships based on trust and the assurance that partners will not act opportunistically or violate relationship norms.

In summary, an effective collaboration and strong relationships among supply chain organisations are crucial in ensuring the successful adoption of digital technologies in supply chains. It is undoubted that digital transformation in supply chains cannot be achieved in isolation, but rather through a coordinated effort among trading partners (Lin and Lin, 2014). In light of this, it is imperative for firms to prioritise building and maintaining strong relationships with their supply chain partners as a means of facilitating successful digital transformation initiatives. Therefore, it can be hypothesised that:

H3c: Interorganisational relationships have a positive impact on the DSC adoption.

5.2.4. Organisational culture's impact on DSC adoption

Numerous studies have highlighted the significant role of organisational culture as a determinant of firms' competitive performance, profitability, innovation efficiency, and supply chain strategies across various industries (Gorondutse and Hilman, 2019; Prasanna and Haavisto, 2018; Gu et al., 2014; Hartnell, Ou and Kinicki, 2011). These findings have encouraged top managers to explore innovative management and change strategies (Gorondutse and Hilman, 2019). Such change often involves the adoption of emerging technologies to enhance business performance. Consequently, organisational culture has been extensively investigated as a critical factor in the firms' successful implementation of strategic technology adoption initiatives (Shao, 2019; Dubey et al., 2019; Lepore et al., 2018; Naranjo-Valencia, Jiménez-Jiménez and Sanz-Valle, 2011; Liu et al., 2010). These studies suggest that organisational culture can either propel or hinder technology adoption.

For instance, studies conducted by Mokhtar and Salimon (2022) and Tseng (2017) have affirmed the positive moderating effect of organisational culture on IT adoption. Meanwhile, LaValle et al. (2010) observed that the lack of productivity in many Big Data projects is often attributable to organisational culture rather than data characteristics or technology deficiencies. Furthermore, Ross, Beath, and Quaadgras (2013) claimed that organisational culture significantly influences the effectiveness of Big Data projects. The possible explanation for these results may lie in the fact that organisational culture exerts powerful influence all aspects of an organisation's practices, including employee behaviours, motivation, knowledge sharing, teamwork, collaboration, and leadership (Ng'ang'a and Wesonga, 2012; Yong and Pheng, 2008). These aspects, in turn, shape technology and innovation adoption and its extent.

Hence, achieving successful digital technology adoption necessitates organisations to utilise culture as a crucial moderating instrument, guiding the digital transformation pathways. As emphasised by Eniola et al. (2019) and Tseng (2017), fostering an appropriate business environment that significantly impacts both business and operational organisational success is critical. Likewise, Gorondutse and Hilman (2019) also believed that organisations with the right cultural attributes can create an enabling environment for the implementation of innovative technologies.

Drawing from the extensive literature on organisational culture, this study proposes that organisational culture may exert moderating effects on firms' adoption of SC4.0 in response to technological, organisational, and environmental (TOE) factors. Thus, it can be hypothesised that:

H4: Organisational culture moderates the relationship between Technological factor and DSC adoption.

H5: Organisational culture moderates the relationship between Organisational factor and DSC adoption.

H6: Organisational culture moderates the relationship between Environmental factor and DSC adoption.

As explained in Chapter 4, the success of DSC adoption is strongly linked to two categories of organisational cultural traits: (a) flexibility and (b) control values. Consequently, hypotheses which examine the moderating influences of both flexibility and control-oriented cultures on TOE factors (specifically H4a, H5a, H6a, H4b, H5b, and H6b) are proposed and elaborated upon below.

It is noteworthy to highlight that the impact of organisational culture on Technological factor, particularly in terms of perceived benefits and risks, has not received extensive attention in the current literature. Most existing studies have primarily focused on how organisational culture moderates the relationships between organisational and environmental factors with regard to technology adoption, but not on the technological factor. For instance, Liu et al. (2010) conducted research examining how both control-oriented and flexibility-oriented cultures affect the relationship between environmental factor – specifically, normative, mimetic, and coercive pressures – and the intention to adopt eSCM. Similarly, Cai, Gu, and Wu (2021) explored how flexibility and control-driven cultures moderate the link between CEO passion and firm innovation. Additionally, Chu, Wang, and Lai (2019) investigated the moderating influence of both flexibility and control-oriented cultures on the relationship between environmental factor – specifically, customer pressure – and green innovation. This has shown a noticeable gap in the existing literature investigating how various types of organisational culture influences the perceived benefits or risks associated with DSC adoption. Consequently, this gap highlights the urgent need for further exploration into the moderating role of different organisational culture types in shaping the relationship between technological factor and the technology adoption, particularly SC4.0 adoption within firms.

5.2.4.1. Organisational culture's moderating impact on the relationship between Technological factor and SC4.0 adoption

It is noted that digital transformation is a risky endeavour, but it can also lead to long-term competitive advantages for firms. Organisations that cultivate a strong flexibility-oriented culture tend to foster innovation, risk-taking, and better tolerance of short-term losses to cope with uncertainty and ambiguity (Hartnell, Ou and Kinicki, 2011; Khazanchi, Lewis and Boyer, 2007). Within such a cultural context, organisations enhance their agility by actively exploring multiple potential future scenarios and adeptly designing and implementing innovative responses and solutions to address the unforeseen situations timely (Van Oosterhout, Waarts and Van Hillegersberg, 2006).

Therefore, in the context of today's highly uncertain, dynamic, and complex business environment, in addition to the unprecedented technological advancements, employees within flexibility-driven organisations are more likely to have higher acceptance of risks. Therefore, they perceive new innovations as a positive force and a real source of opportunities for their organisations (Felipe, Roldán and Leal-Rodríguez, 2017). Furthermore, they consistently adapt and restructure their resources to create responsive solutions for emerging scenarios, whether in the form of new products, services, technologies, or innovative business models (Teece, Peteraf and Leih, 2016). It suggests that from a technological perspective, flexibility can enhance the perceived benefits of digital technology adoption while reducing the impact of the perceived risks, thereby promoting their adoption. Thus, it can be hypothesised that:

H4a: Flexibility-oriented culture moderates the relationship between Technological factor and the DSC adoption.

On the contrary, firms with control-oriented organisational culture emphasise the productivity, stability, and strict adherence to rules and regulations (i.e. formalisation of activities) and excessive authority and limited member participation (i.e. centralisation) (Liu et al., 2010). This focus on control can make firms resistant to changes, hindering their ability to adapt to new technologies (Cao et al., 2015) and limiting their willingness to assume risks and embrace innovation (Child, 1973). This culture also signifies a high level of uncertainty avoidance (Sarooghi, Libaers and Burkemper, 2015; Lewis and Boyer, 2002).

In a high control-oriented culture, organisations tend to adhere strictly to explicit orders and rigid rules, thereby often exhibit caution when it comes to exploring creative and bold ideas in their daily operations and problem-solving processes (Büschgens, Bausch and Balkin, 2013; Naranjo-Valencia, Jiménez-Jiménez and Sanz-Valle, 2011). As a result, organisations within such culture might perceive the adoption of digital technologies and broader digital transformation as a high risky endeavour that could disrupt their stability and daily operations.

Thus, from a technological perspective, a control-oriented culture can increase perceptions of risk associated with digital technology adoption while decreasing perceptions of its potential benefits for the organisation. This, in turn, can impede a firm's willingness to invest in digital technology (Cao et al., 2015). Therefore, the following hypothesis can be formulated:

H4b: Control-oriented culture moderates the relationship between Technological factor and the DSC adoption.

5.2.4.2. Organisational culture's moderating impact on the relationship between Organisational factor and SC4.0 adoption

Furthermore, due to the focus on risk-taking and innovation initiatives, flexibility-oriented culture tends tend to inspire firms to invest their resources in developing unique products and services that distinguish them from their competitors (Liu et al., 2010). As noted by Song and Chen (2014), risk-taking in flexibility culture allows organisation to allocate resources to projects with uncertain payoffs, thereby leading the exploration of novel ideas. Thus, flexibility orientation promotes firms' investment in technical and financial resources necessary for the risky implementation of digital transformation.

In addition, Schuh et al. (2017) emphasised the importance of a human-centred corporate culture that fosters the development of employees' skills and entrepreneurial spirit for the successful implementation of Industry 4.0. To achieve this, organisations must create an environment that encourages employees to experiment with new ideas without fear of repercussions, values their skills and innovative thinking, promotes divergent thinking, views them as part of a community, and offers opportunities for continuous learning and improvement (Veile et al., 2020; Wu et al., 2019). A flexible-oriented approach is considered as human-centred culture that values innovation, creativity empowerment, participation, development through training and education, and self-decision-making of employees to achieve significantly higher performance (Dastmalchian, Lee and Ng, 2000). This may ultimately help develop new technical skills, foster trust and overcome employees' resistance to change (Lewis and Boyer, 2002). Therefore, in a flexible culture, employees' skills, knowledge, willingness to change, and engagement in the decision-making process can be further enhanced during digital transformation initiatives. In summary, from organisational view, by creating an environment that values and empowers employees, organisations can harness their creativity and entrepreneurial spirit to drive digital technology adoption.

Moreover, as mentioned earlier, previous research has highlighted the crucial role of top management in driving firms' digital transformation efforts by possessing a comprehensive understanding of digitalisation, creating a formal context for digitalisation, and leading change (Wrede, Velamuri and Dauth, 2020; Artemenko, 2020; Manfreda and Indihar Štemberger, 2019). In a flexibility culture, top managers exhibit an innovative and entrepreneurial mindset, actively pursuing growth, creativity, and stimulation (Sung and Kim, 2019). They also take the initiative to guide, support and mentor employees, encouraging them to participate and try new things (Hung, Su and Lou, 2022). Therefore, this culture fosters organisations to cultivate cutting-edge output (Denison and Spreitzer, 1991). It implies that flexibility-oriented culture can empower top management to take the lead in digital transformation with greater confidence and expertise. This approach can also reinforce top management's leadership and knowledge towards the implementation of digital transformation. Thus, by nurturing a culture that values innovation, risk-taking, and cutting-edge output, top managers can effectively guide their organisations towards successful digital transformation.

From an organisational perspective, a culture that prioritises flexibility tends to encourage firms' investment in organisational resources, especially in the development of employees' skills and knowledge, their engagement, innovative thinking, and entrepreneurial spirit. Additionally, it fosters top management's confidence and support for embarking on potentially risky DSC endeavours. Therefore, it can be hypothesised that:

H5a: Flexibility-oriented culture moderates the relationship between Organisational factor and the DSC adoption.

On the other hand, firms with a control-oriented culture tend to prioritise stability, rules, and uncertainty avoidance over timely and thus limit investment in organisational resources to support innovation, such as the adoption of Industry 4.0 technologies (Chu, Wang and Lai, 2019). This is because such investments involve significant risks and uncertainties that may threaten the organisation's stability (Brocal et al., 2019). Additionally, control-oriented culture often emphasises maintaining existing processes and systems rather than innovating and exploring innovations (Im, Montoya and Workman Jr, 2013; McLean, 2005). Firms that prioritise control may not allocate sufficient resources to R&D or invest in new technologies that could improve their operations. Therefore, from an organisational standpoint, control-oriented culture disincentivises firms from investing in necessary resources for the risky implementation of digital transformation.

Besides, a control-oriented organisational culture often leads to highly mechanistic structures and simplified job roles with limited discretion for employees. This strong bureaucratic culture tends to discourage creative and ambitious employees, making it challenging for organisations to attract and retain such individuals (Uzkurt et al., 2013). Employees in such structures are often dissatisfied with their jobs and experience feelings of boredom, apathy, and alienation, leading to high turnover and absenteeism rates (Appelbaum and Grigore, 1997). Despite the potential increase in productivity and lower direct labour training costs, their emphasis on bureaucratic structures, efficiency-driven routines, and decentralised decision-making can limit opportunities for organisational learning (Appelbaum and Grigore, 1997) and hinder and firms' capability to deal with technological development uncertainties (Lewis and Boyer, 2002), which are critical to a successful digital transformation. Chu, Wang, and Lai (2019) also suggested that a control-oriented culture's emphasis on stability creates an environment that provides little to no motivation for employees to explore creative and innovative approaches to complete their tasks. Similarly, according to Büschgens, Bausch and Balkin (2013), Naranjo-Valencia, Jiménez-Jiménez and Sanz-Valle (2011) and Erez and Nouri (2010), a managerial approach driven by control causes employees to conform to explicit orders and rigid rules, which can hinder their willingness to explore creative and innovative solutions for daily operations and problem-solving. The underlying cause of this phenomenon is that control negatively affects employees' intrinsic motivation (McLean, 2005), which is essential for developing innovation expertise and creativity skills, as suggested by Amabile (1988).

In addition, a control-oriented culture can reduce the effectiveness of communication and collaboration between employees, which in turn affects the adoption of digital technology.

Research has shown that when an organisation has a high degree of control orientation, there is less open and active communication and interaction among employees and teams due to their strict adherence to defined plans and procedures (Liu et al., 2010; Pearsall, Ellis and Evans, 2008; Khazanchi et al., 2007; McLean, 2005). In the same line, Wiener, Gattringer and Strehl (2018) argued that this culture can lead to resistance, scepticism and disparagement towards external knowledge and ideas, make it challenging to integrate such knowledge into the innovation process. As emphasised by Szymańska (2016), a culture that supports the exchange of external knowledge and information should prioritise employee development, commitment, and participation, and be open to change, which contrasts with a control-oriented culture. In other words, from organisational aspect, the presence of control values will hinder employees' engagement in problem-solving, decision-making, and the pursuit of knowledge improvement and knowledge sharing, which consequently restrain the likelihood of digital technology implementation success.

Notably, when an organisational culture focuses on order, stability, rules, predictability, with the aims of achieving productivity and performance through the pursuit and attainment of well-defined objectives (Stock, McFadden and Gowen, 2007), its members tend to prioritise adhering to established routines and complying with traditional regulations and rules in their daily tasks (Shao, 2019). This can potentially create conflicts with the strategic leadership's efforts to encourage employees to embrace novel ideas, methods, or technologies. Additionally, managers in a control-oriented culture attempt to minimise disruptions in organisational operations (Quinn and Rohrbaugh, 1983), thereby might face limited freedom to act, struggle to receive adequate cooperation, and face challenges of securing necessary resources for their operations, compared to managers in flexible organisations (White, Varadarajan and Dacin, 2003). This culture can also impede independent involvement of top management in problem-solving and their pursuit of creative ideas, thus limiting their divergent thinking (Sarooghi, Libaers and Burkemper, 2015). As a result, top management support may be less effective in achieving strategic plans in organisations dominated by a control and stability-oriented culture (Johnson and Lederer, 2010). This is evident in a study conducted by Shao (2019) that control-oriented culture may even weaken the relationship between strategic leadership behaviours and Information Systems – Business Strategic Alignment. Based on this logic, it can be inferred that from organisational perspective, a control-oriented culture within an organisation may diminish the impact of top management support and knowledge in facilitating the adoption and implementation of digital technologies.

In general, a culture that prioritises control values tends to discourage firms from investing in organisational resources, inhibits employee engagement in the pursuit of knowledge and skills, and diminishes their receptiveness to change. Furthermore, it can also limit top management's understanding and support for digital transformation initiatives. Hence, it can be hypothesised that:

H5b: Control-oriented culture moderates the relationship between Organisational factor and the DSC adoption.

5.2.4.3. Organisational culture's moderating impact on the relationship between Environmental factor and SC4.0 adoption

Lastly, in the context of environment factors, since firms with flexibility-driven culture prioritise responsiveness and long-term growth (Khazanchi et al., 2007), they tend to be more sensitive to market pressure and uncertainties, taking proactive and timely measures to respond to the environment changes (Dai, Chan and Yee, 2018; Felipe, Roldán and Leal-Rodríguez, 2017; Wei, Samiee and Lee, 2014). To proactively adapt to emerging opportunities, they continuously reconfigure their internal strategy processes and resources which may take the form of introducing new products, services, or business models in response to shifting market demands (Teece, Peteraf and Leih, 2016), or making necessary changes to production lines based on customer feedback or market trends (Wu et al., 2019). In this sense, market pressure and volatility may provide strong incentives for firms with greater flexibility to take proactive measures compared to those with greater control (Chu, Wang and Lai, 2019), leading them to adopt digital technologies to differentiate themselves from their competitors. Additionally, according to Anning-Dorson (2021), Stock, McFadden and Gowen III (2007), Stock, McFadden and Gowen (2007), and White, Varadarajan and Dacin (2003), organisations with a strong flexibility orientation are inclined to leverage both internal and external resources to gain a competitive advantage and achieve growth, especially in a highly volatile environment. Therefore, firms with this type of culture may be better positioned to sense and seize market opportunities (Hossain and Kauranen, 2016), such as third-party support or government initiatives towards digital transformation. The focus of this culture on responsiveness, adaptability, and agility eventually enables organisations to successfully navigate turbulent market conditions, quickly adapt under environmental shifts, and remain competitive (Anning-Dorson, 2021). From an environmental perspective, flexibility-oriented culture can moderate the effects of market pressure and support on the firms' adoption of the digital transformation.

Furthermore, the emergence of Industry 4.0 is expected to have a transformative impact on the entire product lifecycle and cannot be attributed to a single company (Anand, Seetharaman and Maddulety, 2022). This necessitates collaboration between firms (Anand, Seetharaman and Maddulety, 2022; Arunachalam, Kumar and Kawalek, 2018; Korpela, Hallikas and Dahlberg, 2017; Yang and Fu, 2017). As claimed by Kittipanya-Ngam and Tan (2020) and Kiel et al. (2017), without the effort of both interfirm coordination, no matter how advanced the technologies are to support the supply chain operations, internal resistances are probable. To facilitate effective collaboration and communication, it is critical to establish an organisational structure that enables transparent communication, and facilitates data and knowledge sharing across organisations, and with external partners (Agrawal, Narain and Ullah, 2019). Therefore, an organisational structure that is suitable for enabling SC 4.0 should be characterised by agility, a horizontal orientation, and a loosely defined hierarchy (Veile et al., 2020; Patterson, Grimm and Corsi, 2003). Such structure would enable information transparency, smooth knowledge sharing, improved collaboration, and better and faster decision-making (Lamba and Singh, 2018). Flexibility orientation emphasises the values of decentralisation, less formality and more agility, allowing open communication and free exchange of knowledge across departments and company boundaries, which ultimately accelerate the learning processes, knowledge and information transfer, and decision-making (Veile et al., 2020). The adoption of a flexible managerial approach, as supported by Dastmalchian, Lee, and Ng (2000), can improve collaboration, teamwork, and communication. Therefore, from an environmental context, this approach can strengthen interfirm collaboration and communication towards the digital transformation of firms.

In summary, there has been substantial investigation into the moderating influence of a flexibility-oriented culture on the relationship between Environmental factor and DSC adoption in existing studies. Particularly, organisations that foster flexibility are more likely to confront heightened market pressures, leverage market support, and exhibit a greater inclination to collaborate with supply chain partners in support of a successful digital transformation. Drawing on these findings, it is possible to formulate the following hypothesis:

H6a: Flexibility-oriented culture moderates the relationship between Environmental factor and the DSC adoption.

On the contrary, despite the control-oriented culture’s focus on markets and customers, its emphasis on efficiency, stability, and authority can limit a firm’s ability to adapt to changes (Felipe, Roldán, and Leal-Rodríguez, 2017; Cao et al., 2015) and respond to environmental requirements in a timely and proactive manner, especially through innovation (Chu, Wang and Lai, 2019). Consequently, this lack of responsiveness may reduce the speed to market for innovation and discourage potential mechanisms such as customisation. Additionally, strict adherence to rules, stability, and specific procedures in a control-oriented culture may hamper firms from diffusing and leveraging technologies to obtain their benefits (Chu, Wang and Lai, 2019). Managers in strong control-oriented culture who accustomed to well-established bureaucratic systems, may encounter difficulties when trying to adapt to a competitive market that demands continuous adjustments to meet changing environmental requirements (Crocitto and Youssef, 2003). As a result, facing pressure and uncertainties from the market environment, firms with high control orientations may be less willing or able to undertake digital technology adoption to address such pressures and changes.

Furthermore, a control-oriented culture is also believed to reduce the effectiveness and openness of communication that extends beyond an organisation's boundaries, leading to challenges in conducting boundary-spanning activities and hindering interorganisational collaborations (Wu, Lin and Chen, 2013). For instance, a study by Wiener, Gattringer and Strehl (2018) also revealed that a corporate culture with a tendency towards stability and control, characterised by a dominant market culture and a distinct hierarchy culture, can impede the willingness to collaborate with external organisations. Therefore, from environmental perspective, control-oriented culture weakens the firms' responsiveness to market pressure, the inter-firm collaboration and communication towards the digital transformation implementation. Drawing upon the insights from this literature, it is possible to formulate the following hypotheses.

H6b: Control-oriented culture moderates the relationship between Environmental factor and the DSC adoption.

5.3. Summary

This chapter explained the rationale behind the hypotheses by drawing on the findings of the literature review on the determinant factors of SC 4.0 adoption and the impact of different organisational types on the relationship between those factors and the adoption decision (see chapter 4). To explain the adoption factors, the theoretical framework of Technology – Organisation – Environment (TOE) integrated with Interorganisational Relationship (IOR) (see Chapter 3) are employed. Furthermore, the Competing Values Framework (CVF) (see Chapter 3) is used to explain the moderating impacts of flexibility and control organisational cultures on digital technology adoption. In the following chapter, appropriate methods and techniques for investigating the suggested research framework and generated hypotheses are explored.

6. CHAPTER 6: METHODOLOGY

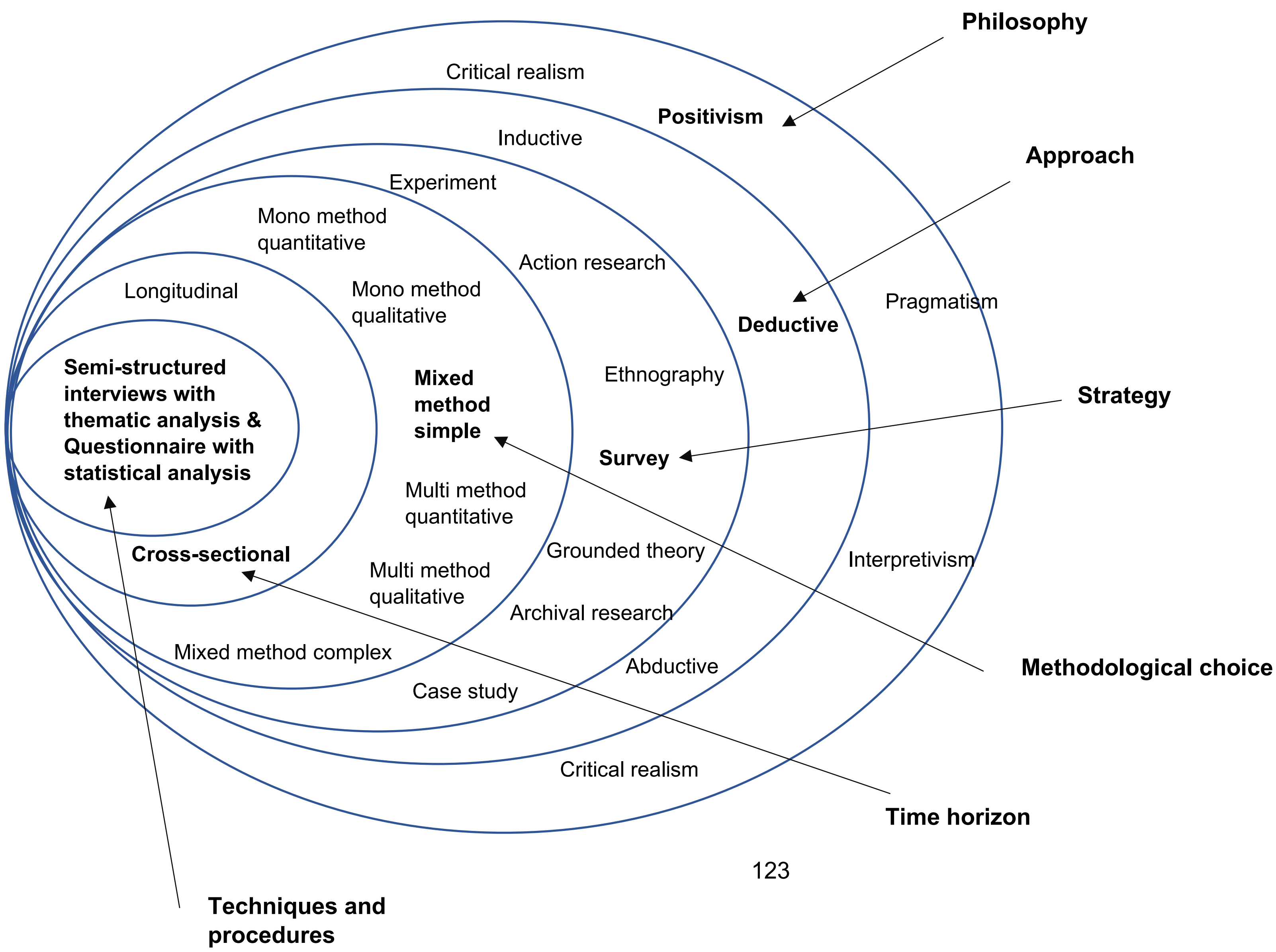
The aim of this research is to develop the SC 4.0 adoption model that is tailored for businesses in Vietnam. To achieve this purpose, an extensive literature review of technology acceptance models (Chapter 3) and SC 4.0 adoption determinants (Chapter 4) was conducted, which led to the development of a conceptual model. It was hypothesised that the adoption of DSC is determined by technological, organisational and environmental factors of DSC, which are moderated by different types of organisational culture (Chapter 5). To validate the hypotheses and appropriateness of the proposed conceptual model, it is essential to develop a well-designed research plan and appropriate data collection and analysis tools which shall be detailed in this chapter.

In recent years, DSC has gained significant acknowledgement from both practitioners and researchers (Oztemel and Gursev, 2020; Liao et al., 2017) who have employed a wide range of research methodologies to analyse the impact of Industry 4.0 on SC. It is widely believed that no single research methodology is inherently superior to others in addressing research problems as each methodology provides unique insights (El-Gohary, 2010). The choice of methodology depends on several factors, including the researcher views of the world (philosophy), research question(s) and objectives, research strategy, and research approach, which will then determine the appropriate methodological choice. Ultimately, the chosen methodology should be appropriate for the research questions and align with the researcher's epistemological and ontological assumptions. Thus, the methodology selected must be reflective of the research problem and context and should be carefully considered in order to ensure that it is the most appropriate methodological choice. Hence, this chapter outlines the development of research design and methodology, providing justification of the selected research methods. It explains how the research aim(s) and objectives were addressed and how research outcomes were obtained.

As summarised in Figure 6-1, a mixed-methods design that combines qualitative and quantitative research methods was employed to study the SC 4.0 implementation factors in Vietnam. Figure 6-1 provides a holistic overview of the research design, highlighting the selected choices that shape the direction of the study. The bold texts are the selected choices in the research. By incorporating these methodological decisions, the research aims to enhance the rigor and effectiveness of its investigation.

Drawing upon the positivists' philosophical stance of this research, the proposed research model was designed to be initially verified and confirmed through semi-structured interviews. The study then employed statistical analysis techniques, namely factor analysis, correlation analysis, and multiple regression, to examine and test the proposed model using empirical data gathered through a questionnaire survey. These analytical methods allow for a comprehensive evaluation of the relationships and patterns within the data, enabling a deeper understanding of the variables and their impact on the research model. To employ both qualitative and quantitative methods in the research, the Qual → QUAN by Creswell and Creswell (2017), Schoonenboom and Johnson (2017) and Hesse-Biber (2015), also known as “Initiation” design by Golicic and Davis (2012), where findings from the initial qualitative method is used to inform the main quantitative method.

Figure 6-1: Research onion of this research (Adapted from Saunders, Lewis and Thornhill, 2019).



6.1. Research Purpose

It is crucial to prepare a research design that can efficiently and effectively answer research questions while minimising expenditure of effort, time, and budget. However, the approach to achieving this goal depends mainly on the research purpose (Kothari, 2004). Researchers have identified three main purposes to research activities including exploratory, descriptive, and confirmatory (or theory testing or explanatory) research (Pinsonneault and Kraemer, 1993; Filippini, 1997). *Exploratory research*, taking place at the early stages of research into a new phenomenon, aims to gain preliminary insights about the topic and assess the phenomenon in a new light, which later provides a base for more in-depth surveys. This type of research helps discover new facets or provide evidence of relationships among the concepts of the phenomenon under investigation (Forza, 2002). Associated with these aims, literature research, in-depth interviews, focus groups and case studies are usually applied (Saunders, Lewis and Thornhill, 2019). Darabi (2007) claimed that exploratory research may develop hypotheses but not necessarily test them. Usually, there is no available model or framework, hence, the concepts need to be better understood and measured (Forza, 2002). Whereas *descriptive research* aims to understand and describe a certain phenomenon; therefore, although the obtained information can provide useful hints and insights for theory development and refinement, its primary aim is not to build and test theory (Malhotra and Grover, 1998; Wacker, 1998). *Confirmatory or explanatory research*, on the other hand, taking place at the stages in which knowledge about the phenomenon has been formulated into a theoretical form using well-defined concepts and models. The primary aim of explanatory research is to establish cause-effect relationships between variables, seeking explanatory answers (Creswell and Creswell, 2017). To achieve this aim, data is collected with the purpose of testing the adequacy of the concepts developed regarding the phenomenon, of hypothesised linkages among factors or concepts, and of the validity and reliability of the models. To gain a clearer understanding of the relationship, the collected data can be analysed using statistical tests, such as correlation analysis (Saunders, Lewis and Thornhill, 2019).

The purpose and questions of this research indicate that this study is mainly exploratory and explanatory. It means that the research is going to explore the phenomena and discover new facets that help to provide a foundation for the development of the survey; and seeking to establish and test the casual relationship between variables in the conceptual framework. In this study, the initial aim was to explore barriers and enablers of SC 4.0 application in the context of Vietnam which is the characteristic of an exploratory research. This is achieved through an extensive literature review and semi-structured interviews with the supply chain experts. Following this, the formulated theoretical framework with well-defined constructs along with hypotheses derived from the literature review and semi-structured interviews is then tested through empirical data obtained from questionnaire survey. This is indicative of explanatory research. Therefore, the study is a hybrid of exploratory and explanatory research, as it aims to gain a comprehensive understanding of the topic while also testing a formulated theoretical framework using empirical data.

6.2. Philosophy Underpinnings of This Research

When embarking on a research endeavour to answer the research questions, it is crucial to determine the philosophical position that will help clarify alternative research designs and methods. As claimed by Saunders, Lewis and Thornhill (2009), a philosophical position is a system of beliefs, assumptions and world views about the nature and development of knowledge. This position inevitably underpins a researcher's comprehension of their research questions, theoretical approach (inductive or deductive approach), methodological choice (qualitative, quantitative, or mixed methods), research strategy (case study, survey, ethnography, etc.), data collection methods (questionnaires, observation, interview, etc.), analysis procedures, and interpretation of the research findings (Gray, 2019; Saunders, Lewis and Thornhill, 2009; Crotty, 1998).

Researchers with unclear understanding of the philosophical underpinnings can risk making their study design and evaluation highly subjective (Baškarada and Koronios, 2018). It is therefore essential for researchers to have a clear understanding of their research philosophy. Their research philosophy is mainly shaped by their philosophical assumptions about the nature of realities, or the kind of world being investigated (ontological assumption), and how acceptable, valid, and legitimate knowledge can be constituted (epistemological assumption). Based on these assumptions, research philosophies can be classified into four main types which are compared based on ontology, epistemology, and its corresponding methodology, as explained in detail in Appendix C1.

In a constellation of worldviews that determines theoretical understanding of SCM research (Golicic, Davis and McCarthy, 2005), there have been four different philosophical paradigms that are favoured by researchers and practitioners, namely positivism, interpretivism or constructivism, realism, and pragmatism. Among these paradigms, positivism has been found to be the dominant philosophical assumptions used in SCM research topic, especially being published in the top North American journals (Flint et al., 2012; Golicic, Davis and McCarthy, 2005; Näslund, 2002). According to positivists' ontology, the world is objective and observable, and researchers are separated from the subject being researched. This dominance has led to the ontological assumption that “SCs are interorganisational forms that have identities independent of social entities, relations and practices that generated them” (Adamides, Papachristos and Pomonis, 2012, p. 907). According to positivism, there are casual relationships existing among supply chain identities despite of how people think of and label them. Therefore, law-like generalisations can be produced to explain and predict the behaviours within SCM context. The scientific background of positivism has benefited SCM research considerably by facilitating the development of generalised theory and knowledge (Mangan, Lalwani and Gardner, 2004). Positivist research philosophy often produces data generalisation through the deductive approach, which is the most suitable for developing a theoretical framework or formulating hypotheses based on literature and theories that are then tested with empirical data (Arlbjørn and Halldorsson, 2002). Hence, the principle of positivism is to test hypotheses.

As the consequence of evolving complexity and dynamics of the supply chain phenomena (Cannella et al., 2018), there has been a criticism towards SCM research for its predominant adoption of positivism perspective (Craighead et al., 2007; Näslund, 2002). It is claimed that this philosophy focuses on context and value-free generalisations (Ryan, 2018; Carcary, 2009), whereas the nature of today’s SCM is dynamic, value-laden and context-dependent (Pederneiras et al., 2022; Besiou and Van Wassenhove, 2015). Hence, there has been an increasing number of papers adopting non-positivism such as interpretivism, pragmatism, and critical realism. While non-positivism research typically focuses on “how” and “why” research questions, positivism research tends to focus on “what” questions. For this reason, positivism is still the dominant paradigm in SCM research that tends to be more quantitative in nature and style. Accordingly, given the nature of this research undertaken in the field of SCM, despite its criticism, the research embraces the philosophical movement of positivism to make objectivistic claims about the organisations as the researcher believes that the facts about organisations can be observed and tested empirically.

The present research reflects an ontological and epistemological stance of the researcher. From an ontological stance, researcher acknowledges the existence of a social reality and facts regarding the success factors and challenges of DSC, whether or not these factors can be observed, exists independently of and comprehended by the supply chain personnel. Therefore, from an epistemological aspect, these factors can be identified, and the casual relationships between these factors and firms’ DSC adoption decisions can be measured through scientific empirical testing and verification of hypotheses to provide facts, enabling the production of law-like generalisations. The research results are also expected to be generalised to developing countries. Despite employing mixed methods, the research is essentially grounded in a positivistic philosophy. It is argued that adopting a positivist philosophy does not necessarily restrict researchers to the exclusive use of quantitative methods (Saunders, Lewis and Thornhill, 2019). Thus, researchers who adopt a positivist' stance can still exercise a choice of mixed methods – combining quantitative and qualitative methods in their study as long as it they align with the researcher's research objectives and purpose. In this study, the qualitative method was employed to develop the quantitative study by exploring barrier and enabler factors that are not explicitly identified in existing literature. This approach aims to confirm the applicability of the proposed conceptual framework, derived from the literature review, in the context of Vietnam. While the focus is not on achieving an in-depth understanding of the phenomena under investigation (Voss, Tsikriktsis and Frohlich, 2002), this approach facilitates the development of a more comprehensive and robust quantitative study. Additionally, the qualitative approach can also be useful in guiding the design of the main survey by providing insights that validate the instruments utilised in the model (Boyer and Swink, 2008). The finalised questionnaire survey is then used to validate the hypotheses and the proposed conceptual framework of the research.

6.3. Research Theory and Design Overview

After the research purpose, scope and philosophical stance have been formulated, it is crucial to prepare the research design. A research design serves as a general plan or a framework of the research that specifies the sources of data collection and analysis, as well as addressing ethical issues and constraints faced by the researchers (Easterby-Smith, Thorpe and Jackson, 2012). The research design should be guided by the research question(s), objectives, and consistency with philosophical stand of the research (Bell, Bryman and Harley, 2022). The preparation of such a design ensures the research to be as efficient as possible and yield maximal output by taking account diverse aspects of the research problems that may arise during implementation (Sileyew, 2019). An impactful research design can minimise bias in data and improve the accuracy of collected data.

This research design for this study includes four essential components, including (1) the research approach, (2) research strategy that align with the research philosophy, (3) the methodological choice (qualitative, quantitative, or mixed methods) and (4) techniques and procedures (Saunders, Lewis and Thornhill, 2019). By carefully considering these elements, the research design can effectively guide the research process and provide valuable insights and meaningful findings. Each element is explained further below.

6.3.1. Research approach

The development of theories can be approached in three different ways: inductive, deductive, and abductive (Osman et al., 2018). In a deductive research approach, theories and hypotheses are formulated based on existing propositions, and the research strategy is designed to collect and analyse data to test these theories and hypotheses (Gregory and Muntermann, 2011). Hence, a deductive approach is usually associated with quantitative research that aims for data generalisation (Saunders, Lewis and Thornhill, 2019). According to Arlbjørn and Halldorsson (2002), the deductive approach is the most suitable for formulating hypotheses and testing their validity, making it a dominant approach in the natural sciences where arguments are based on widely accepted principles, laws or rules (Soiferman, 2010). SCM papers related to Industry 4.0 have been dominantly framed within deductive approach, primarily utilising quantitative research methods as data collection tools to test hypotheses and theories (Oncioiu et al, 2019; Haddud et al., 2017).

Whereas, in an inductive approach, the data is collected to gain a deeper understanding of an existing theoretical perspective or generate new theories related to the investigated phenomena (Kennedy and Thornberg, 2018). Hence, many qualitative research studies employ an inductive approach. However, it is notable that the choice of approach is not strictly limited to qualitative or quantitative nature of the research, but rather determined by the researcher's aim to either test or build theory (Creswell and Creswell, 2017). In essence, both quantitative and qualitative research can employ either a deductive or inductive approach depending on the researcher's aim.

As stated by Creswell and Clark (2017), researchers who follow a deductive approach typically work from a "top-down" perspective: starting with a theory and forming hypotheses, then collecting and analysing data to accept or reject the theory. In contrast, researchers who take an inductive approach work from a "bottom-up" perspective: using participant observations or in-depth interviews to build understanding and generate theories. Therefore, the deductive approach is commonly associated with positivism philosophy, which emphasises empirical evidence and objective truth, while the inductive approach is often favored by interpretivism, which focuses on the subjective experiences and meanings of individuals (Saunders, Lewis and Thornhill, 2019).

The abductive approach, in contrast to the conventional approaches of either moving from theory to data (deduction) or from data to theory (induction), involves a dynamic interplay between deduction and induction (Suddaby, 2006). This approach starts with the observation of a "surprising fact" and then seeks to identify a plausible theory to explain it. Through careful observation, researchers collect sufficiently detailed data to explore the phenomenon and identify emerging themes and patterns. These themes and patterns are subsequently integrated into an overall conceptual framework, thereby building a theory (Saunders, Lewis and Thornhill, 2019). The conceptual framework, along with the theory, is then tested with empirical data and if necessary, revised to ensure their accuracy and validity.

In this study, the deductive approach was adopted to guide a systematic process of idea generation due to the following reasons. This research design commenced with an extensive literature review and established theories aimed to generate hypotheses and develop a theoretical framework which, according to Saunders, Lewis and Thornhill (2019) and Spens and Kovács (2006), is the principle of deductive approach. Subsequently, semi-structured interviews were conducted. Unlike an inductive or abductive approach, which typically employs in-depth interviews to generate theories, the qualitative aspect of this research was developed based on identified themes and a research model derived from the literature review. Given that the majority of research in the field of Industry 4.0 and DSC is predominantly conducted in developed countries (Gress and Kalafsky, 2015; Bhasin and Bodla, 2014), it is plausible that existing adoption models are more directly applicable within the context of developed countries and may not fully address the unique conditions of developing countries, such as Vietnam. Thus, the results obtained from both literature review and semi-structured interviews helped to confirm the applicability of the framework and provide the context for the subsequent main quantitative study, including the development of indicators to define the constructs in the research model. Ultimately, the predominant method of this study is the quantitative, with the aim of testing the hypotheses and proposed research model, and generalising the findings.

6.3.2. Research strategy

Research strategy is a crucial plan developed by researchers to answer the research question(s). According to Al-Ababneh (2020) and Denzin and Lincoln (1995), it serves as a methodological bridge between the chosen philosophy and subsequent choice of research methods for data collection and analysis. There is no particular research strategy that is superior or inferior to any other strategies. Rather, the chosen research strategy should help researchers to achieve a level of coherence throughout their research design, allowing researchers to answer the research question(s) and meet the research objectives (Saunders, Lewis and Thornhill, 2019). In essence, the research strategy should be guided by the research question(s) and objectives, research philosophy and research approach, amount of available time and resources, as well as access to data sources and participants.

After conducting a comprehensive review of the existing literature on DSC, it has been observed that researchers employ various research strategies to investigate the subject. These strategies include experiment/simulation and mathematical modelling, survey research, case study analysis, ethnography, and action research which can be further explained in Appendix C2. Particularly, case study has been extensively used in SCM research (Xu et al., 2022; Alsharidah and Alazzawi, 2020; Anitha and Patil, 2018). In the field of DSC, case study strategy has been employed in various studies, such as the research by Tsolakis et al. (2021) in exploring Blockchain implementation in Thai fish Industry; Alsharidah and Alazzawi (2020) in investigating AI and DSC transformation; or Tönnissen and Teuteberg (2020) in analysing the impacts of Blockchain on operations and SCM. Nevertheless, criticisms have been raised about the ability of case study research to provide a basis for scientific generalisation, reliability, and theoretical contributions to knowledge due to its extensive focus on a particular situation (Saunders, Lewis and Thornhill, 2019; Yin, 1994). Additionally, case study research can be more time, labour and cost-intensive than survey methods (Daniels and Cannice, 2004; Voss, Tsikriktsis and Frohlich, 2002; Nieto and Pérez, 2000; and Schell, 1992) and considered as a risky research method (Yin, 2003). Moreover, the use of mathematical modelling has also increased in recent years (Rahmanzadeh, Pishvaee and Govindan, 2022; Alkahtani et al., 2021; Handanga, Bernardino and Pedrosa, 2021). Whereas ethnography and action research are not favoured by SCM field (Marshall, Metters and Pagell, 2016; Seuring, 2011). Of all the research strategies, survey research has been the most widely used in SCM, (Soni and Kodali, 2012; Kotzab, 2005; Rungtusanatham et al., 2003), especially with almost half of empirical research in DSC employing this strategy (Iddris, 2018).

In this study, survey strategy was employed for several reasons. Firstly, according to Yin (1994), the appropriately selected research strategy should align with type of research questions and objectives, extent of researcher's control over the behavioural events, and the degree of emphasis on the contemporary events against historical events (see Appendix C2). This study's research questions start with "what": "*What are the enablers and barriers of SC 4.0 adoption for firms in Vietnam?*" and "*What is the role of organisational culture in SC 4.0 adoption for firms in Vietnam?*". The study aims to focus on contemporary events, which are the current barriers and enablers of such adoption, and the researcher has no control over the event. Hence, the survey research is an appropriate strategy. In addition to the research questions and objectives, the philosophy and research approach, the amount of time and resources available, and access to data also shape the research strategy. Regarding the research philosophy and research approach, this study adopted the positivist perspective and deductive approach, with the primary aim of testing hypotheses and theoretical models and examining relationships among variables. According to Al-Ababneh (2020), Iddris, (2018), Ivanov et al. (2018), Creswell and Poth (2016), Khan, Liang and Shahzad (2014), Boyer and

Swink (2008), and Cecez-Kecmanovic (2005), survey strategy is considered particularly effective for testing theories and hypotheses. Data collected from a survey strategy can be used to suggest possible reasons for relationships between variables and build a model of these relationships. Thus, this study employed the survey research strategy as it enables standardised information to describe variables and examine their relationships (Malhotra and Grover, 1998), which is the primary objective of this study. In terms of time and resources commitment, due to the limited availability of time and resources, it is inappropriate to undertake any time-consuming and resource-intensive strategies such as action research and ethnography (Simmons and Smith, 2019; Tomal, 2010; Simonsen, 2009; Jeffrey and Troman, 2004). Therefore, the survey strategy is appropriate for this research due to its convenience, cost-effectiveness, and ability to produce generalisable and reliable results (Safdar et al., 2016). Additionally, in support of the survey strategy, a wide range of papers has utilised it to study various aspects of DSC. For instance, Kalaitzi and Tsolakis (2022) employed a questionnaire-based survey strategy to identify the determinants and impacts of supply chain analytics adoption while Mitra, Kapoor, and Gupta (2022) used the survey strategy to study the key antecedents of digital technologies in supply chain in the context of India. Wamba, Queiroz and Trinchera (2020), on the other hand, adopted the survey to examine the opinions of supply chain practitioners about the adoption of blockchain in SC. Therefore, given the requirements of this research and advantages of the survey strategy in addressing the research problems, it has been identified as the most suitable approach out of the available research strategies.

6.3.3. Research methods

When designing a research strategy, it is crucial to achieve methodological coherence by selecting an appropriate research design that can either be quantitative, qualitative or mixed methods (Creswell and Creswell, 2017). The traditional view is that quantitative methods are typically associated with the positivist paradigm, while qualitative methods are more related to interpretivism (Howe, 1988). However, various scholars have argued that methods are not inherently interlinked with paradigms (Azorín and Cameron, 2010; Sandelowski, 2000; Greene, Caracelli and Graham, 1989; Reichardt and Cook, 1980) and can be used independently of epistemological and ontological assumptions (Bell, Bryman and Harley, 2022). The suitability of each method depends on the research circumstances, nature of the research problem, or the identified research gap that the research aims to address (Kivunja and Kuyini, 2017). As previously stated, this research involved the combination of both qualitative and quantitative studies, also known as a mixed methods approach. The choice of mixed methods is further explained below.

(1) Quantitative research designs

Quantitative research works with numeric data and is usually associated with quantitative data collection methods such as questionnaire where large samples of empirical data are obtained to test theories, generate “regularities” data, and develop research models (Boyer and Swink, 2008; Sachan and Datta, 2005; Squire et al., 2006; van Hoek et al., 2005). Quantitative researchers aim to examine the relationships between variables which can be measured numerically, using a range of statistical and experimental techniques (Fischer, Boone and Neumann, 2023; Saunders, Lewis and Thornhill, 2019; Antwi and Hamza, 2015; Walker, 2005). By doing so, researchers can gain insights into how different variables interact and influence each other, which can inform the development of theories, models, and predictions. Furthermore, through rigorous analysis of empirical data, quantitative research can uncover patterns and trends that might not be immediately obvious (Albers, 2017; Goertzen, 2017). Thus, positivists often employ quantitative research design with a deductive approach (Ryan, 2018; Knox, 2003). Although quantitative research methods allow generalisation of consistent, precise and reliable data (Yilmaz, 2013; Newman, Benz and Ridenour, 1998), the design also contains some limitations such as difficulties of addressing complex issues, restricted access to the data, or challenges to understand the context of the investigated phenomenon (Goertzen, 2017).

(2) Qualitative research designs

Qualitative research, on the other hand, involves working with non-numeric data such as words, images, and video clips. It is often coupled with qualitative data collection techniques such as interviews, observations or focus groups, and data analysis procedure such as content analysis that can produce non-numerical data (Saunders, Lewis and Thornhill, 2019). Compared with quantitative research, data obtained from qualitative methods is less generalisable but provides more in-depth insights about the context, offering more details to explain the complex issues or gathering data on sensitive subjects (Richard, 2013. As such, it is usually used by interpretivists who seek to gain deep understanding of individuals’ experiences, meanings, motives, beliefs, values and attitudes, as well as the phenomena being studied to uncover the underlying realities of the social world rather than relying on numbers or statistics (Alharahsheh and Pius, 2020; Thanh and Thanh, 2015; Maxwell, 2012). However, qualitative methods can also be used in positivists’ research as a complement to quantitative methods (Sale, Lohfeld and Brazil, 2002). As Michell (2003, p.5) states “positivism is no barrier to qualitative methods", and Su (2018, p.18) suggests that "the positivist paradigm and qualitative methods can coexist in harmony".

(3) Mixed methods

In recent years, there has been a growing interest among scholars in utilising both qualitative and quantitative methods to study the same phenomenon, commonly referred to as mixed methods research. In essence, mixed methods research is where researcher collects and analyses data, integrate the findings and draws conclusions from both qualitative and quantitative methods or approaches in a single study (Tashakkori and Creswell, 2007). This approach acknowledges that both methods have its own strengths and limitations and that employing them together can provide a more comprehensive understanding of complex research problems (Almalki, 2016; Clark, 2019; Johnson, Onwuegbuzie and Turner, 2007) that cannot be fully addressed by one methodology alone (Creswell and Clark, 2017). The integration of these methods can also help to triangulate the results, enhance the validity and reliability of the findings, and provide a more detailed and nuanced interpretation of the data (Fetters, Curry and Creswell, 2013; Abowitz and Toole, 2010).

According to Seymour (2012), the combination of both qualitative and quantitative methods and the degree of integration depend on the research objectives and the nature of the phenomenon being studied. The ways in which these methods are combined can take various forms, ranging from simple and concurrent to more complex and sequential designs (Saunders, Lewis and Thornhill, 2019) or even integrated form (Farquhar, Ewing and Booth, 2011). Additionally, according to Morgan and Hoffman (2021), Creswell and Creswell (2017) and Bronstein and Kovacs (2013), one method is often weighted more heavily or more dominant than the other. By choosing the most appropriate form of integration, researchers can ensure that their mixed methods approach enhances the strengths of both qualitative and quantitative methods and leads to a more comprehensive understanding of the research problems.

A concurrent mixed methods research design involves running both quantitative and qualitative studies simultaneously within a single phase of data collection and analysis (Saunders, Lewis and Thornhill, 2019; Seymour, 2012). For example, within a research interview, the participants are invited to explain their responses to multiple-choice questions in an open-ended manner. Similar to concurrent mixed methods research, integrated mixed methods research, on the other hand, pose some differences. As stated by Farquhar, Ewing and Booth (2011), integrated mixed methods research involves employing both qualitative and quantitative methods equally and in parallel. Unlike concurrent mixed methods, where both data types are obtained from the same participants or source, integrated mixed methods employ different participants or sources for each method (Saunders, Lewis and Thornhill, 2019). Studies that fall into this category are relatively rare due to the time and cost intensity of conducting both types of research, as well as limited data access (Seymour, 2012). Meanwhile, sequential mixed methods research involves more than one phase of data collection and analysis, wherein different methods are employed in succession within the study to expand or elaborate on the initial set of findings, for example quantitative followed by qualitative and vice versa, either within the same sample or different samples (Seymour, 2012). According to Saunders, Lewis and Thornhill (2019), there are two main designs of sequential mixed methods. Different ways of blending two methods, indicating which method is dominant, are explained in Appendix C3.

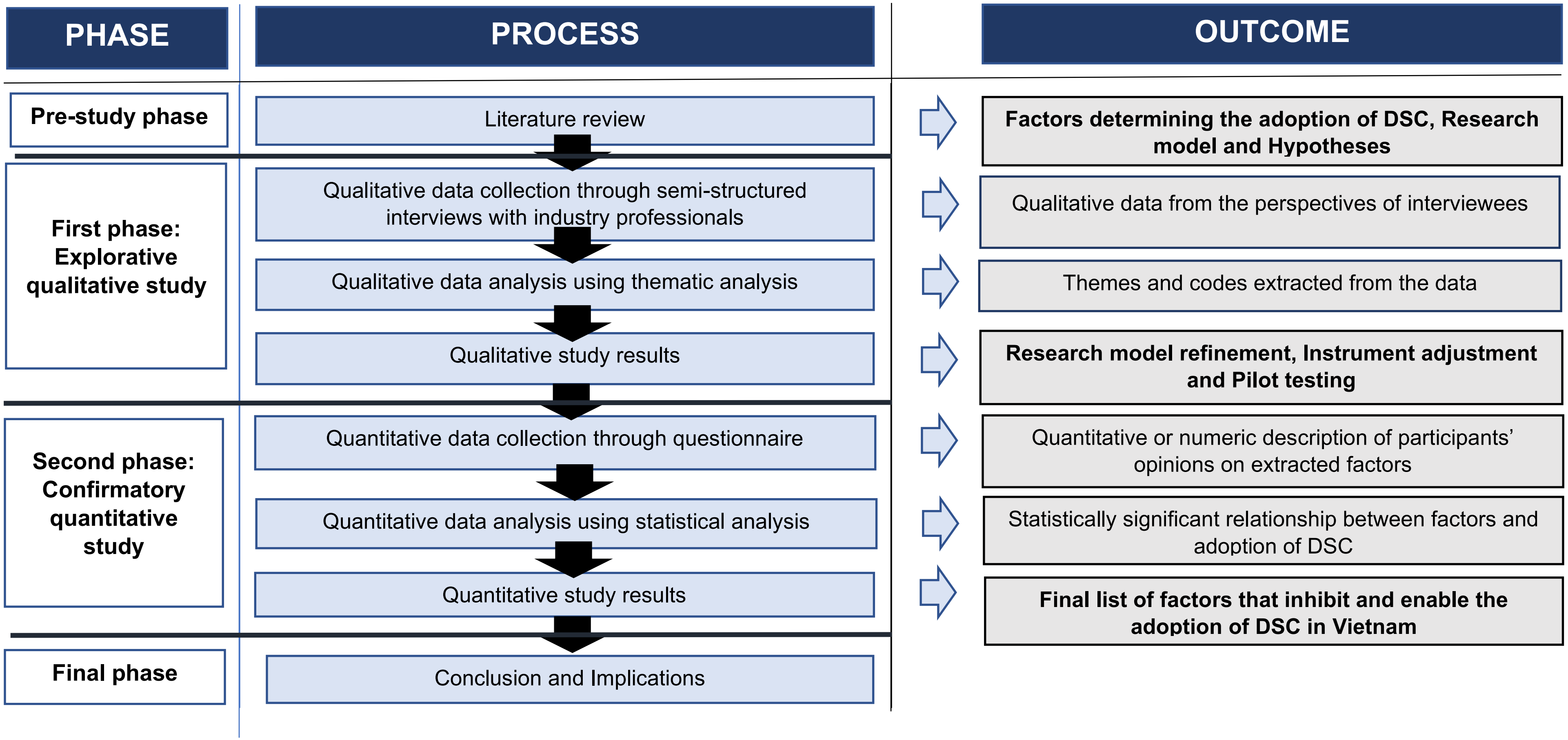
Although the philosophical assumptions inform methodological choice (Coates, 2021), an appropriate methodological approach is not based on the primacy of research traditions applied, researcher's skillset or authority over the research outcomes. Rather, the chosen approach should prioritise the research's purpose and the philosophical realm that best aligns with the issue under investigation (Holden and Lynch, 2004). As claimed by Creswell (2009), Giddings and Grant (2006) and Teddlie and Tashakkori (2003), the combination of quantitative and qualitative methods can be adopted within any research philosophy. Therefore, while the positivism is the philosophy of this research, mixed methods that combine the qualitative and quantitative studies or Qual → QUAN (Morgan and Hoffman, 2021; Creswell and Creswell, 2017) were employed.

According to Boyer and Swink (2008), Carter and Rogers (2008), Batenburg (2007), and Gorard and Taylor (2004), given the limitations and weaknesses of qualitative and quantitative methods, this methodological integration can add reliability and depth to the research data, cross-validate results of a particular method and therefore, yield more coherent, rigorous and multi-dimensional insights than using a single research methodology. Thus, the mixed perspectives have been suggested to enhance the validity and reliability of the research (Patton, 2002) as well as maximise its knowledge yield (McCall and Bobko, 1990), particularly in complex and dynamic SCM problems (Gorard and Taylor, 2004). Especially, this approach can be valuable when there is a requirement to explore, verify and generate theories simultaneously, and when either qualitative or quantitative approaches alone appear insufficient to handle the intricacies of the research questions and subjects (Creswell, 2009; Gorard and Taylor, 2004). Therefore, research methods are often more powerful when used in combination rather than in isolation.

This research aims to explore the critical and unknown factors that are not identified in the Vietnamese context as well as to verify the conceptual framework and hypotheses withdrawn from the literature review. Among different types of mixed methods, the research design for this study follows a sequential explanatory mixed methods approach, with a small qualitative study conducted in the first phase followed by a larger quantitative study in the second phase. This type of design is commonly referred to as *less dominant – dominant* research design or illustrated as Qual → QUAN by Creswell (2017), Schoonenboom and Johnson (2017) and Hesse-Biber (2015). As mentioned above, although both qualitative and quantitative methods were employed, the emphasis was placed on the quantitative study, with the qualitative data collected through semi-structured interviews serving as a complementary component. This qualitative data was used to identify the unknown factors and the types of questions that might be asked, determine items/ variables/ scales for instrument design, and generate theories or classifications of factors (Creswell and Clark, 2017).

During the pre-study phase, a conceptual framework was developed and key determinants of DSC adoption were identified based on the literature review. This is followed by the first phase where the applicability of conceptual framework was explored and confirmed through the semi-structured interviews. These qualitative methods were utilised to facilitate the development of hypotheses and measurement scales as well as provide context to the quantitative results (De Beuckelaer and Wagner, 2007). In second phase, the proposed hypotheses and conceptual framework were tested through a quantitative method with the questionnaires as the data collection tool to obtain the data from a large sample. The flow of this sequential exploratory study is illustrated in the Figure 6-2.

Figure 6-2: An exploratory sequential design for identifying barriers and enablers of DSC adoption (Adapted from Nabi-Meybodi and Alidousti, 2015).



6.3.4. Data Collection and Analysis Techniques

The study uses theories, data and methodological mix to ensure the research validation and robustness (Boyer and Swink, 2008; Singhal et al., 2008). As stated above, to answer the research questions, the study used both qualitative and quantitative methods. Research methods help to translate the research design into practice. The following section explains how the research methods are undertaken in this study, including the way to collect data, analyse data and interpret the results in achieving the research aims. Particularly, in this sequential exploratory study, the 1st phase data (qualitative data) using semi-structured interviews is followed by the 2nd phase data (quantitative data) using questionnaires with the analysis of the 1st phase leading the 2nd phase data analysis.

6.3.4.1. Stage 1: Qualitative study

(1) Qualitative data collection method - Semi-structured interviews

The research interview is regarded as one of the most essential qualitative data collection methods and has gained widespread recognition in the realm of field studies (Qu and Dumay, 2011; Griffee, 2005). It offers researchers a valuable opportunity to gather in-depth and context-rich accounts of participants' experiences (Schultze and Avital, 2011). Even in quantitative studies where it may not serve as the primary data collection method, interviews are frequently employed as a pilot study to gather preliminary insights before designing surveys (Qu and Dumay, 2011). To serve different research needs, there are three interview formats available: structured, unstructured, and semi-structured interviews (Doody and Noonan, 2013).

Structured interviews involve predetermined standardised questions, typically in a specific order with consistent wording (Corbetta, 2003). This approach aims for concise responses, often within predefined response categories (Qu and Dumay, 2011). While structured interviews offer advantages such as time efficiency, reduced researcher subjectivity and bias, easier data analysis, and increased generalisability of findings (Holloway and Galvin, 2016), they leave no room for elaboration, rich detail, or adaptability to interviewees' backgrounds (Berg and Lune, 2017; Doyle, 2004). They are useful for large-scale interview studies within a limited time frame (Patton, 2002) or for topics with well-established literature. For SC 4.0 adoption, due to the limited research exists in developing countries and adoption determinants that are mainly studied in developed nations, structured interviews may not be suitable for data collection in this context.

The unstructured interview approach, unlike structured interviews, starts with an open-ended question and builds follow-up questions based on interviewees' responses (Holloway and Galvin, 2016; Qu and Dumay, 2011). It lacks specific guidelines predetermined questions, or predefined options (Easwaramoorthy and Zarinpoush, 2006). Instead, it adapts to the individual situation and interview context (Hannabuss, 1996), using probing questions to gather in-depth information on the topic. While offering flexibility and in-depth data (Ryan, Coughlan, and Cronin, 2009), it is susceptible to bias, poses data analysis challenges, and can be time-consuming. Unstructured interviews are commonly useful for obtaining narratives behind the interviewees' experiences, exploring unknown topics, or collecting background data (Ryan, Coughlan and Cronin, 2009; Easwaramoorthy and Zarinpoush, 2006). In this research, we aim to identify critical and unknown factors for refining the literature-derived conceptual framework and developing a measurement instrument, not to gain in-depth knowledge about the research topic or understand the stories behind the interviewees' experiences. Thus, unstructured interviews are inappropriate for this study.

The type of interview most used in qualitative research is semi-structured interview (Jamshed, 2014; Longhurst, 2003; Alvesson and Deetz, 2000) that combines elements of both structured and unstructured interviews. In semi-structured interviews, researchers predetermine the broad themes to be covered and the main questions to be asked, providing a framework for the conversation while allowing for flexibility during the interview (Qu and Dumay, 2011; Drever, 1995). This approach encourages a conversational atmosphere where participants have the freedom to explore important issues (Longhurst, 2003). Hence, the pre-determined, semi-standardised structure enables the interviews to be performed in an explanatory manner (Næss, 2018), allowing various themes and sub-topics to emerge naturally during the discussion (Harvey-Jordan and Long, 2001). Researchers can also have greater flexibility to choose the topics to be discussed in response to the interviewee's answer and adapt the interview style, pace, and question ordering to evoke the fullest responses from interviewees. As supported by Corbin and Strauss (2014) and Qu and Dumay (2011), semi-structured interviews have gained popularity due to their ability to draw perspectives from participants, provide further insights, and uncover important and often hidden aspects of human and organisational behaviour (Corbin and Strauss, 2014; Qu and Dumay, 2011). Therefore, the semi-structured interview is widely recognised as the most effective and convenient method for gathering information and exploring interviewees' perceptions, experiences, and attitudes on the topic (Jamshed, 2014; Kvale and Brinkmann, 2009; Harvey-

Jordan and Long, 2001). As highlighted by Qu and Dumay (2011), the underlying assumption of the semi-structured interview is that the questions must be understandable to the interviewee, while simultaneously allowing the interviewer to respond sensitively to the differences in how interviewees perceive the world.

Considering the broad and underdeveloped nature of the concepts of Industry 4.0 and SC 4.0 (Ghobakhloo, 2020A; Posada et al., 2015), especially in developing countries, interviewees may have varying levels of understanding and exposure depending on their roles, positions, and technical knowledge. Hence, by employing semi-structured interview, researchers have flexibility to adapt the style, wording, and order of questions to accommodate interviewees' knowledge and responses. Additionally, new factors related to SC 4.0 adoption may emerge during the interview, which were not initially identified through the literature review. Furthermore, since there is a need for the research to explore Vietnamese organisations' understanding of Industry 4.0 and its application in SCM, and for researcher to familiarise with the current industry practices, it is crucial to conduct semi-structured interviews. This approach allows the research to explore diverse understandings of the concepts among Vietnamese and gains valuable insights into firms' perspectives on the SC 4.0 adoption. Since semi-structured interviews offer more freedom in responses rather than being framed into predetermined survey questions, critical insights about SC 4.0 in the Vietnamese Industry environment can be revealed. Additionally, they provide contextual information to complement the findings from the survey (Fawcett and Magnan, 2002). Considering these reasons, the semi-structured interview method is deemed the most suitable approach for the qualitative study.

The aims of the exploratory semi-structured interviews with industry professionals are to delve into firms' understanding of Industry 4.0 and its application in SCM, as well as gather insights on their viewpoints regarding determinants influencing their firms' adoption of SC 4.0. The interview questions centre on the challenges and enablers of firms' DSC adoption from technological, organisational, and environmental perspectives. The interview results hold practical significance as they represent the collective input of various organisations operating in the SC, including but not limited to manufacturing, logistics and transportation, and government entities. By seeking participation from a broad cross-section of interviewees across various organisations and industries, the study aims to capture a wide spectrum of perspectives, enriching its findings. To ensure consistency and effectively gather the desired information, a well-designed interview guide was used as a framework for the interviews. However, interviewees were encouraged to freely discuss topics they consider important and relevant to the subject matter.

(2) Interview guide development

The interview guide played a crucial role in structuring the interview questions, addressing potential challenges such as complex questions and sensitive topics (Larkin, Flowers, and Smith, 2021). It was further refined through discussions with supervisors to enhance its quality and then shared with potential interviewees to gauge their level of interest and ensure their enthusiastic participation in the interviews. The interview guide comprises a set of core questions and key areas that need to be addressed during the interviews, aligning them with the research questions, aims, and objectives (Bell, Bryman, and Harley, 2022; Taylor, 2005). While the guide provides a focused structure for the interview discussions, it is important to note that it should not be strictly followed or limited to a predetermined sequence or wording of questions (Kallio et al., 2016). Instead, the goal is to explore the research area by collecting similar types of information from each participant (Holloway and Galvin, 2016), while offering participants guidance on relevant topics to discuss (Gill et al., 2008).

As the research's primary data collection objectives are to explore Vietnamese firms' understanding of Industry 4.0 and its application in their SCM; identify the current determinants that influence the adoption decision of SC 4.0 for firms in Vietnam; investigate types of organisational culture embedded in Vietnamese firms; and investigate how different types of organisational culture influence SC 4.0 decision adoption of Vietnamese firms, the interview guide includes four main parts. They aim at exploring the participants' perspectives on Industry 4.0, its application in supply chain activities, barriers and enablers to adoption, and the impact of organisational culture on the adoption of digital technologies (See Appendix D1. Part 1 (Interview introduction) aimed to remind and provide the interviewees with the direction of the interview as well establish a sense of trust and rapport. Part 2 – (Interviewees' information) aimed to explore the interviewee's position and specific responsibilities within the organisation, and years of experience in the industry and the organisation; sector/industry, size and location of their organisation that aim to understand the specific context of their work and experience. Part 3 – (Understanding of Industry 4.0 and digital transformation) investigated the interviewees' comprehension of the concepts and its applications in their organisation and industries. Part 4 – (Technological, organisational, and environmental enablers and barriers enablers, barriers, and organisational culture) focused on exploring the interviewee's perception of the various enablers and barriers that influence digital technology adoption. Special emphasis is placed on the role of organisational culture. Overall, these interview sections aim to provide a comprehensive understanding of the interviewee's position, their organisation's digital transformation level, and the key enablers and barriers they have encountered.

(3) Sampling strategies and sample

Sampling strategy or sampling method for a qualitative study is a process to select participants or cases that can provide rich and meaningful data to answer research questions (Ritchie, Lewis and Elam, 2013). It involves various considerations, including the choice between probability and non-probability sampling methods, determination of an appropriate sample size, and the specific individuals or target population to be included in the sample.

The target population refers to the entire group of individuals or units that the research aims to study, draw conclusions about, or generalise the findings (Casteel and Bridier, 2021; Barnsbee et al., 2018). For the semi-structured interviews, the target population consisted of industry professionals holding management positions in supply chain firms, including manufacturers, distributors, logistics providers, etc. Additionally, experts and managers from organisations closely associated with Vietnamese firms, such as consultancy firms and government entities, were included in the interviews. The target population for interviews categorised into two primary groups can be further explained below:

(i) Managers from SC companies: This group comprises individuals in managerial positions within SC-related companies, such as materials/parts suppliers, manufacturers, logistics providers, distributors, retailers, and wholesalers. The companies represented range from small and medium-sized enterprises (SMEs) to large corporations, encompassing both state-owned and privately owned firms, as well as local and foreign businesses. It is noteworthy that the research does not impose any restrictions on the selection of SC companies based on their digital transformation status. Whether a company has already embarked on its digital transformation journey or is yet to initiate the process, both types of companies were considered eligible for inclusion in the study. The focus of the selection criteria for SC companies was primarily on the qualifications of the managers representing those companies, rather than their specific digital transformation efforts. The criteria for selecting managers from these companies were based on their management level, technological expertise, and involvement in SC activities. To represent their respective companies, managers need to possess a minimum of three years of management experience and hold at least a junior management position (e.g., supervisor or assistant manager). Furthermore, it was also crucial that they actively participate in the daily decision-making process and strategic development of their organisations. Eligibility also extended to those who had expertise and direct involvement in operational activities such as manufacturing, processing, distribution, logistics, etc. as well as those engaged in the applications and development of innovations within these activities. In essence, the ideal interview candidates were experts or managers well-versed in innovation adoption and SC activities.

(ii) Experts and managers from affiliated organisations: To gain a comprehensive understanding of the research topic, the inclusion of participants who actively engage with SC firms through their roles was essential. Consequently, the second group comprised experts and managers from organisations closely associated with Vietnamese firms, including government entities, consultant firms, and technology providers. Drawing on their extensive experience working with diverse businesses across various industries, these individuals can offer valuable insights into the current state of digital technology adoption and digital transformation among firms in Vietnam.

The selection criteria for experts and managers from organisations working closely with firms were based on their management level, level of engagement with Vietnamese firms, and their understanding of firms' digital transformation challenges and incentives. The experts were required to have experience working closely with industry firms, specifically in strategic development or in roles responsible for supporting organisations in operational activities such as the supply of technologies, funding, and policy implementation.

a. Sampling methods

Sampling methods can be broadly categorised into two main types: *probability* and *non-probability* samples. *Probability sampling* is a sampling technique where all units in the population have positive probabilities of inclusion (Vehovar, Toepoel and Steinmetz, 2016; Schreuder, Gregoire and Weyer, 2001). This ensures that the sample is representative of the population, allowing researchers to estimate uncertainty levels and generalise findings to the target population. *Probability sampling* techniques include simple random sampling, systematic random sampling, stratified random sampling, cluster sampling, etc. (Acharya et al., 2013). On the other hand, *non-probability sampling* is a method where the probability of including a particular member of the population in the sample is unknown. In essence, it is a non-random sampling technique in which the researcher selects participants based on their subjective judgment rather than following a random selection process (Sharma, 2017). *Non-probability sampling* technique includes purposive sampling, convenience sampling, snowball sampling, quota sampling, etc. (Acharya et al., 2013).

For stage 1 of this research – qualitative study, *non-probability sampling techniques,* particularly convenience, snowball, and purposive sampling were utilised. According to Higginbottom (2004), Marshall (1996), Luborsky and Rubinstein (1995), probability sampling techniques are typically not applicable to qualitative research, as the focus is on understanding the complexities and nuances of a phenomenon rather than generalising findings to a larger population. Therefore, qualitative research often employs non-probability sampling techniques to provide valuable insights into the studied phenomenon (Higginbottom, 2004). The non-probability techniques utilised in this study, including sampling convenience, snowball and purposive sampling are further explained below.

Convenience sampling is a prevailing non-probability approach (Vehovar, Toepoel and Steinmetz, 2016; Acharya et al., 2013), involving the selection of the most easily accessible subjects based on the convenience of the researcher (Marshall, 1996). This method is often employed when the primary focus is on the ease of data collection and the feasibility of reaching potential participants. While convenience sampling may not guarantee a representative sample of the population, it can provide valuable insights and serve as a practical choice when time and resource constraints are a consideration. In this research, convenience sampling was employed where potential interviewees were contacted through the researcher's personal contact and social networks, including platforms like LinkedIn and Facebook, to compile an initial list of individuals. Additionally, the names and contact of interviewees were identified through their media exposure in press articles or publications. Among these social media platforms, LinkedIn proved to be the most efficient platform for connecting with potential interviewees. The researcher initiated contact through introductory emails and messages on LinkedIn, ensuring in-depth discussions with potential interviewees to explore their career background, understanding of digital transformation, and daily responsibilities. This process, beyond relying solely on LinkedIn profiles, ensured criteria met and built trust between the researcher and participants. For interested and eligible participants, an email was sent containing a Participant Information Sheet and Consent Form (see Appendix D2), outlining research purpose, confidentiality, participant rights, and contact details. The Consent Form required acknowledgment through a signature, fostering a transparent and secure environment for comfortable and valuable information sharing during interviews.

Meanwhile, *snowball sampling*, also known as chain sampling, is the most used method for identifying information-rich key informants (Shaheen and Pradhan, 2019). It involves gathering information about additional *information-rich cases* in the field (Suri, 2011) through initial respondents who are selected (Acharya et al., 2013). Snowball sampling is particularly useful when accessing certain communities or individuals is challenging, as it relies on referrals and networks to expand the sample size. By leveraging existing connections and referrals from initial participants, researchers can gain access to individuals who possess unique insights or belong to hard-to-reach populations, thus enriching the research data and expanding the scope of the study. In this research, additional participants for interviews and questionnaires were identified through referrals from previous participants. Considering the advantages of snowball and convenience sampling methods, such as convenience, cost-effectiveness, and time efficiency, they are well-suited for this research, which aims to explore firms' DSC adoption from the perspectives of busy managers who may be challenging to access. These methods provide a practical solution for reaching a broader population and accommodating the constraints posed by their busy schedules.

Purposive sampling, referred to as judgmental, selective, or subjective sampling (Sharma, 2017), is a sampling technique where researchers exercise their judgment or employ specific criteria to select participants who can offer the most representative or insightful data for the research (Marshall, 1996). In this way, the researchers use their understanding of the research aims and their knowledge of the population to identify individuals who possess the relevant experiences, perspectives, or expertise to provide richest data on the topic. By intentionally selecting participants based on predetermined criteria, purposive sampling enables researchers to gather targeted and valuable insights that align with the research aims. In this study, *purposive sampling* was utilised to achieve this goal, selecting interview based on the specific selection criteria to ensure the inclusion of different participants' roles and responsibilities, company types, industries, levels of digitalisation and diverse range of perspectives in the obtained results.

In summary, this research employs a combination of snowball, convenience, and purposive sampling methods to fulfill its objectives. It is worth noting that the largest disadvantage of non-probability is its potential of resulting in sampling bias, as the sample selection method may favour certain members of the population, thereby limiting the generalisability of the findings to the wider population (Buelens, Burger and van den Brakel, 2018; Vehovar Toepoel and Steinmetz, 2016). Therefore, this qualitative study does not aim to validate the conceptual framework and hypotheses derived from the literature, but rather to confirm their applicability by identifying additional factors not yet explored in existing literature and refining the measurement scales developed for the main quantitative study.

b. Sample size

By following snowball, convenience and purposive sampling methods, a total of 14 directors and managers from diverse organisations were carefully selected to participate in the qualitative phase of the research. These participants were drawn from both manufacturing and services sectors, ensuring a comprehensive representation. The number of interviewees exceeded the minimum requirement of eight, as recommended by McCraken and McCracken

(1988), thereby enhancing the robustness of the findings. The interviewees chosen for the interviews encompass a broad spectrum of roles and positions within the organisations, ranging from junior managers to top-level executives, representing various levels of management within companies. Additionally, the selection process also included consultants who bring valuable expertise and insights into the digital transformation process. Furthermore, government representatives were included to provide a holistic perspective on the subject matter, considering the role of government entities in facilitating and influencing digital transformation initiatives. The deliberate selection of interviewees from diverse industries and organisations ensures a comprehensive exploration of the research topic, as it encompasses a wide range of experiences and perspectives from multiple stakeholders involved in the digital transformation. Their understanding of digital transformation and the level of digitalisation within their respective companies will shed light on various enablers, challenges, and the overall impact of these factors on firms undergoing digital transformation.

(4) Conduct of interviews

The interviews were conducted between March and May 2022 using Microsoft Teams given its convenience and cost-effectiveness. The participants included directors and managers from various levels of management in materials supplying, product manufacturing, distribution, logistics firms, as well as government and consultant firms in Vietnam. The scheduling of interviews was based on the availability and preferences of the interviewees. A total of 14 interviews were conducted, reaching a point of saturation where further data collection was deemed unnecessary. The data saturation point was reached when same themes, patterns, or concepts emerge repeatedly across multiple interviews; participant's responses were consistent and predictable; and the subsequent interviews yielded no new insights and information beyond what has already been identified to address the research question (Guest, Namey and Chen, 2020; Guest, Bunce and Johnson, 2006). With regards to language use during data collection, both languages were available for the participants, but the analysis was conducted in English to ensure consistency and accessibility in communicating the study findings (Table 6-1).

Table 6-1: Use of language in data collection and analysis

Data collection and analysis process	**Language**	
	Vietnamese	**English**
Interviewing	✓	✓

Transcription of the interviews	✓	✓
Coding and analysis	✓	✓
Presentation of main themes and quotations		✓

(5) Qualitative data analysis

Although it was clear that themes emerged during the process of conducting the interviewees, to ensure the trustworthiness of the results and minimise potential interviewer bias, in- depth analysis of the interviews was deferred until all interviews were completed. This approach aimed to prevent the interviewer from unintentionally steering interviewees towards specific topics considered critical by the interviewer, thereby maintaining the integrity of the findings.

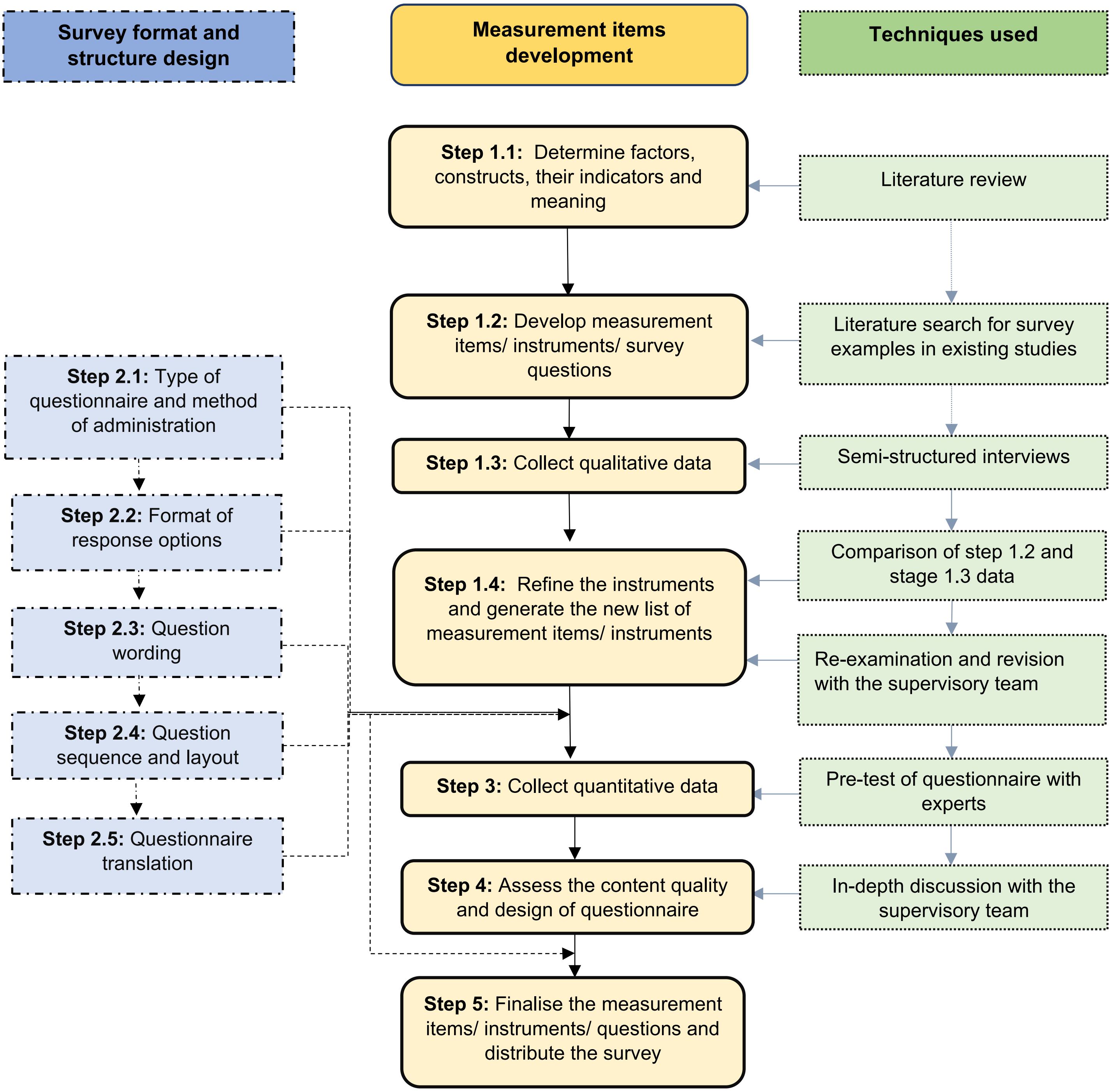
The interviews, initially recorded using Teams video, were meticulously transcribed in their original language, and then thoroughly reviewed multiple times to ensure data accuracy. Subsequently, the transcripts were imported into NVivo 1.6.2 software for analysis. NVivo is a well-established Qualitative Data Analysis Software widely used by researchers to manage large volumes of qualitative data (Dollah, Abduh, and Rosmaladewi, 2017; Siccama and Penna, 2008). The software facilitates the identification of trends, classification of themes, and mapping of relationships among the emerged themes within the interview transcripts (Sotiriadou, Brouwers, and Le, 2014; Wong, 2008). This approach also enables the exploration of diverse perspectives, identification of similarities and differences, and discovery of unexpected insights (Durach, Kembro, and Wieland, 2017; Nowell et al., 2017; Pittaway, Holt, and Broad, 2014). This computer software plays a crucial role in organising the data, generating themes, sub-themes, and categories, thus enhancing the rigor and effectiveness of the analysis process. The qualitative data analysis was therefore facilitated using this computer software.

6.3.4.2. Stage 2: Quantitative study

(1) Questionnaire development:

A systematic five-step process was designed to develop a comprehensive questionnaire for the quantitative study which is illustrated in the Figure 6-3 below. These steps involve designing the survey format and structure, developing validated measurement scales, and utilising appropriate techniques. Given the challenges in data collection within the SCM factor, this meticulous approach is believed to facilitate the effective process of data collection to generate customised questions that are specifically tailored to the unique context of Vietnam.

Figure 6-3: Questionnaire development process (Based on: Churchill, 1979, p.66).



- **Step 1: Construct conceptualisation, and indicators and measurement items development**

  Step 1.1: Development of factors, dimensions, their indicators and meaning

The development of individual questions or measurement items is guided by the factors and their dimensions outlined in the research framework. Therefore, it is essential to firstly define the dimensions and establish their clear definitions by developing well-defined indicators that can effectively capture the desired aspects of these dimensions (Bisbe, Batista-Foguet and Chenhall, 2007) (see Appendix D3). By developing well-defined indicators, researchers can ensure the accuracy and reliability of the data collected (Kimberlin and Winterstein, 2008). The indicators of dimensions identified in the existing literature review can be considered and potentially adopted at this stage. Therefore, the researcher conducted a thorough literature review on the DSC adoption and the role of organisational culture in such adoption (see Chapter 4) to identify the existing indicators.

Step 1.2: Development of questions/ measurement items and their content

Once the dimensions and indicators were identified, the next step is to develop the questions or measurement items for the questionnaire. Researchers have the option of selecting preexisting instruments or developing new ones for their study (Hallberg, 2008). Similarly, it is recommended by Hair Jr, Page and Brunsveld (2019) and Kelley et al. (2003) that to develop an appropriate set of questions or measurement items, it is worthwhile for researchers to conduct an extensive literature review to explore how previous studies have designed their questionnaires and if there are suitable psychometrically tested tools available.

According to Kelley et al. (2003), the use of existing instruments may offer cost-effectiveness and knowledge accumulation, but adjustments in wording may be necessary (Waltz, Strickland and Lenz, 2010) and in some cases, certain items may need to be eliminated (Bailly et al., 2017). There are several reasons for making adjustments. Firstly, it is crucial to ensure the relevance and applicability of the measurement items to the research context by modifying the wording of existing questions to fit the specific context of SC 4.0 in Vietnam. Secondly, rewording the questions helps maintain consistency in the wording and terminology used across the measurement items, ensuring uniformity and coherence in the survey instrument. Lastly, the original questions might have contained complex or unclear language, had a lengthy format which may lead to participants' confusion, frustration and misinterpretation of the questions (Haan, Ongena and Huiskes, 2013), or included multiple statements conveying similar ideas or perspectives (Kishore et al., 2021; Reeve and Fayers, 2005). The rewritten versions can convey the same meaning in a clearer and more concise manner, enhancing clarity for the respondents.

It is important to note that the indicators and measurement items used in this study were primarily derived from prior research. For the measurement items to be selected for this study, the items must accurately capture the meaning of the indicators (refer to Appendix D2 for indicator meanings). They should also have been used repeatedly in numerous studies, suggesting that these items have undergone scrutiny in various contexts. Additionally, the items must demonstrate both reliability and validity through their measures such as factor analysis and internal consistency in previous studies. The measurement items should also have been used and validated in similar contexts such as digital technology applications as it indicates relevance and appropriateness to the focus of this study. Lastly, the items should be suitable for this study's participants in terms of knowledge, language, and cultural relevance as it is essential for ensuring the respondents can understand and engage with the questionnaire effectively. To ensure the items to align with the specific context of Vietnam, several adjustments were made. Hence, in some cases, the original sentences were revised to avoid redundancy and potential confusion, simplifying the questionnaire, and making it easier for respondents to understand and answer the questions (Haan, Ongena and Huiskes, 2013). Additionally, some original sentences were broken down into smaller and more concise sentences to improve clarity and understanding as well as consistency, relevance, and alignment with the research context.

Step 1.3: Collect qualitative data

Since old indicators and measurement items from existing literature may be inadequate (Churchill, 1979) and may not capture the unique conditions of developing countries like Vietnam due to little research in SC 4.0 that has been done in developing countries, this research employed not only the indicators and measurement items from existing literature (Chapter 4) but also newly developed indicators and measurement items derived from the findings of semi-structured interviews with 14 Vietnamese industry professionals (explained in Chapter 7). With this combination of old and emerging indicators and measurement items for the study, the research can develop a robust and comprehensive tool for assessment of the research constructs (Bisbe, Batista-Foguet and Chenhall, 2007). It effectively captures diverse perspectives and experiences related to DSC adoption challenges and drivers in developing countries like Vietnam, ensuring the relevance of the indicators and measurement items in addressing the research questions.

Step 1.4: Refine the instruments and generate the new list of measurement items/ instruments

Drawing from a comprehensive literature review, a conceptual framework was developed. This was then refined based on the feedback from the findings of semi-structured interviews. Upon this, a list of measurement items for each measure or indicator was developed and adjusted for this study to align with the Vietnamese context. After adjustment, the list of measurement items underwent a thorough revision process with the guidance and input of supervisors, leveraging their expertise to identify areas for improvement and anticipate potential data collection issues. Under the revision, every aspect and detail of the questionnaire was critically examined and scrutinised to ensure its alignment with the research aims while also addressing errors and ambiguities. As a result, this process enhanced the overall quality and validity of the questionnaire, ensuring it could elicit accurate and meaningful responses from participants. Appendix D4 presents a comprehensive list of these modified questions or measurement items for the research questionnaire.

- **Step 2: Details of questionnaire format design**

Step 2.1: Type of questionnaire and method of administration

Given the research purpose, positivism philosophy, and survey strategy, the questionnaire and its administration method followed a structured, self-administered approach using internet-mediated software and simplified language (Gray, 2019). Structured questionnaires consist of predetermined and standardised questions with a fixed format, ensuring consistent wording and question order to gather information from the respondents (Cheung, 2021). This approach can lead to higher response rates and more accurate data as it requires lower cognitive load and minimises respondent thinking (Parfitt, 2013). Structured questionnaires also facilitate easier coding and analysis. However, one limitation is that they may overlook respondents' personal insights, particularly when encountering terminological ambiguity or poorly defined concepts, which can affect data accuracy (Gillham, 2008; Johnson and Turner, 2003). Therefore, it is crucial to revise and pre-test the questionnaire to mitigate such inaccuracies.

Step 2.2: Format of response options

The response choices in the questionnaire encompass various formats, including open-ended, fill-in-the-blank, and closed-ended options (Stehr-Green et al., 2003). In this research survey, a combination of closed-ended and open-ended question types was utilised.

The closed-ended questions encompass a variety of formats, including single response and multiple response options with nominal or ordinal categories. The closed-ended questions employed the 5-point Likert scales, ranging from "*strongly disagree*" to "*strongly agree*", to gather information on factors related to DSC adoption. While a broader range, such as 7-point Likert scales, is commonly recommended for the Likert scale, Gupta and Somers (1992) argued that respondents may face difficulty in understanding the significant differences beyond a scale of 5. Similarly, Cavana, Delahaye, and Sekeran (2001) also asserted that a 5-point scale is equally effective compared to scales with more points. Meanwhile, nominal closed-ended questions in checklist format were employed to inquire about the respondents' characteristics such as their position, company size, and Industry. Finally, an open-ended question is included to capture any additional comments or feedback from the participants.

Step 2.3: Question wording

A successful questionnaire design relies heavily on the researcher's ability to empathise with the prospective respondents. Parfitt (2013) recommended that the language and tone of the questions should not overwhelm the respondents. Additionally, the questions should be designed in a simple and familiar manner to eliminate any terminological ambiguity and ensure relevance (McLafferty, 2016). Burgess (2001) also stated some general rules on question wording, including being concise and unambiguous, avoiding double questions, leading questions or questions involving negatives, and asking for precise answer. Especially, it is suggested that technical jargon, slang, and abbreviations should be avoided at all costs (Bee and Murdoch-Eaton, 2016; McLafferty, 2016; Williams, 2003; Mathers, Fox and Hunn, 1998; Stone, 1993). If the use of jargon or terminology is unavoidable, a comprehensive description should be provided to ensure clarity.

Step 2.4: Question sequence and layout

Once the question wording was appropriately designed, the sequence of the questions was determined. According to Song, Son and Oh (2015), the order of the items in the questionnaire can have a significant impact on responses. It is important to arrange the questions in a logical flow to ensure the coherence of the questionnaire. It was suggested to leave easy and sensitive personal questions about the respondents until the end as they are less likely to give such data at the beginning of the questionnaire (Song, Son and Oh, 2015). Similarly, Rattray and Jones (2007) recommended that controversial or emotive items should not be placed at the beginning of the questionnaire, and demographic and/or clinical data can be presented at the end to maintain respondent engagement. The use of complex branching in questions should also be minimised although some questions may be dependent on earlier responses (Burgess, 2001). This could help to reduce the complexity of the topic and prevent respondents' confusion. In terms of questionnaire layout design, it is important to create an attractive and neat appearance of the questionnaire that encourages respondents to participate and comfortably complete the questions (Bryman and Bell, 2011). Excessive use of lines, borders, or boxes that make the page appear dense were therefore avoided. Additionally, choosing a legible font and organising the format in a clear manner will enhance readability for respondents (Burgess, 2001).

Step 2.5: Questionnaire translation

Given that the questionnaire was originally developed in English while the target respondents primarily use Vietnamese as their first language, the questionnaire was translated to Vietnamese by the researcher. As suggested by Douglas and Craig (2007), to ensure conceptual equivalence, the collaborative and iterative translation approach was employed. To ensure accuracy and consistency, a professional translator and a Vietnamese academic were separately engaged to review and validate the translated questionnaire. Their feedback and recommendations were carefully compared and discussed. Furthermore, a Vietnamese literature teacher was consulted to ensure the appropriate use of the Vietnamese language in the questionnaire. Through the collaborative efforts of these professionals and the researcher's careful consideration of their feedback, the questionnaire was refined and finalised, ensuring that it effectively captures the intended meaning and maintains linguistic integrity in the Vietnamese language.

- **Step 3: Pre-test of questionnaire with experts**

After the questionnaire was revised and examined by the supervisors, the next critical phase involved pre-testing with the input of experts. This step served as a vital component, aiming to gather valuable insights and judgments from knowledgeable experts to improve the questionnaire's quality and effectiveness. It allowed for the detection and rectification of errors, incompleteness, redundancy, response variation and potential issues such as question misinterpretation and non-responses that could arise during data collection. Thus, the content validity, format, and scaling of the questionnaire could be improved, leading to a higher response rate and reduced data collection errors (Burgess, 2001).

During the pre-test, a group of 12 UK and Vietnamese academics and professionals with expertise in Industry 4.0 implementation, SCM, or both, participated in a discussion format. These experts were selected based on their knowledge with the research topic and research methods. The experts thoroughly evaluated each question and its measurements, providing valuable feedback on clarity of question statements, appropriateness of the question sequence, format and presentation of the survey. Based on their evaluations, the researchers made informed decisions on whether to retain, modify, or remove specific items to enhance the questionnaire's effectiveness.

The consultations with experts helped in avoiding the risk of receiving insufficient responses due to ambiguous questions, poorly explained concepts, or respondents' potential misunderstanding. Additionally, these discussions facilitated the identification of potential practical problems that could arise during the data collection procedure (Van Teijlingen and Hundley, 2010). Overall, the pre-testing phase with expert input played a crucial role in refining the questionnaire and ensuring its effectiveness in gathering reliable and meaningful data.

- **Step 4: Content quality and questionnaire design assessment**

In response to the valuable feedback and insights provided by the experts during the pre-testing phase, the questionnaire underwent further refinements to incorporate experts' ideas. This iterative process involved in-depth discussions with the supervisory team to make appropriate amendments and ensure the questionnaire accurately captured the desired information.

- **Step 5: Final list of measurement items**

After conducting a thorough assessment of quality and design, the survey instruments which consist of a list of measurement items were finalised and described in this step. These final indicators were carefully chosen to ensure their effectiveness in measuring the constructs outlined in the research framework.

As discussed above, the comprehensive literature review and semi-structured interviews were conducted to identify the appropriate indicators for the constructs and to develop a comprehensive list of measurement items for these indicators in this study. While the Appendix D3 summarises the model factors' dimensions, their corresponding indicators and definitions, Appendix D4 provides detailed information on the original measurement items used in prior studies, their corresponding reworded versions tailored to the Vietnamese context, the specific sources from which they were obtained, as well as the new measurement items developed based on the findings of the semi-structured interviews. Meanwhile, Appendix D5 presents the final form of questionnaire in both English and Vietnamese.

(2) Sampling strategy and sample

As discussed in qualitative study above, developing a sampling strategy is a critical step in research that involves determining how to select a subset of individuals from a larger population to participate in a study and draw inferences about the entire population (Berndt, 2020). The sampling strategy development follows the following steps: identifying the target population of interest, defining the sampling frame that represents the accessible portion of the population, selecting suitable sampling methods or techniques to ensure representative and unbiased sampling, determining the minimum required sample size to achieve reliable and valid results, and ultimately approaching the participants. By carefully navigating these decisions, researchers can construct a well-designed sampling strategy that maximise the accuracy and generalisability of their findings.

a. Target population

As discussed in qualitative study above, the target population refers to the entire group of individuals or units that the research aims to study, draw conclusions about, or generalise the findings (Casteel and Bridier, 2021; Barnsbee et al., 2018). In contrast to the qualitative study whose target population is managers from both supply chain firms and supporting organisations, the target population for the primary quantitative study were only managers from supply chain firms in Vietnam as the survey specifically targeted these firms to gather their perspectives on readiness and challenges in adopting SC 4.0.

b. Sampling methods

For the stage 2 – quantitative study, both *probability and non-probability sampling techniques* were employed. As the aim of the quantitative study is to generalise the findings through a large-scale survey, the probability sampling technique, particularly simple random sampling was used because it ensures that every member of the population has an equal and independent chance of being included for the sample, thereby providing a more reliable and statistically valid means of making inferences about the population (Rahi, 2017). In addition, this approach is not only advantageous but also the preferred choice over non-probability sampling because it significantly enhances the likelihood that the data collected from the study sample closely mirrors the characteristics, attributes, or variables studied within the population of interest (Novosel, 2023). It also mitigates the risk of introducing researchers' biases during the sample selection process. Nevertheless, owing to factors such as declining response rates in probability surveys, the high costs associated with data collection, increased respondent burden, the demand for real-time statistics, and the availability of non-probability data sources like web surveys and social media (Wiśniowski et al., 2020), researchers have increasingly explored non-probability sampling techniques in recent years, despite their limitations in terms of generalisation (Statistics Canada, 2021). Non-probability sampling techniques offer numerous advantages such as lower data collection costs, time efficiency, higher response rates, and quick access to the participants (Stratton, 2021). Thus, in addition to the employment of probability sampling technique, this research also acknowledged the significance of non-probability sampling methods in quantitative data collection, particularly convenience, snowball, and purposive sampling techniques. Additionally, given the research's objective of capturing the perspectives of managers in Vietnamese supply chain firms regarding the adoption of DSC, these non-probability sampling methods, enable the research to reach a more diverse range of participants with relevant knowledge and experiences crucial to the research while accommodating the time constraints faced by busy company managers. The probability (random sampling) and non-probability sampling (convenience, snowball and purposive sampling) techniques utilised in this quantitative study are further explained below.

Simple random sampling stands as the most widely acknowledged and preferred probability sampling technique (Rahi, 2017). In simple random sampling, each element in the target population and every possible sample of a specific size are given an equal chance of being selected (Rahi, 2017). Hence, it typically generates samples that are representative and enables the application of inferential statistics to analyse the collected data (Daniel, 2012). In this research, to access to the survey participants, an initial list of companies was compiled from various governmental websites such as the Ministry of Planning and Investment, Commission for the Management of State Capital at Enterprises, Vietnam National Statistics, or Vietnam Chamber of Commerce and Industry.

In terms of non-probability sampling, the research employed convenience, snowball and purposive sampling techniques. Similar to *convenience sampling* technique employed in qualitative study, the researcher contacted potential survey participants through personal contact and social networks such as Facebook and LinkedIn. Additional participants for questionnaires were also identified through the *snowball sampling* technique, whereby more participants were suggested by previous participants. Furthermore, in anticipation of the common challenge of low response rates in surveys (Shiyab et al., 2023; Saleh and Bista, 2017), the researcher utilized *purposive sampling*. This involved establishing communication with gatekeepers who have influence and access to the target population. These gatekeepers included logistics, manufacturing, and supply chain managers' groups such as Vietnam Logistics Community, Logistics Ho Chi Minh City, Digital Transformation in Manufacturing Process group, etc. As suggested by Lamprianou (2022) and Buchanan and Bryman (2007), surveying through gatekeepers can also be very crucial for quantitative studies. This approach acknowledges the methodological challenge of accessing *hard-to-reach* populations and highlights the significance of gatekeepers in facilitating access to these groups, potentially improving response rates, and expanding the pool of participants (Lamprianou, 2022).

In summary, this research employed a combination of both probability (random sampling) and non-probability (snowball, convenience, and purposive sampling) methods to fulfil its objectives. By adopting these comprehensive approaches, the research ensures a robust and diverse selection of participants who could provide valuable insights for the study. These varied recruitment strategies also enhanced the potential for generalisability of the findings, as the research incorporated a broad range of perspectives from managers in Vietnamese companies. However, it is important to acknowledge that non-probability sampling may pose challenges to the representativeness of the research findings. Therefore, researchers must strive to achieve a minimum sample size or aim for the largest possible sample size, as larger samples tend to yield lower error rates when generalising to the target population (Stratton, 2021; Saunders, Lewis and Thornhill, 2019).

c. Sample size

According to Sekaran and Bougie (2016), the sample size is a portion or subset of the population required to gather sufficient information for generalising the research findings. In survey research, ensuring an adequate sample size is crucial for meaningful results. Without a sufficient sample size, generalising the findings becomes challenging. Several factors must be considered when determining an appropriate sample size, such as budget, time constraints, the number of items, the number of variables, and the complexity of the research model, etc. (Rahman, 2023).

Given the inherent difficulty in determining the exact number of companies in the sampling frame and the lack of a consensus on the response rate, Hair Jr et al. (2018) proposed an alternative method for determining the sample size based on the number of variables in the study. According to Hair Jr et al. (2018), the sample-to-variable ratio should not be less than 5:1, although a ratio of 15:1 or 20:1 is preferable. In this research, with 11 variables, a sample size of 11*5 = 55 is acceptable, but the ideal minimum sample size would be 11*15 = 165 or 11*20 = 220. Another approach for determining sample size is based on the number of questions in the survey. While Suhr (2006) recommended a sample-to-items ratio of at least 5:1, Costello and Osborne (2005) suggested a 20:1 ratio. Thus, for this research with 15 questions in the survey, the minimum sample size should be 15*5 = 75 or 15*20 = 300. Previous studies, such as Forsberg and Rantala (2020), Yeoh et al. (2016), and

Liao, So, and Lam (2016), have followed this 20:1 ratio rule. On the other hand, another commonly employed approach for sample size determination over the past few decades is Roscoe (1975)'s set of guidelines. Roscoe suggested that a sample size greater than 30 and less than 500 is suitable for most behavioural studies, as larger sample sizes may increase the risk of Type II errors (Sekaran and Bougie, 2016). Considering the recommendations from various scholars, the average ideal sample size for this research should fall within the range of 200 to 500.

The questionnaire was carefully designed using the Qualtrics online software and distributed to multiple supply chain businesses in Vietnam. The survey successfully obtained a substantial response from 292 professionals in key positions such as general managers, supply chain managers, production managers, etc., within the logistics and SCM field. This sizeable sample provides a solid foundation for the research and meets the desired criteria for an ideal sample size. The utilisation of Qualtrics online software offers several key advantages. Firstly, it enables the efficient execution of the study, aligning with the constraints of time and resources inherent in the research scope (Malhotra, Birks and Wills, 2012). By leveraging this software, the need for manual data entry by the researcher is eliminated, saving valuable time and effort (Saunders, Lewis and Thornhill, 2019) and the costs associated with data collection can be minimised, contributing to the overall feasibility of the research (Malhotra, Birks and Wills, 2012). Additionally, the utilisation of an online survey also provides researchers a direct connection with a diverse range of companies operating in different industries and regions across Vietnam (Akbari et al., 2023). This approach not only ensured a broad spectrum of respondents but also facilitated the collection of comprehensive and reliable data, enhancing the robustness of subsequent analysis (Baker et al., 2013). However, it is worth noting that the response rate may be lower compared to alternative modes of questionnaire distribution (Saunders, Lewis and Thornhill, 2019).

(3) Conduct of Questionnaires

The questionnaire was distributed from November 2022 to February 2023 using social media such as Facebook, Email, and LinkedIn; personal contacts, various government websites and connection with gatekeepers of logistics, manufacturing and SCM associations and groups. Firstly, as previously highlighted in the convenience sampling method, LinkedIn proved to be an efficient platform for engaging interview participants and was therefore utilised once again for quantitative data collection. After carefully reviewing potential interviewees' profiles on LinkedIn, the researcher initiated contact by sending an introductory message, clearly communicating the research purpose and an invitation to participate in the survey.

Upon receiving agreement from the participants, the survey link was promptly shared with them. Secondly, after compiling an initial list of companies from various governmental websites and connecting with gatekeepers of logistics, manufacturing, and supply chain managers' groups, an email was sent. This email included the researcher's personal information, the research purpose, and the desired requirements for survey participants (e.g., holding managerial roles related to strategy development, technology advancement, digital transformation, supply chain management, and operations management). The email also explicitly communicated the potential contribution of participants to the research and emphasised their importance in shedding light on the subject matter. Once the companies or individuals expressed their agreement, the survey was sent out, accompanied by a polite reminder after a two-week interval to encourage timely completion. Following both probability and non-probability sampling, 292 valid responses were obtained.

(4) Quantitative Data Analysis

The data collected from the survey were analysed employing a range of techniques to gain a deep understanding of the research findings, including descriptive analysis, factor analysis (for exploratory analysis), Cronbach's alpha for construct reliability test, correlation analysis, and multiple regression analyses.

Descriptive analysis served as the foundational step to summarise and present a description of the main characteristics of the 292 respondents. Meanwhile, factor analysis played a pivotal role in exploring the underlying structures, patterns, and relationships within the data (Knekta, Runyon and Eddy, 2019). This method allowed for the identification of latent factors or dimensions, shedding light on complex patterns and interdependencies among variables (Bandalos and Finney, 2018). Cronbach's alpha, a measure of internal consistency, was applied to assess the reliability of constructs within the survey (Taber, 2018; Tavakol and Dennick, 2011). This analysis ensures that the survey items that comprise a construct are consistent and reliable in measuring the intended underlying concept. On the other hand, a correlation analysis aimed examine the relationships and associations between the various variables, providing insights into the strength and direction of their relationships (Gogtay and Thatte, 2017). Finally, multiple regression analyses were conducted to assess the predictive significance and influence of individual independent variables on the dependent variable and to identify the optimal combination of predictors for accurate estimates (Mason and Perreault Jr, 1991). Further elaboration on these analyses is provided in Chapter 8.

This entire data analysis process was facilitated using the widely recognised and respected SPSS Statistics Software Package Version 28. According to Thomes (2018), SPSS has emerged as a revolutionary tool for researchers, simplifying the handling of critical data. It offers a seamless process for storing, analysing, and transforming data, ultimately compiling it to produce a characteristic pattern between different data variables. Additionally, SPSS supports the presentation of results through graphical representation, providing researchers with a visually intuitive way to interpret and comprehend the outcomes of the analysis, further enhancing the research's clarity and depth of understanding. After the qualitative data analysis and quantitative data analysis, both findings will be integrated to support the development of the theoretical framework.

6.3.4.3. Ethical consideration

Primary data collection can lead to certain issues and dilemmas for ethical principles (Saunders, Lewis and Thornhill, 2019). Thus, ensuring adherence to ethical principles is of paramount importance. In this research, the researcher sought ethical approval and adhered to the guidelines provided by the Research Ethics Committee at the University of the West of England (see Appendix D6). During the conduct of data collection process, it is the responsibility of researchers to follow ethical principles to protect the participants' rights, privacy, and well-being throughout the research process, to ensure participants to have a power of freedom of choice to participate in the study, and to promote transparent and truthful reporting (Arifin, 2018; Sanjari et al., 2014). Therefore, to ensure ethical conduct, participants need to be provided with all the necessary information to make an informed decision about their participation (Saunders, Lewis and Thornhill, 2019).

Regarding this research's qualitative data collection, ethical considerations are of significance (Orb, Eisenhauer and Wynaden, 2001). Prior to conducting interviews, participants were provided with a clear explanation of the study's purpose, voluntary nature of participation, potential risks and benefits, confidentiality measures, and their rights. Participants were given the opportunity to ask questions and provided informed consent either in writing or verbally. Voluntary participation was emphasised, ensuring participants had the freedom to withdraw from the study at any stage without facing negative consequences. Additionally, to protect confidentiality and anonymity, unique identifiers were assigned to participants, and their data were securely stored using encryption and password protection. Finally, analysis and reporting were conducted in an anonymous manner, further preserving participant privacy.

Regarding the quantitative data collection of this research, the introduction to the questionnaire included comprehensive details about the research, including information about the research team, the research purpose, clear definitions of the terminologies used in the survey, the value of the participant’s contribution, and assurances regarding participation, such as anonymity and the rights of the respondents. Additionally, contact information for addressing any concerns or queries was also provided to ensure transparency.

In a nutshell, the research methodology can be summarised into three key phases, each contributing to the overall study:

- **Stage 1: Pre-survey or questionnaire development stage:** To establish a strong research foundation and conceptual model, a systematic literature review (SLR) was conducted, supplemented by semi-structured interviews with 14 managers from various companies. The semi-structured interviews, conducted via Teams, provided valuable qualitative insights that, combined with the SLR findings, aided in generating hypotheses and developing the research framework. For qualitative data analysis, the research employed thematic analysis with the support of Nvivo where the results were transcribed, compared, contrasting, and categorised into elements to find the common themes.
- **Stage 2: Pre-test of the survey**: A pre-testing phase involved gathering feedback from 12 professionals and academics to refine and enhance the measurement scale for the research constructs. This iterative process aimed to improve the validity and reliability of the measurement instruments, ensuring their effectiveness in capturing the intended variables accurately.
- **Stage 3: Large-scale survey distribution**: The finalised conceptual framework and hypotheses were then subjected to validation through a comprehensive questionnaire administered using Qualtrics. The survey was distributed among multiple Vietnamese organisations, resulting in a robust dataset comprising 292 responses. Quantitative data analysis was conducted using a combination of descriptive statistics, factor analysis, correlations, and regressions performed with the aid of SPSS software package version 28.

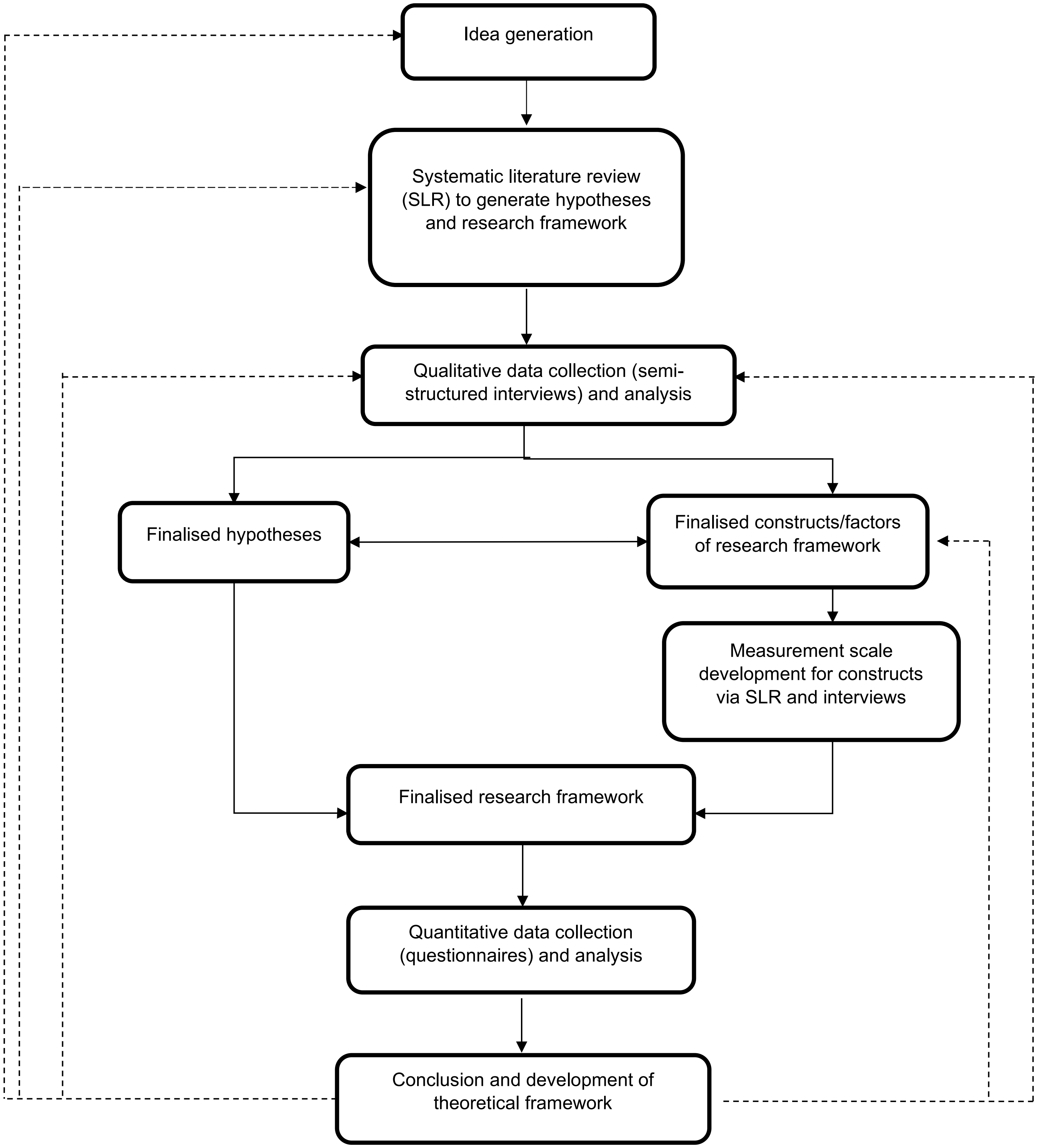
6.4. Summary

This chapter provided a comprehensive overview of the research methodology, addressing the critical aspects and concerns involved in both qualitative and quantitative research approaches. The chapter critically evaluated various research philosophies, approaches, strategies, and methods to carefully determine and justify the most suitable research design and choices that align with the research questions and objectives.

While this research adopted a positivist philosophical stance, it embraced a mixed methods approach, with a predominant emphasis on quantitative methods. The integration of qualitative and quantitative research methods was achieved through a sequential exploratory design (qual => QUAN). This allowed for the integration of diverse research methods, mitigating potential limitations, and yielding comprehensive insights.

The research adopted a deductive approach, where the research framework and hypotheses were constructed based on theoretical and literature reviews. The qualitative method was employed to confirm the applicability of the research framework, which in turn informed the quantitative study. The hypotheses and research framework were subsequently tested through the administration of a questionnaire. This chapter provided a thorough discussion on instrument design, data collection procedures, sampling considerations, participant selection criteria, and ethical responsibilities. The research design of this thesis can be illustrated in the Figure 6-4 below. In the following chapter, the focus shifts to the analysis of both qualitative and quantitative data, unveiling the findings derived from each methodological approach.

Figure 6-4: Research design of this research.



7. CHAPTER 7: QUALITATIVE DATA ANALYSIS AND FINDINGS

As discussed in the preceding chapter, the focus of existing studies primarily centres around the contexts of developed countries or general environments (Liao et al., 2017), rather than focusing on the specific conditions unique to developing countries (Frederico et al., 2019) like Vietnam. This implies that the conceptual framework, along with its constructs and corresponding measures, might lack applicability within the context of Vietnam. Churchill (1979) also highlighted the inadequacy of measurement items derived from existing literature for the formulation of a questionnaire. This suggests the imperative of providing a robust critical argument for proposing additional new measures.

Therefore, to tackle this challenge, after establishing this comprehensive research framework and identifying the barriers and enablers through the SLR, it became imperative to gather insights from practitioners in Vietnam through interviews. In conjunction with the literature review, the interviews with industry professionals served the purpose of revealing significant factors that remain unexplored in the existing literature, aiming to enhance the conceptual framework developed in Chapter 5. In addition, these interviews assisted in offering critical insights substantiated by evidence, thereby justifying the appropriateness of the newly developed measures in addressing the research questions, ultimately helping to develop the questionnaire to collect the quantitative data in the next stage. Given the inherent adaptability of the TOE model as discussed previously, semi-structured interviews were employed to enhance and refine the initial conceptual model obtained from the literature and theoretical reviews. A series of semi-structured interviews involving 14 Industry professionals was undertaken.

After a thorough and detailed discussion of qualitative sampling and data collection in Chapter 6, this chapter comprehensively explains the methodologies employed for analysing the obtained qualitative data as well as the results obtained through the data analysis. The chapter commences by explaining the measures used to ensure the reliability and validity of the qualitative data. Subsequently, the chapter presents the data analysis methods, followed by the profiles of the interviewees and the key findings obtained from semi-structured interviews which align with the major themes and subthemes of the research model. These themes and subthemes are *Technological context* (Perceived benefits and Perceived risks), *Organisational context* (Top management knowledge and support, and Organisational resources) and *Environmental context* (Market pressure, Market support, and

Interorganisational relationships) and *Organisational culture* (Flexibility and Control). The underlying aim of this qualitative study is to validate both the appropriateness of the dimensions and their alignment within the research framework that was developed in Chapter 5.

7.1. Validity, Reliability and Generalisability

To assure the quality of qualitative data, it is paramount for researchers to ensure its reliability, validity, and generalizability (Bell, Bryman and Harley, 2022; Franklin and Ballan, 2001). In the realm of qualitative research, these aspects are crucial due to the subjective nature of the researcher's interpretation that can potentially influence the interpretation of data, leading to the research findings being subjected to scrutiny and scepticism by the scientific community (Golafshani, 2003; Brink, 1993). However, in qualitative study, validity, reliability and generalisabillity are used with caution as concepts of validity, reliability and generalizability are often associated with quantitative study; thus, there have been ongoing debates among academics about the use of these terms (Lerigo-Sampson, 2022).

In qualitative study, validity is often concerned with the accuracy, trustworthiness, and truthfulness of scientific findings, encompassing the description, conclusion, explanation, and interpretation of research outcomes (Maxwell, 2010; Lincoln and Guba, 1985; LeCompte and Goetz, 1982). This trustworthiness and truthfulness of the findings can be achieved through the appropriateness of the tools, techniques, and processes employed in data collection and analysis (Mohamad et al., 2015; Golafshani, 2003). A valid qualitative study should acknowledge the existence of multiple realities, striving to accurately portray participants' perspectives and measure what is intended to be measured (Brink, 1993).

In qualitative study, reliability, on the other hand, pertains to the dependability, consistency, stability, and repeatability of the participants' accounts and the researcher's data collection and recording practices (Seale, 1999; Patton, 1990; Lincoln and Guba, 1985). It entails using consistent methods to obtain comparable results when conducting the same study on the same subject (Noble and Smith, 2015). In essence, reliability or dependability can be achieved when research method and data analysis procedure generate consistent findings over time (Saunders, Lewis and Thornhill, 2019). It is important to acknowledge that the semi-structured nature of interviews can present challenges to achieving consistent findings in research (Saunders, Lewis and Thornhill, 2009). The flexibility inherent in semi-structured interviews may result in a lower level of standardisation, which can potentially impact the consistency of the findings. Additionally, when data is collected in a rapidly changing environment, there is a heightened risk that research findings may not be repeatable (Saunders, Lewis and Thornhill, 2009). This is particularly relevant when studying the dynamic development of technological innovations, such as digital technologies.

In general, a response to the issue of dependability and consistency involves ensuring that researchers demonstrate the suitability of their approach for the research purpose (Arksey and Knight, 1999). In the realm of social science investigations, bias inevitably exists in qualitative research (Smith and Noble, 2014), as it is impossible to fully control or eliminate all social influences (Ryan, 2022). Despite the presence of various biases in qualitative research that can influence the validity and reliability of qualitative findings, biases can be categorised into two primary types which are personal or researcher bias and participant bias.

Personal or researcher bias refers to the researcher's subjective perspectives, beliefs, values or intention that may influence the data collection, analysis, and interpretation process (Johnson, Adkins and Chauvin, 2020). It is widely recognised that researcher bias is inevitable in qualitative studies (Mehra, 2002). This bias can arise when the researcher solely conducts data collection and analysis, leading to potential distortions or unreliability in the results. For example, researchers can decide to interpret the data in the manner that supports their favoured outcome while omitting the data that does not align with their hypotheses. The researcher's bias, if not addressed, can significantly impact the trustworthiness of the data (Brink, 1993). Thus, researchers are required to be transparent about their personal biases, assumptions and values (Hadi and José Closs, 2016; Curtin and Fossey, 2007).

To address the potential bias of the researcher, several measures were implemented to enhance the trustworthiness and dependability of qualitative research. Firstly, a well-structured interview guide was developed to guide the interview process, ensuring consistent and focused data collection. Additionally, the researcher maintained a clear, detailed, and transparent decision trail through a reflective journal that helps document the decisions made, contributing to the auditability and dependability of the research (Lincoln and Guba, 1985). Furthermore, as suggested by Roberts and Priest (2006), thematic analysis is a reliable approach for handling data. This approach involves creating specific codes to describe the data and confirming their stability over time by revisiting previously coded data. The coding process involved multiple iterations of rereading, contrasting, and comparing the data among transcripts to ensure the accuracy and consistency of the coded themes and sub-themes. As a result, this iterative process strengthens the dependency of the analysis and enhances the overall trustworthiness of the findings.

To further enhance the trustworthiness and dependency of qualitative data, a triangulation approach was employed. This involves using multiple sources of data and methods to confirm emerging findings (Halcomb and Andrew, 2005; Graham, 2005; Merriam, 1995) and formulate an overall interpretation of findings (Fusch, Fusch and Ness, 2018; Beuving and De Vries, 2015). Any emerging findings and themes were subjected to a rigorous validation process. Firstly, they were cross-checked against relevant literature to ensure alignment and consistency. Additionally, the supervisory team, consisting of experts in the field of SCM and qualitative data analysis, actively participated in discussions. This collaborative and open process allowed for the challenging of assumptions and the attainment of consensus. This approach is grounded in the understanding that no single method can provide a comprehensive account of the investigated phenomenon (Torrance, 2012). By incorporating data from various sources, complementary perspectives on the same construct can be obtained (Rolfe, 2006). This comprehensive and multidimensional approach contributes to the overall rigor and trustworthiness of the research findings.

Another method for increasing dependability is to ensure technical accuracy in both recording and transcribing process. The interview recordings were carefully listened to multiple times to ensure the accurate representation of the spoken words, while diligently checking for any mistakes or errors during the transcription process. Moreover, an intensive engagement with the data was undertaken, involving a constant back-and-forth movement between the data and its interpretation. This included the use of thick verbatim descriptions of participants' accounts to support the findings, fostering a deep understanding and trustworthiness of the data (Noble and Smith, 2015; Williams, 2015). However, it is essential to highlight that the selection of illustrative quotations was not biased through the selective extraction of the most vivid examples, known as "cherry picking" (Roberts and Priest, 2006). Instead, the chosen quotations aimed to reflect the full range and tone of the responses generated, ensuring a balanced representation of participants' perspectives.

On the other hand, *participant bias* refers to the influence of participants' characteristics, behaviours, or responses on the trustworthiness and dependability of the findings. Participants may provide biased or incomplete information, withhold certain details, or respond in a socially desirable manner, leading to potential distortions in the data (Saunders, Lewis, and Thornhill, 2019). For instance, in qualitative studies, the presence of the researcher during interviews may affect the trustworthiness of the information provided by interviewees, as they may disclose or distort certain details for the sake of information security or may modify their responses based on their perception of what the researcher wants to hear.

To address potential biases from interviewees and ensure the trustworthiness of their responses, several strategies were employed. Firstly, the researcher established a trusting relationship with the interviewees, ensuring they were well-informed about the research’s nature, purpose, and data collection methods both before and during the interviews. This approach, suggested by Cohen, Manion, and Morrison (2017), Alvesson (2003), and Brink (1993), encouraged interviewees to provide full, honest, and accurate accounts of their experiences. To enhance the accuracy of data and minimise misunderstandings, the researcher constantly shared and confirmed their interpretation of interviewees' statements and meanings. According to Slettebø (2021) and Roberts and Priest (2006), this iterative process allows for participant validation, enabling interviewees to reexamine the accuracy of their responses and helping researchers to assess their observations and interpretations of the data. By actively involving interviewees in the validation process, the trustworthiness of the data was improved. Furthermore, as stated above, during the data analysis phase, the obtained results from the interviewees’ responses were meticulously reviewed, compared, and contrasted multiple times to ensure the accuracy and consistency of the data's meanings across different interview scripts. Overall, the combination of establishing a trustful relationship with interviewees, participant validation, and thorough data analysis techniques contributed to addressing interviewees’ biases, validating their responses, and strengthening the trustworthiness of the research findings.

Generalizability, on the other hand, refers to the extent to which findings can be applied in different contexts (Noble and Smith, 2015). Traditionally, it has been associated with quantitative research, which aims to identify universal laws and statistical generalizations (Delmar, 2010). Therefore, generalizability has sparked controversy within qualitative studies, given that qualitative research traditionally emphasizes providing detailed explanations rather than generalizing findings (Polit and Beck, 2010). However, disregarding the potential of qualitative data to generalize findings due to biased premises resulting from “quantitative contamination” could greatly diminish the strength and value of qualitative research (Carminati, 2018). Hence, according to Carminati (2018), Delmar (2010), and Polit and Beck (2010), within qualitative domains, achieving generalizability is feasible when a study’s purpose and research questions strive to develop a new theory to address a gap in the literature (Gheondea-Eladi, 2014), or when careful consideration is given to the conceptualization of generalizability (Hallberg, 2013). Likewise, Bryman and Bell (2015) asserted that it is possible to generalize qualitative findings when they effectively capture the studied concepts and contribute to theoretical developments. This suggests that qualitative research, beyond providing an in-depth understanding of context or human experience, may also seek theoretical generalizability rather than population generalization. In the context of this study, as extensively discussed, the primary objective of the qualitative investigation is to refine the theoretical framework extracted from the literature review, enhancing its relevance in the context of developing countries, with a particular focus on Vietnam, rather than aiming for population generalization.

7.2. Qualitative Data Analysis

Thematic analysis, employed in this study, is a widely recognised method for qualitative data analysis (Lerigo-Sampson, 2022; Saunders, Lewis, and Thornhill, 2019). It involves a rigorous process of comparing the data and categorising it to identify common patterns and themes in the interviews (Braun and Clarke, 2006). It is important to note that thematic analysis not only involves describing the data but also involves interpretation during the selection of codes and construction of themes (Kiger and Varpio, 2020).

To effectively code the data into themes, the researcher followed a systematic coding process suggested by Williams and Moser (2019). Despite various perspectives on coding process, numerous scholars have agreed on three phases of a coding process, following (i) initial or open coding, (ii) axial or focused coding, and (iii) selective or theoretical coding (Saldaña, 2021; Bryman, 2016; Creswell, 2014; Charmaz, 2006; Strauss and Corbin, 1998). Open coding is a fundamental step in qualitative data analysis, aiming to develop meaningful codes for describing, naming, and categorizing the data (Strauss and Corbin, 1990). Open coding initiates with line-by-line analysis where the researcher analyse every sentence, word, or short data segments, etc. (Creswell and Poth, 2016; Birks and Mills, 2015) so that concepts and key phrases are identified, highlighted, and organised into the appropriate sub-themes and main themes (Given, 2008).

According to Nguyen, Kumar, and Soares (2022) and Saunders, Lewis, and Thornhill (2019), the coding process should encompass both deductive and inductive approaches. In a deductive approach, the researcher commences with a framework of a priori codes derived from existing literature review or the developed conceptual research model. In this study, the research model integrates the Technology – Organisation – Environment framework with the Competing Values Framework. The main themes in this framework include Technology, Organisation, Environment, and Organisational Culture, with others serving as sub-themes. These themes and sub-themes are considered a priori codes. The interview statements were subsequently coded into these sub-themes and then assigned to the relevant themes which are Technology – Organisation – Environment – Organisational Culture themes, that proved to be appropriate based on the research findings. However, it should be noted that these prior codes may be inadequate if new concepts emerge during the analysis, such as new factors related to DSC adoption.

Although the development of themes and sub-themes is guided by the existing set of codes in deductive coding which are predetermined by the underpinning theories (Lerigo-Sampson, 2022), no deliberate effort is made to direct or force the information provided by the interviewees toward these predetermined codes. Therefore, the researcher also employed an inductive approach, carefully reviewing and analysing all transcripts to uncover new patterns or themes that were not previously identified in the literature review. Subsequently, a set of new codes, known as emerging codes, were then created to capture these newly discovered elements. This process sometimes requires researchers to consider a broader context while coding at the level of individual sentences or paragraphs, which may lead to code redefinition (Holton, 2008; Charmaz, 2006). Thus, new codes were introduced until saturation is reached, meaning that no more codes emerged. It is important to note that the later interviews were coded more accurately than the initial interviews as the researcher gained more familiarity with the data and developed a deeper understanding of the research topic. Therefore, to ensure consistency and quality of coding, a meticulous review and analysis of each interview was carried out using an updated list of themes, sub-themes, and codes within the NVivo software. This iterative coding process requires researchers to carefully reread, compare, and contrast the transcripts multiple times to ensure the consistency, precision and coherence of data meanings, coding, and analysis (Saunders, Lewis, and Thornhill, 2019). It also provides opportunities to validate and refine the emerging themes and sub-themes as well as prevent the omission of valuable information that might have been overlooked in earlier coding iterations.

Once the information from the interviews was coded into the appropriate themes and sub-themes, the researcher proceeded to the axial coding phase, where researcher investigated and developed the relationships between themes and sub-themes that have been identified in the open coding phase (Strauss and Corbin, 1990). Given the existence of both pre-existing and newly emerging themes, it became crucial to establish linkages between them. Through axial coding, the researcher analysed the contextual, consequential, interactional, and causal relationships within the data (Jones and Alony, 2011).

Finally, in the selective coding phase, once the relationships among major themes and sub-themes were identified and developed during axial coding, they were integrated to form a comprehensive and meaningful theoretical framework that would serve as a guide for the research process (Rahmani and Leifels, 2018; Creswell, 2014). This framework integrates the interconnected relationships between codes, sub-themes, and themes. Table 7.1 below illustrates the relationship between main themes and sub-themes identified and developed through deductive and inductive coding. Items in italic in this table were identified through inductive coding.

Table 7-1: Themes and sub-themes identified through deductive and inductive coding

Factor	Dimensions	Indicators
Technological factor	Perceived risks	Complexity
		Absence of interconnection standards
		Cybersecurity risks
		Short lifespan of technologies
		Incompatibility issues
		High adoption cost
		Dependence on the technology providers
	Perceived benefits	Product/service customisation
		Productivity and flexibility
		Resources savings
		Health and safety
		Quick data capture and analysis
		End-to-end monitoring
		Defects and maintenance reduction
Organisational factor	Organisational resources	Human resources' competence and willingness for change
		Financial resources
		Infrastructure resources
	Top management knowledge and support	Top management support
		Top management knowledge
Environmental factor	Market pressure	Market uncertainties
		Pressure from competitors and customers

	Market support	Government support
		Third-party support
	Interorganisational relationships	Trading partners' readiness
		Trading partners' power
		Trust-based Information sharing
Organisational culture types	Flexibility culture	Loyalty, collaboration, and trust
		Commitment to innovation
		Entrepreneurial spirit
		New or improved products and services
	Control culture	Rules and procedures
		Production and tasks-focus
		Stability
		Results and achievements-focus
DSC adoption	Adoption intention	Intention to transform the business
		Intention to adopt or increase adoption in the future
		Intention to explore the potential of digital technologies
	Adoption actions	Development of digital strategy and plan
		Infrastructure investment
		Development of training course
		Collaboration with third parties
		Collaboration with trading partners
		Integration of digital technologies in operational processes

The data analysis process can be summarised as follows:

- Transcription: All interviews were transcribed from the audio recordings into text documents using Microsoft Word. The interview scripts were transcribed in the original language.
- Initial Reading: The interview transcripts were thoroughly read to gain a comprehensive understanding of the data and familiarize oneself with the content.

- NVivo Preparation: All interview scripts were uploaded into QSR NVivo 1.6.2, a software tool used for data analysis and coding.
- Coding: Relevant “chunks” of data, which can be several sentences or paragraphs, were identified and assigned to appropriate categories. These categories represent the themes or concepts and sub-themes that emerged from the data.
- Categorisation: The units of data were attached to their respective categories to ensure organisation and systematic analysis. This process allowed for a closer examination of the data and facilitated the identification of patterns and connections.
- Alignment with research questions: Throughout the analysis, the focus remained on aligning the findings with the research questions, ensuring that the coded data contributed to addressing these research questions.

After analysing all interview scripts, the qualitative data was used to improve the research framework. The data analysis process confirmed that no major changes were needed in the conceptual framework derived from the literature review. Additionally, the qualitative data was also utilised to develop the questionnaire instruments in the 2nd stage of the study. To present the qualitative findings, the coded quotations were translated from Vietnamese to English to make them accessible to a wider audience. The full list of interviewees’ quotes can be found in Appendix E1. In the subsequent section, the interviewees’ profile and the results of the qualitative fieldwork are presented.

7.3. Interviewees’ Profile

An overview of the profiles of the interviewees reveals their background, position and responsibilities that could explain the rationale behind their perspectives towards the questions. The profiles of 14 interviewees from different companies including position, business location, business size etc. are presented in Table 7-2.

Table 7-2: Interviewees' profile

Coded as	Position	Tenure	Organisation type	Business size
P1	Factory Manager	6 years	Manufacturing	SME
P2	Managing Director	6 years	Logistics	SME
P3	Manager	9 years	Manufacturing	Large
P4	International Distribution Center Director	5 years	Manufacturing	Large
P5	Commercial Director	3 years	Technology Service	SME
P6	CEO	3 years	Logistics	SME
P7	Deputy General Director	3 years	Manufacturing	Large
P8	CEO	13 years	Logistics	Large
P9	Founder and Chairman	14 years	Logistics	Large
P10	CEO	5 years	Logistics	SME
P11	Supply Chain Vice President	3 years	Manufacturing	Large
P12	Production Manager	10 years	Manufacturing	Large
P13	CEO	11 years	Manufacturing	Large
P14	Vice President	30 years	Business association	Large

Out of 14 participants in the semi-structured interviews, 12 interviewees were directly and actively involved in the day-to-day decision-making process, operational activities such as manufacturing, processing, distribution, and logistics or applications and development of new technologies within these activities of the organisations. Meanwhile, the remaining two interviewees (P5 and P14) were from organisations closely working with firms, specifically offering support for the organisations' strategic development through the supply of technologies, funding, and policy implementation. All interviewees possess extensive work experience within their respective companies, spanning from 3 years to 30 years. Moreover, the majority of interviewees originated from large corporations (9 firms), with 5 interviewees representing SMEs.

7.4. Key Interview Findings

7.4.1. Understanding of Industry 4.0

All interviewees emphasised the complexity of grasping the concepts of Industry 4.0 and digital transformation, which often prove challenging to define and quantify. This viewpoint aligns with the conclusions drawn by Kozlovska, Klosova, and Strukova (2021) and Kane et al. (2015), who assert that while digital technology undeniably shapes the lives of individuals in developed societies, Industry 4.0 remains vague and broad and its impact on present-day business operations remains multifaceted and unclear in various aspects in developing countries. In the interviews, many top managers (P2, P5, P6, P10 and P14) have provided vague definitions, viewing Industry 4.0 as either a general technology adoption or fundamental data sharing within online systems, as exemplified by P6's statement.

"*From what I understand, Industry 4.0 refers to investing in technology within the company, increasing productivity on an individual level. All the tasks that used to be done manually are now perhaps being transitioned into a system in order to increase productivity."* (P.6)

On the other hand, certain managers have demonstrated a robust understanding of Industry 4.0, perceiving it as the utilisation of real-time data, digitalisation, machine learning, Big Data, etc. which facilitate communication between machines and other products, enable swift decision-making and real-time predictions of market trends and demand patterns, as stated by P7 and P11.

"*Industry 4.0 involves integrating AI into machines, equipment lines and robots, enabling these machines and equipment to communicate, share information, and automate the production process. The data generated is collected and transmitted back to the control tower.*" (P7)

"*In the 4th industrial revolution, digital technologies such as AI, robotic automation, 5G and more are employed to streamline worldwide real-time data collection, analysis and sharing; and allow end-to-end monitoring and control of supply chain activities such as forecasting, production, warehousing and distribution which increase level of supply chain visibility*." (P11)

These diverse interpretations and perspectives regarding Industry 4.0 can be attributed to factors such as their organisational roles, years of experience, daily responsibilities, size of their business as well as its extent of digitalisation. It is unsurprising that technical managers offer a more comprehensive and closer explanation and insights into Industry 4.0, compared to general managers, as stated by P14 that "*Since I am not an IT expert or a technician, I am unable to provide a technical definition of digital technologies. Nor do I understand how to build, develop, or apply digital technologies*". Another potential reason for the variance in viewpoints and comprehension of Industry 4.0 is the prevalent practice among Vietnamese firms to predominantly outsource the external technology providers' services which inherently integrate digital technologies. As a result, for such companies, their focus tends to be on the functionalities and benefits of the service, rather than the individual technologies included within the service package. Additionally, as suggested by Dikhanbayeva et al. (2021), such vague understanding of the concept could be the wording of governmental policies which only focus on the term with no references to it; thus, the concept remains unclearly defined within the country. Cutlot et al. (2020) further added that the variety of its definitions and its complex nature pose challenges to understand its real scope.

Thus, in order to ensure a clear understanding about Industry 4.0, interviewees were asked about the difference between Industry 3.0 and Industry 4.0. It was found out that many interviewees mistook and were confused between the concept of Industry 3.0 and Industry 4.0 with only few interviewees (P1, P3, P4, P5) who can see the differences between two concepts, as exemplified by P5's statement.

"*The 3rd industrial revolution is the era of computerisation when operational processes were computerised whereas 4th industrial revolution is the era of digitalisation where the supply chain activities, operational processes, machines and equipment are integrated and communicate with each other with the support of digital technologies. In Industry 4.0, machines and equipment or robots do not operate independently like in Industry 3.0, but they are integrated into a control system. Therefore, the difference between Industry 3.0 and Industry 4.0 is in Industry 3.0, things work independently and separately but in Industry 4.0, things are communicated and integrated with the support of IoT.*" (P5)

Given the limited awareness among most company leaders regarding the distinctions between Industry 3.0 and Industry 4.0 technologies, the researcher ensured the questions during the questionnaire development process, with this consideration in mind, were specific about adoption of Industry 4.0 technologies and accompanied by relevant examples to help participants maintain a clear focus on the subject matter of questions.

7.4.2. Implementation of Industry 4.0 in Vietnamese companies and their supply chain activities

The findings from this qualitative study indicate that a majority of companies perceived a sense of urgency towards digital transformation, viewing the adoption of digital technology as a pathway to gaining a competitive advantage in the industry. It was unveiled that certain organisations have extensively digitalised their business processes and operational activities such as forecasting, demand planning, warehouse management, order processing, and production.

"*Comparing to other Vietnamese business, our business has adopted a considerable amount of digital technologies in supply chain activities, from forecasting, production planning, outsourcing, manufacturing and distribution activities and is still on digital transformation journey. We view digital transformation as our competitive advantage*" (P12)

Nonetheless, most organisations are still in the initial stages of digital transformation and the adoption of digital technologies. They have either just embarked on their digital transformation journey or are encountering challenges in the process of digitalisation, as highlighted by P1, P2, P7, P8, P10, P11 and P12. This finding is also supported by Matthess and Kunkel (2020) who claimed that many developing nations are still at early stage of structural change and low level of digital transformation as the science, technology and innovation in these developing countries remain low.

"*Despite the large size of our business, the level of digital technology implementation is still limited as the firm is still relatively young in the market and adheres to traditional working method. However, our business has recognised the benefits of digital transformation or digital technology adoption, prompting us to embrace change*." (P11)

Moreover, all interviewees disclosed that the implementation of Industry 4.0 is contingent upon the industries they operate in. This aligns with findings of Hoyer, Gunawan and Reaiche (2020), Müller, Kiel and Voigt (2018), Bartodziej and Bartodziej (2017) who argued that the degree of digitalisation within organisations is intricately tied to their industry sectors and specific sectors could encounter distinct challenges which are highlighted in the following statements.

"*…Overall, within the chemicals sector, the adoption of digital technologies remains at a low rate. This is mainly due to the potential dangers associated with conducting online* *control of chemical plants from the central control tower. Therefore, despite having sufficient financial resources, our business does not fully digitalise our business.*" (P13)

"*In the textile Industry, the adoption of digital technology is relatively low, with technologies being only minimally incorporated at a few stages of the production line. Moreover, the machinery and equipment within this sector cannot be seamlessly integrated with digital technologies, resulting in a lack of interconnectedness*." (P7)

Several companies maintain the viewpoint that the advancement of Industry 4.0 in Vietnam is still in its nascent stages (P3, P10 and P14). This perspective finds support in the works of Bhagat, Naz, and Magda (2022), Delera et al. (2022), and Roodt and Koen (2020), who argued that the fourth industrial revolution remains largely untapped and underdeveloped, particularly in developing nations. These nations might need to first catch up on the industrial revolutions they missed before fully embracing the possibilities of Industry 4.0.

"*In Vietnam, Industry 3.0 is not yet fully developed and completed; therefore, planning for Industry 4.0 is still too early. Additionally, artificial intelligence (AI) and Big Data are still in the research and experimental stages, and there has not been substantial implementation*." (P3)

In general, the findings highlighted the diverse range of comprehension and perspectives exhibited by the representatives of these companies regarding Industry 4.0 or the so-called digital transformation in Vietnam. These varying viewpoints across different companies could be attributed to the diverse backgrounds, levels of experience in innovation adoption, understanding of technological advancements as well as the distinct industry sectors of the firms. Additionally, the findings also shed light on the extent of digital transformation in their supply chain operations. It has been revealed that some organisations have already achieved a high level of digitalisation, extensively implementing digital technologies in crucial operational areas, given their proactive approach culture to innovation, availability of resources, or a recognition of the competitive advantages brought by such technologies. On the other hand, there are other organisations in the early stages of digital transformation or struggling on the digitalisation journey due to their limited resources, a lack of knowledge and understanding of this disruptive change, the availability of support, and the immaturity of digital technologies in their industry sectors.

7.4.3. Enablers and barriers of SC 4.0 adoption

Following the identification of influential factors through a systematic literature review (SLR), these determinants were categorised into four overarching themes and their respective subthemes: Technology, Organisation, and Environment (integrated with IOR) factors, and Organisational Culture factor. It is important to note that since the research takes a holistic view, the factors were sorted according to specific digital technologies or application scenarios. Therefore, the following result is considered as a compilation of all potential factors that can either inhibit or support adoption of digital technologies. It may be possible in some cases that not all barriers and enablers emerge during the interviews.

7.4.3.1. Technological factor' impact on the SC4.0 adoption

Throughout the interviews, prominent concerns and risks associated with the implementation of digital technologies and digital transformation were revealed, including (1) ambiguous return on investment (ROI) (P1, P2, P4, P5, P7, P9, P11, P12, P13, and P14), (2) heavy reliance on external technology providers (P7, P8, P9, P10, and P11), (3) the short lifespan of digital technologies (P5 and P11), (4) cybersecurity issues (P6, P8, P9, P10, P12, and P13), (5) complexities (P5, P7, P9, P11, P12, and P13), (6) incompatibility challenges (P6, P7, P8, P9, and P11), and (7) cost concerns (P1, P2, P3, P4, P7, P8, P9, P10, P11, P12, and P14). The interviews also shed light on the diverse benefits perceived by the organisations through the implementation of digital transformation in their supply chain activities, including increased profits, improvements in product and service quality, and enhancements in overall business processes (P3, P4, P5, P6, P9, P10, P11, and P12).

(1) Perceived risks

- **Unclear return on investment**

The prevailing agreement underscores the principle that all investment decisions, including those related to digital transformation, must be anchored in the concept of ROI. This highlights the essential requirement for investments into Industry 4.0 to yield tangible business benefits, spur company growth, and enhance overall performance. It is supported by Bogoviz et al. (2019) who claimed that in contrast to developed countries where digitalisation goals typically emphasise marketing aspects, those in developing countries predominately center around financial objectives. According to Chauhan, Singh and Luthra (2021), developing countries often encounter barriers related to costs due to limited financial resources.

For many interviewees, uncertainties regarding measurement of profitability, return on investment (ROI) and duration of ROI stand out as the primary concern for businesses. Such concern of investing in high-cost initiative alongside a high failure risk was also found in the studies by Almeida et al. (2023), Sayem et al. (2022) and Horváth and Szabó (2019). Among the interviewees, there is a broad consensus that investment decisions, including those related to digital transformation, should be based on ROI. This highlights the essential requirement for investments to ensure tangible business benefits, foster company growth, and enhance overall performance (P1, P2, P4, P5, P7, P9, P11, P12, P13, and P14).

"*It is challenging to justify the financial benefits from investments in digital initiatives. The outcomes often appear doubtful, uncertain and invisible*." (13)

"The biggest question is whether the adoption of technologies truly holds financial value for the company…Apart from higher profitability, it is important to ensure increased market demand and improved operational and managerial efficiency. These incentives serve as the driving factors for our business's digitalisation adoption." (P14)

Given the extended timeline of digital transformation spanning years rather than months, its complete impact on the business may not be quickly realised. This ambiguity regarding the pay-off makes companies hesitant about investing in digital initiatives. Therefore, despite the acknowledgement that "*all top managers realise the value of digital transformation or digital technology implementation*" (P9); *"businesses are reluctant to embrace this disruptive change due to a lack of sufficient business cases to prove the feasibility*" (P11) and "*due to the failure to justify projected financial returns*" (P12). Similarly, P7 claimed that "*despite substantial support from our company's top management and abundant resources, digital technology adoption is deemed impractical as our organisation cannot sufficiently demonstrate the expected financial gains*".

Yet, interviewees agreed that in light of a plethora of opportunities and benefits presented by digital technologies, alongside the intense market competition in the digital race, digital transformation is an imperative that cannot be ignored across all industry sectors. Consequently, to prevent business from lagging in the race of digital transformation, enhancing technological capabilities becomes undeniably crucial (Angevine et al., 2021; Kontić and Vidicki, 2018). As a result, the pressure to consistently prove the ROI for digital investments consistently rests on the shoulders of top managers. Therefore, the questionnaire contained questions exploring the participants' perceptions and experiences regarding the transparency and duration of ROI realisation, the challenges they face in justifying investments, and their views on the tangible business benefits and motivations behind digital initiatives in their organisation.

- **Dependence on external technology providers**

Secondly, many companies disclosed their significant reliance on technology providers as a key obstacle to the successful implementation of technologies (P7, P8, P9, P10, and P11). Interestingly, this factor did not emerge as a critical issue in the literature review but was predominantly emphasised by the interviewees. Hence, this factor was included later in the development of the questionnaire.

Particularly, many companies – especially logistics firms that outsource IT services, such as operational process management systems integrated with digital technologies, from foreign providers – expressed concerns about the extent of their business's dependence on technology providers for their services (P7, P9 and P10). These services can include ongoing trainings and system upgrades, which later can cause complications associated with reliance on these providers, as P9 stated that "*There are numerous technology providers in the market, each offering varying levels of service quality. This can significantly impact the success of businesses' adoption of digital technologies, as low-quality technologies or technology services can lead to the failures or slow down the process of technology adoption*". Hence, these firms frequently conduct thorough assessments of technology providers, as asserted by P8 that "*when evaluating any technology, it is imperative for technology providers to demonstrate reliability, offer exceptional after-sales service, possess a dedicated support team to address both technical and operational challenges, provide adept technical guidance, commit to technology deployment roadmaps, and offer flexibility to tailor services to meet the specific needs of the firms. Consequently, the trustworthiness of technology providers is commonly assessed based on their technological solutions and services. This thorough evaluation of the technology provider's creditability plays a pivotal role in the selection process*".

While numerous firms expressed concerns about the inadequate services provided by technology vendors, others also voiced dissatisfaction with the scarcity of relevant and dependable technology providers in the market, as stated by P7.

"*The biggest barrier facing our company in digital transformation is the absence of domestic technology providers within the industry, which compels us to outsource very expensive technologies from overseas sources. Moreover, we have partnered with various* *prominent IT providers in Vietnam, such as FPT, CMC, and Viettel corporations to develop a digital transformation plan. However, no significant progress has been made*."

However, a different perspective emerged from other interviewees who do not consider their reliance on external technology providers as a threat or challenge to their innovation adoption (P10 and P11). These divergent perspectives can be attributed to the specific industry sectors within which these companies operate, as well as the maturity and accessibility of technologies in their respective industries, as stated by P11.

"*There are numerous online technology learning courses and programs available that offer organisations a flexible and cost-effective means to acquire digital skills. As long as organisations possess the necessary financial resources, access to digital technologies becomes feasible*." (P11)

To conclude, one major finding is that a significant number of companies rely heavily on technology providers, and this was not extensively covered in the literature review. Additionally, several interviewees highlighted the scarcity of domestic technology providers as a barrier to digital transformation. Therefore, the questionnaire included questions probing into the extent of reliance on technology providers as well as the availability of technology providers in the market.

- **Short lifespan of digital technologies**

Interviewees also raised another concern about the short lifespan of digital technologies (P5 and P11). This observation is in line with studies of Tran, Binh and Van (2019) and Deloitte (2017) also claimed that Industry 4.0 is expected to accelerate digital transformation throughout global supply chains more rapidly and within a shorter timeframe compared to previous industrial revolutions, owing to the swift progress in technology application and the concurrent economic growth. The rapid pace of technological development contributes to the relatively short lifespan of digital technologies, leading to their quick obsolescence. Consequently, the significantly reduced lifespan of digital technologies has raised concerns among organisations, as stated by P5.

"*One of the criteria for evaluating technologies is its life span. A short lifespan of digital technologies can lead to tremendous waste and inefficiency, as older digital devices and machines become unusable, sluggish or incompatible with other equipment. This may necessitate upgrading the devices and machines to more advanced versions. The lifespan of* *technology should be sufficiently long to justify the investment. Our business would face great financial risk if the applied digital technologies quickly become obsolete*." (P5)

This implies that the questionnaire incorporated a question aimed at exploring participants' perceptions of the lifespan of digital technologies and whether they have faced issues with digital technologies quickly becoming obsolete within their industry.

- **Data privacy and security concerns**

Lastly, many interviewees provided a range of viewpoints on data privacy and security concerns. Many companies previously considered this matter to be of minimal importance but have more recently begun to take it more seriously, particularly within technology product companies and technology-based service companies (P6, P8, P9, P10, P12, and P13). This growing concern aligns with earlier studies that highlighted the primary challenges of securing DSC, which involve unauthorised disclosure and data leaks of shared information among partners (Nagy et al., 2018; Kiel, Arnold and Voigt, 2017; Bhargava, Ranchal and Othmane, 2013). According to Horváth and Szabó (2019), this concern and fear about the secure and safe handling of private data can be intensified in the future due to the wide spread of digital technologies. This can be illustrated by P9's statement:

"*Given the expansive scope of our business, a system malfunction can potentially cause massive data breach, thus prioritising data safety and operational system security becomes our paramount concern and having robust data protection system in place is critical*" (P9)

Consequently, several interviewees shared a viewpoint that the technologies in use should have the capability to ensure data privacy and strengthen data security. As a result, careful evaluation of the data control capability and data storage capacity of these technologies is essential. However, it was pointed out by P10 that despite the escalating concerns about data privacy and security, companies in Vietnam have not taken substantial and adequate actions to address this issue.

"*Although a few organisations acknowledge the importance of data privacy and security, in comparison to European data privacy and security standards, the matter is still not given much seriousness in Vietnam. This has led to numerous cases of data breaches*." (P10)

This underestimation and misconception regarding the significance of data privacy and security in the context of digital transformation could be attributed to a lack of awareness, proper education, fundamental knowledge and good cyber security practices in their daily operations; as well as a shortage of adequate preventive measures and IT specialists to mitigate cyber security threats in Vietnamese firms (Mai and Tick, 2021; Pham et al., 2021). Consequently, companies need to proactively raise awareness about the importance of data privacy and security, bust any common myths and any misconceptions around these issues.

Given that most interviewees have started to take data privacy and security more seriously, the questionnaire comprised questions to explore participants' perceptions of the importance of data privacy and security in their organisations and whether they have observed any potential risks involved in digital technology adoption.

- **Incompatibility issues**

The consensus among interviewees is that achieving seamless integration and interoperability between adopted technologies and existing IT systems, processes, machinery, and equipment within organisations poses a considerable challenge (P6, P7, P8, P9, and P11). Correspondingly, prior studies have highlighted compatibility issues, referring to the extent of alignment with an organisation's current IT systems, as obstacles to the adoption of Industry 4.0 within organisations (Fernando et al., 2023; Akter et al., 2016). For example, Slimane, Coeurderoy and Mhenni (2022) stated that technical incompatibilities that commonly arise with existing computer systems can affect digital supply chain systems and their partners, potentially discouraging firms from adopting such systems. Thus, when a technology is perceived as compatible with the operational systems, firms are more likely to consider adopting the new technology, as stated by P6, P8 and P11.

"…*it is not necessary to adopt the latest technologies, but it is crucial to choose the technologies that are suitable and compatible with the organisational environment*" (P6)

"*Our company cannot integrate digital technologies into its transportation management system due to the lack of advanced and qualified vehicles. Many transport vehicles do not adhere to national standards, making it impossible for our company to implement digital technologies on a large scale*." (P8)

"*Technologies must be compatible with needs and solutions of our organisation.*" (P11)

Given the consensus among interviewees about the challenges of achieving seamless integration and compatibility, the questionnaire incorporated questions aimed at understanding whether participants' organisations have encountered digital technologies that are incompatible with their current IT and operational systems and practices and whether these incompatibility challenges have caused any issues.

- **Complexity issues**

The challenge of implementing digital technologies arises from the complex process of integrating existing systems with new technologies (Njenga et al., 2019; Tashkandi and Al-Jabri, 2015; Low, Chen and Wu, 2011) as this digital transformation demands a certain level of expertise that might not be readily accessible within the organisation. Interestingly, interviewees exhibited diverse perspectives on the complexity of digital transformation. While most companies (P5, P7, P9, P11, P12, and P13) agreed that technology complexity poses a barrier to implementation due to their employees' limited IT skills and knowledge, believing that digital transformation and technology adoption require significant resource investment, few companies (P6 and P10) did not view technology complexity as a problem. This suggests that interviewees might have underestimated the complexity of digital technologies, likely because digital technologies are still in their early stages, and newly introduced technologies are inherently challenging or intricate to use. Furthermore, the novelty and unfamiliarity of such technologies can lead to employees' hesitation in using them.

"*I occasionally take complexity into consideration. However, most of the time, technologies are not overly complicated*." (P10)

"*I do not believe technologies are complex, especially considering that young generations nowadays are fast learners.*" (P6)

This misconception and misunderstanding regarding the complexity of digital technologies can be attributed to a lack of sufficient understanding of their technical and business applications. Consequently, it becomes imperative for firms to foster a more comprehensive knowledge of digital technology applications.

On the other hand, many interviewees held the belief that if a technology is overly complex, it fails to address problems effectively and might even introduce further complications, as the essence of technology should be to simplify the companies' problems (P5, P7, P9, P11, P12 and P13). Consequently, it was agreed by those interviewees that the chosen technology must prioritise user-friendliness and simplicity in its use, as exemplified by P11's and P12's statements.

"…*if a technology is excessively complex, we do not invest in it. The primary principle of investing in technology is that it should bring benefits and efficiency. The second principle, which is just as important, is that it should be easy to use..*." (P11)

"*In my view, if a technology is complex, it should not be utilised because it will not bring effectiveness. Whatever it is, it must be simple for it to truly function efficiently."* (P12)

As technologies become more complex and sophisticated, senior management can play a crucial role by providing a clear vision and strong commitment to foster a favourable environment for innovation (Low, Chen and Wu, 2011; Lee and Kim, 2007). Thus, P5 and P9 have offered valuable suggestions aimed at mitigating the degree of complexity and accelerating the adoption pace of innovations throughout the digital transformation journey. These suggestions include recommendations for top managers to establish well-defined digital transformation pathways and strategies, foster an innovative culture and mindset, and notably, ensure unwavering commitment and engagement from top-level executives.

"*To reduce complexity and ensure the success of the digital transformation journey, it is important to break it down into smaller stages of digitalisation and take incremental steps to digitise daily operational activities. This approach can help simplify the process of digital transformation.*" (P5)

"It is crucial for top management to provide guidance and encouragement to employees, fostering a digital mindset and data-based working habits. This approach ultimately helps overcome resistance to digital changes..." (P9)

Considering the diverse perspectives on technology complexity, the questionnaire included questions that aim to understand participants' perceptions regarding the complexity of digital technologies in terms of the skills and knowledge required within their organisation to effectively navigate these complexities.

- **Cost concerns**

Digital transformation, particularly digital technology implementation requires initial investments that include monthly service charges, maintenance, technology customisation to align with the company's operational system, upgrades to new versions, and the required technical infrastructure. In line with numerous studies, this process incurs substantial implementation and ongoing expenses to secure the availability of new digital technologies, resources, a skilled workforce, and new organisational capabilities (Agrawal, Narain, & Ullah, 2019). Consequently, it is regarded as one of the foremost barriers (Fitzgerald et al., 2014).

Most interviewees indicated that cost holds significant influence over the implementation process given businesses' resource constraints, even for large organisations (P1, P2, P3, P4, P7, P8, P9, P10, P11, P12, and P14). This perspective can be illustrated by P1 and P14's statements as follows.

"*Only a few organisations are prepared to embrace digital transformation, given the high costs associated with technology infrastructure development, such as investments in fast broadband, databases, training, and the development of IT human resources*." (P14)

"*Certainly, the perpetual concern of innovation adoption costs has become even more evident, particularly in the aftermath of Covid*." (P1)

Nevertheless, several companies, particularly SMEs, asserted that the cost of adopting innovation is not a concern, as stated by P5 and P6.

"*…Financially speaking, the cost is not excessively high. There are certainly affordable management software options available. I am of the opinion that the cost is not necessarily a significant barrier; it's more about whether they choose to invest or not*" (P5)

"*We do not mind the costs of technology adoption since we view these expenses as long-term investments that will yield benefits for our business in the future.*" (P6)

The disparity in perspectives regarding the cost of digital transformation can be attributed to a lack of clear understanding about the expenses associated with the digital transformation process. Moreover, this discrepancy may be linked to the scale of businesses: SMEs tend to favour simpler technologies that demand minimal adjustments to their existing systems, leading to a lower innovation adoption cost; whereas larger firms require significant changes and more intricate technologies to align with their extensive operational systems, thereby leading to a higher investment cost for adopting innovations. Additionally, several companies showed a misunderstanding of the digital technologies, perceiving them merely as routine software installations.

Given the varied perspectives on the significance of cost, the questionnaire contained questions aimed at assessing how participants perceive the expenses associated with digital technology infrastructures, maintenance, human resources, training, and other aspects of digital technology implementation.

(2) Perceived benefits

The perception of benefits has been observed to be positively correlated with the rapid adoption and diffusion of innovation (Arnold and Voigt, 2019; Low, Chen and Wu, 2011; Tsai, Lee and Wu, 2010). According to Akbari et al. (2023), Industry 4.0 offers numerous benefits and advantages for improving operations and supply chains, not just in terms of efficiency but also overall effectiveness. Based on the insights gathered from the interviews, it becomes apparent that a wide range of potential benefits for businesses from the adoption of digital technology which serves as strong incentives for companies to actively engage in the process of digital transformation for their operations. The potential benefits of digital technology adoption including increased profits, improvements in product and service quality, and enhancements in business processes (such as cost reduction, operational efficiency, transparency, error and defect elimination, resource and time savings, and interdepartmental collaboration) were the most frequently mentioned benefits across industries and among all interviewees. This is illustrated in the following quotations.

"*Digital technologies have allowed us to minimise our organisation's heavy dependence on human resources, provided better protection for employees' health and safety by automating hazardous manual work*" (P3)

"*Thanks to automation and real-time market data analysis, numerous processes can now be automated. As a result, productivity and team collaboration are enhanced, leading to substantial time savings, which in turn are allocated to critical business activities...*" (P6)

"*Incorporating technologies into our operational system enables our business to reduce the number of employees and save on human resources costs, all while enhancing work productivity, particularly during the Covid-19 pandemic*." (P10)

Based on the insights from interviews regarding the perception of benefits related to digital technology adoption, the questionnaire therefore included questions that assess the participants' perceptions of the benefits associated with digital technology adoption in their organisations.

7.4.3.2. Organisational factor' impact on the SC4.0 adoption

The interviews have brought to light the significant influence of organisational factors on the implementation of digital transformation in their supply chain activities. Among these factors, the availability of organisational resources and the level of knowledge and support provided by top management have been highlighted.

Within the domain of organisational resources, the firm size, industry characteristics, availability of financial resources and technical infrastructure alongside the skills, knowledge and willingness for change of employees emerged as crucial factors, according to all interviewees. Notably, the interviewees also highlighted the role of top management knowledge and support as the most influential factor that determines the success of digital transformation (P4, P5, P6, P7, P9, P10, and P11).

(1) Firm size's impact on the SC4.0 adoption

The size of firms emerged as one of key determinants influencing the digital technology adoption decision (P3, P4, P6, P9, P10 and P13). According to Puklavec, Oliveira and Popovič (2018), Alshamaila, Papagiannidis and Li (2013), Low, Chen and Wu (2011), and Wang, Wang and Yang (2010), given the financial strength, technological competence, and higher risk tolerance, large organisations are inclined to invest in innovative solutions in order to easily collaborate with their supply chain partners, standardise services and operational processes, significantly enhance their business and operational performance. Whereas SMEs are often less likely to embrace digital technologies due to constraints in finances, human resources, and technology capabilities.

"*Since my company is a large enterprise, we have abundant financial resources. In fact, if you do not have money, you cannot adopt technologies…*" (P3)

"*Being a large corporation, our company consistently strives to stay ahead of the curve by anticipating significant global shifts through up-to-date market data analysis so that our company can develop strategic long-term plans for its development*." (P4)

"I believe that digital transformation might not yield substantial benefits for smaller businesses due to the substantial investment required" (P9)

However, various interviewees have claimed that the complex and hierarchical structure in addition to the substantial costs involved in digital transformation of large firms have presented challenges for large firms in the digital transformation journey, comparing to SMEs who are more flexible and adaptable to disruptive changes. For example, P3, P6 and P10 stated that:

"*Due to the complex organisational structures with a broad business scope…our organisation has to adopt various technologies instead of relying on a single technology for all purposes. As a result, this leads to a considerable cost of technology adoption, involving a substantial number of individuals with diverse IT skills and knowledge…In addition, it requires substantial effort of research, experiment, and an extended implementation period. This cost and effort are even more substantial, particularly for leading technology product companies like us*" (P3).

"*Despite making substantial investments in innovation, a number of large firms face challenges when it comes to adopting digital technologies due to their complex organisational structures and the higher adoption costs that come with large-scale implementations, especially when compared to small businesses*" (P6).

"*Small organisations possess a significant advantage over their larger competitors, namely the ability to remain flexible and swiftly adapt to market changes because small firms have a smaller number of employees…and a simpler hierarchy or management structure. These attributes collectively make it easier and quicker for small firms to adopt technologies*…" (P10)

This perspective is reflected in a study by Bilgeri, Wortmann and Fleisch (2017) which revealed that large manufacturing firms like GE or Royal Philips, with multiple business units have faced challenges in developing IoT solutions and implementing their digital strategies due to the unsuitability of current organisational structures and difficulties to incentivize their business units to collaborate on digital plans. This finding contrasts with majority of existing literature. One plausible explanation for the varying perspectives might be that firm size can have different influences across different stages of digital technology adoption and digital transformation journey. According to Zhu, Kraemer and Xu (2003), at the evaluation stage, larger firms exhibit a greater propensity to adopt and expand their use of digital technologies compared to SMEs. This inclination stems from the need to optimise operational efficiency through automation, and the advantages derived from substantial financial and technological capabilities, and economies of scale. However, in the implementation stage, the presence of multiple bureaucratic layers, complex processes, and lengthy decision-making chains in large firms often results in slower responses to changes, thereby hindering their implementation progress. In contrast, SMEs, with their more agile and straightforward structures and procedures, may find the implementation process comparatively smoother.

Nevertheless, one interviewee asserted that the size of the business holds no significance for them in the context of digital transformation. This perspective arises from their experience of early technology adoption, which has given them with an advantage in accelerating the technology integration process.

"Despite our large organisational structure, we have not encountered significant challenges in our digital transformation journey thanks to our early adoption of technology during the company's initial growth stage. By integrating technologies into our operations at early stage, our company has faced less substantial obstacles when the business has expanded in size." (P9)

Broadly speaking there is a consensus that the size of a company has a multifaceted impact throughout the different phases of the digital transformation process. Moreover, there is a prevailing notion that both early and incremental technology adoption offer considerable advantages to businesses, with SMEs in particular standing to gain significantly from such adoption. This highlights the importance of considering the timing and extent of technology integration to ensure a smoother transition towards digital transformation. Thus, when developing the questionnaire, the researcher ensured that it included a question related to firm size based on Vietnamese firm size classification standards.

(2) Firm's industry characteristics

Industry characteristics were found to exert a significant influence on the potential and scope of digital technology adoption within firms (P3, P7, P8, P11, and P13). As highlighted by Tortorella et al. (2023), various industry sectors can either hinder or facilitate a higher degree of digitalisation. Organisation for Economic Cooperation and Development (OECD) (2011) further emphasised that various industry sectors exhibit distinct levels of technological intensity. In essence, firms with greater technological intensities could offer a more favourable environment for extensive digitalisation, whereas companies with lower technological intensity might encounter challenges in adopting Industry 4.0 technologies (Culot et al. 2020; Tortorella, Giglio and Van Dun, 2019). As stated by P11 that "*Depending on the industry characteristics of the business, success is measured by different values. For technology-based products or services such as the electronics industry…a company's success is intricately tied to the rapid development of cutting-edge technology-driven products and services. Thus, technologies stand as both the cornerstone of achievement and the source of profitability*".

In the context of this study, industries such as electronics or transportation manufacturing (e.g., motor vehicles and auto parts) exhibit a high level of technological intensity, thus considering the adoption of digital technologies as strategic imperative. Conversely, industries such as textiles and garment production characterised by low level of technological intensity might face limitations in implementing digital technologies. This distinction in digitalisation level arises from the fact that manufacturing enterprises, particularly those in the technology product sector, are better positioned to embrace digital technologies due to their well-defined production processes and heavy reliance on cutting-edge technologies for their products and services. In contrast, in certain sectors like consumer goods or the textile industry, technologies only serve as tools to facilitate the attainment of organisational objectives. Especially, within logistics and transportation enterprises, there exists a constrained application of and awareness about Industry 4.0 digital technology adoption, even in cases where the Vietnamese company operates as a subsidiary of a multinational corporation. This is due to the dynamic and flexible nature of their services. As a result, these logistics firms must customise their software and operational processes to effectively meet the diverse demands of their clients. For example, P3, P7, P8 and P13 shared that:

"*As a leading figure in technology products, in order to maintain a competitive advantage in the market, our company has to consistently adopt digital technologies and needs to act as pioneers in digital technology adoption to retain our dominant position…*" (P3)

"*Due to the nature of the chemical industry where full digitalisation is unachievable, our company has reached an adequate level of automation. Therefore, I do not find it urgent to adopt many digital technologies for my company, nor do I perceive any challenges that inhibit us from undergoing digital transformation*." (P13)

"*Due to the complex production nature of the textile and clothing industry, in which technology maturity is relatively poor, digital transformation and the adoption of digital technology are more challenging.*" (P7).

"*Due to the nature of the logistics industry…despite receiving substantial support from top management, logistics companies continue to face challenges in fully digitising their business operations. As a result, there is a low level or almost no adoption of digital technologies among SMEs, particularly within the logistics sector. Even for large logistics organisations, they are only adopting fundamental technology tools and systems*." (P8)

In conclusion, the extent of technology adoption is contingent upon the specific industry within which a business operates. This highlights the crucial role that industry characteristics play in shaping the integration and utilisation of technology within organisations. Therefore, during the questionnaire development, a question asking the industry type the business operates in was included the questionnaire.

(3) Organisational resources

- **Financial resources**

Financial resources refer to the availability of budgets allocated to cover the costs associated with learning and integrating new systems (Chwelos, Benbasat and Dexter, 2001). It emerged as a significant determinant in the acceptance of technology within organisations (To and Ngai, 2006). Therefore, according to Maduku, Mpinganjira and Duh (2016), the significance of financial support should not be underestimated, as the absence of adequate financial resources poses challenges for companies to afford both IT equipment and skilled professionals necessary for digital transformation. Furthermore, having sufficient capital enables companies to better navigate disruptions that may arise during the adoption and implementation of new technologies (Sila, 2013). Hence, all organisations acknowledged the pivotal role of financial readiness in their digital transformation journey, as stated by P3 and P12.

"*If you have the financial resources, you can invest in technologies and hire the right personnel for those technologies*." (P3)

"*Financial capability is a prerequisite for organisations' adoption of digital technologies. Therefore, without sufficient financial resources, technology transformation cannot be achieved, regardless of the efforts of top management*." (P12)

Interestingly, most organisations indicated that they possess sufficient financial resources, which enable them to readily adopt technologies (P4, P6, P7, P9, P9, P10, P12, P13, P14). As a result, they do not consider financial constraints as a barrier, as stated by P7 and P9:

"*Our organisation has a sufficient budget allocated to digital transformation*.... *Financial concern is not an issue...Budgets for digital transformation have been approved by the leadership, but the results of Industry 4.0 have not been demonstrated or proven yet*." (P7)

"*Our company has allocated budgets and human resources to prepare the organisation's digital transformation*." (P9)

Even for small enterprises, financial resources are not perceived as a barrier to technology adoption. For example, the CEO of a small logistics and manufacturing company stated that their business faced no financial challenges when adopting technologies, stating that "*Every time a new technology is adopted, our sales increase significantly*" (P6). Similar to the findings of studies conducted by Lai, Sun and Ren (2018) and Maduku, Mpinganjira and Duh (2016), it is notable that all the organisations, including large companies and SMEs, have sufficient financial resources for their digital transformation. However, this finding is inconsistent with the research conducted by Horváth and Szabó (2019) which claimed that firms, especially SMEs, encounter the substantial challenges related to financial shortage during their digital transformation journey, limiting them from investing in new technologies. This divergence in viewpoints could potentially be attributed to the possibility that certain interviewed managers lacked a comprehensive understanding of all the financial requirements entailed in the adoption of digital technologies and the digital transformation process. As a result, they might have overestimated their financial resources available for the extensive technological reform.

For questionnaire development, the researcher therefore included questions that explore participants' perceptions of their organisation's financial readiness for digital transformation such as their budget allocations, funding for IT equipment and personnel and whether they have experienced any financial challenges during their digital transformation journey.

- **Employees' skills, knowledge and willingness for change**

Technological revolutions often lead to widespread job layoffs or the obsolescence of conventional skills (Lawrence, 1968). Consequently, the growing prominence of digital technologies and digital transformation is placing a significant demand on employees to possess broader skills and a diverse knowledge of various technologies (Leesakul et al., 2022; Singh and Hess, 2020). Thus, according to Vial (2021) and Warner and Wäger (2019) employees' digital skills, knowledge and capabilities are seen as critical dynamic capability of organisations during digital transformations, as stated by P11.

"*Recruiting a skilled team with expertise in change management to oversee the digital transformation process and transition activities within the company is essential. Profound changes, like the adoption of new technologies, demand not only the integration of these technologies into the operational systems but also the implementation of effective governance practices and models. This, in turn, necessitates business leaders to possess both management and digital competencies and to challenge the organisation's conventional mindset to effectively guide the transformation process*." (P11)

However, numerous companies emphasised the growing challenge they face in terms of a shortage of digitally adept workforce possessing essential skills in IT, management, and languages, as well as the knowledge gaps between the top managers and the employees who execute the plans (P1, P5, P6, and P11). The scarcity of skills and knowledge gaps pose a significant obstacle to their ability to effectively implement digital technologies, as stated by P5 and P6. This finding aligns with studies by Karre et al. (2017) and Müller and Voigt (2017) which revealed that one of the major challenges to Industry 4.0 implementation faced by firms is the lack of skilled workforce and the need for staff training.

"*One of the challenges with the organisations is the gap in awareness, knowledge and understanding of digitalisation between top management and employees…Despite leadership's good understanding and knowledge of Industry 4.0, the digitalisation visions might not be achieved or the plan is not executed successfully due to the knowledge gap between management levels and even middle management and employee level*." (P5)

"*Knowledge gaps among employees or between employees and managers can jeopardise the digital transformation process; thus, ensuring that all employees are equipped with sufficient digital knowledge is critical*" (P6)

However, despite the present scarcity of pertinent skills and knowledge among employees, many interviewees do not view it as a substantial obstacle, as exemplified by P3's, P4's and P9's statements. They hold the belief that in today's context, young employees swiftly grasp knowledge and rapidly acquire IT skills. Additionally, they are confident that with ample resources at their disposal, externally obtaining the necessary skills can be relatively easy for firms. They also expressed confidence in their employees' skills due to their relatively young age, open-mindedness, and readiness to embrace new technologies. This viewpoint can be attributed to the presence of proficient and youthful professionals within their organisation and industry.

"*I do not think acquiring IT skilled employees can become a barrier, as you can access to such employees if the company has sufficient financial resources…With sufficient funds, you can obtain individuals with different level of knowledge and degrees, even the desired patents" (P3)*

"*IT and management skills can be outsourced*." (P4)

"*Well, our team is relatively young which means that the implementation of new technologies does not encounter many obstacles. Our management team is also young, therefore we do not face many issues in terms of innovation adoption*." (P9)

Apart from the shortage of relevant skills, another common challenge that firms frequently confront during technology adoption is employee resistance and non-cooperation. This resistance can stem from factors such as age, limited technical background, familiarity with traditional working methods, or the company's past successful approaches, as believed by P7, P9 and P11. Whether intentionally or unintentionally, newly introduced technologies bring about changes in daily routines and processes, disrupting users' personal comfort zones (Özdemir-Güngör and Camgöz-Akdağ, 2018). These changes often lead to uncertainties and, in some cases, perceived threats. Consequently, resistance to change emerges as individuals react to this disruption (Nov and Ye, 2008). According to Horváth and Szabó (2019), organisational resistance can originate from employees who fear job loss due to new technologies or lack the necessary skills. This resistance can also extend to middle managers.

"*Employees in our business are not strongly adaptive to the market changes, which hamper our change initiatives*" (P7)

"*Our employees are resistant to changes. They have established routines and prefer the traditional work methods*". (P9)

"*Firms have a tendency of basing strategies on the past successful experience, making it unlikely for them to introduce drastic changes…Most of employees and even certain managers are accustomed to traditional and predictable routines since introducing changes demand them to acquire more advanced skills...*" (P11)

However, there were other interviewees who believed that there are no organisations where employees are either entirely opposed to or fully in favour of adopting new technologies or operational systems (P6 and P11).

"*There are also other employees who are willing and welcome new working methods, operational systems, and technologies*". (P6)

"*In reality, no company functions in a way where suggestions are made and everyone instantly agrees. Or there is no immediate resistance like "I'm not doing it, I'm not doing that..It is a common situation where some individuals, particularly those from the older generation, disagree or resist technological changes. Whereas, younger-generation employees are more open and enthusiastic about adopting new ideas and technologies..."* (P11)

Hence, to embrace the digital revolution, interviewees emphasised the significance of acquiring pertinent skills like IT, management, and English language proficiency which enable employees to access new technological knowledge effectively, as exemplified by P9 and P10's belief.

"*With proper instructions and guidance, employees will be able to effectively adopt technologies*." (P10)

"*Offering training is one of the future objectives of our organisation... It is imperative to provide comprehensive and ongoing training in digital skills for both top management and employees in preparation for the digital transformation journey*" (P9)

Moreover, it was suggested that organisations should focus on developing employee engagement strategies to foster early and rapid technology adoption, thereby helping to mitigate resistance to change and retain talent. As stated by Nicolás-Agustín, Jiménez-Jiménez and Maeso-Fernandez (2022), employee involvement is one of the essential practices to foster innovative behaviours and execute digital transformation process. Other interviewees also emphasised the importance of cultivating a data-driven business culture and recommended incentivising staff with a benefits-focused approach (P2 and P9).

"*Incorporating the adoption of technologies and innovations into employee performance evaluations, and rewarding them with financial incentives based on their efforts to learn and apply technologies, can help incentivise employees to feel more responsible and interested, enhancing their willingness to integrate technology into their daily work habits"* (P2)

"*The collection and analysis of up-to-date data through the utilisation of technologies are integral components of our company's operational routine... Importantly, leaders should highlight the economic and rational benefits of technology adoption for employees... It is also crucial to involve employees in weekly meetings, providing them with the opportunity to share their challenges and achievements within the new culture. This approach can significantly improve the acceptance of disruptive technology adoption among employees."* (P9)

In summary, it is crucial to effectively promote the adoption of digital technologies to help employees realise the potential and value these technologies offer in terms of reducing workloads, enhancing productivity, and improving efficiency, without necessarily replacing their roles. This approach can foster employees' confidence and enthusiasm to actively participate in the company's digital transformation journey. Given the importance of employees' skills and knowledge, willingness for change, and the given organisational trainings for successful digital transformation, the questionnaire included questions that aim to assess the perceived employee readiness in terms of skills and knowledge (e.g., IT, management, language), the availability of trainings, and employee engagement and cooperation toward digital transformation within organisations.

- **Technical infrastructure**

Technological infrastructure encompasses the installed network technologies and enterprise systems that establish a foundation for the development of digital technologies (Low, Chen and Wu, 2011). There is wide agreement among interviewees that comprehensive IT modernisation and robust technical infrastructure are prerequisites for companies before embarking on the digital transformation or adopting digital technologies (P1, P3, P6, P7, P8, P9, P11, P13 and P14). This entails features such as fibre connectivity, broadband capabilities, and data centres that allow fast data transmission, real-time data access and collection, alongside machinery and equipment facilitating seamless technology integration. In line with findings of studies conducted by Henao-Ramírez and Lopez-Zapata (2022), Martins et al. (2019), Chan and Chong (2013), Lin and Lin (2008) and Lin (2008), firms with advanced IT infrastructure are more likely to effectively implement technologies. Nonetheless, several interviewees mentioned their business's inadequate technical infrastructure as an obstacle to their digital transformation efforts, as revealed by P1 and P11.

"*Slow network connection in our business's area significantly affected our work progress*." (P1)

"*Existing technology infrastructure in our company greatly constrains our business' long-term digital technology investment plan*." (P11)

Similarly, Kache and Seuring (2017) highlighted that the absence of robust IT infrastructure needed to manage data and comprehend extensive information was identified by experts as the most significant hurdle in technology adoption. The authors point out that a significant factor contributing to the shortage of capable IT infrastructure is frequently linked to the timing of financial investment cycles. Thus, the replacement or upgrade of the existing IT infrastructure is frequently impeded due to the assets not being fully amortised at the time of the upgrade. In these circumstances, companies consistently face the challenge of rationalising and prioritising the ongoing investments in the technologies needed for such adoption.

However, despite some interviewees highlighting infrastructure challenges, others believed that technical infrastructure only presents a minor challenge rather than a significant obstacle for their organisations (P6, P8, P9 and P13). They asserted that their companies have already made substantial investments in basic technical infrastructure. They also proposed commencing digital transformation by taking incremental steps to progressively enhance the IT and operational systems. Likewise, a study by Low, Chen, and Wu (2011) also recommended that firms considering adopting cloud computing could begin with a gradual implementation, gradually expanding processes by developing more internet infrastructure or portable electronic equipment. Additionally, interviewees emphasised that a partial investment in digital technologies is insufficient for a complete digital transformation, as true digitalisation necessitates a collaborative investment in infrastructure across all levels of the business (P1, P3, P7, P11 and P14).

"*I don't think IT infrastructure concerns are too significant*." (P8)

"*We have gradually and significantly built and invested in our IT infrastructure... Our early investment in technical infrastructure has become an advantage that enables our company to implement technologies."* (P9)

Given the diverse perspectives of interviewees towards the significance of IT infrastructure, the questionnaire incorporated a question designed to investigate the readiness of organisations' technological infrastructure, including aspects such as high-speed internet, data centres, security system and equipment for technology integration in the context of digital transformation.

(4) Top management support and knowledge

Previous studies have emphasised the significance of top management digital transformation processes. Particularly, their comprehensive understanding of digitalisation, establishment of a well-structured context for digital initiatives, their commitment and support, and their leadership in driving changes, collectively enable the smooth execution of transformational processes and strategic actions throughout the entire organisation (Govindan et al., 2022; Arnold, Veile, and Voigt, 2018; Yeh and Chen, 2018; Oliveira, Thomas and Espadanal, 2014). According to Wrede, Velamuri and Dauth (2020), the decisions taken by top managers significantly shape the direction a company's digital transformation journey. Among managers, there is a widespread agreement that the digital transformation of a business greatly depends on the top management's expertise, visions, and understanding of digital technology applications (P4, P5, P6, P7, P9, P10, and P11). Equally important is their active engagement and endorsement to drive this transformation forward.

"*In fostering innovation adoption, leadership stands out as the crucial factor. When leaders are not only convinced but also understand the significance of integrating innovation within the company, they proactively restructure the organisational systems to support the deployment of the innovation and ensure policy compliance… Thus, it is important that the top management must embrace changes, then the rest of the organisation will follow suit."* (P4)

"*Whatever transformation you embark upon, it all hinges on leadership*" (P5)

Therefore, the experts stressed the necessity for top management to have innovative leadership mindset and sense of urgency towards digital transformation to accelerate the pace of technology adoption, as revealed by P10, and P11. They asserted that if leaders do not possess a comprehensive understanding of the technological development, market trends, and the unique challenges facing their companies, the potential for large-scale technology implementation becomes restricted, while the likelihood of making wrong decisions increases. According to Abbu et al. (2022) and Kane et al. (2019), digital transformation requires leaders to have a profound understanding of technological possibilities that enables leaders to develop clear digital strategies and engage employees in such transformation process. If leaders lack these competences and knowledge, leaders must proactively develop and nurture these skills within the team to be able to fully leverage the advantages of digital transformation (Cortellazzo, Bruni and Zampieri, 2019). Leaders' digital literacy becomes especially crucial in a culture of top-down management approach where senior leaders bear the responsibility for all key decisions.

"*Top managers with the capability and knowledge, as well as a desire to scale the business, are likely to follow the technology market trends. In addition to having sufficient knowledge of digital transformation, it is crucial for top management to recognise the urgency of this radical change and effectively communicate this urgency to their employees*." (P11)

"*If top managers possess limited understanding, commitment, or knowledge, they are less likely to endorse digital transformation. Moreover, if they assume full responsibility for technology adoption due to the company's top-down approach, there is a risk of making incorrect decisions*." (P10)

Furthermore, interviewees emphasised that cultivating an innovative culture is vital for the success of digital transformation, as exemplified by P9's statement. He asserted that top management's firm commitment can effectively address employee resistance concerns by enforcing change rigorously. This approach compels both the companies and employees to integrate digital technologies seamlessly into operational processes and consistently daily utilise real-time data.

"*If top managers exert their power and control over employees in the pursuit of digital transformation, employees are left with no choice but to either comply with the orders or leave the organisation…. It is essential for top managers not only show the commitment to technology adoption but also to practically apply these changes and involve employees in the process of change*… *It is important for top management to cultivate employees' habits of collecting and utilising real-time data, while also rewarding them for their innovative achievements*" (P9)

In addition to creating an innovative and data-driven culture, according to majority of interviewees, organisational leaders must also have a clear digital transformation vision and a well-defined set of digital transformation goals, then communicate these goals and delegate the tasks to lower-level managers along with mentoring them (P1, P2, P3, P4, P5, P6 and P9). As stated by Abby et al. (2022) and Kane et al. (2019), digital transformation visions are crucial for the success of such transformation and leaders should communicate such visions to employees to foster a shared understanding and commitment to achieve these goals. All interviewees also noted the essential need for commitment across the entire to ensure the smooth execution of the transformation plan. For example, P6 stated that:

"*Despite the modest size of our business, our top management is willing and enthusiastic to make significant investments in digital technology adoption in order to expedite the growth of the business. We align technological reform with the business strategy and objectives to underpin success in the market, particularly helping the organisation in quickly controlling things, responding to the market changes and accurately planning resources to enhance our business' competitive advantage*." (P6)

However, the research also uncovered a noteworthy barrier to digital transformation originating from top management. This obstacle arises from their lack of a sense of urgency and a comprehensive understanding of the potential offered by digital technology which led to the absence of clearly defined digital pathway for firms. The lack of sense of urgency can be attributed to the tendency of top managers to base organisational strategies on past successes, which have historically led to the company's competitive edge. Meanwhile, transformations driven by new approaches such as digital technology adoption require significant investments and organisational restructuring. These endeavours may result in uncertain ROI, particularly for SMEs. As a result, some top managers, especially from SMEs, might be hesitant to take proactive actions, as stated by P7 and P10. This highlights the significance of organisational leaders having a robust awareness and in-depth understanding of Industry 4.0 and its principles so that a clear strategic roadmap for the digital transformation for the company can be formulated.

"*One of the primary barriers to technology adoption is that many businesses leaders do not prioritise digital transformation or have a sense of urgency. They are also unwilling to take on potential risks involved in the journey of digital transformation*" (P10)

"*Although our business's top management is determined and proactive in pursuing digital transformation…, our organisation is still struggling to start the journey due to the lack of clarity regarding the approaches and methods required to formulate a detailed plan and establish a clear direction towards for the process of digital transformation*." (P7)

Overall, the absence of digital technology application knowledge within top management was identified as a barrier to its adoption. This implies that without a proper comprehension of digital transformation at the top management level, the sense of urgency, and organisational determination, the organisation's efforts and actions become ineffective and fruitless.

Since the interviews highlighted the crucial role of top management in driving digital transformation, the questionnaire included questions that assess the leadership's understanding and experience, level of commitment and dedication to allocate time, resources and effort as well as develop clearly defined vision for digital initiatives. In addition, questions were designed to understand if these goals are communicated effectively throughout the organisation and whether tasks are delegated and mentored to lower-level managers. Questions also examined whether leadership provides support and guidance to employees involved in digital transformation initiatives. Lastly, these questions explored their willingness to embrace change, take potential risks, and cultivate an innovative driven culture within the organisation.

7.4.3.3. Environmental factor' impact on the SC4.0 adoption

Through the interviews, a diversity of Vietnamese organisations' viewpoints has emerged concerning the impact of environmental factors on their DSC adoption. According to majority of interviewees, the presence of competitor and customer pressure as well as the interfirm relationships have driven companies to accelerate the digital transformation efforts in their supply chains (P2, P3, P4, P6, P7, P8, P9, P10, P11, and P12). Whereas perspectives on government and third-party support were more neutral.

(1) Competitor and customer pressure

Notably, the driving force behind most of Vietnamese companies' pursuit of digital transformation stems primarily from the mounting pressure of fierce market competition and growing customer demands, rather than a pure desire for innovation. The interviewees widely agreed that the intense pressure exerted by competitors and customers compels their companies to embark on the journey of digital transformation (P2, P3, P4, P6, P7, P8, P9, P10, P11, and P12). This is rooted in the belief that companies adopting digital technologies can achieve a competitive edge, expand their market share, and fulfil customer expectations through innovative developments.

Regarding competitive pressure, there is a consensus among the interviewees that digitalisation is a vital prerequisite for survival in the fiercely competitive market. Similarly, competitive pressure has consistently been identified as a crucial factor influencing the adoption of innovation and technologies in previous studies (Jeyaraj, Rottman, and Lacity, 2006). According to Henao-Ramírez and Lopez-Zapata (2022) and Tien et al. (2020), the existing utilisation of technology among companies significantly impact the adoption of emerging technologies. It has intensified the competitive pressures within their industries, driving companies to recognise the imperative of adopting digital technologies to prevent losing power in the market and to sustain their position. Confronted with these competitive pressures, certain firms embrace digital technologies to enhance various aspects such as inventory management, supply chain visibility, accurate data collection and analysis, and operational efficiency (Conner, Manogharan, and Meyers, 2015; Wang, Wang, and Yang, 2010).

In fact, certain firms in Vietnam are making substantial efforts to transition into fully digital ecosystems to remain competitive on a global scale (P3, P5, P7, P8, P9, P10, P11, and P12). These firms recognise that the pursuit of digital transformation by their competitors, which poses a threat to their market share, forcing them to engage in the digitalisation race to ensure their competitiveness in the market. Notably, high-tech companies in Vietnam face even more intensified competition, necessitating swift actions and substantial investments in digital transformation and cutting-edge technologies to secure their leading position. For example, P8 and P12 stated that:

“*The logistics industry constantly changes, pressuring logistics companies to continuously improve and adapt in response to market demands*.” (P8)

“*Facing the increasingly fierce low-cost competition, businesses must redefine their operational and management methods, which can be achieved with the support of digital technologies*...*The pace of digital transition is accelerating across all industry sectors in Vietnam, as companies increasingly perceive digital transformation as a competitive advantage*” (P12)

In the context of customer demands, it has become evident that the motives for today’s businesses to digitise arises from the need to meet customer expectations for innovative, rapid, and customised services, as well as to align with the growing preference for more sustainable products and environmentally friendly production processes, as believed by P2, P3 and P11.

“*Customers essentially do not concern with the quantity or extent of technologies a company is adopting; they are primarily concerned with whether the service is fast, transparent, and efficient. This, in turn, has prompted companies to pursue the adoption of digital technology*”. (P11)

“*The customer’s desire for fast, transparent, efficient, and cost-effective services indirectly compels companies to adopt digital technologies to achieve the desired level of customer service quality*.” (P3)

Additionally, the study revealed that market uncertainties, particularly Covid-19 in this case, have intensified the market pressure, leading to a shift in market demand and customer behaviours. Market uncertainties have been widely acknowledged as a catalyst for accelerating the digitalisation efforts of companies. This finding is in accordance with the prevailing view of previous literature, which suggests that companies operating in environments characterised by high uncertainty are more motivated to adopt technologies that enable them to analyse and predict market changes, facilitating rapid decision-making (Prause, 2019; Patterson, Grimm and Corsi, 2003). According to the interviewees P4 and P9, the discourse around Industry 4.0 existed prior to Covid-19, but it was only in the wake of the pandemic that companies began to expedite and take the process of digital transformation more seriously. According to a study by Ngo et al. (2023) in Vietnam, such significant acceleration of digital transformation rate was partly driven by an increased consumer adoption of digital services and products under Covid 19’s social distancing rule. The interviews also revealed a significant impact of Covid-19 on a wide range of companies, with logistics firms being particularly affected by employee shortages. The pandemic compelled companies to undertake a restructuring of their operational systems, aiming for increased simplicity, efficiency, and reduced dependency on human resources. This restructuring facilitated the smoother adoption of technologies, thus accelerating the process of digital transformation. Moreover, the pandemic is seen to have played a role in reshaping employees' and organisations' mindsets and awareness regarding the crucial role of technologies in daily work and business operations, ultimately leading to enhanced productivity.

"*Covid has significantly impacted the business environment and accelerated digital transformation process for businesses*". (P4)

"*…Only when Covid-19 impacted every company did our business partners come under pressure to implement digital transformation in order to maintain competitiveness in the market*…*Covid-19 also provided our business with the opportunity to recognise the importance of reducing reliance on labour force to mitigate operational risks which therefore drive our business to embrace technological reform*." (P9)

Indeed, a survey conducted by McKinsey & Company (2021) shows that Covid 19 has accelerated the speed of digital technology adoption by several years. Nonetheless, it is not the case for several types of companies where Covid 19 had no impact due to the nature of their industry sectors. For example, P8 and P13 asserted that:

"*Our business had already embraced a certain extent of digital transformation before this crisis event. Given the characteristics of the chemical industry that requires onsite control of factories, chemical companies are advised not to implement a full digital transformation*" (P13)

"*Despite the impact of Covid 19, digital technologies cannot be fully implemented into transport management due to our substantial reliance on human resources. Therefore, market uncertainties such as Covid may not have significant impact on these companies*." (P8)

In general, the interview results have provided valuable insights into the motivations for digital transformation, particularly focusing on market competition, customer demands, and the impact of market uncertainties like Covid-19. Thus, for the development of the questionnaire, questions that aim to assess whether companies are driven by competitive pressure and changes in customer demands and whether digitalisation is essential for survival in their competitive market, were included.

(2) Market support

The perspectives on the role of market support, which includes both governmental and third-party support, in driving digital transformation, vary among the interviewees.

- **Government policies and support**

Government's incentive policies and support have been consistently found to enhance the willingness and speed of supply chain digital transformation (Gao etl al., 2024) through R&D development and digital cost subsidies (Wang et al., 2023; Xie et al., 2022). Regarding the government's role, all interviewees appreciated the government's vision for digitalisation and its efforts to facilitate companies' digital journeys. Several companies acknowledged the government's emphasis on the importance of digitalisation for Vietnamese firms and its active involvement in supporting businesses through digital transformation initiatives (P1 and P3). These initiatives encompass the development of national internet infrastructure, such as 4G and 5G, the creation of favourable investment terms for technology companies, and the formulation of detailed digital strategies and plans.

"*The government is also aiming for development of Industry 4.0. The government is not only advancing 5G networks but also exploring the possibilities of 6G networks…When looking at administrative processes, customs procedures, import and export protocols, as well as legal documentation, substantial digitisation efforts have been undertaken... I do not think the government is creating any obstacles; rather, they are striving to support businesses in enhancing their competitiveness by developing the IT infrastructure…*" (P1)

"*In order to promote the development of high technology industry, the government is also encouraging local companies to invest in the high technology sector while offering open and favourable investment conditions, such as reduced requirements for technology transfer or tax rebates, to attract foreign high technology companies*." (P3)

However, numerous managers have expressed their lack of awareness concerning any supportive policies, programs, or plans for digital transformation in businesses (P1, P3, P7, P8, P9, P11 and P12). Meanwhile, they also believed that the government's understanding of digital transformation remains ambiguous and insufficient. Moreover, the absence of a clear legal framework issued by the government has been impeding the progress of digital transformation in businesses, despite the government's efforts to provide more regulatory clarity which suggests a gap between the government actions and the companies. The interviewees also revealed that there exists a deficiency in effective methodological approaches, limited planning capabilities and national project management skills, as well as a lack of enforcement of laws and policies related to the national-scale digital transformation plan. Prior studies have also highlighted the insufficiency of government support and policies, including the absence of legal frameworks, as a barrier stifling digital transformation (Majumdar, Garg and Jain, 2021; Toufaily, Zalan and Dhaou, 2021). For example, P3 and P11 believed that:

“*However, the Vietnamese government’s understanding and awareness of digital transformation remain vague. There is little understanding about the benefits and contributions of digital technologies towards the economy and their applications*…*The transition from detailed plans to concrete actions remains challenging. Therefore, the government needs to significantly enhance its capacity to coordinate and implement digital transformation plans*…*Currently, the government is limited to only encouraging and issuing general guidance and policies, such as clean, environmentally friendly, and sustainable technologies. The support is mainly given to SMEs and start-ups, such as building national innovation centres to provide funding and support for SMEs’ product tests, launch, marketing, etc*… *The access to national funding is difficult with complex and costly administrative processes’*” (P3)

“*Numerous documents, countless official letters, and many calls for changes – yet, there is no comprehensive plan in place. Thus, I truly feel that the current role of the state remains too restricted, not yet evident or present somewhere that I do not know. Simply put, it appears that the state is not taking significant actions to catalyse digital transformation within businesses. I have not seen such endeavours being implemented*.” (P11)

On the contrary, a minority of leaders argued that businesses should take an independent stance in developing their own digital strategies, mapping out the trajectory for digital transformation, and making well-informed technology investments (P1, P3 and P7). They emphasised the need to avoid overreliance on government support and its predefined roadmap for or navigating the digital transformation journey. From their standpoint, the government’s primary role should lie in providing support and fostering economic growth, while leaving the task of strategic digitalization to individual businesses. According to these perspectives, Vietnamese businesses still lack a substantial degree of autonomy. Moreover, these leaders asserted that the extent of digitalisation varies across industries and depends on the specific types and characteristics of each business, making it difficult for the government to have a comprehensive plan.

“*We cannot expect the government to hold our hand; that is only feasible through the leadership of businesses themselves. Businesses need to formulate their own strategies,* *develop products that meet market demands, and then channel investments in the right direction…*" (P1)

Lastly, the interviewees reiterated the crucial role of the government in offering digital guidance, formulating strategic direction, and providing comprehensive guidelines (P3, P5, P8 and P14). They emphasised the importance of the government's involvement in nurturing workforce skills and establishing a robust legal framework to support businesses' digital transformation efforts. Thus, there was a consensus that, beyond formulating general policies, the government should proactively develop programs aimed at encouraging businesses to invest in digitalisation. For example, P3 and P14 claimed that:

"*In order for Vietnamese businesses to capitalise on the opportunities presented by the evolution of digital technology, it is important for the government to enhance the effectiveness of governance at all levels, along with improving the business and investment environment, such as executing administrative reforms, streamlining or simplifying administrative processes or procedures related to the business sector.*" (P14)

"*The role of the government here should involve understanding the needs and challenges of businesses, creating a supportive legal framework and mechanisms, as well as providing businesses access to financial funding for implementing digital transformation. The government should not blindly apply the same digital strategies and roadmaps from other countries. Instead, it should focus on understanding the national economic characteristics and market challenges, and how technologies can solve current market problems, rather than simply trying to keep up with other countries' technology advancements*". (P3)

In general, the interviews have provided diverse insights into the perceptions and expectations of businesses regarding the government's role in digital transformation. Based on these insights, the questionnaire incorporated questions to investigate whether companies have benefited from or are aware of specific government initiatives (e.g. investments in internet infrastructure, tax incentives, or technology transfer requirements) and a clear legal framework (e.g. technical standards, labour policies and data protection laws) to support firms' digital transformation.

- **Third-party support**

Concerning third-party support, existing literature emphasises that assistance from academic institutions, funding programs, banks, and business associations significantly influences the adoption of technology (Tripathi and Gupta, 2020; PWC, 2016B; Oesterreich and Teuteberg, 2016). Within the Vietnamese context, the impact of third-party support on firms' digital transformation is observed to be diverse. On one hand, the absence of third-party support, such as limited access to financial resources through funding programs or financial institutions, has been identified as a hindrance to firms' efforts in digital transformation, as stated by P7 and P9.

"*The success of our business's digital transformation heavily relies on technology providers that are currently unavailable in the market. As a result, our organisation has partnered with large IT firms like FPT to prepare for digital transformation…*" (P7)

"*The availability of external financial resources is limited. Additionally, businesses face high financing costs due to high interest rates and difficulties in accessing capital from banks or the government. Companies seeking government subsidies are required to navigate complex and challenging administrative procedures. (P9)*

On the other hand, there are firms that hold the belief that they cannot depend on support and resources from third-party organisations to embrace digital business transformation (P7 and P13). One plausible explanation could be that either these firms are hesitant to seek external support, or such assistance might not be readily available in Vietnam.

"*Rarely did our business rely on external companies, and these external entities only played a subordinate role in adopting digital technology*." (P13)

Given the diverse perspectives of the interviewees towards the role of third-party support in digital transformation initiatives, the questionnaire designed questions aimed at exploring the interviewees' perception of the impact of third-party support on their digital transformation efforts. These questions inquired about interviewees' experiences and challenges related to accessing financial resources from banks and government funds for digital transformation, as well as their perceptions of the availability of funding programs and support options from academic institutions, business associations, or other organisations that could aid in digital transformation.

(3) Interorganisational relationships

According to Vietnamese firms, the integration of digital technologies within the supply chain necessitates robust collaboration and active interaction among trading partners (P5, P9 and P11). The existing body of literature consistently emphasises the significance of involving multiple stakeholders in the process of adopting digital technologies. For example, studies conducted by Greenhalgh et al. (2004) and Frambach and Schillewaert (2002) reveal that informal interorganisational collaboration among supply chain partners serves as a catalyst for early-stage technology implementation. These findings emphasise the crucial role of collaborative efforts in driving innovation within supply chains.

"*In the last 3 - 4 years, establishing partnerships within the supply chain has become critical for the mutual success and competitive advantage of all supply chain stakeholders. Even suppliers now collaborate with each other to provide the best service to clients, rather than competing against each other as in the past*." (P5)

"The key to a successful digital transformation that benefits everyone lies in building strategic partnerships and fostering collaboration among all parties which is essential to as no single party can accomplish this alone. Obviously, by involving implementation partners or technology partners, the likelihood of reaching mutual visions and strategies for adopting digital technologies increases. Additionally, the early identification of major obstacles that impede digital technology adoption by all supply chain stakeholders can help mitigate risks of failure in later stages" (P9)

"*Nowadays, supply chain stakeholders actively support each other in embracing digital changes*". (P11)

According to Toufaily, Zalan and Dhaou (2021), supply chain collaboration extends beyond merely establishing data sharing standards and protocols; it fully encompasses the utilisation of network effects and technological value. As discussed in Chapter 5, an effective collaboration among supply chain partners in DSC adoption is highly influenced by various factors, including (1) the trading partners' power, (2) supply chain partners' digital readiness and (3) trust-based information sharing.

- **Trading partners' pressure**

According to Low, Chen and Wu (2011), trading partners' pressure is one the most influential determinants of firms' digital technology adoption. Unsurprisingly, it was found that the pressure from trading partners is a significant driver of digital technology adoption to majority of firms across industries in Vietnam (P1, P3, P4, P6, P7, P8, P12 and P14). Large and powerful companies are likely exerting strong pressure on suppliers which are small companies to adopt digital technologies to improve automation and digitalisation level. Therefore, the more powerful the partners are, the more pressure from them, the more inclined to embrace digital innovations firms are. For example, a study by Abed (2020) that examines the factors influencing 181 Saudi Arabian firms in technology adoption indicated that trading partners' pressure has the most significant influence on firms' behavioral intention of technology use. Similarly, in this study, P6 and P12 claimed that:

"*Our partners exerted pressure on us to operate with greater speed, precision (without errors), and transparency throughout our operational processes. They also demanded real-time updates and tracking for products. Therefore, we were compelled to adopt digital technologies to meet these demands*." (P6)

"*A few years ago, our large business encouraged our partners to embrace digital transformation; however, more recently, our business has had to exert pressure on our partners to expedite this process."* (P12)

However, the finding is inconsistent with a large chemicals and detergent firm that found external pressure was not an important adoption factor in their industry.

"*In the chemical Industry, we neither influence nor are influenced by our partners to adopt digital technologies or implement digital transformation*". (P13)

Given the consensus among majority of interviewees about the significant power and pressure of their trading partners in driving a firm's digital transformation, the questionnaire included questions which aim to measure the influence of trading partners on a firm's digital technology adoption decisions and whether businesses perceive external pressure from trading partners as a significant driver of such adoption.

- **Trading partner's readiness**

The full value of digital transformation and the adoption of digital technology is truly harnessed when it gains widespread understanding, recognition, and large-scale implementation, with the active involvement of trading partners. A firm's decision to embark on DSC adoption relies not just on its own efforts to digitise its value chain, but also is influenced by the adoption progress and digital readiness of its trading partners along the value chain (P2 and P9). Substantial empirical evidenced highlighted the significance of trading partner readiness in successful implementation of technologies, given that partner relationships emerge as crucial determinants of the adoption and execution of interorganisational systems (Awa and Ojiabo, 2016; Lin and Lin, 2008; Lin, 2008; Zhu, Kraemer and Xu, 2003). This highlights the networking nature of DSC which emphasizes the involvement of supply chain partners, rather than individual firms focusing solely on digitizing their own stages within the supply chain.

"Due to different sizes, market power, and business sectors, each organisation possesses a distinct level of financial and technical resources, as well as a willingness to undertake digital reform. Therefore, even with sufficient resources and a strong commitment to embracing digital transformation, certain organisations find themselves constrained, slowed down, or unable to fully harness the potential of digital technologies due to the lack of readiness on the part of their trading partners." (P2)

However, as highlighted by other interviewees, there is a noticeable lack of awareness, education, and understanding concerning the practical impacts and effective applications of digital technologies among supply chain partners (P8 and P9). Addressing this lack of knowledge regarding the potential value of such technologies becomes imperative. Thus, P9 emphasised the necessity of educating their supply chain partners about the far-reaching implications of digital technology adoption on their business operations and customer interactions.

"*At times, our company needs to provide education to our business partners about technology adoption*" (P9)

Given the organisations' concerns about their trading partners' digital readiness and the potential impact of their trading partners' readiness and willingness on a firm's ability to fully harness the potential of digital technologies, the questionnaire contained questions aimed at assessing how businesses perceive the readiness of their trading partners for digital transformation.

- **Trust-based information sharing with supply chain partners**

Undoubtedly, achieving a successful digital transformation process depends on the organisation's trading partners demonstrating a willingness to collaborate and openly exchange information and knowledge (Korpela, Hallikas and Dahlberg, 2017). Such collaboration ensures that every entity within the supply chain network understands and embraces the transformative potential of digital technologies. Jointly addressing challenges, sharing lessons learned, and collectively leveraging new opportunities, knowledge and information sharing with trading partners lay a solid foundation for a successful and impactful digital transformation (Singh, Kumar, and Chand, 2019; Chong and Bai, 2014). Nonetheless, interviewees (P5, P6, and P13) have expressed a concern regarding their trading partners' reluctancy to disclose information due to a matter of principles or fear of losing their critical and advantageous information and knowledge to their competitors. For example, P5 and P13 shared that:

"*It is crucial to have a mutual information-sharing platform or standards for supply chain stakeholders that allows continuous, flexible and up-to-date information exchange for effective decision-making*." (P5)

"*For our firm, it is unnecessary for us to share extensive information and data with partners, only some information about orders, products, and business transactions need to be shared*" (P13)

Based on the insights gained from the interviews regarding supply chain collaboration and information sharing, the questionnaire consisted of questions aimed at assessing the level of collaboration and information sharing practices among trading partners within the context of digital supply chain implementation, as well as understanding whether concerns about reluctance to disclose information hinder collaborative efforts.

7.4.4. Organisational culture's impact on the SC4.0 adoption

Organisational culture has been proposed as one of the most influential factors that significantly influences firm's effectiveness in implementing digital technologies (Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz, 2020). Organisational culture can facilitate digital transformational process and unlease the potential values from digital tools. The interviewees emphasised the significant role of corporate culture in providing support for technological reform, nurturing innovation, and fostering the adoption of technology within the company. This view is supported by a study by Wokurka et al. (2017) which revealed that multiple companies embarking on digital transformation have encountered failures due to clashes with their organisational culture; thus, a successful digitalization requires firms to develop a digital culture that can support such disruptive change – a corporate culture is tailored for digitally transforming business. In this study, while certain interviewees believed that an organisational culture driven by flexibility enhances technological adoption, while values focusing on control hinder it (P1, P2 and P8), other interviews revealed a synthesis of both flexibility and control-driven cultural characteristics, rather than being strictly defined by a single cultural type (P3 and P12). Indeed, the interviews have indicated that no organisation can be exclusively defined by control-driven or flexibility-driven values. Instead, organisations tend to embrace both orientations, with one aspect occasionally exhibiting slightly greater prominence than the other, which ultimately supported their digital transformation.

Majority of interviewees agreed that a combination of flexibility and control values within the organisational culture can yield benefits and excessively focusing on either of these values may not be advantageous for organisations operating in a dynamic and rapidly evolving environment. This can be illustrated by a statement from P9: "*The culture that focuses on teamwork, discussions, arguments and debates can foster creativity and bring forth the best ideas; however, the digital transformation progress can be slowed down if it involves too many stakeholders in the decision-making process*". Hence, this implies that the process of digitalisation does not occur within a culture that exclusively emphasises either discipline or innovation. Earlier research also reinforces and elaborates upon the interplay between flexibility and control values, suggesting that flexibility values nurture a culture of experimentation and empowerment, while control values provide boundaries for evaluation and decision-making (Khazanchi, Lewis and Boyer, 2007). The interviewees also observed that even though their organisations incorporated both control and flexibility values, they still tend to lean more towards either a direction of control or flexibility. This observation aligns with the findings of Shao, Feng, and Liu (2012) and Khazanchi, Lewis, and Boyer (2007), who suggest that although a company can embrace a mixture of different organisational culture typologies, specific value orientations tend to hold greater influence than others.

According to the Competing Value Framework, the inclination of organisational culture towards either flexibility or control is shaped by the organisation's structure, which can be either centralised and inflexible or decentralised and adaptable; and by the organisation's goals and strategies, whether they prioritise stability, predictability, and control, or innovation, creativity, risk-taking, and collaboration (Cameron, 2009; McDermott and Stock, 1999).

(1) Organisational structure

The interviews revealed two contrasting viewpoints. Firstly, certain interviewees (P1, P2, P6, and P8) asserted that a flat and decentralised organisational structure accompanied by a culture of flexibility fosters the adoption of innovation, whereas a centralised and rigid structure aligned with a culture of control hinders such adoption. This perspective aligns with studies by Mustafa et al. (2022) who claimed that a decentralized organizational structure facilitates constant exchange of information and ideas which ultimately enhances faster recognition of new emerging knowledge, technological development, and innovation in the market. Therefore, it is argued to be more compatible and appropriate for experimenting with digitalization trends. Whereas bureaucratic and centralized structure do not fit with digitalization logics (Mustafa et al., 2022). For example, P1 and P8 claimed as follows.

"*Digital transformation necessitates organisations to review and redefine their business processes and organisational structures, making them more flexible and flatter that enable faster and smoother information sharing and communication…Thus, we aim to decentralise our organisational structure, granting a high level of autonomy to employees…*" (P1)

"If the governance processes and procedures are not optimised, and the structure is too hierarchical, centralised, inflexible and complex, the flow of information and decisions is slowed down, significantly impacting the digital transformation effort. On the other hand, a simple and flexible organisational structure and processes can facilitate the adoption process …The process of digitalisation requires our organisation to restructure its systems to be simpler and more flexible in management, effective in communication, and easier to guide employees through technology adoption." (P8)

The alternative viewpoint presented by other interviewees argues that a combination of both structures offers benefits due to the inherent strengths and weaknesses of each culture (P3 and P12). On the one hand, a culture centred on strict control, and a highly hierarchical and centralised system can impede the organisation's technological reform efforts, such as potential information delays and the resulting lack of flexibility and independence in adopting appropriate digital technologies for various business units. Additionally, an increased risk of failure arises when decisions are predominantly made by top management. On the other hand, these organisational leaders also observed that a centralised hierarchical structure with a top-down approach can expedite firms' digital transformation. Particularly, in the case of large firms, this approach is seen as quicker than allowing individual departments or different business units to navigate the adoption process independently. Likewise, it has been argued that a decentralised and flexible structure empowers organisations to identify the most suitable technologies and digital transformation journey through collective discussion, critical evaluation, and inputs from various stakeholders. However, it is worth noting that decentralisation can sometimes hinder the pace of digital technology adoption due to the complexity of involving numerous stakeholders. Considering these observations it is suggested that a balanced integration of both flexibility and control values within organisations is paramount to the successful digital transformation.

"*The organisational culture centred around values of both disciplines and innovation is likely to accelerate the digitalisation process. On the other hand, an innovative culture without* *discipline can slows down the process, and a culture focusing solely on discipline may result in employee resistance to changes."* (P12)

"*Indeed, decentralisation allows fast and easy communication, information sharing, flexibility, and the freedom to be innovative and creative...Our organisation is making an to shift towards a more decentralised and flexible structure. However, a large firm's decentralised structure can also become a hinderance, especially for multinational corporations with business units lacking sufficient knowledge about digital transformation.…Our firm's leadership style, which used to be dictatorial and controlling, along with its high hierarchical structure and limited inter-departmental collaboration have paradoxically facilitated rapid innovation by strictly enforcing it to all levels of employees. Therefore, in order to remain the leading position in the industry and accelerate digital transformation, it requires employees to obey rules, procedures, processes and "do what they are told"…However, it is important to note that the organisational culture is influenced by national culture, thus difficult to change completely…*" (P3)

(2) Organisational strategies and goals

It was observed that the nature and unique characteristics of each business play a significant role in shaping their goals. While some companies prioritise objectives like digital technology adoption, achieving world-class products, or becoming industry leaders with cutting-edge technologies, others place their focus on attaining efficiency, productivity, operational excellence, continuous learning, creativity, and adaptability to market changes (P1, P2, P3, P4, P9, P11, P12 and P13). In essence, these organisations foster an environment of continuous improvement, innovation, R&D, and unconventional thinking. Therefore, within their organisations, information, ideas, and best practice are frequently exchanged through open communication channels like teamwork and departmental collaborations, regular staff meetings, and even the creation of knowledge-sharing websites where best practices are systematically disseminated among various business units. These aims and practices drive these companies to enthusiastically embrace digital transformation and the adoption of digital technologies, as stated by P1, P3 and P9.

"*We aim to create the latest and world-leading products, while focusing on continuous improvement*." (P1)

"We have built global and regional team as well as R&D department dedicated to digitalisation and innovation adoption, with the aims of assessing the IT quality, managing

cyber security risks and other technological risks, and facilitating the sharing of best practices and experiences" (P3)

"*Our primary aim is not industry leadership; rather, we focus on achieving operational excellence through digital transformation. In this context, operational excellence means meeting customer needs, reducing costs, and delivering greater value to our customers. For us, effective teamwork and the exchange of information and ideas are foundational.*" (P9)

Another fundamental element of digital transformation centres around cultivating a data-centric strategy. It is evident by the fact that the companies that inclined to adopt digital technologies are those fostering a data-driven culture (Mueller, 2022). In such organisations, there is an emphasis on encouraging, and at times even compelling, employees to utilise current data for optimising business operations, enhancing transparency, efficiently managing human resources, and supporting decision-making processes. As stated by Fischer, Wiener and Strahringer (2023), and Akatkin and Yasinovskaya (2019), the transition to and development of data-centric strategy is one of the key enablers for realisation of digitalization. Thus, many businesses are striving to become a data-driven organisation (Fischer, Wiener and Strahringer, 2023). Thus, P9 suggested that a radical change like the digital transformation requires an innovative corporate culture to take root and develop.

"*We are making efforts to instil a data-driven and innovative culture at all levels of management and among employees, aligning this culture with the digital goals of the company…One of our organisation's Widely Important Goals is to enhance the utilisation of data in decision-making from 0% to 100%... We aim to shift employees' habits towards frequent data usage and change their mindset regarding the significance of using data on a daily basis for business purposes…Furthermore, engaging employees in the digital transformation journal is also of paramount importance*." (P9)

It was widely believed by P1, P3, P9, P11, P12 and P14 that companies undertaking extensive digital transformation must develop effective communication of their digital visions and strategies, involving employees, transforming their habits, and aligning all department towards the unified digitalisation goals. As believed by P9, this collective effort enhances the likelihood of achieving digital transformation success.

"*To align employees to the organisation's digital goals, ensuring that employees recognise the benefits of their dedication to the overall performance of the organisation…We proactively communicate our digital transformation goals to employees across all levels, involve employees in discussion and strategy revisions during regular company meetings, and* *ensure a solid understanding of their valuable contribution in achieving digital goals as well as guide them towards fulfilling these goals by developing KPI, dashboards and training initiatives*." (P9)

(3) The link between organisational culture and top management

The most striking observation to emerge from the data is that although both top management and organisational culture were highly valued by the managers, as per the interviewees' perspective, the support and knowledge of top management are considered even more crucial than the organisational culture when it comes to technology adoption. This perspective holds true even in large organisations, where top managers are often replaced with new individuals who might own different visions, core values, and strategies. Although organisational culture has evolved since the establishment of the organisation and had a substantial impact on employee behaviours, the managers believed that top managers still play the most influential role within the organisation (P4, P6 and P9). This is because they not only set the trajectory for the future and initiate necessary changes to align with market trends, but also have the power to shape the overall organisational culture. As stated by Abdallah, Shehab and Al-Ashaab (2022), top management plays a vital role in fostering a digital transformation-friendly and actively encourages the adoption of digital transformation practices.

"*I believe that despite the organisation's long-standing development of its culture, a change in top management could potentially shift the corporate culture to align with the new values introduced by the incoming leadership*." (P4)

"*Corporate culture mirrors the leadership style of the top management; therefore, decision regarding digital transformation must originate from the top management level, and then be disseminated to middle and lower management levels*." (P6)

"*Although both culture and top management play equal roles in the technological transformation journey, the changes should first take root at the leadership level before permeating the organisational culture level*…" (P9)

On the other hand, despite claiming that both corporate culture and the commitment of top managers facilitated and accelerated the digitalisation process, an interviewee proposed that in case of large firms, changes cannot be solely driven by the top managers alone but must involve the entire organisation.

"*Corporate culture plays a more significant role than top management, especially in large organisations…In many cases, the efforts of top managers may not suffice to drive a substantial change throughout the entire organisation if a majority of employees are resistant to change. This is where organisational culture steps in*." (P12)

Nevertheless, despite varying perspectives regarding the crucial role of both top management and organisational culture, it is undeniably argued that these two factors are intricately intertwined and jointly contribute to the positive changes and practices within the organisation (Basahel and Alshawi, 2014; Dartey-Baah, Amponsah-Tawiah and Sekyere-Abankwa, 2011; Niemann and Kotze, 2006; Schein, 1992). This signifies that the effectiveness of one is dependent on the presence of the other, as stated by P9 and P11.

"*If top management is decisive and determined, but the culture remains stagnant, unadaptable, rigid and inflexible, or if the culture is dynamic and flexible but leaders lack vision and earnest commitment to digital transformation, this massive change cannot be implemented effectively. Therefore, for technological reform to take root and develop, both corporate culture and top management need to go hand in hand*…" (P9)

"*It is a chicken-or-the-egg causality dilemma. It is not necessary that the leaders influence and create the corporate culture, but the corporate culture can also tremendously affect and shape the top managers' leadership style and their business goals; thus, this relationship is closely intertwined*." (P11)

To sum up, when considering organisational culture, the questionnaire embraced the flexibility and control scales, but the data analysis also explored the joint impact of organisational culture as a whole, given the arguments from interviewees on the joint role of both values.

7.5. Summary

A comprehensive qualitative study was undertaken to initially explore and subsequently confirm the practicality of the conceptual model that was formulated in Chapter 5. To confirm the applicability of the conceptual model, data was collected from 14 organisational managers. These managers were either directly engaged in day-to-day decision-making, operational activities, and the application and development of new technologies within their organisations, or they maintained close collaboration with firms in the market to support those firms' business growth, such as government entities or consultancy firms. To gather information from study participants, the general interview guide approach discussed in Chapter 6 was employed.

In this chapter, based on the findings obtained from most interviewees, the four main deductive themes and nine corresponding subthemes derived from literature review, were confirmed in the Vietnamese context. The identified themes are as follows: Technological factors including Perceived benefits and Perceived risks; Organisational factors, including Top management knowledge and support, and Organisational resources; Environmental factors, including Market pressure, Market support, and Interorganisational relationships; and Organisational culture factor, involving Flexibility and Control.

The chapter started by presenting the background of the interviewees, followed by discussions of the significant findings derived from the interviews in alignment with the specified main themes and subthemes. Subsequently, these findings were employed in developing questionnaire items, ensuring their relevance with the Vietnamese context.

With the confirmation of the applicability of the conceptual model in this study, the subsequent chapter presents the analysis of quantitative data acquired through questionnaire surveys. This analysis aims to test the hypotheses and assess the model's fitness.

8. CHAPTER 8: QUANTITATIVE DATA ANALYSIS AND FINDINGS

The preceding chapter effectively validated the relationships inherent in the research model. The present chapter outlines the methodologies employed for analysing the obtained quantitative data, which in turn serves the purpose of assessing the validity of the proposed research model and testing the formulated hypotheses. Additionally, a detailed explanation and discussion of the obtained quantitative data is presented.

The chapter initiates with a rigorous validation and reliability assessment of the identified factors through exploratory factor analysis (EFA) and Cronbach's alpha respectively as they determine the credibility and trustworthiness of the study's findings (Mohajan, 2017; Maxwell, 2010). Subsequently, the chapter presents profiles of the survey respondents. Next, the hypotheses positing relationships among the variables are subjected to scrutiny via correlation and multiple regression analyses. Finally, the study's findings are meticulously presented and explained. These findings not only align with the predefined research objectives but also offer valuable insights into the study's profound implications for advancing wider research efforts and enhancing practical applications.

8.1. Validity Test – Exploratory Factor Analysis (EFA)

In quantitative study, validity refers to the extent to which research instruments accurately measure or reflect the intended constructs or variables (Heale and Twycross, 2015). Validity of a research instrument assesses the extent to which an instrument indicator claims to measure (Thatcher, 2010; Brink, 1993). It is the degree to which the results are truthful. So that it requires research instrument (questionnaire) to correctly measure the concepts under the study (Pallant, 2011). To test the validity of the research instruments, factor analysis is a powerful technique that can help to reduce dimensionality in a dataset by condensing the variation present in multiple variables into a smaller number of uncorrelated factors (Yong and Pearce, 2013; Tinsley and Tinsley, 1987). Two main classes of factor analytic methods are Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (Loewen and Gonulal, 2015).

According to Bandalos and Finney (2018), Orçan (2018), and Levine (2005), EFA is the preferred approach when researchers develop new scales for construct measurement, there is absence of measuring scale or a theoretical basis, or when the relationships among items are not known. EFA is especially valuable in studies which involve translation from the original language to a new language that leads to the risks of translation errors, cultural differences, or variations in item interpretation (Orçan, 2018). On the other hand, CFA is recommended if the researcher aims to assess the uni-dimensionality of an already established scale of measurement or wants to test relationships.

Given the fact that this quantitative study developed new scales for construct measurement and the survey was translated from English to Vietnamese, EFA emerged as the appropriate method for data analysis. By employing EFA, researchers can identify potential issues, such as items loading onto different factors or poor item discrimination, which could be indicative of problems with translation or cross-cultural adaptation. When conducting EFA, researchers often encounter the challenge of handling missing data, which is a common issue in this type of analysis (Goretzko, Heumann and Bühner, 2020; Weaver and Maxwell, 2014). The survey ensured no missing values in the variables for all completed responses by requiring participants to answer every question before proceeding to the next. Additionally, incomplete responses were removed to ensure no missing data for data analysis. Moreover, to facilitate the analysis on SPSS, it is essential to reverse all statements with a negative meaning. This step ensures that all items within a scale have a consistent directional relationship with the construct of interest (Weijters, Baumgartner, and Schillewaert, 2013). Sürücü and Maslakci (2020) suggested to apply reverse coding when the scale contains all positive statements but some of them are negative. For the survey, items that were reversed include:

- "*Digital transformation is a complicated and long process*",
- "*Digital technology adoption requires integration with our existing operational system and working environment*",
- "*Digital technology adoption lacks unified standards for information sharing*",
- "*Digital technology adoption needs complex skills and experience*",
- "*Digital technologies are prone to security and privacy issues*",
- "*Digital technologies may have a short lifespan and be obsolete quickly*",
- "*Digital technologies are incompatible with existing work practices and business environment characteristics*",
- "*Digital technologies are incompatible with existing IT systems*",
- "*Digital technology incompatibility with existing IT system generates poor data quality and low reliability*",
- "*Adoption costs of digital technologies are greater than its short-term benefits*",

- "*Continuous upgrade and maintenance, training and after-sale support of digital technologies are highly dependent on external technology providers*", and
- "*There is a lack of industrial technology providers within the country*".

Following the reversal of the negatively worded items, an EFA was conducted using SPSS version 28. When conducting an EFA, it is crucial to assess the appropriateness of the data by analysing the correlation among the variables. If there is little to no correlation among the variables or the correlation is very low, the suitability of factor analysis will be seriously questioned. To test the data's appropriateness, two commonly suggested tests are the *Kaiser-Meyer-Olkin* (KMO) measure for sample adequacy and *Bartlett's Test of Sphericity* for the validity and suitability of the data to the study's problem (Rojas-Valverde et al., 2020; Maskey, Fei and Nguyen, 2018; Van Truong, Pham, and Vo, 2016). While the KMO ranges from 0 to 1, an accepted index worldwide is considered to be over 0.6. As described by Kaiser (1974) that statistic greater than 0.9 as marvellous, greater than 0.8 as meritorious, greater than 0.7 as middling, greater than 0.6 as mediocre, greater than 0.5 as miserable, and less than 0.5 as unacceptable. In this study, the KMO measure of sampling adequacy is 0.907, indicating the appropriateness of the quantitative data for factor analysis.

For EFA, the *Bartlett's Test of Sphericity* should yield a p-value less than 0.05. If the p-value is below the predetermined significance level of 0.05, it indicates significant intercorrelation among the variables, suggesting that they are not independent, and that factor analysis is appropriate for the dataset. *Bartlett's Test of Sphericity* of this study yielded a result of 0.000, which is less than 5%, indicating a highly significant relationship among the variables, making the data appropriate for factor analysis.

In addition to conducting KMO and *Bartlett's Test of Sphericity*, it is recommended to assess the communalities, which indicate the extent of variance a variable shares with all other variables included in the study. A relatively small value of the communality indicates that the specific variable may not align well with the factor solution and should be considered for exclusion from the factor analysis. While communalities range between 0 and 1, items having communalities below 0.4 were considered uncorrelated, whereas values ranging from 0.40 to 0.70 signified a range of low to moderate communality, and a value of exceeding 0.80 pointed to a strong communality (Daud et al., 2022). Hence, in alignment with the perspectives of De Silva, Chinna, and Azam (2019), Randler et al. (2016), and Costello and Osborne (2005), it is advisable to retain communalities of 0.4 or higher for robust factor analysis, while items with communalities below 0.4 are worth considering for exclusion. Therefore, items exhibiting a communality score below 0.4 were omitted from the analysis. The communalities of this study's data all exceed 0.4, signifying that none of the items need to be removed.

After evaluating the data's suitability for EFA, Yong and Pearce (2013) advised researchers to carefully choose the appropriate extraction method. There is an array of extraction methods available. According to Costello and Osborne (2005), among extraction methods, *Principal Component Analysis* (PCA) stands out as one of the most widely used exploratory data reduction procedures in the social sciences, and it is the default method in SPSS. PCA is preferred for its ability to extract the maximum variance from the dataset, effectively reducing a large set of variables into a smaller set of *principal components* (Tabachnick and Fidell, 2007) or *factors* (Loewen and Gonulal, 2015) which account for majority of the variance in the original variables (Statistics, 2015). Similar to exploratory factor analysis, PCA is a technique used for variable reduction, making them comparable in some respects (Statistics, 2015). As a result, PCA is considered a highly reliable and error-free extraction method for EFA (Parsian and Dunning, 2009; Bryman and Cramer, 2004).

After determining the extraction methods, it is crucial to identify the number of latent factors to retain (Auerswald and Moshagen, 2019). In fact, overextraction may result in factor splitting, where manifest variables with population loadings on one factor are divided into multiple factors after rotation (Wood, Tataryn and Gorsuch, 1996). This can result in less parsimonious models with constructs of limited explanatory value and an increased likelihood of Heywood cases, such as negative variance estimates (Yong and Pearce, 2013; De Winter and Dodou, 2012). On the other hand, under extraction leads to considerable error on all factor loadings, regardless of their weight in a properly specified model (Wood, Tataryn, and Gorsuch, 1996). Additionally, it degrades the factor scores when compared to those in a correctly specified model (Fava and Velicer, 1996). Maskey, Fei, and Nguyen (2018) also highlighted that in cases of under-factoring, measured variables intended to load on factors not included in the model may mistakenly load on factors that are part of the model, leading to poor estimates of the factor loadings. Therefore, it is crucial to carefully choose the criterion that best fits your study when determining the number of factors to extract.

To determine the appropriate number of factors, researchers often rely on *Eigenvalues* and the *Scree test* (i.e., scree plot). Kaiser's criterion, which suggests retaining factors with Eigenvalues above 1 (Kaiser, 1960), is commonly used as a rule of thumb (Yong and Pearce, 2013) and thus is the default in many statistical packages (Maskey, Fei, and Nguyen, 2018). However, solely using *Eigenvalues* can lead to an overestimation of the number of factors extracted (Costello and Osborne, 2005). Therefore, Yong and Pearce (2013) recommended utilising the *Scree test* in combination with *Eigenvalues* to determine the appropriate number of factors to retain. Moreover, in accordance with the guidance of Yong and Pearce (2013), an *Unrotated factor solution* was also chosen as allows the generation of an *Unrotated pattern matrix*, which facilitates a comparison of factors before and after rotation.

Next, to enhance the interpretability of factor loadings, the factors undergo rotation in an n-dimensional space, where n represents the number of factors. The goal is to obtain an optimal simple structure that aims to have each variable load on as few factors as possible, while maximising the number of high loadings on each variable (Costello and Osborne, 2005; Park, Dailey, and Lemus, 2002; Rummel, 1970). The ultimate objective of the simple structure is to define distinct clusters of interrelated variables for each factor, thereby facilitating easier interpretation (Cattell, 2012).

There are two major rotation strategies: orthogonal rotation and oblique rotation (Yong and Pearce, 2013; Abdi, 2003; Kieffer, 1998). *Orthogonal rotation methods* (e.g., Varimax, Equimax, Quartimax, etc.) impose the constraint that factors are independent of each other, while *Oblique rotation methods* (e.g., Promax, Oblimin, Quartimin, etc.) allow factors to be correlated. It is commonly believed that orthogonal rotation produces a simpler and more easily interpretable structure of factors (Park, Dailey, and Lemus, 2002). Among orthogonal rotation techniques, *Varimax* is considered the best and most widely used (Maskey, Fei, and Nguyen, 2018; Samuels, 2017; Costello and Osborne, 2005; Bryman and Cramer, 2004). According to Yong and Pearce (2013), *Varimax* minimises the number of variables with extreme loadings (high or low) on a factor and reduces the correlation between factors, making it easier to interpret and understand each factor individually.

Additionally, as suggested by Yong and Pearce (2013), *Rotated Solution* and *Loading plots* were selected. *Rotated Solutions* provide the output for interpreting the rotated factors, while Loading plot(s) generate a factor loading plot. Finally, the *Maximum Iterations for Convergence* was used to determine the number of times SPSS will search for an optimal solution. The default value of 25 is usually sufficient for most analyses.

Finally, in the *Options* section of the Factor analysis on SPSS, *Exclude case listwise* was selected to avoid overestimation of factors within the data, as discussed earlier. To facilitate interpretation, the *Suppress small coefficients* option using an *Absolute value below 0.4* was utilised, following the guidance of Guadagnoli and Velicer (1988), where values greater than 0.4 are considered stable. Stevens (2012) also recommended a cut-off of 0.4, regardless of sample size, for interpretative purposes.

Based on the established criteria, two items, namely "*Our company will gain competitive advantage from digital transformation*" and "*Our company shares information with our trading partners frequently*" were removed from further analysis due to factor loadings lower than 0.4. Additionally, two other items, "*There is a lack of industrial technology providers within the country*" and "*Basic Information and Communication Technology infrastructure such as fast broadband and 4G,5G network are available in our business area*" did not load significantly on any factor and were also excluded from the analysis.

Following the removal of disqualified items, the EFA was rerun to ensure the stability of the original factor structure, as parameter changes may occur after item removal (Knekta, Runyon, and Eddy, 2019; Al-Qerem, Ling, and AlBawab, 2017; Samuels, 2017). During this rerun, the item "*Independent training providers in Vietnam offer trainings on digital skills*" was also removed as it failed to load significantly on any factor. After eliminating this item, the EFA was repeated, resulting in the identification of 12 factors that collectively explain 68.537% of the variance among the study items. Table 8-1 reveals that the KMO now stands at 0.907, and Bartlett's Test of sphericity remains significant, while all communalities surpass the required value of 0.4.

Table 8-1: KMO and Bartlett's Test

	Results	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.907	
Bartlett's Test of Sphericity	Approx. Chi-Square	10520.667
	df	1540
	Sig.	.000

However, among these 12 factors, one factor was derived from a cross-loading item "*Digital technology incompatibility with existing IT system generates poor data quality and low reliability*". This suggests that there are in reality 11 factors extracted from the EFA. These 11 factors include (1) *Perceived benefits*, (2) *Perceived technical standards-related risks*, (3) *Perceived technical capabilities-related risks*, (4) *Organisational resources*, (5) *Top management knowledge and support*, (6) *Market pressure*, (7) *Market support*, (8) *Interorganisational relationships*, (9) *Organisational culture*, (10) *Adoption intention*, (11) *Adoption actions* (see Table 8-7).

8.2. Reliability Test – Cronbach's Alpha

Reliability in a quantitative study refers to the consistency, repeatability and stability (Twycross and Shields, 2004). In other words, it extent in which a research instrument consistently yields the same results when applied under the same circumstance on multiple occasions. As discussed previously, while EFA was used to assess the validity of the created scales, Cronbach's alpha was utilised to assess the internal consistency or reliability of the obtained scales. Thus, after EFA, a reliability analysis using Cronbach's alpha was conducted. Cronbach's alpha values range from 0 to 1, with higher values indicating stronger internal consistency (Waljee et al., 2010). Typically, Cronbach's alpha values between 0.6 and 0.8 are considered acceptable (Streiner, Norman, and Cairney, 2016). Although the standard Cronbach's alpha value is set at 0.7, according to Streiner, Norman, and Cairney (2016), Malloy-Diniz et al. (2015), Lin, Su and Chien (2006), Verbeke et al.(2005), Cronbach's alpha values above 0.6 are deemed adequate while values below 0.6 suggest that the items within the scale lack sufficient interconnectedness to measure the underlying factor. In line with prior research studies, which have commonly used a Cronbach's alpha cut-off value of 0.6, this value was adopted as the threshold for this analysis. The results of the reliability analysis demonstrate satisfactory reliability for all factors with values above 0.6. Consequently, based on this cut-off value of 0.6, the internal consistency of these nine main factors and two subfactors was confirmed. The Table 8-2 shows a summary of the EFA and Cronbach's alpha results for the factors and their measurement items.

Table 8-2: Summary of the EFA and Cronbach's alpha results for the factors and their measurement items

Factors of the theory model	Dimensions of theory model	Factors of EFA	Items	Mean	EFA Loadings	Reliability (Cronbach's alpha)
Technology	**Perceived benefits**	1.Perceived benefits	Ben_1: Digital technology adoption improves product/service customisation	4.12	0.721	**0.917**
			Ben_2: Digital technology adoption improves productivity and flexibility to market changes	4.27	0.791	
			Ben_3: Digital technology adoption improves employees' health and safety	3.82	0.748	
			Ben_4: Digital technology adoption increases resource efficiency/ savings (e.g. labour, energy, materials)	4.19	0.792	
			Ben_5: Digital technology adoption allows timely market data capture and analysis for faster decision making	4.42	0.762	
			Ben_6: Digital technology adoption allows effective information sharing and monitoring to improve supply chain visibility	4.38	0.803	
			Ben_7: Digital technology adoption reduces product/service defects and breakdown maintenance for better product/service quality	4.04	0.793	
	Perceived risks					**0.833**
		2.Perceived technical standards-related risks	Risk_1: Digital transformation is a complicated and long process	3.75	0.671	0.745
			Risk_2: Digital technology adoption requires integration with our existing operational system and working environment	4.17	0.433	
			Risk_3: Digital technology adoption lacks unified standards for information sharing	3.16	0.656	
			Risk_4: Digital technology adoption needs complex skills and experience	3.42	0.743	
			Risk_5: Digital technologies are prone to security and privacy issues	3.44	0.522	
		3.Perceived technical capabilities-related risks	Risk_6: Digital technologies may have a short lifespan and be obsolete quickly	2.88	0.594	0.78
			Risk_7: Digital technologies are incompatible with existing work practices and business environment characteristics	2.43	0.768	
			Risk_8: Digital technologies are incompatible with existing IT systems	2.54	0.821	
			Risk_9: Digital technology incompatibility with existing IT system generates poor data quality and low reliability	3.01	0.667	
			Risk_10: Adoption costs of digital technologies are greater than its short-term benefits	3.39	0.578	
			Risk_11: Continuous upgrade and maintenance, training and after-sale support of digital technologies are highly dependent on external technology providers	3.5	0.475	
Organisation	**Organisational resources**	4.Organisational resources	OrgRe_1: Our company has an adequate technology infrastructure (e.g. wireless Internet, databases, security system) to support digital technology adoption	3.86	0.782	**0.864**
			OrgRe_2: Our company has adequate financial resources to support digital technology adoption	3.79	0.744	
			OrgRe_3: Our company has necessary skills and knowledge (e.g. management, digital technology knowledge, English) and trainings to understand application of digital technologies	3.64	0.695	
			OrgRe_4: Our company's employees are willing and welcome new working methods, ideas and technologies	3.84	0.591	
	Top management knowledge and support	5.Top management knowledge and support	TopMa_1: Top management communicates a sense of digital transformation urgency to the whole organisation	3.94	0.723	**0.862**
			TopMa_2: Top management actively establishes a clear vision, strategies and roadmap for digital transformation	3.96	0.724	

Factors of the theory model	Dimensions of theory model	Factors of EFA	Items	Mean	EFA Loadings	Reliability (Cronbach's alpha)
			TopMa_3: Top management has adequate knowledge and experience in digital transformation	3.68	0.692	
			TopMa_4: Top management engages, guides and supports employees in digital transformation process	3.75	0.613	
			TopMa_5: Top management is willing to take potential risks such as financial and operational risks involved in digital transformation	3.63	0.611	
Environment	**Market pressure**	6.Market pressure	MarPres_1: Changes in market demand are difficult to predict	3.70	0.680	**0.645**
			MarPres_2: Our company is under pressure from competitors and/or customers to adopt digital technologies	3.52	0.691	
	Market support	7.Market support	MaSup_1: The government provides incentives to support digital transformation (e.g. financial subsidies, tax rebates, investment into national infrastructure)	2.99	0.830	0.846
			MaSup_2: The government has devised sufficient laws and policies to support digital transformation (e.g. labour policies, technical standards, data protection)	3.13	0.846	
			MaSup_3: Vietnamese universities are preparing the graduates with the skills and knowledge for digital transformation	3.30	0.639	
			MaSup_4: It is easy to access to and obtain financial support for digital transformation from local banks/ other financial institutions within the country	2.90	0.784	
			MaSup_5: There is third party support within the country for digital transformation (e.g. business associations, funding programs, research institutes)	3.22	0.629	
	Interorganisational relationships	8.Interorganisational relationships	InterRe_1: Our trading partners are willing to adopt digital technologies	3.48	0.756	0.787
			InterRe_2: Our trading partners have HR, technical and financial resources for adopting digital technologies	3.41	0.755	
			InterRe_3: Our trading partners provide incentives and support (e.g. training, sharing best practices) to encourage our company to adopt digital technologies	3.15	0.681	
			InterRe_4: Our major trading partners with high bargaining power demand/pressure our company to adopt digital technologies	2.92	0.529	
			InterRe_5: Our company and our trading partners ensure information sharing is confidential	3.77	0.448	
Organisational culture		9.Organisational culture				**0.902**
	Flexibility culture		OrgCul_1: The glue that holds our company together is loyalty, teamwork and mutual trust. This means for our company, commitment to the company runs high	4.10	0.758	
			OrgCul_2: The glue that holds our company together is commitment to innovation in products/ services/ processes	3.99	0.665	
			OrgCul_3: Our company is a very dynamic and entrepreneurial place. This means our company's employees are willing to stick their necks out and take risks	3.76	0.571	
			OrgCul_4: Our company emphasises growth through developing new ideas. This means for our company, generating new or improved products/ services/ processes is important	4.05	0.689	
	Control culture		OrgCul_5: The glue that holds our company together is formal rules and policies. This means for our company, following rules is important	4.00	0.556	
			OrgCul_6: Our company is a very production-oriented place. This means in our company, people are concerned with getting the job done	4.03	0.756	
			OrgCul_7: Our company emphasises permanence and stability. This means for our company, control and efficient and smooth operations are important	4.10	0.672	

Factors of the theory model	Dimensions of theory model	Factors of EFA	Items	Mean	EFA Loadings	Reliability (Cronbach's alpha)
			OrgCul_8: Our company emphasises outcomes and achievements. This means for our company, accomplishing goals is important.	4.15	0.711	
	Overall DSC adoption					**0.923**
		10.Adoption intention	AdotInt_1: Our company plans to digitally transform the business	4.02	0.519	0.880
			AdotInt_2: Our company plans to explore and evaluate the potential of digital technologies	4.01	0.677	
			AdotInt_3: Our company plans to adopt or increase adoption of more digital technologies in the next 5 to 10 years	4.05	0.697	
		11.Adoption actions	AdoptAct_1: Our company has a clear strategy and plan for digital transformation	3.82	0.729	0.921
			AdoptAct_2: Our company has a close collaboration with third parties (e.g. consultancy firms, technology providers, universities) to digitally transform the business	3.75	0.736	
			AdoptAct_3: Our company collaborates with trading partners to implement digital technologies	3.65	0.732	
			AdoptAct_4: Our company invests in technology infrastructure to prepare for digital transformation	3.86	0.731	
			AdoptAct_5: Our company designs training courses or use external training providers to equip employees with digital knowledge and skills	3.64	0.727	
			AdoptAct_6: Our company has integrated digital technologies into the whole operational processes	3.45	0.711	

Following the validity and reliability test, descriptive analysis of the quantitative study was performed, serving as the foundational step to summarise and present a description of the main characteristics of the 292 respondents.

8.3. Participants' Profile

Out of the 2,300 emails and messages that were sent, a total of 479 responses were received, indicating a response rate of 20.83%. Following a preliminary screening process to remove incomplete surveys, the dataset was narrowed down to 292 valid responses, resulting in a response rate of 12.7%. This screening step ensures that only complete and usable data is included for further analysis.

The Table 8-3 offers a comprehensive overview of the participants' organisational positions in the survey. The largest proportion, accounting for 50% of the respondents, consists of individuals in middle management roles (e.g., Head of Department and Factory Manager). Following closely behind, 25% of the participants hold senior management positions (e.g., Director, Chairman, and General Manager). Whereas junior managerial roles (e.g., Assistant Manager and Supervisor) make up 16.8% of the respondents. The remaining 8.2% of participants hold various other positions within the organisation.

Table 8-3: Respondents' company position

	Frequency	**Percent**
Junior management (e.g. Assistant manager, Supervisor)	49	16.8%
Middle management (e.g. Head of department, Factory manager)	146	50%
Senior management (e.g. Director, Chairman, General manager)	73	25%
Others (if others, please specify your position)	24	8.2%
Total	292	100%

Regarding the operating region of the participant's company, Table 8-4 reveals a significant majority (71.2%) of participants from companies based in the Southern region of Vietnam while 28.1% of participants working for companies located in the North. Notably, less than 1% of participants reported their companies being situated in the Middle region. These findings highlight the concentration of participant companies in the Southern and Northern regions of Vietnam, with a limited representation in the Middle region.

Table 8-4: Company's operating region(s) in Vietnam

	Frequency	Percent
North	82	28.1%
Middle	2	0.7%
South	208	71.2%
Total	292	100%

The data presented in Table 8-5 provides insights into the ownership structure of the companies represented by the participants. The results highlight a clear dominance of 100% foreign-owned companies among the participants, exceeding 50% of the participants. In contrast, approximately 27% of the participants are employed in companies that are 100% domestically owned. The presence of foreign-domestic partnerships, other types of businesses, and state-owned enterprises is relatively smaller, accounting for 12.3%, 7.9%, and 2.7%, respectively.

Table 8-5: Company's business type

	Frequency	Percent
State-owned business	8	2.7%
Foreign-domestic partnership business	36	12.3%
100% Foreign-owned business	147	50.3%
100% Domestic-owned business	78	26.7%
Others	23	7.9%
Total	292	100%

The survey results reflect a significant concentration of participants employed in 100% foreign-owned businesses, which explains the predominant presence of participants from large companies. According to the data presented in Table 8-6, 68.2% of participants represent large companies while the remaining participants are associated with small and medium-sized enterprises (SMEs).

Table 8-6: Company size

	Frequency	Percent
Micro-sized company	6	2.1%
Small-sized company	35	12%
Medium-sized company	52	17.8%
Large company	199	68.2%
Total	292	100%

The data showcased in Table 8-7 offers profound insights into the diverse industry types of the companies represented by the participants. These industries can be broadly categorised into three main types: Primary, Secondary, and Tertiary. Primary industries are involved in the extraction or supply of natural raw materials that are further processed into commodities and products for consumers, including Agriculture (plantation, farming, crops production such as rice, cashew, coffee, etc); Mining (coal, minerals, etc.); and Forestry (paper, pulp, wood) industry. Secondary industries take the raw materials provided by the primary Industry and convert them into commodities and products for consumers. This category includes Manufacturing industries like Textiles and Garment; Construction; Transport equipment manufacturing (motor vehicles and auto parts, motorcycles and bicycles, aircraft equipment, railroad equipment, etc.); Oil and Gas production; Electronics (computers, laptops, mobile phones, TVs, electrical appliances, etc.); Chemicals (plastics, cleaners, paints, agricultural chemicals, rubber, pharmaceuticals, etc.); Metals production (iron, steel, etc), Food, Drink and Tobacco. Tertiary industries are the services sector of an economy, offering various services to consumers, including Wholesale/Retail Trade; Postal and Telecommunication Services; Professional Services (real estate agent, insurance, IT services, etc.); Hotels, Catering and Tourism; Financial Services; Transportation and Logistics; Health Services; Education; Utilities (water, gas, and electricity); and Media and Graphics (newspapers, books, television, etc.).

The results reveal that a significant number of survey respondents come from secondary industries (40.4%) and tertiary industries (42.5%). Additionally, more than 16% of respondents work in companies that operate in more than two fields of industries, indicating a considerable degree of industry diversification among the participants.

Table 8-7: Industry type

	Frequency	Percent
Primary	2	0.7%
Secondary	118	40.4%
Tertiary	124	42.5%
More than one Industry	48	16.4%
Total	292	100%

Following descriptive analysis, a regression analysis was performed to assess the relationship between research model variables. Regression analysis does not only determine the presence of a significant relationship or association between variables but also generate estimations of predictive relationships among variables (Vetter and Schober, 2018; Ramcharan, 2006). Essentially, regression enables the quantification of the impact of one variable’s change on another, revealing causal connections between them. Among various regression methods, multiple regression stands out as the most prevalent (Kumari and Yadav, 2018; Tranmer and Elliot, 2008; Weisberg, 2005). To facilitate the multiple regression analysis, key regression assumptions must be met. Key regression assumptions are further elaborated below.

8.4. Regression Assumption Check

An initial step in checking regression assumptions involved conducting a correlation test among these factors to assess the applicability of multiple regression methods. Hence, a correlation analysis was performed involving all the factors to measure the strength of their associations. The widely employed correlation method is the bivariate Pearson’s correlation coefficient (r), which ranges from -1 (indicating a perfect negative linear relationship) to 1 (representing a perfect positive linear relationship) (Akoglu, 2018; Pallant, 2011). This coefficient provides a numerical summary of the direction and strength of the linear relationship between two variables (Prematunga, 2012; Bewick, Cheek, and Ball, 2003; Pallant, 2011). A correlation coefficient close to +1 suggests a robust positive linear relationship, where one variable increases as the other increases. Conversely, a value near -1 suggests a strong negative linear relationship, where one variable decreases as the other increases. A value near

0 indicates the absence of a linear relationship, although nonlinear relationships could still exist between the variables. The outcomes of the Pearson correlation analysis (see Appendix E2) validate the significant correlation between independent variables and dependent variables at the 0.01 and 0.05 levels (1-tailed). Consequently, the conditions for conducting multiple regression analyses are met.

Additionally, one of the primary assumptions of multiple regression is the absence of multicollinearity in the dataset, as collinearity or multicollinearity can pose challenges to constructing an effective regression model (Daoud, 2017; Alin, 2010). Multicollinearity occurs when two or more predictor variables in a statistical model exhibit linear relationships, and this phenomenon is sometimes referred to as collinearity (Dormann et al., 2013). The negative sides of multicollinearity are substantial, as it can distort results derived from multiple linear regression analysis, inflate the variances of regression coefficients, and widen confidence intervals (Kim, 2019; Yakunina and Bychkov, 2015; Tu et al., 2005). As a result, the statistical significance of individual variables may be diminished. Variables that would have been statistically significant in the absence of multicollinearity might lose their significance when multicollinearity is present. Additionally, while multicollinearity may not directly diminish a model's overall predictive power, it can lead to regression coefficient estimates that lack statistical significance (Midi, Sarkar, and Rana, 2010). Such effects can detrimentally impact the overall fit and quality of the model. This implies that the model might fail to accurately capture the genuine relationships between independent variables and the dependent variable.

Regarding the assessment of multicollinearity, the Variance Inflation Factor (VIF) and Tolerance serve as widely utilised metrics for measuring the extent of multicollinearity among independent variables within a regression model (Alauddin and Nghiem, 2010; O'Brien, 2007). These metrics provide a formal way of quantifying multicollinearity, estimating the extent to which the variance of a regression coefficient inflates due to multicollinearity. In practice, a VIF value around 10 has often been adopted as a general threshold to identify significant or severe multicollinearity (Lavery et al., 2019; Alauddin and Nghiem, 2010; O'Brien, 2007). Similarly, Belsley (1991) proposed that VIF values ≥ 5 to 10 signal the presence of multicollinearity among predictors in the regression model, with VIF > 10 suggesting weakly estimated regression coefficients due to multicollinearity. Thus, a VIF threshold of 10 was chosen for evaluating multicollinearity. As illustrated in Table 8-8, the results strongly indicate the absence of substantial multicollinearity issues among the independent variables.

Table 8-8: VIF result with DSC adoption intention, DSC adoption actions and Overall DSC adoption as dependent variables

		Collinearity Statistics	
		Tolerance	***VIF***
Independent variables	Perceived benefits	.556	1.799
	Perceived risks*	.830	1.205
	Organisational resources	.567	1.764
	Top management knowledge and support	.536	1.865
	Market pressure	.749	1.336
	Market support	.755	1.324
	Interorganisational relationships	.613	1.632
	Organisational culture	.492	2.031

* *Perceived technical standards-related risks* and *Perceived technical capabilities-related risks* were merged into one factor to align with the original framework and avoid repetition.

In addition to multicollinearity assessment, other essential assumptions of regression were verified, including autocorrelation through the analysis of the Durbin-Watson value and normality using the Kolmogorov-Smirnov test before proceeding with multiple regression analyses. Regarding the Durbin–Watson statistic, as a prudent rule of thumb, Field (2009) suggested that values falling below 1 or exceeding 3 raise a significant concern. The Durbin–Watson values were calculated as 1.906 with *DSC Adoption intention* as the dependent variable, 2.160 with *DSC adoption actions* as the dependent variable, and 2.035 with the *Overall DSC adoption* as the dependent variable (see Table 8-9). These values signify an acceptable level of correlation between adjacent residuals.

Table 8-9: Autocorrelation test Durbin-Watson result with DSC adoption intention, DSC adoption actions and the Overall DSC adoption as dependent variable

		Dependent variables		
		DSC adoption intention	DSC adoption actions	Overall DSC adoption
Independent variables (Predictors)	Perceived benefits Perceived risks Organisational resources Top management knowledge and support Market pressure Market support Interorganisational relationships	1.906	2.160	2.035

Concerning the assessment of normality, Mishra et al. (2019), Kim (2013), and Razali and Wah (2011) suggested that the Shapiro–Wilk test is more suitable for small sample sizes (<50), while the Kolmogorov–Smirnov test is preferable for n ≥ 50. For both tests, the null hypothesis posits that the data are drawn from a normally distributed population. When P > 0.05, the null hypothesis is accepted, indicating normally distributed data (Mishra et al., 2019). Given the sample size exceeding 50 in this study, the Kolmogorov–Smirnov test results were utilised (Table 8-10).

Table 8-10: Normality test results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Perceived benefits	.212	292	<.001	.728	292	<.001
Perceived risks	.077	292	<.001	.959	292	<.001
Organisational resources	.202	292	<.001	.890	292	<.001
Top management knowledge and support	.149	292	<.001	.925	292	<.001
Market pressure	.188	292	<.001	.933	292	<.001
Market support	.089	292	<.001	.980	292	<.001
Interorganisational relationships	.096	292	<.001	.956	292	<.001
Organisational culture	.202	292	<.001	.828	292	<.001
DSC adoption intention	.209	292	<.001	.875	292	<.001
DSC adoption actions	.145	292	<.001	.916	292	<.001
Overall DSC adoption	.121	292	<.001	.914	292	<.001

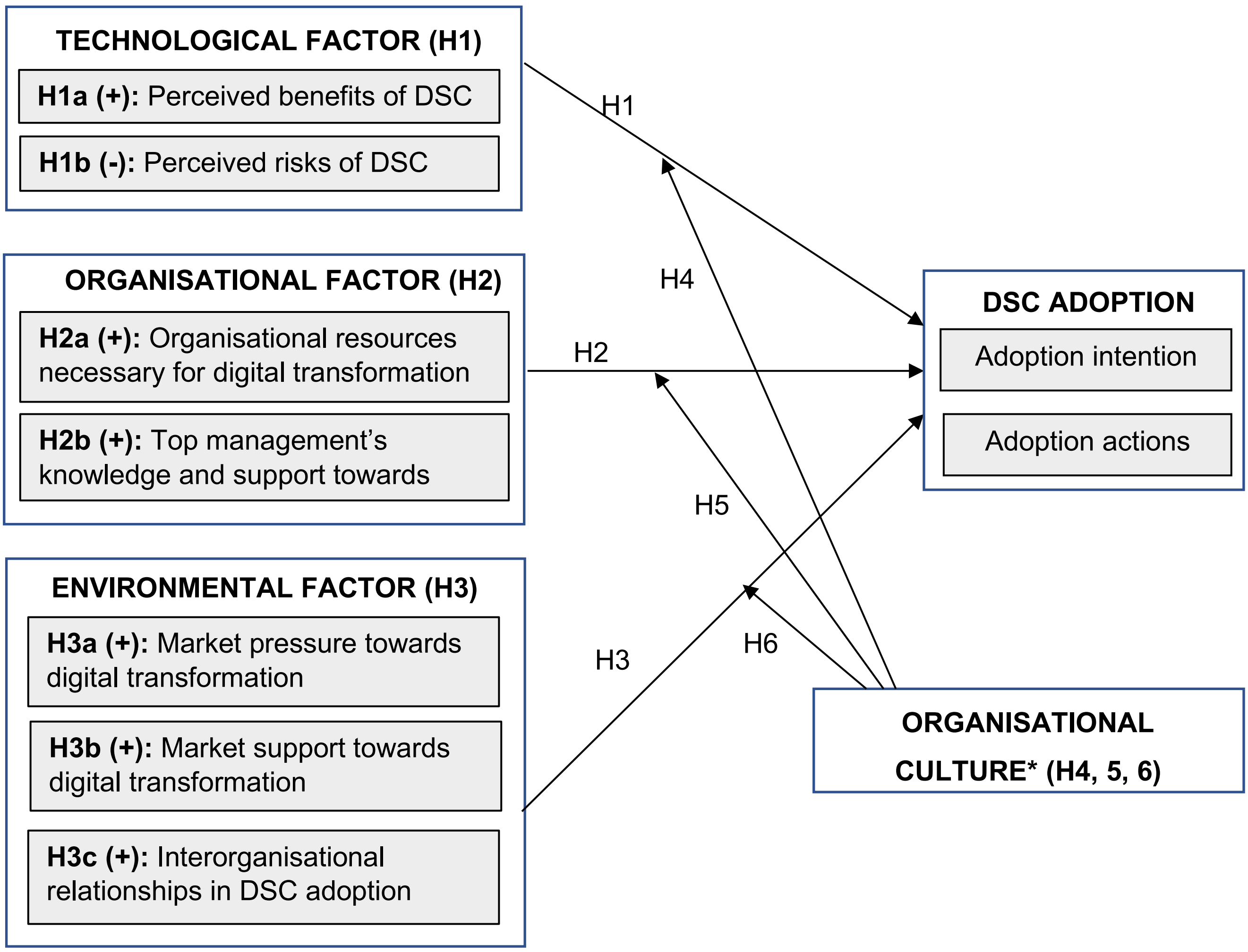
a. Lilliefors Significance Correction

Normality tests indicated a deviation from normal distribution as the Kolmogorov-Smirnov test for variables yielded significant results ($p < 0.001$) (Table 8-10). Nevertheless, the Central Limit Theorem posits that even when the underlying variable is skewed or not normally distributed, for sufficiently large samples, the means tend to approach a normal distribution, (Sainani, 2012). Researchers generally consider a sample size of around 80 adequate or "sufficiently large" for a t-test, even in the presence of substantial deviations from normality (Lumley et al., 2002). Additionally, Uttley (2019) suggested that the assumption of normality can be less important as the sample size increases above 30, as sample sizes of N ≥ 30 often yield a normal distribution of sample means for most cases, except for extremely non-normal distributions that are outliers in their departure from normality. In such extreme non-normal distributions, larger sample sizes may be required for the sampling distribution to approach normality; however, such distributions are uncommon in most research studies. This suggests that, for practical purposes, a sample size of 30 or more is generally sufficient to assume that the sampling distribution of sample means approximates normality, even if the population distribution does not. In light of this, the sample size of 292 responses in this study validates an acceptable normality assumption for sample means, despite potential non-normality in individual data within each sample.

8.5. Hypothesis Testing

To conduct a regression analysis, it is imperative to thoroughly examine the assumptions underlying regression. Given that regression assumptions were met, multiple regression analyses were conducted to evaluate the hypotheses. The hypotheses tested are summarised in Figure 8-1.

Figure 8-1: Hypotheses tested in this study.



*Note: Based on the EFA results, the *Flexibility culture* and *Control culture* factors were combined to create the *Organisational culture* factor. Therefore, the research will solely examine the moderating impact of the *Organisational culture* factor on the relationship between *TOE* factors and *DSC adoption*.

To investigate the six main hypotheses concerning these TOE factors, a series of multiple regression analyses were conducted. Variables that were conceptually related to each other were grouped as blocks to examine their collective impact on DSC adoption. Furthermore, as previously mentioned, the study aims to assess how these TOE factors influence various stages of DSC adoption, including DSC adoption intention and DSC adoption actions. The associations between these TOE factors and DSC adoption intention and DSC adoption actions were also examined separately using multiple regression analyses. The following section provides a detailed exploration of the results obtained from conducting multiple regression analyses to test all hypotheses.

Firstly, regarding the explanation of variance in *Overall DSC adoption, DSC adoption intention*, and *DSC adoption actions* by TOE factors, Table 8-11 illustrates a statistically significant impact. Collectively, these factors account for 52.6% of the variance in *Overall DSC adoption*, as indicated by $F(3,288) = 106.602$, $p < 0.001$. In addition, these factors also exhibit a significant statistical impact on *DSC adoption intention*, jointly explaining 34.1% of the variance in *DSC adoption intention* with $F(3,288) = 49.714$, $p < 0.001$. Finally, these factors demonstrate a significant statistical impact on *DSC Adoption Actions*, collectively accounting for 54.8% of variance in *DSC adoption actions*, as evidenced with $F(3,288) = 109.927$, $p < 0.001$.

Table 8-11: Overall impact of independent variables (TOE) on the dependent variables (Overall DSC adoption, DSC adoption intention and DSC adoption actions)

Dependent variable	R square		df	F	Sig.
Overall DSC adoption	52.6%	Regression	3	106.602	<.001[b]
		Residual	288		
		Total	291		
DSC adoption intention	34.1%	Regression	3	49.714	<.001[b]
		Residual	288		
		Total	291		
DSC adoption actions	53.4%	Regression	3	109.927	<.001[b]
		Residual	288		
		Total	291		

Predictors: Technological factor, Organisational factor, and Environmental factor.

On the other hand, when investigating the impact of TOE's dimensions, it was found that the cumulative impact of TOE's dimensions *on Overall DSC adoption* is statistically significant. These dimensions collectively explain 55.5% of the variance in *Overall DSC adoption*, with $F(7,284) = 50.641$, $p < 0.001$. Furthermore, these dimensions exhibit a significant statistical impact on *DSC adoption intention*, jointly explaining 40.7% of the variance with $F(7,284) = 27.798$, $p < 0.001$. Lastly, these dimensions also demonstrate a significant statistical impact on *DSC adoption actions*, collectively accounting for 54.8% with $F(7,284) = 49.237$, $p < 0.001$ (Table 8-12).

Table 8-12: Overall impact of Perceived benefits, Perceived risks, Organisational Resources, Top management knowledge and support, Market pressure, Interorganisational relationships, Market support on overall Adoption, DSC adoption intention and DSC adoption action

Dependent variable	R square		df	F	Sig.
Overall DSC adoption	55.5%	Regression	7	50.641	<.001[b]
		Residual	284		
		Total	291		
DSC adoption intention	40.7%	Regression	7	27.798	<.001[b]
		Residual	284		
		Total	291		
DSC adoption actions	54.8%	Regression	7	49.237	<.001[b]
		Residual	284		
		Total	291		

Predictors: Perceived benefits, Perceived risks, Organisational resources, Top management knowledge and support, Market pressure, Interorganisational relationships, Market support.

Secondly, regarding the results of multiple regression analyses, a comprehensive summary of the distinctive impact of TOE factors on *Overall DSC adoption, DSC adoption intention* and *DSC adoption actions* is presented in Table 8-13. Upon analysing the beta values, it is clear that the most substantial factor across *Overall DSC adoption, DSC adoption intention,* and *DSC adoption actions* is *Organisational factor*, characterised by the highest beta values ($\beta = 0.521$; t-value= 10.727; $p<0.001$), ($\beta = 0.415$; t-value= 7.248; $p<0.001$), ($\beta = 0.525$; t-value= 6.710; $p<0.001$) respectively.

Table 8-13: Results of multiple regression analyses on TOE factors

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
Technological factor	.076	1.755	.118*	2.309	.018	.413
Organisational factor	.521***	10.727	.415***	7.248	.525***	10.898
Environmental factor	.292***	6.335	.209***	3.858	.317***	6.952

*p < 0.05; **p< 0.01; ***p≤ 0.001

Meanwhile, Table 8-14 demonstrates the distinctive impact of TOE's dimensions on *Overall DSC adoption, DSC adoption intention*, and *DSC adoption actions*. Through the analysis of the beta values, it becomes evident that the most substantial dimensions across *DSC adoption, DSC adoption intention*, and *DSC adoption actions* is *Top management knowledge and support*, characterised by the highest beta values (β= 0.404; t-value= 7.999; p<0.001), (β= 0.386; t-value= 6.612; p<0.001), (β= 0.342; t-value= 6.710; p<0.001) respectively.

Table 8-14: Results of multiple regression analyses on dimensions of TOE factors.

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	***t value***	***Beta***	***t value***	***Beta***	***t value***
Independent variables						
Perceived benefits	.118*	2.371	.182**	3.161	.029	.577
Perceived risks	.046	1.069	.037	.738	.047	1.069
Organisational resources	.144**	2.748	.034	.555	.229***	4.325
Top management knowledge and support	.404***	7.999	.386***	6.612	.342***	6.710
Market pressure	.146**	3.198	.176***	3.340	.086	1.865
Market Support	.050	1.103	-.054	-1.040	.147***	3.221
Interorganisational relationships	.198***	3.976	.146*	2.540	.212***	4.214

*p < 0.05; **p< 0.01; ***p≤ 0.001

Additionally, six control variables were measured in this study, including *company size, company location, position of the respondents, decision-making autonomy of the company, business type* and *industry*. Following Vietnamese government laws, this study assess firm size using an ordinal scale based on the number of employees in a firm, annual revenue, and their business sectors. Regarding the impact of control variables, the analysis revealed that *firm size* demonstrated a statistically significant influence on *Overall DSC adoption (*$\beta = 0.097$; t-value=2.275; $p<0.05$) and *DSC adoption actions* ($\beta = 0.118$; t-value=2.769; $p<0.01$). However, no significant impact was observed on other variables (See Appendix E3).

The contribution and impact of independent variables, including TOE factors and their respective dimensions on the dependent variables, particularly *Overall DSC adoption* (considering *DSC adoption intention* and *DSC adoption actions*) are further explained in the subsequent subsections.

8.5.1. Technological factor's impact on DSC adoption

H1: Technological factors have significant impact on DSC adoption.

In the context of testing H1, the regression analysis was conducted to examine the significant influence of *Technological factor* on *Overall DSC adoption*. The results indicate that there is no statistically significant relationship between *Technological factor* and *Overall DSC adoption* ($\beta = 0.076$; t-value= 1.755, $p > 0.05$), leading to the rejection of H1. However, it is worth noting that a statistically significant impact of *Technological factor* on *DSC adoption intention* was identified, as supported by $F(3,288) = 49.714$, $p<0.001$. Specifically, *Technological factor* exhibited a statistically significant positive influence on *DSC adoption intention* ($\beta = 0.118$; t-value= 2.309, $p < 0.05$). Conversely, the regression analysis revealed a different outcome regarding the impact of *Technological factor* on *DSC adoption actions*. In this case, the impact was found to be statistically insignificant, as indicated by $\beta = 0.018$; t-value= 0.413, $p > 0.05$.

As discussed in detail in Chapter 5, *Technological factor* encompasses two key aspects: *Perceived benefits* and *Perceived risks* associated with digital technology adoption and the broader digital supply chain transformation. These aspects gave rise to the development of two hypotheses, H1a and H1b. Therefore, this research also aims to assess the influence of these dimensions on DSC adoption, as elaborated below.

H1a: Perceived benefits have a positive influence on DSC adoption.

The hypothesis examines whether *Perceived benefits* have a positive impact on *DSC adoption*. To test hypothesis H1a, the dependent variable *Overall DSC adoption* was regressed onto the predicting variable *Perceived benefits*. The analysis revealed a statistically significant effect of *Perceived benefits* on *Overall DSC adoption*, as indicated by $F(7,284)= 50.641$, $p<0.001$. The results also support H1a by confirming a statistically significant positive influence *of Perceived benefits* on *Overall DSC adoption* ($\beta= 0.118$; t-value= 2.371, $p <0.05$).

Furthermore, in terms of the impact of *Perceived benefits* on *DSC adoption intention*, the results indicate that *Perceived benefits* also significantly predict *DSC adoption intention*, with $F(7,284) = 27.798$, $p < 0.001$. This suggests that *Perceived benefits* can play a significant role in determining *DSC adoption intention* ($\beta= 0.118$; t-value= 3.161, $p < 0.01$). These outcomes strongly suggest a positive effect of *Perceived benefits* on *DSC adoption intention*. Conversely, the analysis did not find a significant impact of *Perceived benefits* on *DSC adoption actions* ($\beta= 0.029$; t-value= 0.577, $p > 0.05$).

H1b: Perceived risks have a negative influence on the DSC adoption.

In the context of H1b testing, the regression analysis aimed to explore the potential negative impact of *Perceived risks* on *DSC adoption*. Following internal consistency analysis, *Perceived risks* included both risk dimensions (*Perceived technical standards-related risks* and *Perceived technical capabilities-related risks*) for the purpose of testing the hypothesis via regression. These two types of risks were merged into one factor to align with the original framework and avoid repetition. The results indicated that there was no statistically significant effect of *Perceived risks* on *Overall DSC adoption* ($\beta= 0.046$; t-value= 1.069, $p > 0.05$). Similarly, no statistically significant impact of *Perceived risks* on *DSC adoption intention* ($\beta= 0.037$; t-value= 0.738, $p > 0.05$) or *DSC adoption action* ($\beta= 0.047$; t-value= 1.069, $p > 0.05$) was observed. Furthermore, the positive weight observed for *Perceived risks* in relation to *Overall DSC adoption, DSC intention*, and *DSC adoption action*, leads to the rejection of hypothesis H1b.

8.5.2. Organisational factor's impact on DSC adoption

H2: Organisational factor has a significant impact on DSC adoption.

Hypothesis 2 (H2) examines the significant impact of *Organisational factor* on *Overall DSC adoption*. To test H2, regression analysis was conducted, regressing the independent variable *Overall DSC adoption* onto the predicting variable *Organisational factor*. The results demonstrate a statistically significant influence of *Organisational factor* on *Overall DSC adoption*, as indicated by $F(3,288) = 106.602$, $p < 0.001$, thus confirming H2. Further analysis reveals a statistically significant positive impact of *Organisational factor* on *Overall DSC adoption* ($\beta = 0.521$; t-value = 10.727, $p < 0.001$). This impact is also observed on *DSC adoption intention* ($\beta = 0.415$; t-value = 7.248, $p < 0.001$) and *DSC adoption actions* ($\beta = 0.525$; t-value = 10.898, $p < 0.001$).

As discussed in Chapter 5, *Organisational factor* includes *Organisational resource availability* and *Top management knowledge and support*, leading to the development of H2a and H2b. Therefore, the influence of these two dimensions on *Overall DSC adoption, DSC adoption intention and DSC adoption actions* are investigated below.

H2a: Availability of organisational resources has a positive influence on DSC adoption.

When examining the positive influence of *Organisational resources* on *Overall DSC adoption*, the results show a statistically significant effect on *Overall DSC adoption* with $F(7,284)= 50.641$, $p<0.001$. The outcome also validates H2a by demonstrating the positive impact of *Organisational resources* ($\beta= 0.144$; t-value= 2.748, $p <0.01$). However, despite having a positive impact on the *DSC adoption intention*, *Organisational resources* does not have statistically significant impact, as evidenced by ($F(7,284) = 27.798$, $p < 0.001$), with $\beta= 0.034$; t-value= 0.555, $p>0.05$. Meanwhile, *Organisational resources* significantly influence *DSC adoption actions* with $F(7,284) = 49.237$, $p< 0.001$. The results also indicate the positive impact of *Organisational resources* ($\beta= 0.229$; t-value= 4.325, $p <0.001$).

H2b: Top management knowledge and support have a positive influence on the DSC adoption.

The dependent variable *DSC adoption* was regressed onto the predicting variable *Top management's knowledge and support* to test hypothesis H2b. The results demonstrates a statistically significant influence of *Top management's knowledge and support* on the *Overall DSC adoption* with $F(7,284)= 50.641$, $p<0.001$. The results further support H2b by confirming the statistically significant positive impact of *Top management's knowledge and support* on

Overall DSC adoption (β= 0.404; t-value= 7.999; p<0.001). Likewise, this variable is identified as a significant predictor of both *DSC adoption intention* with F(7,284) = 27.798, p < 0.001 and *DSC adoption actions* with F(7,284) = 49.237, p< 0.001, which indicates the pivotal role of *Top management's knowledge and support* in determining *DSC adoption intention* (β= 0.386; t-value= 6.612; p<0.001) and *DSC adoption actions* (β= 0.342; t-value= 6.710; p<0.001).

8.5.3. Environmental factor's impact on DSC adoption

H3: Environmental factor has significant impact on DSC adoption.

When examining the influence of *Environmental factor* on *Overall DSC adoption*, the analysis reveals a statistically significant impact, as indicated by F(3,288) = 106.602, p < 0.001, thus confirming H3. Additionally, the results demonstrate a statistically significant positive influence of *Environmental factor* on *DSC adoption*, with β = 0.292, t-value = 6.335, and p < 0.001. This statistically significant positive impact is similarly observed on *Overall DSC adoption intention* (β = 0.209, t-value = 3.858, p < 0.001) and *DSC adoption actions* (β = 0.317, t-value = 6.952, p < 0.001).

As discussed in Chapter 5, *Environmental factor* consist of (a) *Market pressure*, (b) *Market support*, and (c) *Interorganisational relationships*, leading to the formulation of H3a, H3b, and H3c. Consequently, impact of these three subfactors or dimensions on *Overall DSC adoption, DSC adoption intention*, and *DSC adoption actions* is explored below.

H3a: Market pressure has a positive influence on the DSC adoption.

Conducting a regression analysis to examine hypothesis H3a yielded compelling results. Specifically, the analysis showcased a statistically significant effect of *Market pressure* on *Overall DSC adoption* (F(7,284)= 50.641, p<0.001). This implies a substantial and positive impact of *Market pressure* on the *Overall DSC adoption*, substantiated by β= 0.146; t-value=3.198; p<0.01, thereby providing support for H3a.

Furthermore, the same predictor was found to exert a significant influence on *DSC adoption intention* (F(7,284) = 27.798, p < 0.001), underscoring the pivotal and positive role of *Market pressure* in fostering the intention to adopt DSC (β= 0.176; t-value=3.340; p<0.001). Conversely, this factor did not exhibit any statistically significant effect on *DSC adoption actions* (F(7,284) = 49.237, p< 0.001), given the coefficient value β= 0.086; t-value=1.865; p>0.05.

H3b: Market support has a positive influence on the DSC adoption.

Regarding the role of *Market support* in *Overall DSC adoption*, despite exhibiting a positive effect on *Overall DSC adoption* as hypothesised, regression analysis reveals no statistically significant impact of *Market support* on such adoption (β= 0.086; t-value=1.103; p>0.05) which therefore rejected the H6. Similarly, no statistically significant effect of *Market support* on *DSC adoption intention* was found (β= -0.054; t-value= -1.040; p>0.05). However, *Market support* emerged as a statistically significant predictor of *DSC adoption actions* with F(7,284) = 49.237, p< 0.001; with the results underscoring its positive influence on the *adoption actions of DSC* (β= 0.147; t-value=3.221; p<0.001).

H3c: Interorganisational relationships have a positive impact on the DSC adoption.

The results regarding the influence of *Interorganisational relationships* exhibited statistical significance across multiple aspects. Notably, the analysis indicated statistical significance in relation to *Overall DSC adoption* (F(7,284)= 50.641, p<0.001), *DSC adoption intention* (F(7,284) = 27.798, p < 0.001), and *DSC adoption actions* (F(7,284) = 49.237, p< 0.001). Additionally, the results also generated the validation for H3c by confirming the positive impact of *Interorganisational relationships* on *Overall DSC adoption* (β= 0.198; t-value=3.976; p<0.001). This statistically significant and positive impact of *Interorganisational relationships* extended to both *DSC adoption intention* (β= 0.146; t-value=2.540; p<0.05) and *DSC adoption actions* (β= 0.212; t-value=4.214; p<0.001).

8.5.4. Control factors' impact on DSC adoption

Six control variables were measured in this study, including *company size, company location, position of the respondents, decision-making autonomy of the company, business type* and *Industry*. Following Vietnamese government laws, this study assess firm size using an ordinal scale based on the number of employees in a firm, annual revenue, and their business sectors. Regarding the impacts of control variables, the analysis revealed that *firm size* demonstrated a statistically significant influence on *Overall DSC adoption (*β= 0.097; t-value=2.275; p<0.05) and *DSC adoption actions* (β= 0.118; t-value=2.769; p<0.01) while having no statistically significant impact on DSC adoption intention (β= 0.057; t-value=0.149; p>0.05). However, no significant impact was observed on other variables (See Appendix E3).

8.5.5. Organisational culture's moderating impact on the relationships between TOE factors and DSC adoption

As previously highlighted in the factor analysis results, the *Organisational culture* is the combination of *Flexibility culture* and *Control culture*. Therefore, this research will not separately explore the moderating impact of flexibility culture and control culture as suggested in the research model. Instead, it will examine the overall impact of *Organisational culture* as a moderator on the relationships between *TOE factors* and *Overall DSC adoption* (considering *DSC adoption intention* and *DSC adoption actions*). Thus, only hypotheses H4, H5, and H6 will be subject to empirical testing.

It is crucial to emphasise that despite the presence of both control and flexibility cultures, the *Organisational culture* is dominantly control-oriented and less influenced by flexibility values. This tendency stems from the fact that the items linked with Control culture display notably higher positive loadings (0.756, 0.711, 0.672, 0.556) on the *Organisational culture* factor, while items associated with Flexibility culture possess slightly lower loadings (0.758, 0.689, 0.665, 0.571) (refer to Table 8-7). As higher factor loadings denote a stronger correlation with the factor, whereas lower loadings indicate weaker relationships (Brown, 2009), it suggests that the respondents' perception of the *Organisational culture* is more aligned with control-driven aspects rather than flexibility-driven aspects.

The hypotheses 4 to 6 investigate the moderating role of *Organisational culture* in the relationship between the adoption determinants and DSC adoption. Theories proposing interactions between independent causal variables in determining a dependent variable suggest that the nature of the relationship between the independent variable X and the dependent variable Y depends on the moderator variable Z (Arnold, 1982). According to Arnold (1982), the presence of a situation where the X – Y relationship's form is contingent on Z statistically implies a significant X x Z interaction. Thus, to explore the hypothesised moderating effects outlined in H4 to H6, multiple regression analyses were conducted to study the impact of the moderating variable and its interaction effect between the independent variable X and the moderator variable Z (X x Z) on the dependent variable Y. If the interaction effect X x Z emerges significant, it signifies the influence of X on Y varies across the range of the moderator variable Z (Dawson and Richter, 2006). In essence, this interaction effect can either positively or negatively moderate the relationship between X and Y, ultimately supporting the assumptions or hypotheses regarding the impact of moderator Z on the X – Y relationship.

It is noteworthy that the moderation effect of *Organisational culture* has been assessed for both statistically significant factors of DSC adoption (*Organisational factor* and *Environmental factor*) and the subfactors or dimensions (*Perceived benefits, Organisational resources, Top management knowledge and support, Market pressure*, and *Interorganisational relationships*); as well as for a statistically insignificant factor (*Technological factor*) and the statistically insignificant subfactors or dimensions (*Perceived risks* and *Market support*). This decision is prompted by the circumstance where, despite these factors not exhibiting significant impacts on the dependent variables, their interaction effects with the independent variables do emerge as statistically significant. In simpler terms, when the moderator Z is absent, the connection between the independent variable X and the dependent variable Y lacks significance. This implies that the influence of independent variable X on dependent variable Y depends on the value of moderator Z. Furthermore, the study also seeks to explore the moderating influence of *Organisational culture* across different phases of DSC adoption, specifically *DSC adoption intention* and *DSC adoption action*. A moderation analysis was conducted using linear regression in SPSS, with standardised values for the predictor and moderator variables.

Before constructing interaction terms in regression models to examine the moderating effect, a preliminary step involves transforming the variables intended for use in the moderation model. This is typically achieved through mean centring or standardisation of both independent and moderator variables, ensuring that the mean value of each variable becomes zero (Anderson et al., 2013; Frazier, Tix and Barron, 2004). *Standardising variables* is more favourable as it is easier than manually centring the mean of variables (Anderson et al., 2013; Frazier, Tix and Barron, 2004). The standardised independent and moderator variables were created by *Save standardized values as variables* in SPSS (Analyse → Descriptive Statistics). Subsequently, these standardised variables served as the foundation for generating six interaction effect variables, representing the interplay between each standardised independent variable and the standardised moderator variable. These interaction variables were named as follows:

TFxOC (ZTechnological factor x ZOrganisational Culture)

- *PRxOC (ZPerceived Risks x ZOrganisational Culture)*
- *PBxOC (ZPerceived Benefits x ZOrganisational Culture)*

OFxOC (ZOrganisational factor x ZOrganisational Culture)

- *ORxOC (ZOrganisational Resources x ZOrganisational Culture)*
- *TMxOC (ZTop Management x ZOrganisational Culture)*

EFxOC (ZEnvironmental factor x ZOrganisational Culture)

- *MPxOC (ZMarket Pressure x ZOrganisational Culture)*
- *MSxOC (ZMarket Support x ZOrganisational Culture)*
- *IORxOC (ZInterorganisational Relationships x ZOrganisational Culture)*

With these standardised variables and their respective interaction terms in place, the final step involved conducting regression analyses. Each standardised independent variable (adoption determinants), along with the standardised moderator variable (*Organisational culture*), and their corresponding interaction variables, were included as independent variables that influence the dependent variables (*Overall DSC adoption, DSC adoption intention*, and *DSC adoption actions*). Considering the presence of independent variables, moderator variables, and dependent variables, distinct combinations of these variables were examined individually. Regression analyses were performed separately to enable a focused examination of individual determinants' effects and their specific interactions with *Organisational culture*. The outcomes, including Beta coefficients and t-values, have been consolidated and presented in the Table 8-15 provided below.

In line with the approach proposed by Hair Jr et al. (2021), Variance Inflation Factors (VIFs) were computed to evaluate the presence of multicollinearity among the standardised explanatory variables for DSC adoption, DSC adoption intention, and DSC adoption actions. The observed VIF values consistently fall well below the threshold of 5, underscoring that multicollinearity is not a point of concern within this study (Hair Jr et al., 2021).

Table 8-15: Summary of Organisational culture's moderating impact results

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
H4: Organisational culture moderates the relationship between Technological factor and DSC adoption						
TFxOC (ZTechnological factor x ZOrganisational Culture)	-.126*	-2.397	-.141*	-2.553	-.084	-1.509
- PBxOC (ZPerceived Benefits x ZOrganisational Culture)	-.157**	-2.683	-.135*	-2.182	-.149*	-2.370
- PRxOC (ZPerceived Risks x ZOrganisational Culture)	.138*	2.473	.115	1.946	.134*	2.252
H5: Organisational culture moderates the relationship between Organisational factor and DSC adoption.						
OFxOC (ZOrganisational factor x ZOrganisational Culture)	-.090	-1.778	-.118*	-2.036	-.043	-.819
- ORxOC (ZOrganisational Resources x ZOrganisational Culture)	-.104*	-1.999	-.146*	-2.525	-.041	-.754
- **TMxOC (ZTop Management x ZOrganisational Culture)**	-.084	-1.639	-.084	-1.458	-.068	-1.231
H6: Organisational culture moderates the relationship between Environmental factor and DSC adoption.						
EFxOC (ZEnvironmental factor x ZOrganisational Culture)	-.090	-1.745	-.110	-1.931	-.051	-.958
- MPxOC (ZMarket Pressure x ZOrganisational Culture)	-.128*	-2.385	-.116*	-2.042	-.114*	-1.973
- MSxOC (ZMarket Support x ZOrganisational Culture)	-.102*	-2.009	-.105	-1.911	-.079	-1.513
- IORxOC (ZInterorganisational Relationships x ZOrganisational Culture)	-.068	-1.353	-.102	-1.826	-.020	-.385

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

H4: Organisational culture moderates the relationship between Technological factor and DSC adoption.

Table 8-16 below shows that while *Technological factor alone* does not have statistically significant impact on *Overall DSC adoption* (β= 0.061; t-value=1.264; $p>0.05$) and *DSC adoption intention* (β= 0.093; t-value=1.815; $p>0.05$), the interactions between *Technological factor* and *Organisational culture* yield statistically significant and negative results. This suggests that *Organisational culture* acts as a negative moderator in the relationship between *Technological factor* and *Overall DSC adoption* (β= -0.126; t-value= -2.397; $p<0.05$), as well as between *Technological factor* and *DSC adoption intention* (β= -0.141; t-value= -2.553; $p<0.05$). This indicates that these relationships are conditional on the level of *Organisational culture* and weaker in its presence. In other words, the impacts of *Technological factor* on *Overall DSC adoption* and *DSC adoption intention* are contingent on the specific characteristics of *Organisational culture*. On the other hand, the interaction between *Organisational culture* and *Technological factor* on *DSC adoption actions* was observed to be insignificant (β= -0.084; t-value= -1.509; $p>0.05$), suggesting that *Organisational culture* does not moderate the relationship between *Technological factor* and *DSC adoption actions*.

Table 8-16: Organisational culture's moderating impact on the relationship between Technological factor and DSC adoption (including DSC adoption intention and DSC adoption actions)

Dependent variables	Overall adoption		Adoption intention		Adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZTechnological Factor	.061	1.264	.093	1.815	.017	.322
ZOrganisational Culture	.546***	9.844	.467***	7.993	.517***	8.722
TFxOC	-.126*	-2.397	-.141*	-2.553	-.084	-1.509

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

As discussed in Chapter 5, *Technological factor* encompasses two key aspects: (a) *Perceived benefits* and (b) *Perceived risks*. Therefore, this research further test H4 by evaluating how *Organisational culture* moderates the relationships between these two dimensions and *DSC adoption.*

The outcomes of the regression analysis in Table 8-17 below revealed a significant effect of *Organisational culture* on *Overall DSC adoption* (β= 0.494; t-value=8.218; $p<0.001$), *DSC adoption intention* (β= 0.416; t-value=6.557; p<0.001), and *DSC adoption actions* (β= 0.475; t-value=7.386; p<0.001), signifying a positive correlation between *Organisational culture* and *Overall DSC adoption*, as well as *DSC adoption intention and actions*.

Furthermore, an intriguing observation was made regarding the impact *of Perceived benefits* on *Overall DSC adoption*. Although a statistically significant impact was evident in the absence of *Organisational culture*, its direct impact became insignificant when *Organisational culture* and the interaction effect were taken into account (β= 0.072; t-value=1.329; p>0.05). This implies that the impact of *Perceived benefits* on *Overall DSC adoption* was contingent upon the consideration of the *Organisational culture*.

Additionally, the interactions between *Perceived benefits* and *Organisational culture* exhibited statistical significance and negative relationship with *Overall DSC adoption* (β= -0.157; t-value=-2.683; p<0.01) and *DSC adoption intention* (β= -0.135; t-value=-2.182; p<0.05). This signifies that the effect of *Perceived benefits* on *Overall DSC adoption* and *DSC adoption intention* varied based on the level of *Organisational culture*. Specifically, the positive effect of *Perceived benefits* on *Overall DSC adoption* and *DSC adoption intention* was stronger for organisations with lower *Organisational culture* compared to those with strong *Organisational culture*.

On the other hand, despite statistically insignificant impact on *DSC adoption actions*, its effect was significantly and negatively moderated by *Organisational culture* (β= -0.149; t-value=-2.370; p<0.05). The results indicate that the relationship between *Perceived benefits* and *DSC adoption actions* is not consistent across different levels of *Organisational culture*. The situation can be described as “partial moderation” as the magnitude or direction of the effect of *Perceived benefits* on *DSC adoption actions* are influenced by the presence of *Organisational culture* and may differ depending on the level of *Organisational culture*.

Table 8-17: Organisational culture’s moderating impact on the relationship between Perceived benefits and DSC adoption

Dependent variables	**Overall DSC adoption**		**DSC adoption intention**		**DSC adoption actions**	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZPerceivedBenefits	.072	1.329	.133*	2.333	-.005	-.093
ZOrganisationalCulture	.494***	8.218	.416***	6.557	.475***	7.386
PBxOC	-.157**	-2.683	-.135*	-2.182	-.149*	-2.370

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

Table 8-18 shows that while *Perceived risks* does not directly influence *Overall DSC adoption* and *DSC adoption action*, the interactions between *Perceived risks* and *Organisational culture* yield statistically significant and positive results which suggests that *Organisational culture* acts as a positive moderator in the relationship between *Perceived risks* and *Overall DSC adoption* (β= 0.138; t-value=2.473; p<0.05), as well as between *Perceived risks* and *DSC adoption actions* (β=0.134; t-value=2.252; p<0.05). This indicates that these relationships are conditional on the level of *Organisational culture* and stronger in its presence. In other words, the impacts of *Perceived risks* on *Overall DSC adoption* and *DSC adoption actions* are contingent on the specific characteristics of *Organisational culture*.

Table 8-18: Organisational culture's moderating impact on the relationship between Perceived risks and DSC adoption

Dependent variables	**Overall DSC adoption**		**DSC adoption intention**		**DSC adoption actions**	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZPerceived Risks	-.020	-.414	-.041	-.814	.006	.124
ZOrganisationalCulture	.546***	9.996	.494***	8.519	.490***	8.429
PR_OC	.138*	2.473	.115	1.946	.134*	2.252

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

H5: Organisational culture moderates the relationship between Organisational factor and DSC adoption.

Based on Table 8-19, moderation analysis results have revealed no statistically significant interactions between *Organisational factor* and *Organisational culture* on *overall DSC adoption* (β= -0.090; t-value= -1.778; p>0.05), suggesting that *Organisational culture* does not moderate the relationship between *Organisational factor* and *Overall DSC adoption*. This insignificant moderating impact of Organisational culture was also observed on the relation between *Organisational factor* and *DSC adoption actions* (β= -0.043; t-value= -0.819; p>0.05). On the other hand, the interaction between *Organisational culture* and *Organisational factor* on *DSC adoption intention* was observed to be significant (β= -0.118; t-value= -2.036; p<0.05), suggesting that *Organisational culture* moderates the relationship between *Organisational factor* and *DSC adoption intention*.

Table 8-19: Organisational culture's moderating impact on the relationship between Organisational factor and DSC adoption (including DSC adoption intention and DSC adoption actions)

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZOrganisational factor	.460***	9.016	.309***	5.298	.522***	9.788
ZOrganisational Culture	.291***	5.058	.306***	4.651	.218***	3.610
OFxOC	-.090	-1.778	-.118*	-2.036	-.043	-.819

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

In further testing for H5, various combinations of Organisational factor' dimensions with *Organisational culture* were also tested. As a result, the analyses investigated the effects of Organisational culture on Organisational factor through its interaction with (a) *Organisational resources* and (b) *Top management knowledge and support*.

Upon analysing the significance of the moderating effect, the findings in Table 8-20 below revealed a negative and statistically significant moderating impact of *Organisational culture* on the relationship between *Organisational resources* and *Overall DSC adoption* (β= -0.104; t-value=-1.999; p<0.05). This suggests that an increased *Organisational culture* negatively moderated the relationship between *Organisational resources* and *DSC adoption*. However, the results indicated no statistically significant moderating impact of *Organisational culture* on the relationship between *Organisational resources* and *DSC adoption actions* (β= -1.999; t-value=-0.754; p>0.05). Additionally, it was intriguing to discover that even though no statistically significant impact of *Organisational resources* was found on *DSC adoption intention*, its relationship was negatively influenced by *Organisational culture* (β= -1.46; t-value=-2.525; p<0.05). This suggests that the effect of *Organisational resources* on *DSC adoption intention* is contingent upon the specific characteristics of *Organisational culture*.

Table 8-20: Organisational culture's moderating impact on the relationship between Organisational resources and DSC adoption (including DSC adoption intention and DSC adoption actions)

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZOrganisationalResources	.310***	6.324	.177***	3.260	.385***	7.536
ZOrganisationalCulture	.415***	7.321	.396***	6.324	.351***	5.948
ORxOC	-.104*	-1.999	-.146*	-2.525	-.041	-.754

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

Regarding the moderating impact of *Organisational culture* on the relationships between *Top management* and *Overall DSC adoption* (including *DSC adoption intention* and *DSC adoption actions*), the results in Table 8-21 below revealed that *Organisational culture* does not moderate the positive relationship between *Top management knowledge and support* and *Overall DSC adoption* (β= -0.084; t-value=-1.639; p>0.05), *DSC adoption intention* (β= -0.084; t-value=-1.458; p>0.05), and *DSC adoption actions* (β= -0.068; t-value=-1.231; p>0.05). This implies that *Organisational culture* does not play a critical role in shaping how *Top management knowledge and support* influence the intention and decision to adopt DSC.

Table 8-21: Organisational culture's moderating impact on the relationship between Top management knowledge and support, and DSC adoption (including DSC adoption intention and DSC adoption actions)

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZTopManagement	.422***	8.246	.327***	5.723	.434***	7.919
ZOrganisationalCulture	.327***	5.684	.322***	5.020	.265***	4.308
TM_OC	-.084	-1.639	-.084	-1.458	-.068	-1.231

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

H6: Organisational culture moderates the relationship between Environmental factor and DSC adoption.

Based on Table 8-22 below, moderation analysis results have revealed no statistically significant interactions between *Environmental factor* and *Organisational culture* on *Overall*

DSC adoption (β= -0.090; t-value= -1.745; p>0.05), *DSC adoption intention* (β= -0.110; t-value= -1.931; p>0.05) and *DSC adoption actions* (β= -0.051; t-value= -0.958; p>0.05), suggesting that *Organisational culture* does not moderate the relationship between *Environmental factor* and *Overall DSC adoption*, *DSC adoption intention* and *DSC adoption actions*.

Table 8-22: Organisational culture's moderating impact on the relationship between Environmental factor and DSC adoption (including DSC adoption intention and DSC adoption actions).

Dependent variables	**Overall DSC adoption**		**DSC adoption intention**		**DSC adoption actions**	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZEnvironmental factor	.292***	5.978	.161**	2.975	.368***	7.257
ZOrganisational Culture	.441***	8.006	.430***	7.076	.363***	6.343
EFxOC	-.090	-1.745	-.110	-1.931	-.051	-.958

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

To test H6, various combinations of Environmental factor' dimensions with *Organisational culture* were also tested. As a result, the analyses investigated the effects of *Organisational culture* on *Environmental factor* through their interaction with (a) *Market pressure*, (b) *Market support* and (c) *Interorganisational relationships*.

Based on the analysis findings in Table 8-23 below, the interaction effect between *Market pressure* and *Organisational culture* was found to be statistically significant and negative in relation to both *Overall DSC adoption* (β= -0.128; t-value=-2.385; p< 0.05) and *DSC adoption intention* (β= -0.116; t-value=-2.042; p< 0.05). These findings indicate that *Organisational culture* reduced the impact of *Market pressure* on *Overall DSC adoption* and *DSC adoption intention*. Similarly, a comparable moderating impact of *Organisational culture* was observed in the context of the relationship between *Market pressure* and *DSC adoption actions* (β= -0.1164; t-value=-1.973; p< 0.05) although this relationship was statistically insignificant in the absence of *Organisational culture*. This highlights the importance of considering the role of *Organisational culture* in shaping the impact of *Market pressure* on *DSC adoption* as a whole and *DSC adoption intention* in particular.

Table 8-23: Organisational culture's moderating impact on the relationship between Market pressure and DSC adoption (including DSC adoption intention and DSC adoption actions)

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZMarketPressure	.179***	3.782	.177***	3.522	.144**	2.842
ZOrganisationalCulture	.495***	8.953	.441***	7.498	.451***	7.580
MP_OC	-.128*	-2.385	-.116*	-2.042	-.114*	-1.973

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

Table 8-24 below reveals that in the absence of the moderator variable, the impact of *Market support* on *Overall DSC adoption* was statistically insignificant. However, the presence of *Organisational culture* reduced this relationship (β= -0.102; t-value=-2.009; p<0.05). In contrast, no statistically significant moderating impact of Organisational culture was found on the relationship between *Market support* and *DSC adoption intention* (β= -0.105; t-value=-1.911; p>0.05) or *DSC adoption actions* (β= -0.079; t-value=-1.513; p>0.05). This indicates that *Organisational culture* does not significantly moderate the effect of *Market support* on *DSC adoption intention* and *DSC adoption actions*.

Table 8-24: Organisational culture's moderating impact on the relationship between Market support and DSC adoption (including DSC adoption intention and DSC adoption actions).

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZMarketSupport	.146**	3.124	.003	.052	.265***	5.482
ZOrganisationalCulture	.536***	10.144	.516***	9.073	.449***	8.254
MS_OC	-.102*	-2.009	-.105	-1.911	-.079	-1.513

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

Based on Table 8-25 below, the moderation analysis findings revealed the insignificant moderation of *Organisational culture* on the relationships between *Interorganisational relationships* and *Overall DSC adoption* (β= -0.068; t-value=-1.353; p> 0.05), *DSC adoption* *intention* (β= -0.102; t-value=-1.826; p> 0.05), and *DSC adoption actions* (β= -0.020; t-value=-0.385; p> 0.05). This implies that *Organisational culture* does not play a critical role in shaping how *Interorganisational relationships* influences the intention and decision to adopt DSC practices.

Table 8-25: Organisational culture's moderating impact on the relationship between Interorganisational relationship and DSC adoption.

Dependent variables	Overall DSC adoption		DSC adoption intention		DSC adoption actions	
	Beta	*t value*	*Beta*	*t value*	*Beta*	*t value*
Independent variables						
ZInterorganisationalRelationships	.295***	6.179	.165**	3.127	.370***	7.453
ZOrganisationalCulture	.463***	8.656	.442***	7.473	.392***	7.059
IOR_OC	-.068	-1.353	-.102	-1.826	-.020	-.385

*Note: Statistical significance: *p < 0.05; **p< 0.01; ***p≤ 0.001*

8.5.6. Hypotheses testing: summary

Table 8-26 below summarises the regression and moderation analysis results. In summary, based on the results of the moderation analysis, it was observed that *Organisational culture* negatively moderates the relationship between *Technological factor* and Overall DSC adoption. This is noteworthy because in the regression analysis, *Technological factor* did not exhibit a statistically significant impact on *overall DCS adoption*, suggesting that this relationship changes when considering *Organisational culture*. On the other hand, in the moderation analysis findings, *Organisational culture* does not moderate the relationship between two factors: *Organisational factor* and *Environmental factor*, and *Overall DSC adoption*. This contrasts with the regression analysis, where both *Organisational factor* and *Environmental factor* had statistically significant direct impacts on *Overall DSC adoption*.

When exploring the dimension level of *Technological factor*, it was interesting to find out that that *Organisational culture* positively moderates the relationship between *Perceived risks* and *Overall DSC adoption* even though *Perceived risks* do not have a statistically significant direct impact on *Overall DSC adoption*, suggesting that this relationship changes at the presence of *Organisational culture*. Meanwhile, *Organisational culture* has a negative and significant impact on the relationship between *Perceived benefits* and *Overall DSC* *adoption* despite *Perceived benefits* having statistically insignificant direct effect on *Overall DSC adoption* in the presence of *Organisational culture*.

On the other hand, when considering the dimension of *Organisational factor*, it was observed that although *Top management knowledge and support* have a statistically significant impact on *Overall DSC adoption,* no moderating impact of *Organisational culture* was found on this relationship. It suggests that *Organisational culture* does not significantly influence how *Top management knowledge and support* affect *Overall DSC adoption*. Conversely, a negative and significant moderating effect of *Organisational culture* was identified in the relationship between *Organisational resources* and *Overall DSC adoption*.

Finally, at the dimension level of *Environmental factor*, a negative and significant moderating effect of *Organisational culture* was observed on the relationship between two dimensions: *Market support* and *Market pressure*, and the *Overall DSC adoption*. This suggests that *Organisational culture* significantly influences how *Market support* and *Market pressure* affect the *overall adoption of DSC*. There was no moderating impact identified in the relationship between *Interorganisational relationships* and *Overall DSC adoption,* despite statistically significant direct influence of *Interorganisational relationships* on *Overall DSC adoption*. It implies that *Organisational culture* does not play a significant role in shaping how *Interorganisational relationships* influence *Overall DSC adoption*.

Table 8-26: Summary of hypothesis testing results.

HYPOTHESES	RESULTS
H1: Technological factor has a significant impact on DSC adoption.	Rejected
H1a: Perceived benefits has a positive influence on DSC adoption.	*Supported*
H1b: Perceived risks have a negative influence on the DSC adoption.	*Rejected*
H2: Organisational factor has a significant impact on DSC adoption.	Supported
H2a: Availability of organisational resources has a positive influence on DSC adoption.	*Supported*
H2b: Top management's knowledge and support have a positive influence on the DSC adoption.	*Supported*
H3: Environmental factor has a significant impact on DSC adoption.	Supported
H3a: Market pressure has a positive influence on the DSC adoption.	*Supported*
H3b: Market support has a positive influence on the DSC adoption.	*Rejected*
H3c: Interorganisational relationships have a positive impact on the DSC adoption.	*Supported*
H4: Organisational culture moderates the relationship between Technological factor and DSC adoption.	Supported
H5: Organisational culture moderates the relationship between Organisational factor and DSC adoption.	Rejected
H6: Organisational culture moderates the relationship between Environmental factor and DSC adoption.	Rejected

8.6. Summary

To empirically test the proposed research framework (as outlined in Chapter 5), Chapter 8 explained quantitative data analysis methods and techniques employed to validate the significance of the hypothesised relationships between constructs. For this purpose, the chapter firstly provided a description of the characteristics of the 292 respondents which is equivalent to a response rate of 12.7% from the 2,300 surveys distributed. Through this descriptive analysis of the data, it becomes evident that most participants held positions in middle management (50%) and were employed by large companies (68.2%) with foreign ownership (50%), predominantly located in the Southern region (71.2%). Furthermore, these companies primarily operated within the secondary and tertiary industries, accounting for 40.4% and 42.5% respectively.

Following the initial descriptive analysis, a series of validity assessments through Exploratory Factor Analysis (EFA) and reliability evaluations using Cronbach's alpha were undertaken. Subsequently, the acquired results were further elucidated using principal component analysis to provide a comprehensive understanding of how variables would be grouped into coherent components or factors. After the elimination of factor loadings below the specified threshold of 0.4, EFA was rerun, leading to the identification of nine factors, respectively perceived benefits, perceived risks, top management knowledge and support, organisational resources, market pressure, market support, interorganisational relationships, organisational culture, DSC adoption (considering DSC adoption intention and DSC adoption actions). To ensure the reliability of these fine factors, Cronbach's alpha analysis was carried out, confirming the robustness of these factors ($\alpha > 0.6$).

Finally, multiple regression analyses were conducted on the dataset to examine the hypotheses. In the next chapter, the key findings of these analyses would be comprehensively explained and discussed, offering insights into potential justifications for the observed outcomes.

9. CHAPTER 9: FINDINGS DISCUSSION

The previous chapter detailed the quantitative data analysis methods utilised to validate the hypothesised relationships between constructs in the research model. In this chapter, the findings are discussed based on the main research questions of this study. The goal of this study was to assess the factors influencing DSC adoption (including intention and actions) by using an integrative lens that combines the Technological, Organisational, and Environmental (TOE) perspectives and insights from IOR. The study also aims to understand the impact of organisational culture on such adoption. Therefore, as stated in Chapter 1, two research questions (RQs) were investigated:

RQ1: What are the enablers and barriers of SC 4.0 adoption for firms in Vietnam?

RQ2: What is the role of organisational culture in SC 4.0 adoption for firms in Vietnam?

The subsequent sections provide a detailed elaboration on how research questions were addressed in the context of this study. In summary, the questionnaire findings in Chapter 8 revealed that the Technological factor did not significantly influence Overall DSC adoption (β= 0.076; t-value= 1.755, $p > 0.05$), but one of its dimensions named Perceived benefits was likely to influence DSC adoption (β= 0.118; t-value= 2.371, $p < 0.05$). Additionally, firms that were influenced by organisational context (β = 0.521; t-value = 10.727, $p < 0.001$) and environmental context (β = 0.292, t-value = 6.335, and $p < 0.001$) were more likely to adopt DSC. Particularly, within organisational context, organisational resources (β= 0.144; t-value= 2.748, $p < 0.01$) and top management knowledge and support (β= 0.404; t-value= 7.999; $p<0.001$) facilitated DSC adoption. Meanwhile, within environmental context, market pressure (β= 0.146; t-value=3.198; $p<0.01$) and interorganisational relationships (β= 0.198; t-value=3.976; $p<0.001$) played a significant role in influencing the adoption of DSC. Among these factors, it was obvious that top management knowledge and support emerged as the foremost drivers determining the extent of Overall DSC adoption, followed by interorganisational relationships. The results also indicated different determinants have different impacts on different stages of DSC adoption process. Particularly, while perceived benefits, top management knowledge and support, market pressure, and interorganisational relationships help to predict DSC adoption intention; firms' DSC adoption actions are determined by organisational resources, top management knowledge and support, market support, and interorganisational relationships. In the subsequent section, this study comprehensively examines the influence of each factor on DSC adoption as well as DSC adoption intention and actions to address the RQ1 and RQ2.

9.1. RQ1: Enablers and barriers of SC 4.0 Adoption for Firms in Vietnam

As discussed in Chapter 1, the aim of the first research question is to identify the determinants that either hinder or facilitate SC 4.0 adoption in Vietnam. As detailed in Chapter 3, the research is grounded in the Technology – Organisation – Environment framework. Thus, the discussions in this chapter are organised around four overarching themes and their responsive subthemes: Technology, Organisation, and Environment (integrated with IOR disciplines) factors.

9.1.1. Technological factor's impact on SC 4.0 adoption

Data analysis unveiled that the broader technological context did not fully influence the DSC adoption (β= 0.076; t-value= 1.755, $p > 0.05$). Notably, perceived benefits emerged as a significant and positive driver of DSC adoption (β= 0.118; t-value= 2.371, $p < 0.05$). Intriguingly, despite their potential negative connotations, perceived risks were not found to have a significant impact on the overall DSC adoption (β= 0.046; t-value= 1.069, $p > 0.05$).

9.1.1.1. Perceived benefits' impact on SC4.0 adoption

Unsurprisingly, perceived benefits were found to exert a positive and significant influence on the firm' decisions to adopt DSC. The finding aligns with similar studies documented in the literature (Arnold and Voigt, 2019; Lin et al., 2018; Maduku, Mpinganjira and Duh, 2016; Osakwe et al., 2016; Leung et al., 2015; Lin, 2014) which claimed perceived benefits as a driving force behind this technological and digital reform. As highlighted in the work of Wang, Wang, and Yang (2010), expected benefits can serve as motivation for the adoption and expansion of innovation technology since employees recognise the inherent advantages of the new system in enhancing work efficiency. Consequently, the more benefits they perceive, the greater the level of DSC adoption.

This finding also aligns with the insights gathered from the interviews (Chapter 7) which claimed that a wide range of potential benefits associated with digital transformation served as strong incentives for firms to willingly embrace digital technology adoption, as illustrated by a statement from P9: "*One of the primary benefits that motivated our business to embark on digital transformation is the potential to achieve substantial revenue through cost reduction,* *resource saving, and increased productivity…The adoption of digital technologies has enabled our business to enhance customer service by efficiently handling a high volume of customer orders, improving communication between operational systems, and increasing the speed of product and service delivery…. Additionally, the pandemic has helped our business to realise the potential of digital technologies in reducing our business's reliance on labour force*". Similarly, the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO, 2018) conducted a study assessing the awareness and readiness for digital transformation in Vietnam, with a focus on agriculture and industry sectors. Findings indicate that majority of surveyed organisations acknowledged the significance of digital technology and its transformative potential in production and business. Thus, the present study underscored the pivotal role of organisations' perception of the advantages associated with DSC adoption in accelerating the pace of such technological transformation.

The benefits of DSC adoption identified by the study included improvements in product and service customisation, increased productivity, enhanced flexibility in responding to market changes, improvements in employee health and safety, increased resource conservation, facilitation of real-time market data analysis for swift decision-making and efficient information sharing, as well as reductions in product and service defects and breakdown maintenance. Observed from the mean values of benefits-related items (refer to Table 8-7), it became evident that among these benefits identified, greater data-driven decision-making (4.42 out of 5) and effective information sharing and monitoring (4.38 out of 5) were found to be the most advantageous for firms, followed by productivity and flexibility to market changes (4.27 out of 5); resources saving (4.19 out of 5); and product and service customisation (4.12 out of 5). This implies that Vietnamese firms predominantly embrace digital technologies in their supply chains to rapidly access real-time market data and streamline information sharing to accelerate decision-making processes, enabling them to respond effectively to market volatility and intense price competition. Similarly, according to Xu and Chen (2018), the digital technology adoption in supply chains has the potential for capturing essential data and information from the production environment in real-time, which then can be leveraged to adjust production schedules corresponding to the changing market environment.

Additionally, perceived benefits were found to have significant and positive impact on DSC adoption intention ($\beta = 0.118$; t-value= 3.161, $p < 0.01$), implying that when organisations perceive that there are benefits associated with adopting DSC, they are more likely to express an intention to do so. Thus, perceived benefits are a critical factor influencing DSC adoption intention. This result corresponded to prior studies which claimed that the belief that digital technologies enhanced work performance significantly impacted the intent for technology adoption (Nguyen and Luu, 2020; Tsai, Lee and Wu, 2010). Nonetheless, despite this positive impact, perceived benefits were not identified as a determinant of DSC adoption actions (β= 0.029; t-value= 0.577, $p > 0.05$). This implies that even though organisations may acknowledge the benefits of DSC and express an intention to adopt it, this perception did not necessarily translate into actual actions to implement the DSC. In other words, the recognition of benefits does not guarantee that the DSC will be adopted in practice.

This discrepancy could be attributed to the organisation's low level of digital maturity. At less digital maturity levels, there may be more obstacles and delays that can hinder the translation of intentions into actions and the effective implementation of technological changes. These challenges may include an unclear return on investment (ROI), the firm's risk aversion, a preference for adhering to familiar and well-established practices, limited IT infrastructure, financial constraints, or resistance from employees to changes as identified in this study. Therefore, even though perceived benefits can generate positive intention toward DSC adoption, these challenges could potentially discourage firms from making investments in digital technologies, even when there are significant perceived benefits from DSC. For example, despite the acknowledgement that "*all top managers realise the value of digital transformation or digital technology implementation*" (P9); *"businesses are reluctant to embrace this disruptive change due to a lack of sufficient business cases to prove the feasibility*" (P11) and "*due to the failure to justify projected financial returns*" (P12).

9.1.1.2. Perceived risks' impact on SC4.0 adoption

Unexpectedly, perceived risks or concerns related to complexity, technical integration requirements, shortage of information sharing standards, security and privacy issues, short lifespan, technical incompatibility, poor data quality, substantial adoption costs and dependence on technology providers, did not emerge as significant determinants in this study. This unexpected outcome contradicts prior research (Wong et al., 2020; Hsu, Ray and Li-Hsieh, 2014; Oliveira and Martins, 2011; Wang, Wang and Yang, 2010), which indicated that perceived risks, particularly regarding data privacy and security, complexity, and compatibility, played a substantial role in influencing technology adoption decisions. This result contradicts the findings of several studies conducted in more developed countries. For instance, a study conducted in Taiwan by Wang, Wang, and Yang (2010) proposed that firms often prioritise the potential problems or risks associated with technology adoption, such as complexity, over its competitive advantages. As a result, according to those authors perceived benefits were found to have no significant impact on innovation adoption, while perceived risks served as the primary determining factor.

One plausible explanation for the insignificance of perceived risks in this study could be the immaturity of digital technologies in Vietnam (Alexandrova and Zabolotskaya, 2021) and the uncertainties surrounding associated complexities, costs, and return on investment as identified in the interviews. It was affirmed by most of the interviewees that their businesses' emphasis on short-term financial and operational gains, coupled with the often unclear and time-consuming nature of return on investment, presents a challenge for firms when it comes to rationalising significant investments in digital transformation. Additionally, this contradictory result may be due to the shortage of knowledge and understanding of the risks involved in digital transformation, necessitating a thorough and comprehensive understanding and exploration. This correlation suggests that perceived risks might still present barriers to DSC adoption, even if they did not emerge as prominent determinants in the current analysis.

However, this contradiction does not mean that firms in Vietnam neglect technological risks in DSC adoption. Based on the mean values of the risks-related items (see Table 8-7), challenges in integrating operational systems and working environments (4.17/5), as well as the long and complicated nature of digital transformation (3.75/5), were strongly acknowledged by most respondents. Similar findings were also observed in the interviews, as illustrated by interviewees:

"... *If the technology is overly complicated, it also has an impact on the users…*" (P7)

"*Our company cannot integrate digital technologies into its transportation management system due to the lack of advanced and qualified vehicles. Many transport vehicles do not adhere to national standards, making it impossible for our company to implement digital technologies on a large scale*." (P8)

"*Vietnamese firms often encounter significant compatibility issues between their internal IT systems and the technologies developed by foreign technology vendors…*" (P9)

9.1.2. Organisational factor's impact on SC4.0 adoption

The findings revealed the most significant and positive role played by the organisational factor ($\beta = 0.521$; t-value = 10.727, $p < 0.001$) in driving digital transformation adoption, particularly with organisational resources ($\beta = 0.144$; t-value= 2.748, $p < 0.01$) and top management knowledge and support (β= 0.404; t-value= 7.999; $p<0.001$). Notably, among all DSC adoption dimensions, it is striking to observe that top management expertise and support stand out as the most influential indicator of this adoption process.

9.1.2.1. Organisational resources' impact on SC4.0 adoption

Predictably, the findings indicated the dependence of DSC adoption on organisational resources including technology infrastructure, financial resources, skills and knowledge and willingness for change. These results were consistent with existing literature (Gangwar, Date and Ramaswamy, 2015; Chan and Chong, 2013) that suggested organisations exhibiting higher levels of readiness for innovation are more likely to embrace DSC. Thus, managers and policy makers in charge of making strategic decisions should prioritise the allocation of human, financial, and technological resources, including tangible physical infrastructures and intangible knowledge, as well as the recruitment of IT-skilled employees (Chandra and Kumar, 2018; Gangwar, Date and Ramaswamy, 2015).

In the same line, Henao-Ramírez and Lopez-Zapata (2022) emphasised that as firms possess stronger technological competencies and resources, managers are more inclined to recognise the benefits of technology and be motivated to foster the development of new competencies that reinforce competitive advantage. Similarly, Maduku, Mpinganjira, and Duh (2016) argued that without adequate financial resources, firms cannot afford the necessary infrastructure or technology experts. The initial process of startup and ongoing operational costs demands substantial capital; with a robust financial foundation, companies are equipped to navigate any potential challenges that might arise during the adoption and implementation of new technologies (Sila, 2013). In this respect, organisations with greater access to financial resources are more likely to adopt technology. Additionally, according to Gangwar, Date and Ramaswamy (2015), to improve employees' technical proficiency and develop a dedicated workforce for digital transformation, managers must develop robust and effective training programs. Such trainings enable employees to grasp the usefulness, functional and technical aspects of digital technologies, thus acquiring first-hand knowledge and experience. This equips them with a strong educational background, valuable experience, a sense of responsibility, and extensive knowledge for proficiently utilising digital technologies. Consequently, they find it effortless to grasp and appreciate the significance of these technologies in their job performance.

This quantitative result aligns with the qualitative findings derived from the interviews, underscoring the crucial role of financial resources, human capital, and technical infrastructure in supporting the process of digital transformation within firms, as illustrated by statements of P11 and P12.

"*Recruiting a skilled team with expertise in change management to oversee the digital transformation process and transition activities within the company is essential. Profound changes, like the adoption of new technologies, demand not only the integration of these technologies into the operational systems but also the implementation of effective governance practices and models. This, in turn, necessitates business leaders to possess both management and digital competencies and to challenge the organisation's conventional mindset in order to effectively guide the transformation process*." (P11)

"*Financial capability is a prerequisite for organisations' adoption of digital technologies. Therefore, without sufficient financial resources, technology transformation cannot be achieved, regardless of the efforts of top management*." (P12)

Nevertheless, the findings also unveiled an intriguing insight. While organisational resources did not emerge as a significant predictor of DSC adoption intention, they exerted a substantial influence on DSC adoption actions. This outcome contrasts with the studies conducted by Gangwar, Date, and Ramaswamy (2015) and Hsu, Ray, and Li-Hsieh (2014), which claimed that organisational resources, including IT knowledge, infrastructure, and financial assets, significantly impact technology adoption intention. These studies suggested that firms equipped with abundant resources remain familiar with the cutting-edge IT advancements, stay updated with the ever-evolving trends within the dynamic IT landscape, and thus are better positioned for technology adoption. The contradictory result in the present study could be attributed to the fact that when firms have an intention to implement digital transformation, they might not fully comprehend the actual impact of organisational resources on the adoption process, as evidenced by interviewees' vague understanding of Industry 4.0. The significance of resources might not become apparent until they initiate DSC initiatives and confront challenges related to resource availability. During the intention phase, firms might prioritise exploring the potential benefits of DSC, such as enhanced efficiency, improved decision-making, and strategic implications. As they transition to the action phase, the focus shifts to operationalising the adoption, where resource considerations become more salient. Secondly, firms may have an incomplete understanding of the specific organisational resources requisite for successful DSC adoption during the intention phase. While they may acknowledge the importance of resources in a general sense, they might not have a comprehensive grasp of the types and quantities of resources needed for effective DSC implementation.

Finally, the data mean values (all measurement items are above 3 out of 5) (see Table 8-7) also revealed interesting insights about the current state of organisational resource availability of the Vietnamese businesses, the most remarkable observation arising from the dataset is the presence of organisational resources in the adoption of digital technology. This result is also reflected in interview findings which revealed that many organisations indicated they possess sufficient financial resources and human resources which enable them to readily adopt technologies. The possible explanation for such result could be attributed to the fact that majority of survey respondents come from large foreign firms (50%) with sufficient organisational resources to embrace digital transformation. Therefore, they do not consider organisational resources as current barriers, as stated by P3, P7 and P9.

"*I do not think acquiring IT skilled employees can become a barrier, as you can access to such employees if the company has sufficient financial resources. So I believe that financial resources are the most critical facto*r… *With sufficient funds, you can obtain individuals with different level of knowledge and degrees, even the desired patents" (P3)*

"*Our organisation has a sufficient budget allocated to digital transformation*.... *Financial concern is not an issue...Budgets for digital transformation have been approved by the leadership* (P7).

"*We have gradually and significantly built and invested in our IT infrastructure... Our early investment in technical infrastructure has become an advantage that enables our company to implement technologies."* (P9)

This is surprising, given that the lack of capital resources, employees' inadequate skills and experience, as well as IT infrastructure, have been identified as barriers in several studies (Chuc and Anh, 2023; Clohessy and Acton, 2019; Joachim, Spieth, and Heidenreich, 2018). For example, a study by Chuc and Anh revealed that the existing level of digital literacy of Vietnamese workers are insufficient to meet demands of digital transformation. Thus, according to the authors, there is a need to upgrade the quality of education and training to adapt to digital transformation requirements. This view was also shared by other firms in the interviews, emphasising their limited and incapable organisational resources, as illustrated by P5 and P11.

"*One of the challenges with the organisations is the gap in awareness, knowledge and understanding of digitalisation between top management and employees…Despite leadership's good understanding and knowledge of Industry 4.0, the digitalisation visions* *might not be achieved or the plan is not executed successfully due to the knowledge gap between management levels and even middle management and employee level*." (P5)

"*Existing technology infrastructure in our company greatly constrains our business' long-term digital technology investment plan*." (P11)

Another surprising aspect revealed by the data is the level of confidence managers exhibit towards their employees' openness to embracing technologies when more than 70% of survey participants expressed agreement or strong agreement with the idea that their employees are willing and welcome new working methods, ideas and technologies. This stands in contrast with existing studies (Toufaily, Zalan and Dhaou, 2021; Varshney, 2020; Basyal and Wan, 2020; Mirković et al., 2019) and earlier interviews, which have highlighted the common challenges firms face in technology adoption due to employee resistance to substantial changes. For example, according to P9, "*Our employees are resistant to changes. They have established routines and prefer the traditional work methods as they are not given incentives to make changes, meanwhile changes always involve challenges and difficulties*". Similarly, P7 stated that "*Employees in our business are not strongly adaptive to the market changes, which hamper our change initiatives.*" This conflicting result could potentially be attributed to several factors. Firstly, a significant number of survey respondents come from large foreign firms or companies with a considerable number of young employees, known for their readiness to embrace new technologies and changes. Another plausible explanation is that the respondents primarily consist of middle and senior managers who may have limited direct interaction with employees, leading to differences in their assumptions regarding employee attitudes toward change.

9.1.2.2. Top management support and knowledge's impact on SC4.0 adoption

Highlighted by the positive findings in the regression analysis, it becomes evident that top management knowledge and support emerged as the strongest driving force behind both overall DSC adoption and its different stages, particularly DSC adoption intention and actions. The finding aligns with prior studies, including those by Maduku, Mpinganjira, and Duh (2016), Lin, Lee and Lin (2016), Gangwar, Date, and Ramaswamy (2015), Ramirez-Correa, Rondan-Cataluña and Arenas-Gaitán (2015), Tsai, Lee, and Wu (2010) and Wang et al. (2010). These studies have consistently demonstrated a positive correlation between effective top management support and knowledge and the successful implementation of technology adoption.

For instance, Lin, Lee and Lin (2016) and Wang et al. (2010) emphasised that, given the complex nature of DSC implementation involving resource integration and process reengineering, it becomes imperative for top managers to foster a supportive climate and allocate sufficient resources for embracing new technologies. In the same line, Gangwar, Date, and Ramaswamy (2015) argued that top management effectively influenced their employees through persuasive communication and by motivating their desired work behaviours. As technological complexities increase, top management can create an innovation-friendly atmosphere, offering essential resources like time, space, equipment, and human resources (Lai, Sun, and Ren, 2018; Lee and Kim, 2007). Furthermore, if top managers possess a solid understanding of digital technologies and recognise their potential to enhance the organisation's financial and operational performance, they are more inclined to champion and implement such transformative changes. As noted by Chuc and Anh (2023), the multifaceted nature of digital transformation necessitates top managers to possess not only administrative skills but also an understanding of the potentials and benefits offered by the digital technologies. Thus, the adoption of technology is commonly steered through a top-down approach, particularly because top management must firstly realise the potentials of the technology in enhancing organisational performance, then overcoming perceived challenges, and finally capitalising on business opportunities (Henao-Ramírez and Lopez-Zapata, 2022). The survey findings were also consistent with the interview findings where all the interviewees stressed the significant role of top management knowledge and support in driving digital transformation, as stated by P5, P7 and P9.

"Whatever transformation you embark upon, it all hinges on leadership" (P5)

"*It is all about the mindset of leadership. Without their conviction, it is nearly impossible to achieve anything. Once leadership is determined, the implementation of digital transformation can move forward."* (P7)

"*If top managers exert their power and control over employees in the pursuit of digital transformation, employees are left with no choice but to either comply with the orders or leave the organisation."* (P9)

Additionally, the survey results revealed that a significant majority of Vietnamese firms expressed their agreement and strong agreement with the ideas that their top management has sufficient knowledge and experience (64% of survey participants), along with a willingness to undertake financial and operational risks (63% of survey participants). There was also a strong consensus among survey participants that their top managers have dedicatedly and actively developed clear visions, strategies, and roadmaps for digital transformation, and communicated a sense of digital transformation urgency to the whole organisation (78% of survey participants) while guiding and supporting employees throughout this transformative process (73% of survey participants). Most participants in the quantitative study were from large multinationals (which aligns with the sample requirements with regards to knowledge and understanding of digitalisation) but considering the predominance of SMEs in Vietnam (SMEs account for 98% of all businesses of Vietnam) (Vietnam Briefing, 2017), the role of top managers is even more crucial to drive digital transformation initiatives. This is reflected in the diverse perspectives gained from interview participants (from different organisation types) who shared their enthusiasm and willingness to embrace Industry 4.0 technologies and digital transformation, as stated by P6.

"*Despite the modest size of our business, our top management is willing and enthusiastic to make significant investments in digital technology adoption in order to expedite the growth of the business. We align technological reform with the business strategy and objectives to underpin success in the market, particularly helping the organisation in quickly controlling things, responding to the market changes and accurately planning resources to enhance our business' competitive advantage*." (P6)

The results emphasised that companies have higher likelihood of success in new technology adoption when their top management is supportive, willing to take risks and has a solid understanding of such radical change. Given that top management directs and shapes daily and future investment decisions, as well as organisational culture, it comes as no surprise that digital transformation primarily takes root at the top management level. It is also crucial for top management to be convinced that the benefits of digital transformation outweigh its costs. This is supported by P4, who stated that "*In fostering innovation adoption, leadership stands out as the crucial factor. When leaders are not only convinced but also understand the significance of integrating innovation within the company, they proactively restructure the organisational systems to support the deployment of the innovation and ensure policy compliance. This principle holds true for all facets, not solely limited to innovation adoption, that must start from top management… Thus, it is important that the top management must embrace changes, then the rest of the organisation will follow suit."*

This suggests that in developing countries like Vietnam, top management plays a critical role in driving digital transformation, as stated by Khan et al. (2022) that the structural changes required for Industry 4.0 adoption in developing countries is not possible without the involvement and commitment of top management. However, it is interesting to note that studies conducted in the context of developed countries have identified a weaker positive influence of top management support (Arnold, Veile and Voigt, 2018). For example, a study by Wang, Wang, and Yang on RFID adoption in Taiwan revealed that the organisational attributes of top management support did not exert a significant impact on RFID adoption. Similarly, according to Rahayu and Day (2015) and Ghobakhloo et al. (2012), in developed countries, critical challenges of technology adoption centre on the lack of trust, alongside concerns about security, and privacy risks, whereas in developing countries the primary obstacles were related to management issues. This characteristic is evident within the context of Vietnamese national culture, which is characterised by a substantial power distance and a centralised decision-making system, suggesting that important business decisions are predominantly made by senior leaders or managers (Nguyen and Truong, 2016; Napier, 2006). It can therefore be concluded that the strong relationship between top management knowledge and support, and the adoption of DSC in this research underscores the significance of engaging with top managers to secure their buy-in into the digital journey.

9.1.3. Environmental factor's impact on SC4.0 adoption

The findings shed light on the fact that the environmental factor ($\beta = 0.292$, t-value = 6.335, and $p < 0.001$), particularly market pressures ($\beta = 0.146$; t-value=3.198; $p<0.01$) and interorganisational relationships ($\beta = 0.198$; t-value=3.976; $p<0.001$) have emerged as significant determinants of overall DSC adoption. However, despite its positive nature, market support has been observed to hold an insignificant impact on this adoption ($\beta = 0.086$; t-value=1.103; $p>0.05$).

9.1.3.1. Market pressure's impact on SC4.0 adoption

As previously highlighted, market pressures, particularly competitive pressure and customers' pressure, were the determinants behind Vietnamese firms' overall DSC adoption. This finding implies that firms in Vietnam are aware of the need to adopt digital technologies to respond more swiftly to their competitive and volatile business environment. This finding aligns with insights from both the interview results and numerous previous studies on technology adoption (Alam et al., 2021; Gareeb and Naicker, 2015; Oliveira and Martins, 2011; Chong and Ooi, 2008; Zhu, Kraemer and Dedrick, 2004; Wu, Mahajan and Balasubramanian, 2003; Zhu, Kraemer and Xu, 2003; Kuan and Chau, 2001).

Firstly, it implies that when firms encounter pressure from competitors and customers, or when their competitors implement digital transformation as a competitive instrument, they feel compelled to digitally transform their business and supply chains to maintain their competitive edge; thus, they are more inclined to implement changes and innovations more aggressively (Hossain, Standing and Chan, 2017; San Martín, López-Catalán and Ramón-Jerónimo, 2012). This assertion is supported by the fact that a substantial majority of companies (over 80% of respondents) agreed or strongly agreed that digital transformation is instrumental in gaining competitive advantages within the industry. Similarly, there is a consensus among the interviewees that digitalisation is a vital prerequisite for survival in the fiercely competitive market, as illustrated by P3, P11 and P12.

"*The customer's desire for fast, transparent, efficient, and cost-effective services indirectly compels companies to adopt digital technologies to achieve the desired level of customer service quality*." (P3)

"*Recent initiatives by competitors to adopt digital transformation have put our business under significant pressure to embrace digital technologies in order to survive.*" (P11)

"*The pace of digital transition is accelerating across all industry sectors in Vietnam, as companies increasingly perceive digital transformation as a competitive advantage*" (P12)

Secondly, it also revealed that market uncertainties had a significant impact on digital technology adoption. Most respondents acknowledged the challenge of predicting shifts in market demand. It implies that increasing environmental uncertainties foster the adoption of digital technologies to enhance information flows and adaptability in response to market fluctuations. Chuc and Anh (2023) further emphasised the significance of business digital transformation, particularly considering the COVID-19 pandemic. The authors asserted that a significant number of enterprises, particularly larger ones, have recognised the necessity of embracing digital technologies. This is consistent with interview findings, which also unveiled that Covid 19 pandemic triggered significant shifts in market demand, compelling firms to restructure their traditional business model and embrace digitalisation, as mentioned by P9.

"Only when Covid-19 impacted every company did our business partners come under pressure to implement digital transformation in order to maintain competitiveness in the market…Covid-19 also provided our business with the opportunity to recognise the importance of reducing reliance on labour force to mitigate operational risks which therefore drive our business to embrace technological reform." (P9)

However, the findings also revealed an interesting insight that while external pressure exhibits a significant impact on DSC adoption intention (β= 0.176; t-value=3.340; $p<0.001$), it does not play a significant role in determining DSC adoption actions (β= 0.086; t-value=1.865; $p>0.05$). Indeed, the perceived pressure from the market, competitors, or changing customer demands can garner initial enthusiasm and drive firms to consider digital transformation to stay competitive (Ali et al., 2023; Gangwar, Date and Ramaswamy, 2015). However, although Vietnamese firms are aware of the benefits of DSC adoption for their competitive advantage, market pressure is not determinant of their adoption. According to Oliveira, Thomas and Espadanal (2014), during the execution phase, other technological and organisational factors are more critical in determining the actual adoption actions. For example, if the organisation's culture is resistant to change, or organisation lacks the necessary resources to adopt DSC, the impact of market pressure on actual adoption actions may be insignificant.

9.1.3.2. Market support's impact on SC4.0 adoption

A noteworthy observation is that, despite its positive influence on overall DSC adoption, market support does not significantly affect such adoption (β= 0.086; t-value=1.103; $p>0.05$). This discovery contrasts with the existing studies, especially in developed countries (Raj et al., 2020; Lin et al., 2018; Szczygielski et al., 2017) that emphasised the necessity of considering market support, particularly government and third-party support, as drivers of DSC adoption. For instance, Raj et al. (2020) asserted that government support in regulating standards and implementing technical infrastructure could propel the adoption of Industry 4.0 technologies among businesses. Nonetheless, the result from the present study aligns with perspectives from several interviewees as well as with several prior studies (Arnold and Voigt, 2019; Borgman et al., 2013) which found that market support had an insignificant impact on technology adoption.

One plausible explanation for the insignificant impact of market support on DSC adoption might be that certain variables could exert a predominant influence on such adoption, thereby diminishing the impact of other variables (Puklavec, Oliveira and Popovič, 2018). This is evident in the work of Caldeira and Ward (2002) where the prominence of management involvement and the availability of IT knowledge were considered to outweigh the external support. In this study, the regression analysis results highlight the prevailing determinants of DSC adoption that are top management knowledge and support, and interorganisational relationships. Another possible explanation is the diversity of managerial opinions among survey and semi-structured interview respondents regarding the role of third-party and government support in driving firms' digital transformation. Several respondents believed that the support from the Vietnamese government and external organisations (e.g., banks and financial institutions) for firms' digital transformation initiatives are accessible and sufficient, as believed by P1.

"*The government is also aiming for development of Industry 4.0…I do not think the government is creating any obstacles; rather, they are striving to support businesses in enhancing their competitiveness by developing the IT infrastructures…Now businesses can secure loans from banks and access fundings*" (P1)

This perspective also aligns with the statements by Chuc and Anh (2023) who claimed that Vietnamese government provides digital transformation support to businesses through various means such as tax incentives, and promotion of innovation and science, and favourable investment laws to key industries such as high-tech activities and industrial products, and R&D activities. Whereas some respondents disagreed or remained neutral on this matter. This disagreement or neutral perspective may stem from the fact that many firms may not have a comprehensive awareness of the full extent of government support and third-party solutions. However, as pointed out by Oliveira, Thomas, and Espadanal (2014), this does not necessarily imply that firms are neglecting or unaware of market support. It could indicate that existing regulations designed to promote the adoption of digital technologies have not been fully embraced by decision-makers within organisations. They might also be hesitant to leverage external support or overlook these factors in their decision-making process (Arnold and Voigt, 2019) or such support is insufficient or does not exist (Bhardwaj, Garg and Gajpal, 2021). For example, Phuong (2020) claimed that the absence of established legal frameworks has hindered the progress of digital transformation in Vietnam, particularly the ability to pilot new business models and services. According to the author, key areas such as data transactions, database security, personal data protection in the digital space lack clear regulatory oversight. Additionally, there are no established guidelines governing the ethical use of artificial intelligence or regulations regarding digital identity, authentication, and electronic verification. This inadequate legal infrastructure leaves Vietnam ill-equipped to combat unfair competition and safeguard Vietnamese businesses in cyberspace. This perspective is further illustrated by the statements of P3 and P11 below.

"…*Currently, the government is limited to only encouraging and issuing general guidance and policies, such as clean, environmentally friendly, and sustainable technologies. The support is mainly given to SMEs and start-ups, such as building national innovation* *centres to provide funding and support for SMEs' product tests, launch, marketing, etc… The access to national funding is difficult with complex and costly administrative processes*"" (P3)

"*Numerous documents, countless official letters, and many calls for changes – yet, there is no comprehensive plan in place. Thus, I truly feel that the current role of the state remains too restricted, not yet evident or present somewhere that I do not know*…" (P11)

Therefore, several managers believed that government's incentives and third-party support should be adequate to facilitate a smoother transition to digitalisation for firms. This viewpoint could be attributed to the fact that many firms encounter various hurdles, ranging from financial constraints to technical incapability, therefore appreciate the significant role of the government and external organisations in providing crucial support such as subsidiaries and tax rebates (Phuong, 2020). The data also shed light on the fact that while a considerable number of respondents expressed satisfaction with the government's enacted laws and policies to promote digitalisation, other respondents held the view that the government could have further enhanced the legal framework. This divergence aligns with the interview findings, where participants similarly stressed that despite the presence of a legal framework for supporting digital transformation, more efforts are needed to enhance the clarity, transparency, and enforcement of these regulations and policies, as illustrated by P14's and P5's statements.

"*It is imperative for the government to accelerate the finalisation of supportive programs, detailed policies, and guiding circulars for businesses. This will help create a favourable environment and incentives for businesses on their digitalisation journey, ensuring that the country does not miss out on this opportunity*." (P5)

"*In order for Vietnamese businesses to capitalise on the opportunities presented by the evolution of digital technology, it is important for the government to enhance the effectiveness of governance at all levels, along with improving the business and investment environment, such as executing administrative reforms, streamlining or simplifying administrative processes or procedures related to the business sector.*" (P14)

However, some managers suggested that businesses should take a proactive role in spearheading digital transformation, rather than depending heavily on support from the government or external entities, as stated by P1, which might also explain the results obtained in the questionnaire regarding market support.

“*We cannot expect the government to hold our hand; that is only feasible through the leadership of businesses themselves. They need to formulate their own strategies, develop products that meet market demands, and then channel investments in the right direction… So I believe the government manages at the macro level*.” (P1)

One plausible explanation for this stance could be that firms with adequate organisational resources or established partnerships with trading partners may be less motivated to explore alternative options, including government-sponsored initiatives. Additionally, government policies and regulations in Vietnam are often perceived as complex and bureaucratic (Benedikter, 2016). For example, according to Chuc and Anh (2023), the existing legal document system suffers from synchronization issues, overlaps, and inconsistencies, making them unsuitable for the demands of digital transformation. Concerns about the additional compliance burdens associated with government-supported initiatives might also limit firms from fully embracing them.

Interestingly, although market support may not significantly impact the overall DSC adoption and DSC adoption intention, it emerges as a crucial determinant of successful DSC adoption actions ($\beta = 0.147$; t-value=3.221; $p<0.001$). This might be attributed to the fact that during the initial intention phase, firms tend to prioritise evaluating benefits of digital transformation, their top management support, and the market pressure for DSC adoption. If they lack the government support, the influence of external market support may not have a substantial impact on their intention to adopt DSC. However, government and third-party support are more likely to influence adoption actions once firms have committed to the idea of DSC adoption. Once the decision is made, firms become more receptive to seeking external support to ensure the implementation’s success. This is particularly relevant if the support addresses specific challenges, provides guidance, or reduces implementation barriers. This intriguing result also suggests future research is required to explore the rationale behind the insignificant and insignificant impact of market support on the overall DSC adoption and DSC adoption actions respectively.

9.1.3.3. Interorganisational relationships’ impact on SC4.0 adoption

Furthermore, the findings also highlighted the significance of trading partners, including their power on other firms, their willingness to share information and their digital readiness in driving not only the overall course of DSC adoption ($\beta = 0.198$; t-value=3.976; $p<0.001$) but also its individual stages, particularly DSC adoption intention ($\beta = 0.146$; t-value=2.540; p<0.05) and DSC adoption actions (β= 0.212; t-value=4.214; p<0.001). This is reinforced by the fact that successful DSC adoption necessitates the collaboration and synchronisation across various entities in the value chain (Weerabahu et al., 2022; Büyüközkan and Göçer, 2018). This facilitates seamless integration within SC, promotes standardisation and compatibility across systems and processes, and enables real-time data sharing. Therefore, organisations embracing digital technologies actively foster the formation of networks with their industry players and the sharing of their resources to effectively address the diverse and swiftly evolving needs of customers (Ilin, Ivetić and Simić, 2017; Ngah, Zainuddin and Thurasamy, 2017), as believed by P9.

"The key to a successful digital transformation that benefits everyone lies in building strategic partnerships and fostering collaboration among all parties which is essential to as no single party can accomplish this alone. Obviously, by involving implementation partners or technology partners, the likelihood of reaching mutual visions and strategies for adopting digital technologies increases. Additionally, the early identification of major obstacles that impede digital technology adoption by all supply chain stakeholders can help mitigate risks of failure in later stages" (P9)

As mentioned in Chapter 5, the effectiveness of collaboration among supply chain partners in DSC adoption is significantly influenced by several factors, including (1) the power of trading partners, (2) the digital readiness of supply chain partners, and (3) the extent of information sharing.

Firstly, regarding the trading partners' power, according to Low, Chen and Wu (2011), the decision for firms to adopt digital technologies is dependent on whether they have been influenced by convincing power, such as financial incentives from their trading partner, or through coercive power, where a more dominant firm mandates a less influential counterpart to digitally transform their operations (Low, Chen and Wu, 2011). Illustrative instances of companies exerting coercive influence can be observed in cases such as Wal-Mart, which mandates its partners to adopt RFID technology or risk forfeiting their business relationship (Chong and Ooi, 2008). This is also consistent with findings from semi-structured interviews which revealed that the pressure from trading partners is a significant driver of digital technology adoption to majority of firms across industries, as illustrated by the statements of P6 and P12.

"*Our partners exerted pressure on us to operate with greater speed, precision (without errors), and transparency throughout our operational processes. They also demanded real-*

time updates and tracking for products. Therefore, we were compelled to adopt digital technologies to meet these demands." (P6)

"*A few years ago, our large business encouraged our partners to embrace digital transformation; however, more recently, our business has had to exert pressure on our partners to expedite this process."* (P12)

However, it is surprising that a substantial number of survey respondents disagreed and stayed neutral (71%) that trading partners with considerable bargaining power exerted pressure on them to embrace digital technologies. One possible explanation for these contradictory findings is that most respondents belong to larger firms (68%) with strong power to compel smaller partner firms to adopt digital technologies for standardising their products and services. This explanation sheds light on why a large subset of respondents believed their company faced minimal or no pressure from trading partners.

Secondly, it was intriguing to find that a significant percentage of survey respondents (56%) agreed or strongly agreed that the trading partners of firms exhibited willingness, and another substantial percentage (50%) agreed or strongly agreed that they possessed the necessary skills, knowledge, technical proficiency, and financial resources for successful digital transformation. This finding stands in contrast to the outcomes of interviews and earlier studies (Zhu, Kraemer, and Xu, 2003), which frequently highlighted the challenges arising from trading partners' lack of readiness in digitalising their businesses. For instance, during the interview, P9 stated that "*At times, our company needs to provide education to our business partners about technology adoption*". One plausible explanation for this contrasting result between the survey and interviews could be that majority of respondents are from large firms (68%) which have requested their partners to digitally transform their businesses, thus believed that their partners are well-prepared and willing to embrace digital transformation. This suggests that future research should explore further the willingness and readiness of firms within supply chains to embrace digital transformation.

Finally, it is an unexpected result that a significant percentage of respondents (69%) also showed their agreement to the idea that their firms and their trading partners ensure the information sharing is confidential. This finding is conflicting with the existing literature (Oncioiu et al., 2019; Saberi et al., 2019) and the insights gained from semi-structured interviews which revealed that many organisations are reluctant to disclose and share critical information with their supply chain partners, as illustrated by the statements of P6 and P13.

"*Nonetheless, businesses are reluctant or find it unnecessary to share information with their trading partners due to the scope and size of their operations.*" (P6).

"*For our firm, it is unnecessary for us to share extensive information and data with partners, only some information about orders, products, and business transactions need to be shared*" (P13)

The conflicting finding between the qualitative and quantitative data may be attributed to the differences in industries and firm sizes of the interviewees and the survey respondents. This result suggests the need for future research to investigate the information sharing issues among supply chain partners in Vietnamese firms.

9.1.4. Control variables' impact on SC4.0 adoption

Specifically, among various control variables, firm size stands out as the only significant control variable having impact on DSC adoption. The impact of control variables, as observed in this study, aligns with the findings of previous studies by Chatzoglou and Chatzoudes (2016) and Oliveira, Thomas and Espadanal (2014). It suggests that different firm sizes might have different impacts on the adoption of DSC.

On the one hand, a substantial body of literature suggested that large companies possess the resources necessary to cover the cost and investment risks associated with the adoption of emerging technologies (Oliveira, Thomas and Espadanal, 2014; Chong and Chan, 2013; Low, Chen and Wu, 2011), whereas smaller firms often confront resource limitations that hinder their capacity to implement digital technologies (Thiesse et al., 2011). This viewpoint is also consistent with several insights from semi-structured interviews, as illustrated by the statements of P3 and P9.

"*Since my company is a large enterprise, we have abundant financial resources. In fact, if you do not have money, you cannot adopt technologies*" (P3)

"I believe that digital transformation might not yield substantial benefits for smaller businesses due to the substantial investment required" (P9)

On the other hand, several studies argued that large companies frequently encounter critical hurdles such as rigid organisational structures, inertia, bureaucratic procedures and limited internal collaboration when executing digital strategies (Bilgeri, Wortmann and Fleisch, 2017; Zhu et al., 2006). This perspective is echoed by the statements of P6 and P10.

"*Despite making substantial investments in innovation, a number of large firms face challenges when it comes to adopting digital technologies due to their complex organisational structures and the higher adoption costs that come with large-scale implementations, especially when compared to small businesses*" (P6)

"*Small organisations possess a significant advantage over their larger competitors, namely the ability to remain flexible and swiftly adapt to market changes because small firms have a smaller number of employees, more compact facilities, fewer information-sharing requirements, and a simpler hierarchy or management structure…On the other hand, changes within large organisations may face slowdowns due to their greater organisational inertia and complex organisational structure*…" (P10)

In essence, the size of a firm exerts a multifaceted impact at different stages of DSC adoption, with both small and large firms having their own advantages in digital transformation. The findings highlight the potential benefits of early and incremental digital technology adoption which can expedite the overall process of digital transformation. The divergence in perspectives regarding firm size also suggests the need for future research to explore the role of firm size in various phases of the digital transformation process.

9.2. RQ2: Role of Organisational Culture in SC 4.0 Adoption in Vietnam

As detailed in Chapter 1, the aim of the second research question was to examine the role of organisational culture in SC 4.0 adoption in Vietnam. This research revealed the complex interactions between organisational culture (specifically, flexibility-control orientation in this study) and the key determinants of SC 4.0 adoption in Vietnam, namely perceived benefits, perceived risks, organisational resources, top management knowledge and support, market pressure, market support, and interorganisational relationships. Thus, this research makes a valuable contribution by uncovering how the effects of organisational culture may differ in different adoption stages and how it may interact with factors to shape the DSC adoption outcomes.

9.2.1. Organisational culture in Vietnam

The most significant observation in the quantitative data analysis was the coexistence of both control-oriented and flexibility-oriented cultures within Vietnamese firms (as indicated in EFA). This finding aligns with insights from several interviewees, indicating that the combination of both cultural types positively influences digital technology adoption and overall digital transformation efforts, whereas organisations with either a strict control culture or complete flexibility culture may impede digital transformation, as suggested by P12.

"*The organisational culture centered around values of discipline and innovation is likely to accelerate the digitalisation process. On the other hand, an innovative culture without discipline can slow down the process, and a culture focusing solely on discipline may result in employee resistance to changes."* (P12)

The results conflict with several studies which previously suggested a positive link between flexibility-driven culture and innovation adoption while viewing control-oriented culture as a hinderance (Naranjo ‐ Valencia, Jiménez ‐ Jiménez and Sanz ‐ Valle, 2011). This can be attributed to the characteristics of flexibility culture, wherein organisations prioritise informal and horizontal structures, autonomy, teamwork, and participation, which therefore foster creativity, risk-taking, growth, open knowledge sharing, cooperative communication, commitment to the organisation, and adaptability to dynamic environments. Thus, flexibility-culture is believed to encourage innovation adoption (Shao, 2019; Liu et al., 2010). In contrast, within a control-oriented culture, organisations strive to minimise operational disruptions and prioritise a tightly structured approach with formal authority and established rules and regulations (White, Varadarajan and Dacin, 2003) to standardise outputs for optimal efficiency. Guided by the value of order and stability, a control-oriented culture is believed to impede a firm's efforts toward innovation (Shao, 2019; Valencia, Valle and Jiménez, 2010; Martins and Terblanche, 2003).

The underlying explanation for this paradoxical discovery is that flexibility values play a crucial role in fostering the development of new ideas and driving radical changes, such as digital transformation. Yet, when these ideas and plans for transformative change are solidified and put into action, it becomes essential to adhere to procedures, processes, and rules to ensure the smooth and effective operations so that change can be implemented successfully. Consequently, while flexibility encourages employee empowerment and creative freedom, control values provide the necessary structure for nurturing creativity and innovations within well-defined boundaries (Khazanchi, Lewis and Boyer, 2007).

This finding was also consistent with Felipe, Roldán and Leal-Rodríguez (2017) and Lewis and Boyer (2002) identified that certain attributes inherent to control culture can lead to more agile organisations. Such culture aids firms in effectively monitoring and assessing the outcomes of innovation. One example illustrates this concept is Toyota Production Process that requires a culture of disciplines and routinised processes to closely monitor the quality and promptly address the problems, thereby fostering a culture of continuous innovation (Spear and Bowen, 1999). Similarly, Felipe, Roldán and Leal-Rodríguez (2017) suggested that firms can benefit from a certain degree of stability, control and order – especially during crises and periods of uncertainty which requires fast and quick decision-making and plan execution. Thus, it is essential to effectively balance and regulate the level of control values to maximise their advantageous impact on the firms. Hence, the results of the moderation analysis indicate that the integration of both control and flexibility cultures exerts a significant and positive influence on the comprehensive DSC adoption, spanning across all stages of the DSC adoption process.

According to Shao, Feng and Liu (2012) and Khazanchi, Lewis and Boyer (2007), although a firm can exhibit a combination of different organisational culture typologies, it is usually dominated by specific value orientations. In this case, although organisational culture in Vietnamese firms combines both flexibility and control culture values, as discussed previously, it was found that the control values are slightly more dominant than the flexibility values. The presence of flexibility culture values such as teamwork, mutual trust, commitment to innovation, improvement or development of new ideas of products and services, suggest that the organisations in Vietnam have the potential for adaptability and openness to change, as stated by P2, P3 and P4.

"*We engage in sharing ideas and best practices with other countries and focus on continuous improvement for our operational system… We ensure that our objectives and goals are clearly communicated to everyone*…" (P2)

"We have built global and regional team as well as R&D department dedicated to digitalisation and innovation adoption, with the aims of assessing the IT quality, managing cyber security risks and other technological risks, and facilitating the sharing of best practices and experiences" (P3)

"*The pillars of our success lie in teamwork, the exchange of ideas, and the sharing of best practices among our members…Additionally, we aspire to lead the Industry in which we operate*" (P4)

However, the factor loadings for the flexibility culture measurement items (0.758, 0.689, 0.665, 0.571) are relatively lower than the control culture measurement items (0.756, 0.711, 0.672, 0.556), indicating that the organisational culture might not fully embrace or prioritise flexibility and innovation. Especially, observed from the means of measurement items (see Table 8-7) of the Organisational culture, mean of the flexibility values such as dynamic, entrepreneurial, and risk-taking values are lowest (3.76 out of 5), comparing to the means of control values such as goals and outcomes-orientation (4.15 out of 5), and permanence and stability (4.10 out of 5). This could be explained by the high power distance in Vietnamese national culture which implies that Vietnamese organisations heavily focus on hierarchy, order, centralisation, and rules (Ozgen and Minsky, 2016). This perceived inequality in power as well as the high perceived corruption may impact Vietnamese companies' dynamic capabilities as firms may have limited access to resources, documents and entrepreneurial initiatives (Ozgen and Minsky, 2016). Thus, Vietnamese companies may incline towards gradually renewing its capabilities and embrace incremental innovations that improve existing process and methods instead of radical innovations. In addition, Vietnam is ranked a low to moderate score in uncertainty avoidance index which means that practical experience is valued over strict principles, deviations from societal norms are more readily accepted, flexibility and openness to innovation are common (Hofstede Insights, 2023). However, according to Nguyen and Truong (2016), Vietnamese people including domestic corporate managers sometimes could be threatened by ambiguous situations so they often try to avoid these uncertainties by establishing some formal rules and detailed operation plans to prevent problems that may occur. They have a certain level of risk aversion, delay to make immediate decisions when feeling uncertain, and tend to reject unprecedented ideas or behaviours (Cuong and Swierczek, 2008). However, in normal daily lives, Vietnamese people are quite flexible and easy adapt to real-life situation, sometimes they believe that everything happening depends on fate (Nguyen and Truong, 2016). Therefore, it can be concluded that organisational culture in Vietnam combines both flexible and control culture with the main focus on outcome, stability, collaboration, trust and improvement while a dynamic and entrepreneurial and innovation-committed environment is low in Vietnamese organisational culture.

9.2.2. Organisational culture's moderating impact on SC4.0 adoption in Vietnam

One of the research objectives is to investigate how distinct organisational culture values shape the adoption of SC 4.0 within Vietnamese firms. In this context, the study focuses on the moderating impact of the integration of flexibility and control cultural values on the relationship between TOE factors and DSC adoption. The explanations regarding the moderations results are given below.

9.2.2.1. Organisational culture's moderating impact on the relationship between technological factor and DSC adoption

As discussed in Chapter 8, the flexibility-control organisational culture negatively moderates the relationship between technological factor and DSC adoption (β= -0.126; t-value= -2.397; $p<0.05$). This implies that within a strong organisational culture characterised by dominance of control values, Vietnamese organisations' perceptions of technological characteristics have a weaker impact on DSC adoption. Since technological factor includes perceived risks and perceived benefits, the moderating impact of organisational culture was also tested on the influence of perceived risks and perceived benefits on DSC adoption (including DSC adoption intention and DSC adoption).

Firstly, it is evident that organisational culture negatively moderated the relationship between perceived benefits and the adoption of the DSC (β= -0.157; t-value=-2.683; $p<0.01$). In brief, the effect of perceived benefits on DSC adoption was strongest when organisational culture had least influence, progressively decreasing in significance as the influence of organisational culture becomes stronger. The observed outcome can be attributed to the slight dominance of control-oriented values within the organisational culture of Vietnamese firms identified above. When characterised by control-oriented cultural values, organisations typically demonstrate a tendency towards exerting control, while also displaying a preference for risk avoidance and aversion to uncertainty (Sarooghi, Libaers and Burkemper, 2015; Child, 1973), thus having a more conservative approach when it comes to embracing new technologies (Cao et al., 2015). Even when the organisation recognises substantial benefits, the prevalence of dominant control values and the presence of low entrepreneurial and risk-taking values grounded in Vietnamese culture can lead to hesitation, caution and concerns among decision-makers about uncertainties and potential risks associated with radical innovations, particularly digital transformation (Nguyen and Truong, 2016; Cao et al., 2015). This cautious approach can reduce the positive impact of perceived benefits on the decision to adopt DSC. Additionally, as the organisational culture places significant emphasis on production-oriented values, it indicates organisations' strong commitment to efficiency, productivity and task completion (Stock, McFadden and Gowen, 2007). This leads to a preference for adhering to the existing practices that have been proven effective (Shao, 2019), rather than taking risks associated with adopting new digital technologies, even if the perceived benefits are promising. It indicates that the importance of perceived benefits is weaker in organisations with stronger control value culture.

Secondly, it was observed that despite the insignificant impact of perceived risks on DSC adoption, this relationship is positively moderated by the organisational culture (β= 0.138; t-value=2.473; $p<0.05$). The plausible explanation for this intriguing result is that organisational culture placing a significant emphasis on control values, emphasising stability and rigorous control mechanisms is likely to prioritise risk management, uncertainty avoidance and caution in decision-making over timely and proactive investment in organisational resources to support innovation (Chu, Wang and Lai, 2019; Brettel, Chomik and Flatten, 2015; Sarooghi, Libaers and Burkemper, 2015). Therefore, in the context of adopting digital technologies which inherently involve substantial risks and uncertainties capable of jeopardising the organisation's stability (Brocal et al., 2019), top managers in such cultures might be more sensitive to perceived risks and actively seek strategies to mitigate them. In addition, due to extreme focus on production, outcomes and achievements – evident by the high factor loadings in these characteristics – top managers in such culture might be goals-oriented (Brettel, Chomik and Flatten, 2015; Iivari and Huisman, 2007), and therefore reinforce a risk-averse stance toward digital transformation as they aim to achieve predefined objectives without taking unnecessary risks (Felipe, Roldán and Leal-Rodríguez, 2017; Stock, McFadden and Gowen, 2007). As a result, the heightened awareness, proactive risk management and goals-oriented approach can increase perceptions of risks associated with digital technology adoption. Additionally, the culture with a strong emphasis on control, stability, efficiency and production may have hierarchical and well-structured decision-making processes (Song and Thieme, 2006). Thus, these processes often involve thorough assessments of risks and potential consequences before adopting new technologies. Such structured decision-making allows the organisation to carefully evaluate perceived risks and influence decisions about digital transformation. Furthermore, as discussed above, organisational cultures with control values and low entrepreneurial values tend to adopt a more conservative approach towards changes and innovation. This conservative stance means that the perceived risks of digital transformation can carry significant weight in the decision-making process, thereby within such culture, the impact of these perceived risks on the adoption of digital technologies is further increased.

In summary, organisational culture negatively moderates the relationship between technological factor (including perceived risks and perceived benefits) and DSC adoption. It suggests that the dominance of control-oriented values in the organisational culture creates an environment where the perceived risks and resistance to change outweigh the potential benefits of adopting digital technologies. In other words, such an organisational culture can hampers the positive influence of perceived benefits and may amplify the concerns related to perceived risks.

9.2.2.2. Organisational culture's moderating impact on the relationship between organisational factor and DSC adoption

As revealed in Chapter 8, the flexibility-control organisational culture does not significantly moderate the relationship between organisational factor and DSC adoption (β= -0.090; t-value= -1.778; p>0.05). In other words, the organisational culture does not have a notable impact on how the organisational factor influences DSC adoption. Since organisational factor includes organisational resources, and top management knowledge and support, the moderating impact of organisational culture was examined on the relationships between these two dimensions and DSC adoption (including DSC adoption intention and DSC adoption actions).

Firstly, the observed negative moderating effect of organisational culture on the relationship between organisational resources and DSC adoption (β= -0.104; t-value=-1.999; p<0.05) signifies that as organisational culture intensifies, the direct link between organisational resources and DSC adoption is reduced. This trend could be attributed to the emphasis of Vietnamese culture on permanence and stability. This is evident by the fact that while the organisational culture might highlight the importance of fostering growth, new ideas, innovation, and risk-taking, their factor loading is comparatively lower in comparison to the factor loadings associated with control culture values such as rules and policies, permanence and stability (see Table 8-7). This indicates the preference towards a conservative approach to resource allocation, prioritising the preservation of the current state and efficiency of operations. Therefore, it tends to lead to risk-averse decision-making rather than committing to resource investment and reconfiguration to accommodate potentially disruptive changes and market opportunities (Felipe, Roldán and Leal-Rodríguez, 2017). Decision-makers in such culture attempt to minimise disruptions in organisational operations, face limited freedom to act, and struggle to receive adequate cooperation and necessary resources for their operations, compared to managers in strongly flexible organisations (White, Varadarajan and Dacin, 2003). Hence, it suggests that the organisation's actual investment in innovation and new resource development might be limited or the organisation might be hesitant and cautious to allocate resources towards innovation adoption, particularly digital technologies when they perceive the potential risks associated with such investments, even if the organisation possesses the required competence. Consequently, the impact of organisational resources on digital technology adoption is decreased due to inadequate investment in supporting new idea development.

Secondly, it was observed that despite the negative impact of organisational culture, its insignificant moderating effect on the relationship between top management knowledge and support and DSC adoption (β= -0.084; t-value=-1.639; $p>0.05$) implies that top management's substantial influence in driving digital transformation initiatives remains consistent, regardless of the extent of organisational culture. This can be attributed to the remarkably strong direct effect of top management's expertise and support on the decision of implementing digital transformation, which outweighs the moderating impact of organisational culture. It implies that while the culture has aspects of both control and flexibility, the influence of top management support on digital technology adoption remains consistent across different cultural dimensions. Therefore, regardless of the prevailing culture, the significance of top management knowledge and support is widely acknowledged as a critical success factor for the successful implementation of digital technologies. Certainly, prior research has consistently demonstrated that within numerous organisations, the knowledge and support of top management are considered the foremost and most pivotal driving forces behind any successful initiative or change, particularly with regard to innovation adoption in developing countries (Bag et al., 2022; Kashada, Li, and Koshadah, 2018; Teeroovengadum, Heeraman, and Jugurnath, 2017; Maduku, Mpinganjira, and Duh, 2016; Cohen, Mou, and Trope, 2014).

In summary, organisational culture does not moderate the overall relationship between organisational factors and DSC adoption. However, when examining the specific dimensions of organisational factor, a significant negative moderating effect of organisational culture was observed on the relationship between organisational resources and DSC adoption. In contrast, there was no significant effect of organisational culture on the relationship between top management knowledge and support and DSC adoption. This suggests that the dominance of control-oriented values in the organisational culture can hinder the positive influence of organisational resources on DSC adoption but may not be significant enough to impact the strong correlation between top management knowledge and support and the implementation of digital transformation.

9.2.2.3. Organisational culture's moderating impact on the relationship between environmental factor and DSC adoption

As mentioned above, the flexibility-control organisational culture did not significantly moderate the relationship between environmental factor and DSC adoption (β= -0.090; t-value= -1.745; p>0.05). In other words, the organisational culture did not have a significant effect on how the environmental factor influences DSC adoption. As environmental factor includes three dimensions which were market pressures, market support, and interorganisational relationships, the moderating impact of organisational culture was examined on the relationships between these three dimensions and DSC adoption (including DSC adoption intention and DSC adoption actions).

Firstly, as revealed in Chapter 8, the influence of organisational culture reduces the positive effect of market pressures on the adoption of DSC, as evidenced by the significant and negative moderating impact of organisational culture on this relationship (β= -0.128; t-value=-2.385; p< 0.05). This could be attributed to the prominence of permanence and stability within the Vietnamese organisational culture, suggesting a preference for maintaining the current state of operations. Within such a cultural context, market pressures and uncertainties, which often requires organisations to be agile, adaptive, flexible and open to change in response to dynamic market conditions (Zhou and Li, 2010; Mohammed, Shankar, and Banwet, 2008), might be perceived as disruptive or risky. However, the presence of control-oriented cultural values implies a more risk-averse approach to decision-making and a reluctance to embrace disruptive changes initiated by top-level management. Such a culture inherently resistant to change can reduce an organisation's responsiveness and flexibility in the face of market pressures and its willingness to adopt digital technologies (Ghobakhloo et al., 2022; Agrawal, Narain, and Ullah, 2019; Horváth and Szabó, 2019). Therefore, this preference for stability and efficient operations could potentially impede the organisation's agility in addressing market pressures, thereby reducing the influence of market pressure on the successful implementation of digital transformation.

Secondly, it was interesting to find that despite the insignificant impact of market support on DSC adoption, this relationship was negatively moderated by the organisational culture (β= -0.102; t-value=-2.009; p<0.05). As the research uncovered a noteworthy finding that Vietnamese organisational culture distinctly prioritises production, outcomes, and achievements, within this culture, the values of autonomy, self-reliance, and independence for innovation adoption might be prioritised. Thus, the organisations might be less inclined to rely on external support, including government incentives or third-party collaborations, for digital technology adoption. While government support and third-party assistance can certainly offer compelling incentives for digital technology adoption, the organisational culture's focus on autonomy, independence and internal goals rather than external support can lead to a weaker impact of market support on digital technology adoption. Furthermore, within this culture, there exists a tendency to maintain a high level of control over their operations and strategic decision-making processes, as evidenced from the higher factor loadings of control culture values, as mentioned above, compared to flexibility culture values. Therefore, engaging with external partners such as government agencies, could potentially lead to increased scrutiny and involvement in the organisation's innovation adoption strategies and plans, that may not align with the culture's preference for innovation autonomy. Additionally, market support often involves aligning with external entities, which may introduce uncertainties and complexities. As discussed above, in this culture, decision-makers might be more risk-averse (Felipe, Roldán and Leal-Rodríguez, 2017), thus negatively moderating the relationship between market support and digital technology adoption.

Thirdly, it was observed that despite the significant influence of interorganisational relationships on DSC adoption, the findings revealed the insignificant moderating impact of organisational culture on this relationship (β= -0.068; t-value=-1.353; $p > 0.05$). This suggests that the substantial impact of interorganisational relationships outweighs the moderating influence of organisational culture, implying that the influence of interorganisational relationships as a crucial determinant of digital technology adoption may remain consistent regardless of the culture values. This intriguing finding can potentially be attributed to the critical role that interorganisational relationships play in various aspects of an organisation's operations, including innovation, collaboration, and knowledge sharing (Xu et al., 2022; Franco and Haase, 2020; Niazi, 2017). Prior research also underscores the primary driving force of interorganisational relationships in determining the success of innovation adoption, especially in developing countries (Chen, Li, and Chen, 2021; Salisu and Abu Bakar, 2018; Niazi, 2017). For example, collaboration among firms in innovation adoption can yield advantages such as accessing external expertise, pooling resources, and gaining a competitive edge (Wang and Hu, 2020). Thus, according to Monferrer et al. (2021), Chu, Lai, and Wang (2020), and Young and Wilkinson (1998), owing to the contribution of interorganisational relationships to overall competitiveness of firms, their significance is widely acknowledged across diverse organisational cultures. This implies that organisations, regardless of their cultural orientation, generally recognise the benefits of fostering positive interorganisational relationships. As a result, the organisational culture might not have a strong enough moderating effect to outweigh the significant impact of interorganisational relationships in DSC adoption.

In conclusion, while the flexibility-control organisational culture does not significantly moderate the overall relationship between environmental factors and DSC adoption, its influence becomes apparent when examining specific dimensions. Particularly, it was found out that organisational culture exerts a negative moderating effect on the relationships between market pressure and DSC adoption, as well as between market support and DSC adoption. In contrast, the influence of organisational culture on the relationship between interorganisational relationships and DSC adoption was not found to be significant. This suggests that the prevalence of control-oriented values within Vietnamese organisational culture can reduce the positive impact of market pressures and market support on DSC adoption. However, this moderating effect may not be significant enough to influence the robust role of interorganisational relationships in driving DSC adoption.

9.3. Summary

In this chapter, a discussion of the key findings from analyses were provided, aiming to shed light on the possible explanations for the observed outcomes. The research outcomes unveiled that organisational and environmental factors play pivotal roles as determinants of DSC adoption in Vietnamese firms whereas technological factor does not have significant impact on such adoption. When examining the specific dimensions of these factors, the analyses revealed that perceived benefits, top management knowledge and support, organisational resources, market pressure, and interorganisational relationships determine the success of DSC adoption in Vietnam. Conversely, the impact of perceived risks and market support on DSC adoption was not evident. Moreover, the results emphasised the substantial significance of top management knowledge and support, followed by the interorganisational relationships, as the driving forces that yielded the greatest influence in the successful implementation of DSC. Additionally, when examining the significance of these dimensions on different stages of DSC adoption which are DSC adoption intention and DSC adoption actions, it was observed that perceived benefits, top management knowledge and support, market pressure and interorganisational relationships significantly predict DSC adoption intention, while organisational resources, top management knowledge and support, market support and interorganisational relationships significantly determine DSC adoption actions.

The outcomes further highlighted the intriguing coexistence of control and flexibility values within Vietnamese organisational culture. While this culture undeniably plays a significant and positive role in DSC adoption, the interplay of these values, slightly favouring control-oriented values, has exerted a negative influence on the impact of perceived benefits, top management knowledge and support, organisational resources, market pressure, market support, and interorganisational relationships on DSC adoption. In contrast, it has magnified the influence of perceived risks on the adoption process. Additionally, while the advantages of blending control and flexibility values in organisational culture are evident, the results underscored the importance of prioritising flexibility values, particularly emphasising entrepreneurial, dynamic, and risk-taking attributes within the organisations. Subsequently, the final chapter reveals research limitations, suggest new directions for DSC research in developing countries, as well as present crucial implications on theoretical and practical fronts.

10. CHAPTER 10: CONCLUSION

In response to the pressing need for Vietnamese firms to integrate digital technologies into their supply chains, this study investigated the successful implementation of DSC and identify the factors that influence Vietnamese firms' ability to harness digital technologies within their supply chain operations. To accomplish this objective, the research explored the theoretical underpinnings guiding Vietnamese firms' DSC adoption and empirically validated a conceptual model that outlines the factors influencing both DSC adoption intention and actions. This study contextually proposed a DSC adoption model for Vietnamese firms to address the theoretical and practical gaps especially by utilising Technology – Organisation – Environment framework as the core foundation of this investigation. Additionally, recognising the multifaceted impact of flexibility and control organisational culture values, as well as the principles of interorganisational relationship in driving innovation adoption effort (Lewis and Boyer, 2002), this paper further explored these two factors with interorganisational relationships incorporated into the environmental factor in order to build a more comprehensive multilevel understanding of SC 4.0 adoption.

This study demonstrated the significance of employing a mixed research methodology when assessing a firm's DSC adoption intention and actions, both within and across its organisational boundaries. The qualitative component of this research proved instrumental in yielding valuable insights that informed the refinement of the DSC research framework and the subsequent development of the quantitative component. On the other hand, the quantitative component served to test the theoretical model of DSC adoption and examine the hypothesised relationships among the model's constructs. These complementary qualitative and quantitative findings were subsequently synchronised to provide in-depth discussions of the proposed DSC adoption model tailored to the Vietnamese context.

In this Conclusion Chapter, the study highlights both theoretical and practical contributions and implications while acknowledging its inherent limitations. Furthermore, it outlines potential avenues for future research and the directions it opens for further exploration.

10.1. Theoretical implications

This study offers valuable theoretical contributions to the academic literature on SC4.0 adoption in terms of its definition, comprehensive SLR of its success factors, development of its adoption model and measurement items for Vietnamese context, overall impact of these success factors on overall SC 4.0 adoption and its individual stages, and moderating role of organisational culture in such adoption. Firstly, it provided a historical overview of the four industrial revolutions, highlighting the distinctions between supply chains in the 3^{rd} and 4^{th} industrial revolutions and their respective implications for supply chain development. The study also presented a comprehensive and inclusive conceptualisation of SC 4.0, drawing upon a thorough review of the existing literature in the field.

Secondly, as previously highlighted in Chapter 1, there is a clear imperative for a more comprehensive exploration of the implications and implementation of Industry 4.0 technologies within supply chains. This research fills this gap by undertaking an exhaustive systematic literature review of both the enablers and barriers of SC 4.0, approaching the subject from the dual perspectives of Industry 4.0 and SC 4.0. To the best of the researcher's knowledge, no such comprehensive review has been conducted from both these perspectives to date, making this study a pioneering effort that yields valuable insights into the current state of research in the field of SCM.

Thirdly, given the scarcity of studies in the SC 4.0 domain, particularly within emerging and developing economies, and the importance of verifying established theories across various contexts to ensure their practicality, this research took the initiative to construct and validate a research model. This model was devised to investigate the factors influencing the adoption of SC 4.0 or DSC in developing nations, with a specific emphasis on Vietnam. This study holds significance as it provides a theoretical foundation for investigating DSC adoption from various perspectives, thereby contributing to the literature on DSC adoption. To the best of our knowledge, this study stands as the first to theoretically specify and empirically test the determinants of DSC or SC 4.0 adoption in Vietnam. It achieves this by integrating the Technology – Organisation – Environment (TOE) framework and the disciplines of interorganisational relationships. Although the TOE framework has emerged as the dominant theoretical lens for studying Industry 4.0 adoption (Ghobakhloo et al., 2022; Lin et al., 2018; Senyo, Effah and Addae, 2016) and DSC adoption (Callinan et al., 2022; Chittipaka et al., 2022; Gökalp, Gökalp and Çoban, 2022), the parameters or dimensions within the TOE contexts have been continuously worked on by other scholars with purpose of broadly strengthening the theoretical base of the model and its capability to explaining and predicting the adoption of various types of IT innovation in different scenarios. Therefore, according to

Oliveira and Fraga (2011), the specific dimensions identified within the TOE contexts may vary across different studies and different technology adoption contexts. In this study, the empirical findings enhance the validity and application of the TOE framework in explaining SC 4.0 implementation in the context of Vietnam. Given the unique characteristics of the Vietnamese market, the SCM development and Industry 4.0 maturity level, the research has identified perceived benefits within the technological context; top management knowledge and support, and organisational resources within the organisational context; and market support, market pressure, and interorganisational relationships within the environmental context, as the determinants of DSC adoption in Vietnamese firms. Furthermore, the measurement items or questions developed for this research's questionnaire to measure the dimensions of TOE factors are distinct from the prevailing measurements found in existing TOE studies, as they were specifically designed and amended to capture the Vietnamese context. This effort resulted in the development of a comprehensive set of measurement items that are both relevant and appropriate for Vietnamese context. Additionally, this study fills in the existing gap in DSC literature by confirming the applicability of TOE framework in examining DSC adoption. The study suggests that the extent of DSC adoption is not solely influenced by the inherent characteristics of the technologies themselves, but also contingent on various factors tied to the organisational and environmental context. The study's findings emphasise the value of the proposed model, which is potential to serve as a theoretical framework for investigating the adoption of other IT innovations as well.

Furthermore, considering the existing research gaps, specifically the limited investigation into the impacts of different organisational culture types on DSC adoption in developing countries, along with the contradictory empirical results on the influence of the organisational culture, this study examined the moderating role of flexibility and control-oriented culture values in shaping the relationships between determinant factors and DSC adoption. The research findings revealed that Vietnamese organisational culture integrates both flexibility and control cultures with control values slightly dominating. That explains why such culture negatively moderates most of the relationships between determinant factors and DSC adoption.

Finally, in light of the scarcity of research addressing the impact of determinants at various stages of DSC adoption, this study significantly contributes to the field of innovation and technology adoption by evaluating how different factors influence not only the overall DSC adoption but also its individual stages. Particularly, in this study, it was revealed that perceived risks, top management knowledge and support, market pressure, and interorganisational relationships predict the intention of Vietnamese firms to adopt DSC. Meanwhile, the DSC adoption actions of Vietnamese firms are influenced by organisational resources, top management knowledge and support, market support, and interorganisational relationships.

10.2. Managerial implications

The empirical findings of this research offer valuable managerial and practical insights, enhancing managers' understanding of the factors and circumstances influencing SC4.0 or DSC adoption. As a result, practical recommendations and guidelines for decision-makers to shape policies, strategies, and implement changes for SC4.0 adoption are provided. By drawing on the research model, managers can assess the suitability of their current conditions for DSC adoption. The research model comprises not only the technological attributes defining the nature of DSC but also a series of organisational and environmental conditions. Managers must take into account these contextual factors to ensure a positive intention and effective adoption of DSC.

Within the technological context, firms' perceptions of the potential benefits of digital transformation, particularly in enhancing data-driven decision-making, information sharing, monitoring, resource saving, and product and service customisation, serve as strong incentives for Vietnamese firms to willingly embrace and enthusiastically support digital transformation initiatives. The research highlights that Vietnamese firms primarily adopt digital technologies in their supply chains to swiftly access real-time market data and streamline information sharing to expedite decision-making processes, which enable them to respond effectively to market volatility and intense price competition. However, it has been observed that even though Vietnamese organisations may acknowledge the benefits of DSC and express a positive intention towards its adoption, this perception does not always translate into concrete actions to implement DSC. This discrepancy between intention and action can be attributed to various challenges and obstacles that hinder the transformation of intentions into actions, even in the presence of significant perceived benefits from DSC. Therefore, to initiate the process of adopting DSC, organisations should begin by acknowledging and cultivating a positive perception of the benefits it brings as well as remove barriers and challenges that hinder their firms from DSC adoption. Managers play a crucial role in this endeavour by proactively seeking information on the advantages of DSC adoption and sharing success stories from other organisations to both employees and trading partners (Lin, 2014). Nevertheless, based on the quantitative findings, it appears that perceived risks are not a significant determinant of DSC adoption in Vietnamese firms. This finding contradicts the qualitative insights, which revealed companies' concerns about the unclear return on investment (ROI) when justifying significant investments in digital transformation. This highlights the importance for managers to ensure that firms are aware of the costs, complexities, and potential risks associated with digital transformation since digital transformation inherently carries risks, and business model transformation is often time-consuming and costly (Fabian, Dong, and Bhattacharya, 2021). Especially, the interview findings revealed the underestimation and misconception of Vietnamese firms regarding the significance of data privacy and security in the context of digital transformation. According to Mai and Tick (2021) and Pham et al. (2021), this underestimation could result from the inadequate awareness and shortage of proper education and trainings, as well as poor cyber security practices and preventive measures in their daily operations. It suggests that Vietnamese companies should proactively raise awareness about the importance of data privacy and security, bust any common myths and any misconceptions around these issues.

In the organisational context, the research findings emphasise the pivotal role of top management and their support in driving DSC adoption within Vietnamese firms. This is particularly important due to the significant power distance and centralised decision-making system in Vietnam (Nguyen and Truong, 2016; Napier, 2006). This highlights the paramount importance of top management's enthusiastic involvement, willingness to take financial and operational risks, and their active development of clear visions, strategies, and roadmaps for digital transformation initiatives. Especially, aligning technology strategy with business strategy is the key to expedite the transformation process. They should also communicate the urgency of digital transformation throughout the organisation, guiding and supporting employees during this transformative process. This process may involve top management's guiding or even enforcing employees to adhere to the established plans. Especially in times of radical changes like digital transformation, strong leadership, possibly through Chief Digital Officers (CDOs) who can provide a strong sense of direction and allocating responsibilities to distinct managers, is crucial to rally the organisation behind the initiative (Kunisch, Menz and Langan, 2022). For SMEs, outsourcing digital specialists who manage digital topics, facilitate and champion changes, and serve as the primary point of contact for employees can be a viable approach (Fabian, Broekhuizen, and Nguyen, 2021). The research further uncovered that despite a high awareness of the benefits of digital technologies in enhancing operations and competitive advantage, many Vietnamese managers have vague and broad perceptions of Industry 4.0 and digital transformation. Some find it challenging to define and measure these concepts, leading to misunderstandings and confusion. Therefore, the research suggests that it is crucial for organisations to equip top managers with a comprehensive understanding of digital technologies and the digital transformation process, focusing on constructing a clear digital pathway outlining the stages of digitalisation, requirements, and investment guidance for each phase. Additionally, within the organisational context, the research findings highlight the significant role of organisational resources, including employees' skills, knowledge, willingness to adapt to change; financial resources; and technical infrastructure, in driving DSC initiatives. To address the changes and requirements for new roles and skills necessary for digital technology adoption, organisations can employ two strategies. First, they can enhance their employees' technical proficiency through in-house digital skill training programs. Second, they can outsource third-party training, such as online courses or mini university degrees (Fabian, Dong, and Bhattacharya, 2021). These training opportunities enable employees to gain a profound understanding of digital technologies, their functionalities, and technical aspects, thus equipping them with knowledge and hands-on experience to responsibly utilise digital technologies. In addition to upskilling, organisations should address inertia and resistance to change which affect not only large organisations but also SMEs. For established firms, effective communication, comprehensive planning, and adequate time for implementation, along with sufficient support for employees in adapting to change, are advisable (Fabian, Dong, and Bhattacharya, 2021). A common approach involves establishing separate units that operate outside company rules and bureaucracy to facilitate learning and enable organic change. Clear communication and strong leadership have been shown to help employees adapt to new situations. Furthermore, to ensure the successful implementation of your digital transformation strategy, it is essential to allocate a sufficient and realistic budget, accompanied by a well-structured budgeting plan that aligns with the digital transformation goals and strategies while accommodating cross-departmental and cross-functional needs. The budget should clearly define the company's financial objectives, allocate resources appropriately, and offer a transparent overview of the investments needed at each stage. Finally, the research findings suggest that digital transformation is an incremental process rather than an instant deliverable. Therefore, digital transformation requires collaborative efforts across different departments and business units over an extended period to gradually invest in, build, expand, and maintain the necessary IT infrastructures.

Within the environmental context, Vietnamese firms are under significant pressure to implement and accelerate digital transformation in their operations and SCM, especially in response to rapid market demand changes caused by market uncertainties, notably the Covid-19 pandemic. This crisis has highlighted the competitive advantage that digital technology adoption provides to firms in quickly and effectively dealing with demand fluctuations and evolving customer preferences (Barczak et al., 2022; Kutnjak, 2021; Priyono, Moin and Putri, 2020; Wade and Shan, 2020). The findings hold important practical implications that the more intense the competitive and market pressures and uncertainties firms face in their inndustry, the more likely they are to adopt digital technologies. However, despite a positive intention to implement or accelerate digital transformation, the research results reveal that market pressures do not play a significant role in determining the firms' DSC adoption actions. This suggests that while Vietnamese firms acknowledge the importance of digital transformation, they may encounter challenges in actually adopting it in their supply chains despite market pressures. Managers should therefore proactively reassess their digital transformation strategies to ensure they align with current market dynamics such changes in customer demands, competition, and other external factors. They should also allocate the required resources and tackle any obstacles that impede the actual adoption of DSC. Furthermore, within the environmental context, although market support, particularly government support (e.g., funding programs, national digital transformation policies, and plans) and third-party support (e.g., from universities, financial institutions, technology providers, and business associations), does not emerge as a crucial determinant of DSC adoption intention, it still determines the DSC adoption actions and success of Vietnamese firms. This suggests that the absence of government policies and support, including incentives and substantial research and development efforts, acts as barriers to firms' digital transformation (Majumdar, Garg and Jain, 2021). An interesting finding of this study is that the communication and dissemination of government policies and national programs to businesses are not effective, leading to a lack of awareness among interviewees regarding existing supportive programs, plans, or policies. Hence, it is imperative that government policies and programs are designed to be practical, addressing the digital transformation challenges and motivations of various firms across different industries, sizes, and regions. Their information must also be communicated clearly and effectively to individuals and businesses relevant to the cause, while also enabling businesses to have a say in the national digital transformation plan. Furthermore, this highlights the importance of managers staying well-informed about government policies and actively participating in government programs, funding initiatives, and national digital transformation policies. Managers should also explore research and networking opportunities to investigate potential support programs, partnerships, or collaborations with external organisations such as universities and business associations. These external entities can provide valuable guidance and resources that facilitate the adoption of digital technologies, enabling firms to access expertise, technological solutions, and Industry insights. Lastly, in the context of the environment, the research emphasises the crucial role of interorganisational relationships. Particularly, it highlights the persuasive and coercive influence of trading partners, their willingness to share information, and their digital readiness in propelling digital transformation initiatives. Undoubtedly, the intricate and evolving work of digital transformation cannot be accomplished in isolation. It demands collaboration and partnership with other leaders and experts within the ecosystem, including customers, suppliers, consultants, and vendors. Thus, to ensure the successful implementation of DSC, it is imperative for managers to proactively cultivate and sustain robust, trust-based relationships with their trading partners. This involves establishing common digital objectives to secure mutual benefits derived from digital transformation, enhancing collaboration and technological partnerships through regular exchange of knowledge, best practices, insights from successful digital transformation experiences, and information. Such an endeavour necessitates a shared commitment among all supply chain entities to a unified set of values.

Moreover, this study offers a significant contribution to the understanding of organisational culture's impact on digital transformation. It underscores the importance of managers recognising that culture can significantly impede digital transformation within their companies (Fabian, Dong, and Bhattacharya, 2021). Thus, it is essential for managers to understand their organisational culture to develop effective adoption strategies for digital transformation. This research, by investigating the cultural factors that either drive or hinder adoption, provides valuable insights that can assist organisations in overcoming cultural barriers and facilitating the adoption process. Particularly, the research findings underscore the importance of harmonising both control and flexibility culture values within organisations. Rather than viewing these values as conflicting, firms should encourage their seamless coexistence in the organisational culture. While a culture that fosters flexibility is conducive to innovation and transformative changes, there is also a clear benefits to maintaining a degree of stability, control, and order, especially during crises and uncertain periods that necessitate rapid decision-making and execution. This is because when ideas and plans for transformative change are put into practice, adhering to established procedures, processes, and rules becomes essential for successful implementation. It suggests that achieving a balance and regulation of control values is paramount to maximise their positive impact on firms. Thus, organisations should nurture values like creative freedom, employee empowerment, and teamwork to foster innovation while also demonstrating explicit controls for effective evaluation of innovations. However, it is noteworthy that control values, such as goal-orientation, permanence, and stability, slightly outweigh flexibility values like dynamism and risk-taking within Vietnamese culture. This cultural aspect can influence the dynamic capabilities of Vietnamese firms in adopting radical innovations such as digital technologies, as evidenced by the negative moderating impact of such organisational culture. Therefore, managers should be aware that while coexistence of flexibility and control values is necessary, a stronger inclination toward flexibility values can enhance a firm's agility, adaptability, and readiness for radical changes and innovation, such as DSC. Yet, the transition to a more flexibility-oriented culture is a gradual process that can take place over years and necessitates a long-term perspective. It is also crucial to acknowledge that cultural changes are typically accompanied by periods of instability and the departure of some employees. As a result, organisations should develop a comprehensive, long-term vision and plan for culture transformation. To initiate this process, smaller-scale units operating independently from the company's bureaucratic structure are often recommended, enabling them to learn and adapt to digital transformation effectively (Tumbas, Berente and vom Brocke, 2018). This approach allows companies to gradually expand their digital operations without disrupting existing value creation methods (Fabian, Dong, and Bhattacharya, 2021). Thus, managers should explore how their firms can nurture shared values to effectively drive innovations and the adoption of digital technologies.

Ultimately, the research findings unveiled that the appropriateness of digital technology adoption depends largely on how technologies are utilised and their resulting benefits to the organisations, rather than the specific types of technologies. Technologies should be viewed as tools that can aid in achieving business objectives but are not the sole determining factor. In fact, an organisation's competitive advantage is significantly influenced by the innovation and quality of its products and services. The study also indicates that while the initial adoption of digital technologies may pose an expense for SMEs, it enables firms to achieve faster scaling, respond more effectively and promptly to market changes, rather than waiting until they have grown larger to implement technologies. Since digital transformation cannot occur rapidly or overnight, it necessitates a gradual and continuous transformation process that takes years to yield fruit. This journey requires the company's unwavering commitment, long-term investment in infrastructure, and a consistent training and awareness campaigns to emphasise the importance of DSC adoption among employees. The DSC strategy, upon which the digital plan is developed, must consistently align with the leaders' vision. Effective communication of the company's goals and objectives is crucial, extending to mid-level management and front-line employees to prepare them for the significant change. Thus, to achieve full digital transformation of the business and its operations and SCM, it is critical to begin investing in digital technologies within the operational systems from the early stages of the business's growth.

In summary, this research provides a foundation for managers and policymakers to make informed decisions regarding SC4.0 adoption and implementation in Vietnam by allowing for more effective resource allocation, and providing initial guidance for company development plans and establishment of future initiatives like SC4.0 centres of excellence or knowledge exchange networks which ultimately promote the growth of fully-connected and future-proof supply chains in Vietnam.

10.3. Limitations and Future Research

Despite the intriguing findings and their substantial implications for both academia and practical applications, it is essential to interpret the results of this study cautiously, due the following limitations, which indicate potential avenues for future research.

(1) This study focuses on examining the influence of determinants on adoption intention and actions. Future research could extend this by exploring the facilitators and obstacles encountered by firms in the processes of adopting digital technologies and undergoing digital transformation. This may necessitate researchers to gather longitudinal data rather than the cross-sectional data used in this study.

(2) Given that Industry 4.0 is still in its developmental stage in Vietnam, rather than examining specific Industry 4.0 technologies within SCM, this study takes a more comprehensive approach by investigating the adoption of Industry 4.0 as a whole within the SCM context. Nevertheless, it is important to acknowledge that the enablers and barriers may differ among various Industry 4.0 technologies. Therefore, the proposed model can be tested at different Industry 4.0 technologies to further validate the findings.

(3) Since the majority of respondents in this study are from large foreign firms in Vietnam, there is a potential bias in the findings. These results may not be universally applicable to all local large firms or SMEs in Vietnam. Given the difference in digital readiness between foreign and local firms, future research could explore DSC adoption within the context of local Vietnamese firms.

(4) Since the survey was open to everyone and was anonymous, it was impossible to check the number of respondents in the same company, potentially resulting in cases with few respondents from the same organisation. Future research could address this issue by collecting responses from various organisations to facilitate comparisons and contrasts among firms in terms of their digital transformation readiness, challenges, and drivers.

(5) Since this research explores the adoption of digital technologies across firms within supply chains, future studies could concentrate on individual firms within the supply chain, such as manufacturers or logistics providers. Due to their distinct business characteristics, they may encounter unique challenges in IT innovation adoption, as indicated by the qualitative findings of this research.

(6) Given that Industry 4.0 is still in its early stages in Vietnam, this study examined DSC adoption across various company sizes, industries, regions, and business types, to provide a comprehensive view of DSC adoption in Vietnam. Future research is encouraged to explore DSC adoption within specific segments, whether it be by business

size, industry type, business category, or region, as the barriers and motivators impacting firms' digital transformation can differ based on these business characteristics.

(7) Since Vietnamese firms have an unclear and vague understanding of digital transformation and digital technology adoption, future research is recommended to assess the extent of a firm's digitalisation or digital maturity level. This will provide a more precise understanding of the challenges and facilitators of DSC adoption since different digital maturity levels might correspond to distinct DSC enablers and barriers.

(8) In the majority of existing studies, sustainability has not been highlighted as a prominent factor driving digital transformation, largely due to limited research in managing supply chain sustainability through Industry 4.0 technologies (Bag et al., 2021). Moreover, sustainability was not addressed by the interviewees in this study. However, with the escalating impact of climate change globally, sustainability has garnered significant attention within the operations and SCM community, given its crucial role in fostering supply chain resilience (Dey et al., 2023). Notably, recent studies have positioned sustainability as a key driver of digital transformation (Robertson and Lapiņa, 2023), especially in emerging economies. For instance, Garcia-Torres et al. (2019) noted that some firms are integrating digital technologies into their sustainability strategies. This is because digital solutions have the potential to establish closed-loop supply chains for sustainability (Chauhan, Parida, and Dhir, 2022). Therefore, future research could investigate the impact of sustainability as an enabler on the adoption of digital supply chain practices among Vietnamese firms.

(9) During the investigation of the impact of TOE factors on DSC adoption, it was observed that, despite the hypothesised relationships, there was no significant connection between technological characteristics and DSC adoption. Similarly, at the dimension level, no significant relationships were found between perceived risks and DSC adoption, and between market support and DSC adoption. Additionally, when examining the moderating influence of organisational culture on the relationships between TOE factors and DSC adoption, no significant moderating impact of organisational culture was identified in the relationships between organisational factors and environmental factors and DSC adoption. Meanwhile, at the dimension level, organisational culture did not significantly moderate the relationships between top management knowledge and support and DSC adoption, as well as between interorganisational relationships and DSC adoption. Although statistically insignificant, these findings deserve further scrutiny in future research.

(10) Since research data is limited to the Vietnamese context, future research should obtain data and evaluate the proposed model in other developing countries to enhance the validity of the findings. Additionally, future research can expand its scope to

compare DSC adoption challenges and enablers in different countries or regions to identify regional differences and potentially transferable best practices in digital transformation.

10.4. Concluding Remarks

In summary, this doctoral research was carried out to investigate the factors influencing the adoption of DSC or SC4.0, with a specific focus on DSC adoption intentions and actions within the context of Vietnam. The thesis is structured across ten core chapters, including the research introduction (Chapter 1), research context (Chapter 2), theoretical foundations (Chapter 3), literature review (Chapter 4), the development of hypotheses and the research model (Chapter 5), the research methodology employed to address the research questions and test the hypotheses (Chapter 6), analysis and findings of qualitative data (Chapter 7), analysis and findings of quantitative data (Chapter 8), a discussion and explanation of the qualitative and quantitative results (Chapter 9), and finally, a conclusion that explores the main implications of the study, its limitations, and recommendations for future research (Chapter 10). Although prior studies have investigated SC 4.0 adoption in developed countries, there has been a notable shortage of studies that explore this adoption in developing countries, particularly Vietnam – one of key players in global supply chain – that is currently facing a plethora of challenges in accelerating such digital transformation (Cuong and Le, 2024). This study offers substantial contributions to the understanding of SC4.0 adoption, providing valuable practical and theoretical insights into the determinants of adoption, particularly emphasising the significance of top management knowledge and support, the role of interorganisational relationships, the influence of organisational culture, and how these factors come into play at different stages of SC 4.0 adoption. It highlights the need for a balanced approach to flexibility and control-oriented culture values, emphasising the advantages of favouring flexibility values for an effective digital transformation and suggesting promising directions for future studies in the fields of SCM and digital transformation. The knowledge and principles gained within this work will support the optimised development of SC4.0 in Vietnam; offering practical suggestions to the organisation about cultural settings, policies, strategies, resource allocation and other changes so that a theoretical framework can be built for the planning and implementation of SC 4.0 not only in Vietnam but also for the developing countries where the 4th revolution has emerged and influenced the supply chain.

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12. LIST OF APPENDICES

APPENDIX A – Technology Adoption Models

Appendix A1 – Innovation Diffusion Theory (IDT)

Firstly published in 1962 and then popularised and fine-tuned by Rogers (1995), Innovation diffusion theory (IDT) has been recognised as one of the most prominent models used to examine the adoption rate for various technologies across different channels and stages (Wu et al., 2013; Ifinedo, 2011; Mora - Monge, Azadegan and Teich, 2010; Melville and Ramirez, 2008). When studying the rate of technological innovation diffusion or adoption, Rogers (2003) proposed two categories of factors, including Innovation Characteristics and Organisational Characteristics. Factors within the Innovation Characteristics are the perceived attributes of technological innovation that can either promote or inhibit innovation diffusion. The five attributes within Innovation Characteristics are Relative advantage (perceived benefits or superiority of the technology to existing practices), Compatibility (perceived consistency and suitability of the innovation with existing values, past experiences, needs of potential adopters or organisational structures), Complexity (perceived difficulties to understand and use the innovation), Trialability (perceived degree in which the innovation can be experimented) and Observability (perceived degree in which results of the innovation are visible to others) influence the innovation adoption decision. The theory suggests that high degree of relative advantage, compatibility, trialability and observability of the innovation leads to fast adoption rate whereas high level of complexity is negatively associated with the rate of adoption. Rogers also embedded innovation adoption within the context of a social system and suggested that innovation diffusion is a communication process that utilises various channels within the social systems, therefore, also being influenced by the Organisational Characteristics factors. These factors are individual leader's characteristics (leadership towards the change), internal organisational structural characteristics (centralisation, complexity, interconnectedness, size of organisation, and organisation slack), and external characteristics (system openness).

The Theory of Innovation Diffusion (IDT) has gained widespread recognition for its robustness in explaining technology acceptance and diffusion across various disciplines, technologies, and cultures (Van den Berg and Van der Lingen, 2019). However, existing literature suggests that IDT is commonly used in conjunction with other models such as TAM or TOE, rather than in isolation, when examining the adoption of digital technologies. For instance, Ullah et al. (2021) integrated TAM with IDT to investigate Blockchain technology adoption, while Sabi et al. (2016) utilized this combination in studying cloud computing adoption. Similarly, Hsu, Ray, and Li-Hsieh (2014) incorporated IDT into the TOE model to examine cloud computing adoption.

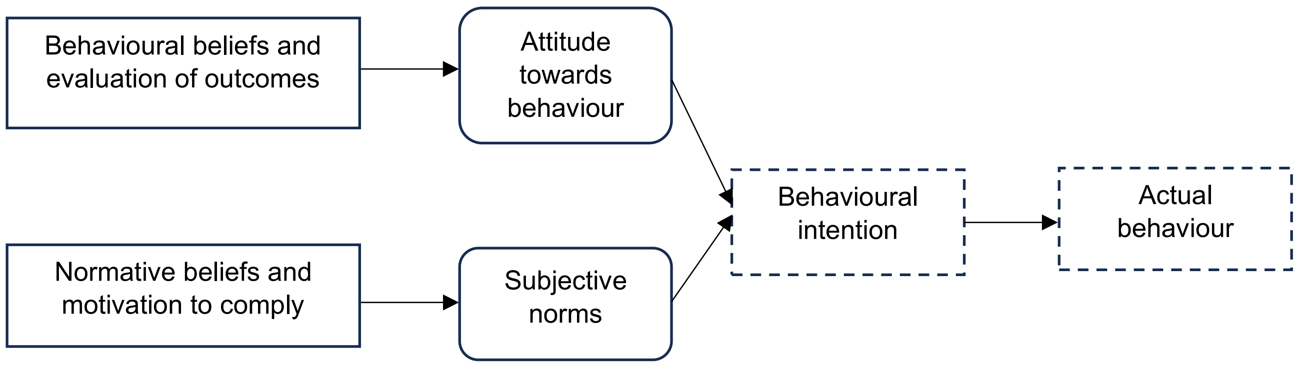
The reason behind this trend is the criticism directed at IDT for oversimplification (Damanpour, 1996). Despite a large number of studies employing IDT across diverse disciplines, the application of IDT varies with researchers proposing different changes. Consequently, this lack of cohesion has impeded the theory's advancement and limited its consistent application (Meyers, Sivakumar, and Nakata, 1999). Downs Jr and Mohr (1976) also cautioned that the multitude of variables employed in studies can lead to inconsistent research findings, thereby reducing the theory's heuristic value.

Additionally, IDT has been criticised for its limited consideration of certain variables that play a crucial role in the adoption of innovations (Masood and Egger, 2019; Plsek and Greenhalgh, 2001). Typically, IDT has been accused of neglecting Environmental factor such as government, Industry and community influences as its attention was primarily given to Organisational and Technological factors when examining innovation diffusion. Although IDT has been proven useful in explaining the adoption of some innovations, it may not be the most suitable theoretical framework for investigating the adoption of DSC. Unlike other innovations, DSC adoption is complex, requiring extensive coordination and integration across multiple organisations that extend beyond the boundaries of individual firms (Lin, 2014). Therefore, to effectively study DSC adoption, alternative theoretical frameworks that specifically account for the unique challenges and interorganisational dynamics associated with DSC implementation may be more appropriate.

Appendix A2 – Theory of Reasoned Action (TRA)

TRA, a social psychology model introduced by Fishbein (1967) and formalized by Fishbein and Ajzen (1975; 1980), is widely used to study consciously intended behaviors. It aims to examine the relationship between beliefs, attitudes, intentions and behaviours, and has been applied successfully in various disciplines concerned with volitional human behaviour, ranging from health to consumer behaviour (Rehman et al., 2007). The model proposes that an individual's intention to perform a behavior is the main predictor of behavior, and that the key determinants of behavioral intention are the “individual's attitudes” and “subjective norms”. Attitude refers to the individual's favorable or unfavorable evaluation of a particular behavior, while subjective norm refers to the individual's perception of social pressure that can encourage or discourage them from engaging in that behavior. As the contribution of attitudes and subjective norms can vary based on the behavioural context and the individual (Rehman et al., 2007), by examining the attitudes and subjective norms, researchers can suggest whether the individual will perform the intended behaviour. According to the theory, attitudes are the result of behavioural beliefs that performing the behaviour will lead to a particular outcome, and the evaluation of these expected outcomes in terms of likelihood or subjective probabilities of an outcome materialising. Subjective norm, on the other hand, is determined by beliefs about how others expect the individual to behave and on the motivation to comply with referents' expectation (Ajzen, 2005). The relationship between factors is shown in the Figure A2-1.

Figure A2-1: Theory of Reasoned Action (Fishbein and Ajzen, 1975)



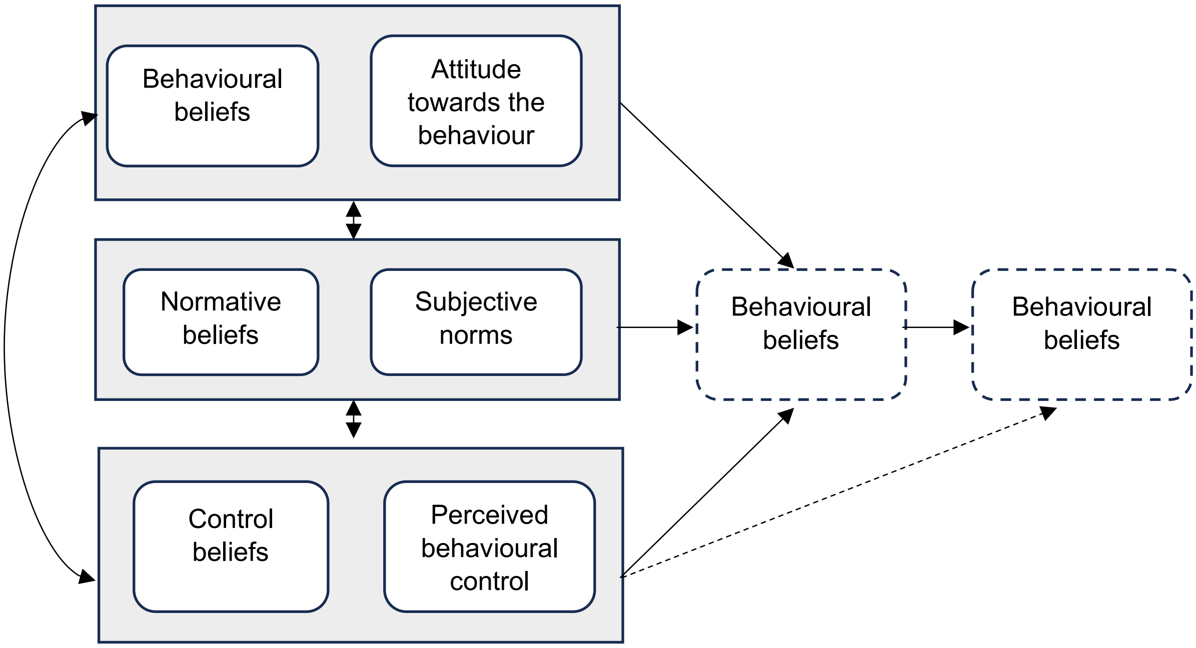
A thorough review of the existing literature reveals a striking absence or minimal utilisation of TRA in examining the adoption of Industry 4.0 technologies. This scarcity can be attributed to the inherent limitations of the theory, which have hindered its widespread application in this context. One limitation is that the theory does not account for critical variables that can influence behavior (Sheppard, Hartwick and Warshaw, 1988), such as the interpersonal and social relations in which individuals act, as well as the broader social context (Terry, Gallois and McCamish, 1993). Although TRA takes subjective norms into account, it is limited to individual perceptions of these social phenomena. Furthermore, attitudes and subjective norms towards a behaviour can vary across cultures, as Bagozzi et al. (2000) suggested that people from different cultures weigh subjective norms and existing attitudes differently. The further requirement of the theory is that the behaviour must be under volitional control. Therefore, according to Ajzen (1991), TRA can poorly predict the situations where individuals have low levels of volitional control. These limitations demonstrate the need for further refinement and revision of the theory. Since TRA primarily focuses on individual-level behavior and the influence of attitudes and subjective norms, the theory is deemed inadequate to explain the adoption of DSC which a complex process that occurs at both organisational and interorganisational level (Shamout et al., 2022). The decision to adopt DSC technologies may be influenced by factors beyond just individual attitudes and social norms, such as organisational culture, resource availability, and business strategies. Additionally, the adoption of DSC is not solely reliant on an individual decision, but rather a collective decision made by companies. Hence, the TRA is not applicable for studying the adoption of SC 4.0.

Appendix A3 – Theory of Planned Behaviour (TPB)

TPB, which was developed by Ajzen (1991) as an extension of TRA, aimed to address the original model's shortcomings in dealing with low volitional control situations. The theory proposes that in addition to attitudes and subjective norms, behavioural intentions are also influenced by the perceived behavioural control.

According to the theory, an individual’s behaviour is guided by three factors: (1) behavioural beliefs about the likely outcomes of the behaviour and evaluations of these expected outcomes, (2) normative beliefs about the normative expectations of others and the motivation to comply with these expectations, and (3) control beliefs about availability of skills and resources required, requisite opportunities, as well as the contextual or situational constrains to perform the target behaviour. Respectively, the behavioural beliefs lead to a favourable or unfavourable attitudes towards the behaviours; while normative beliefs shape the subjective norms. This relationship is expressed in Figure A3-1.

Figure A3-1: Theory of Planned Behaviour (Ajzen, 1991)

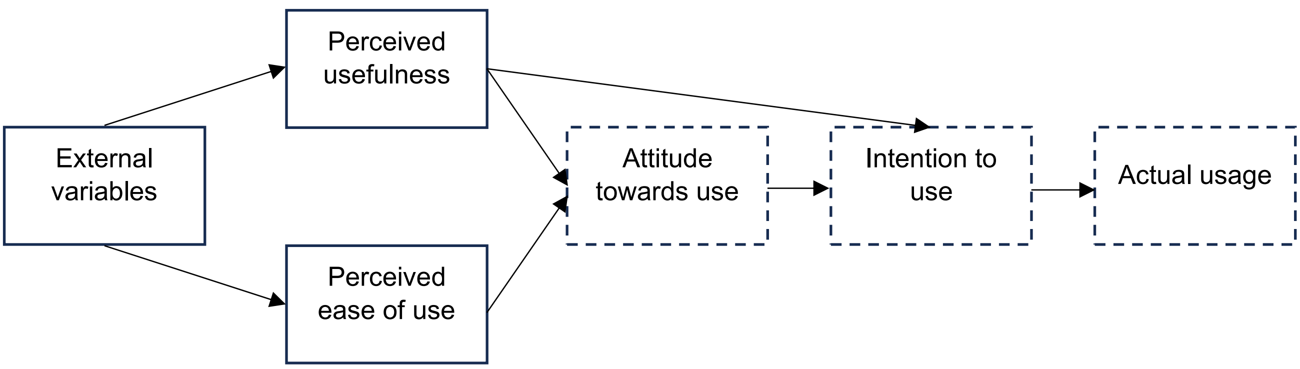


Similar to IDT, TPB has been widely integrated with other models such as TAM or being extended by incorporating additional constructs to investigate technology adoption. For example, Toni et al. (2021) have adopted and extended TPB by including inhibitors and environmental aspects to examine study consumers' intention towards the automotive 4.0. Likewise, Abbas and Mehmood (2021) and Mohr and Kühl (2021) have integrated TPB with TAM to examine digital marketing adoption and AI adoption respectively. Nonetheless, upon reviewing the current literature, it is evident that TPB is minimally utilised in the study of Industry 4.0 adoption, especially in the context of SC 4.0 adoption. This can be attributed to the theory's inherent limitations and the criticisms it has received. The main focus of criticism has been the limited predictive validity of the theory (Sniehotta, Presseau and Araújo-Soares, 2014) as it fails to account for other variables that can influence behavior when there is continuing evidence that other factors such as fear, threat, past experiences or other normative influences such as environmental or economic factors can influence individuals' behaviours (Davies, Foxall and Pallister, 2002). The theory has also been criticised by many scholars for its exclusive focus on rational reasoning, disregarding unconscious influences on behaviour (Sheeran, Gollwitzer and Bargh, 2013) and the presence of emotions beyond anticipated outcomes (Conner et al., 2013). It is proved by a review by Hardeman et al. (2002) claiming that available evidence is insufficient to draw a robust conclusion about the usefulness of the theory. Similar to TRA, TPB primarily focuses on individual-level behavior in relation to technology adoption. However, DSC adoption is a complex and multifaceted phenomena that extends beyond individual perspectives. It involves collaboration among multiple organisations and requires decisions at both the organisational and interorganisational levels (Papadonikolaki, 2020). Therefore, the individual-level determinants of TPB which are individual attitudes, subjective norms, and perceived behavioral control, may not fully capture the intricacies and complexities of DSC adoption which requires an exploration of a broader range of diverse and interrelated factors. Thus, TPB is considered limited in its ability to fully address the multifaceted nature of DSC adoption in this study.

Appendix A4 – Technology Acceptance Model (TAM)

Among the many theoretical models, the Technology Acceptance Model (TAM) (Davis, Bagozzi and Warshaw,1989) was extensively employed in the information systems and marketing research studies to investigate the technological innovation adoption behaviour, particularly at an individual level. According to TAM, users' decision to adopt the technology is primarily influenced by two determinants or the so-called "beliefs" in the model, namely Perceived Usefulness (the degree in which the user believes that using the technology will improve their job performance) and Perceived Ease of Use (the degree in which the user believes that using the system would be effortless). These beliefs form the person's attitude towards the information systems, which in turn determine their behavioural intention and eventually their use of the technology. The original TAM is depicted in Figure A4-1.

Figure A4-1: Technology Acceptance Model (TAM) (Davis, Bagozzi and Warshaw, 1989)



The examination of existing literature reveals a substantial body of research that has utilized TAM to investigate the adoption of Industry 4.0 and SC 4.0. These studies often integrate TAM with other theories or models, or extend the model by incorporating additional constructs. For instance, Bakar et al. (2022) combined TAM with the Technology Readiness

Index (TRI) to evaluate and predict the behavioral intention to use industrial automation technology in the manufacturing sector. Similarly, Wamba and Queiroz (2022) integrated TAM with IDT, RBV, DC, and Institutional theory to explore the diffusion of Blockchain across supply chains.

Although a wide range of empirical and conceptual research studies has justified the significance of TAM model in explaining technological innovation adoption, the model has some limitations. Firstly, critics have noted that the attributes of TAM are too simplistic and incomplete (Taylor and Todd, 1995). Additionally, similar to IDT and TRA, TAM does not explicitly consider the external factors (Yousafzai, Foxall and Pallister, 2010). Hence, this makes it less effective in identifying contextual or situational barriers when applied across various situations. Gangwar, Date and Ramaswamy (2015) also claimed that although external variables were discussed in the model, insufficient emphasis was placed on them, and their definitions and significance varied across contexts, indicating a lack of clarity in the model's external attributes. In the context of DSC, its adoption is a collaborative effort that involves strong cooperation among SC organisations (Yang, Fu and Zhang, 2021). The adoption of DSC is influenced not only by internal factors such as organisational culture and resource availability but also by external factors such as market competition and interfirm collaboration. These factors are not the primary focus of TAM, which primarily considers individual attitudes and beliefs towards technology. Given the multifaceted nature of DSC adoption and the need to consider both internal and external environment factors, TAM may not be the most appropriate framework for exploring DSC adoption.

Appendix A5 – Unified Theory of Acceptance and Use of Technology (UTAUT)

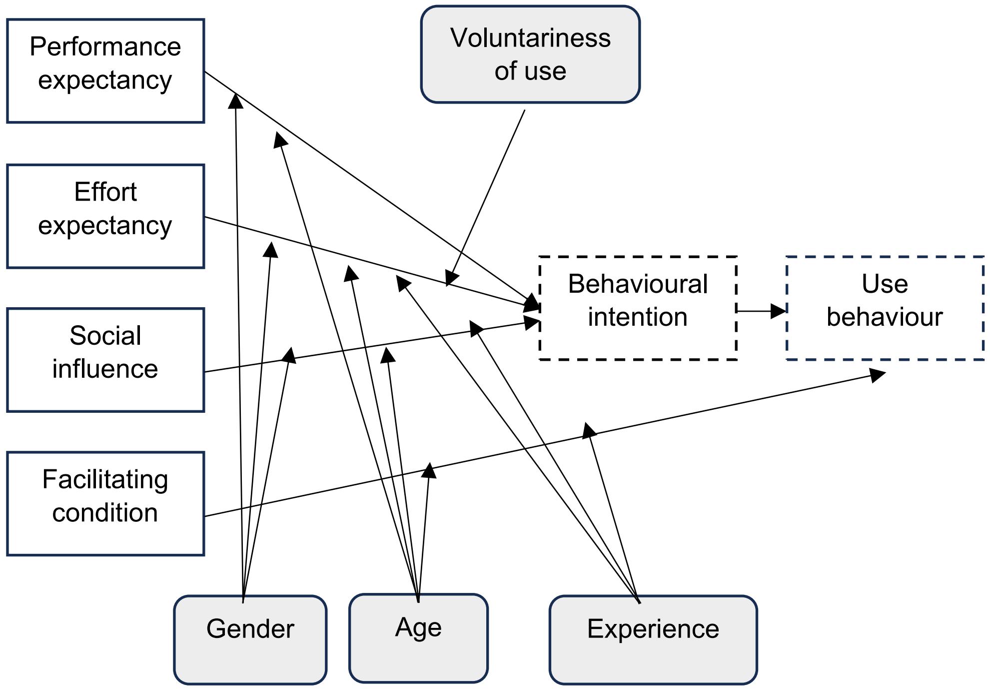
The field of technology adoption research has witnessed a use of a plethora of theories and models aimed at exploring various systems and technologies in diverse contexts. As a result, researchers face a dilemma when choosing the most appropriate models from a wide variety of competing models and theories (Williams, Rana and Dwivedi, 2015). In response to this challenge and to unify the literature associated with new technology adoption, Venkatesh et al. (2003) developed UTAUT model that brings together the alternative views regarding user's technology behaviour and acceptance by combining the most significant factors from eight competing technology acceptance models to explore the users' behavioural intention of IT. According to Venkatesh et al. (2003), there are several theoretical models investigating technology acceptance; however, research studies usually neglect the contributions of other models and do not evaluate these models when selecting the fit models and constructs. Hence, the authors integrated and tested eight theories to propose UTAUT which includes the most important 33 core constructs of these theories.

UTAUT suggested that four determinants which are Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions have significant impact on user's behavioural intention and subsequent behaviour. These determinants are moderated by Gender, Age, Experience, and Voluntariness of Use. Performance Expectancy refers to the user's perception of how the technology can improve their productivity and thus, lead to performance gains, which is conceptually and empirically similar to Perceived Usefulness in TAM. Effort Expectancy is the degree in which using the technology is free from effort, which it is conceptually and empirically identical to Perceived Ease of Use in TAM. Social Influence refers to the importance an individual places on others' opinions of their technology use, while Facilitating conditions is the individual's perception that organisational and technical resources are available to support the use of technology. The model is illustrated in Figure A5-1 below.

Given its ability of integrating eight theories to provide diverse perspectives into technology adoption, UTAUT has been extensively employed in the studies of Industry 4.0 and SC 4.0 adoption. For instance, Francisco and Swanson (2018) have employed UTAUT to study the adoption of Blockchain for supply chain transparency. Similarly, Uba and Whitfield (2020) also used the model to explore the adoption of blockchain technology in the oil and gas Industry supply chain. On the other hand, the framework was applied in the study of Ronaghi and Forouharfar (2020) to understand the usage of IoTs in smart farming.

While UTAUT is a widely used model of technology adoption in a variety of settings and contexts, it has also faced criticism for its limited ability to account for the unique characteristics of specific use situations and context (Williams, Rana and Dwivedi, 2015). Additionally, UTAUT has predominantly been applied to investigate technology adoption at the individual level, rather than at the organisational or interorganisational level (Kiwanuka, 2015). As a result, UTAUT may not offer organisations sufficient insights to fully capture the complexity of technology adoption in their unique organisational and environmental settings, particularly in collaborative environments like supply chains. Hence, while UTAUT is a valuable framework for understanding technology adoption at the individual level, it may not be the most suitable framework for exploring the complexities and dynamics of DSC adoption.

Figure A5-1: Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003)

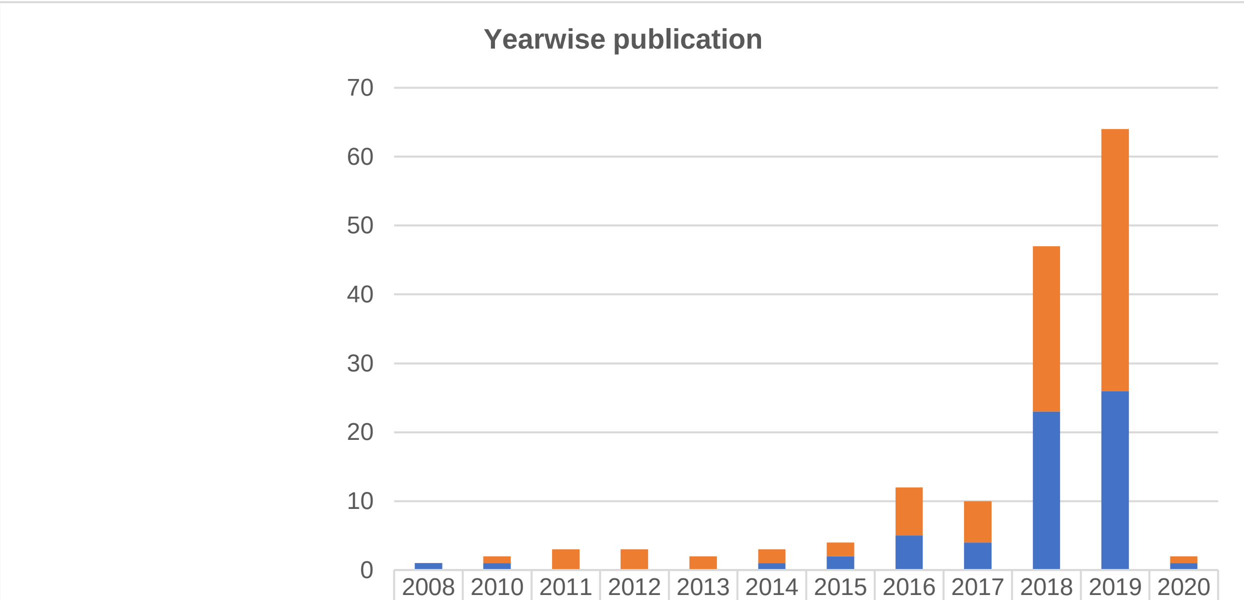


APPENDIX B – SLR: Descriptive Analysis Outcome

The descriptive analysis technique, as proposed by Haneem et al. (2017), aims to identify trends in the distribution and development of related literary works over time, as well as the authors, sources/databases, and major journals or publishers. The descriptive analysis of the SLR reveals several trends in the literature on Industry 4.0 and its implementation in SCM. These trends include a growing interest in the topic over time, as evidenced by the increasing number of publications in recent years. Additionally, the analysis revealed that certain authors and publishing sources have been particularly influential in the field.

Moreover, the descriptive analysis technique enables the identification of gaps in the literature, such as the relatively low number of scientific articles on implementation factors and applications of Industry 4.0 in SCM in certain databases. This information can inform future research efforts and help researchers to focus their attention on areas where additional contributions are needed. The subsequent section will present the descriptive findings obtained from the systematic literature review.

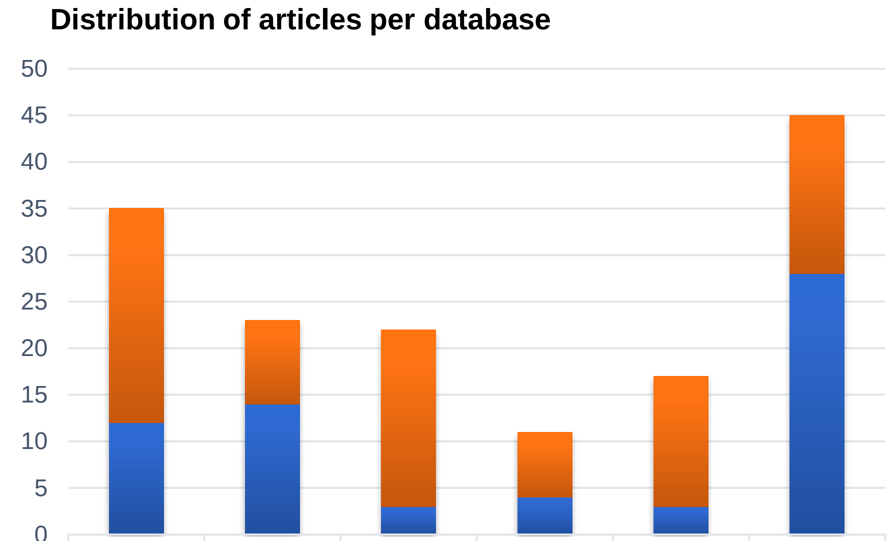
Figure B-12-1: Year wise publications.



	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
I4.0 generally focused articles	0	1	3	3	2	2	2	7	6	24	38	1
SC 4.0 focused articles	1	1	0	0	0	1	2	5	4	23	26	1

In term of year wise publications, the literature identified in this study consisted of 153 papers that were published between 2008 and 2020. Figure B-1 displays the distribution of these papers across the studied period. Out of the 153 articles, 64 were focused on digital supply chain (SC 4.0) while the remaining 89 were generally focused on Industry 4.0. The figure highlights the presence of a growing trend in the number of articles that explores the implementation factors of Industry 4.0 and SC 4.0 specifically, suggesting an increasing interest in these areas. This trend may be attributed to the high pressure from the competition and market, as well as the opportunities presented by emerging technologies, which have encouraged more organisations to investigate Industry 4.0 and integrate it into their supply chain systems to tackle new challenges (Qin, Liu and Grosvenor, 2016).

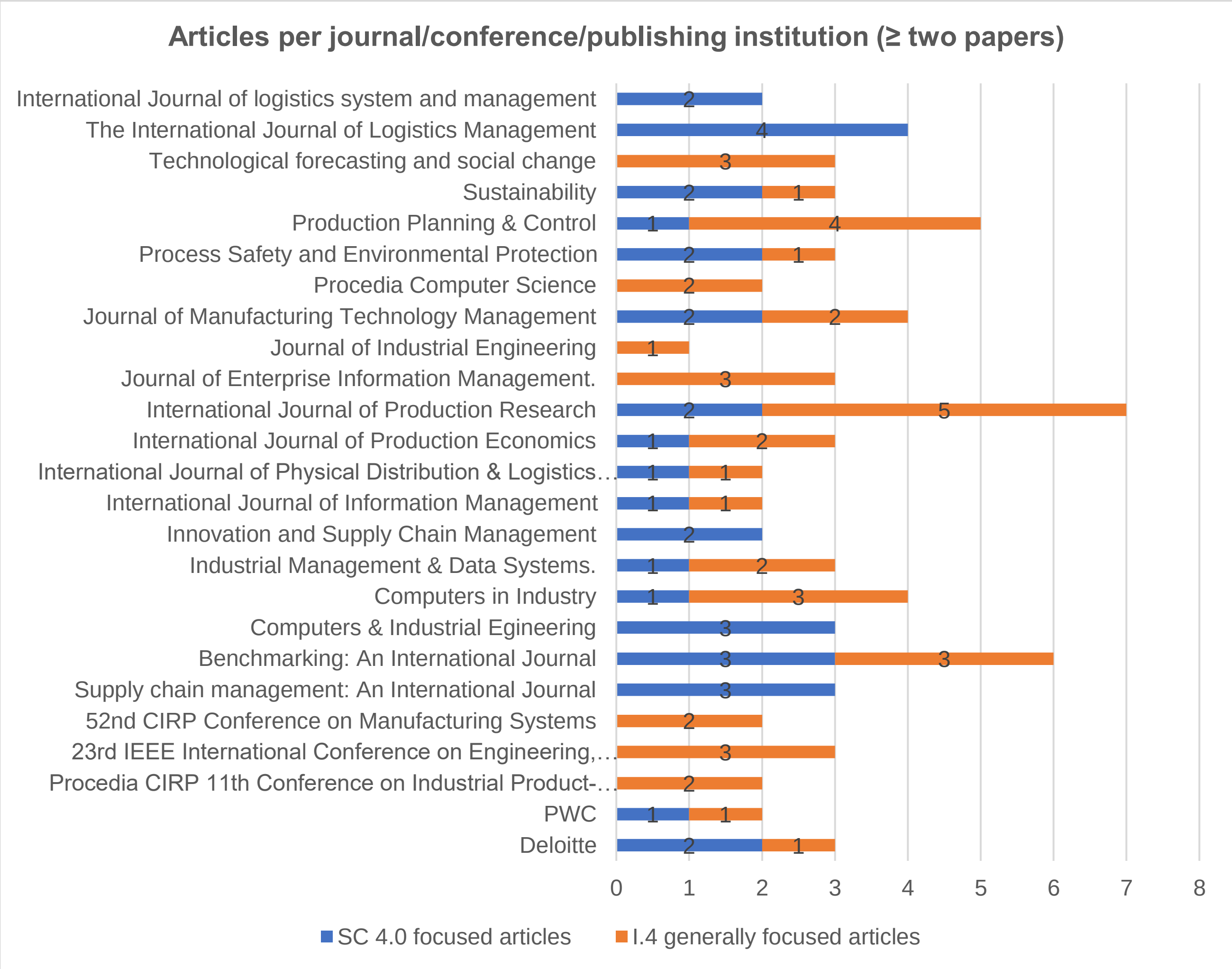
Figure B-12-2: Contribution from databases.



	Science direct	Emerald	Scopus	Taylor and Francis	Business Source	Google scholar
I.4 generally focused articles	23	9	19	7	14	17
SC 4.0 focused articles	12	14	3	4	3	28

Regarding the distribution of articles per database, as illustrated in Figure B-2, a significant proportion of the articles are concentrated in Google Scholar and Science Direct, with Scopus and Emerald following closely behind. However, the number of articles in Taylor and Francis and Business Source Complete is comparatively lower. Notably, Scopus and Business Source have a relatively low number of scientific articles (only three articles in each database) on the implementation factors and applications of Industry 4.0 in the context of supply chain, compared to a higher number of papers solely focused on Industry 4.0 (19 and 14 articles, respectively). Conversely, both Emerald and Google Scholar have experienced a remarkable surge in SC 4.0 focused articles, surpassing the number of Industry 4.0 generally focused ones within their respective databases. The surge in interest in this field is a clear indication of its significance and implies the need for further exploration to establish reference frameworks that can be used as a basis for future research. This will help to consolidate the field and enhance our understanding of DSC.

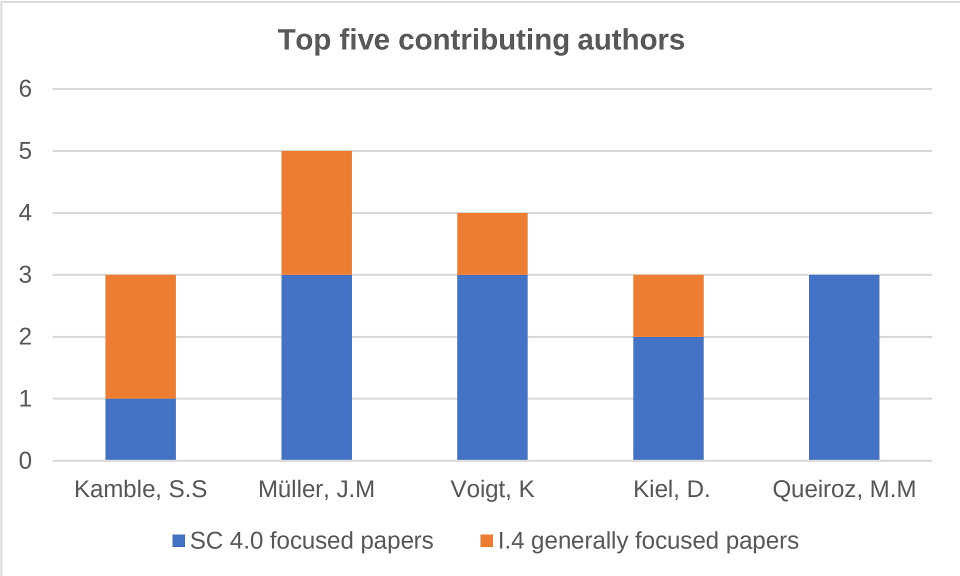
Figure B-12-3: Contributions by journals/conferences and publishing institutions.



In term of contribution by journals and publishing institutions, Figure B-3 depicts the considerable attention given by numerous journals, conferences, and publishing institutions to Industry 4.0 and its implementation in SCM. The study identified 153 articles published in 108 different publishing sources, such as institutions, journals, and conferences. To illustrate their significant contribution and avoid a lengthy chart, sources with only one article were excluded from the figure.

According to the findings in Figure B-3, the International Journal of Production Research, Benchmarking: An International Journal, and Production Planning & Control are the top three most reputable sources, with 7, 6, and 5 articles respectively. They are followed by the International Journal of Logistics Management, Journal of Manufacturing Technology Management, and Computers in Industry, each with 4 articles. These sources have made a significant contribution to the literature on Industry 4.0 and supply chain, indicating their value to researchers.

Figure B-12-4: Top five contributing authors.



In term of contribution by authors, Figure B-4 highlights the top five authors who have demonstrated a substantial commitment, contributing to at least three papers with significant focus on Industry 4.0 and SC 4.0 development. It is evident that Muller J.M has shown remarkable dedication to the research development of Industry 4.0, particularly in the supply chain domain, having solely published and co-published five papers with co-authors. Voigt K follows with four articles, while Kamble S.S, Kiel D, and Queiroz M.M have each published three articles. Queiroz, in particular, exhibits significant enthusiasm for the application of Industry 4.0 in the supply chain, contributing all three research papers in this field. Notably, while some authors have conducted research studies in both Industry 4.0 and SC 4.0 development, there are those who focus solely on one area.

APPENDIX C – Research Methodology

Appendix C1 – Summary of Research Philosophies

Table C1-1: Summary of research philosophies (Adapted from Saunders, Lewis and Thornhill (2019); Iofrida et al. (2014); Bryman and Bell (2011); Lincoln, Lynham and Guba (2011); Crotty (1998); Guba and Lincoln (1994)

	Positivism	Interpretivism	Pragmatism	Critical realism
Ontology	There is only one single objective truth or social reality, determined by immutable natural laws. Therefore, social reality is observable, external and exists independently of human perceptions or interpretations.	There are multiple realities as they are created by individual experiences and interpretations. Therefore, social reality is complex, dependent from subject, and constructed through the meanings that they develop in social and experiential contexts.	There are multiple realities as the social reality is constantly re-negotiated, debated and interpreted based on their usefulness and practicality in addressing problems and unpredictable situations. Therefore, reality is not fixed or universal, but rather is the practical consequences of ideas.	Reality and knowledge are shaped by historical and social context, and is therefore specific to its time and place, and that social facts are social constructions agreed upon on by individuals or communities. Therefore, reality is external, objective, independent, stratified but at the same time imperfectly understandable and not directly accessible through observation alone. Rather, reality is a complex and multifaceted construct that is shaped by a variety of social, cultural, and historical factors.
Epistemology	Reality can be measured by strictly scientific empirical testing and verification of	Reality can be comprehended by in-depth exploration of the underlying meanings of the	Reality can be measured and interpreted through multiple different methods as no single point of view	Reality can be observed by looking beyond the surface-level observations of phenomena and instead seeking to

	hypotheses, and examination of casual relationships to yield pure data and facts that are free from human interpretation or bias so that law-like generalisations can be produced.	events, activities and subjects. However, this exploration is always influenced by prior beliefs, values, assumptions, and interests, which shape the way the world is investigated and understood.	can ever provide a complete and comprehensive picture. Rather, any method(s) that can provide credible, well-founded, reliable and relevant data, and enable successful action is/ are the best one(s). This suggests that different methods may be appropriate for different contexts and purposes.	identify the underlying structures, causes, and mechanisms that generate them. This involves in-depth historical analyses of social and organisational structures, and examining how they have evolved and transformed over time.
Methodology	Typically deductive approach, quantitative, highly structured, large samples (Experiment research, Survey research, etc.)	Typically inductive approach, qualitative, small samples, and in-depth investigation/ (Ethnography, Grounded research etc.)	Mixed methods (Action research, Design-based research, etc.)	Retroductive, mixed methods to investigate the social structures and how they have changed overtime
Typical methods	Questionnaire, statistical analysis, structured interviews, etc.	In-depth interviews, observation, interpretive case studies, etc.	Combination of both qualitative and quantitative methods	Combination of both qualitative and quantitative methods

Appendix C2 - Summary of Research Strategies

Table C2-1: Summary of research strategies

Research strategy	Case study	Ethnography	Action research	Experiment/ Simulation and modelling	Survey
Nature and its application	An in-depth investigation into a phenomenon within its real-life context (Yin, 2017). It is commonly used to build theory rather than test it (Jaspers, 2003). The number of papers across scientific disciplines have employed both single or multiple case strategy (Jaspers, 2003)	This studies the culture or social world of groups of people within an organisation or society (Saunders, Lewis and Thornhill, 2019), requiring researchers to immerse themselves in the group being studied, often for an extended period of time, in order to observe and interact with them. It is most relevant when researchers aim to gain an in-depth understanding of the context or experiences of the participants, rather than simply measuring and analysing objective data (Korstjens and Moser, 2017; Granot, Brashear and Cesar Motta, 2012).	It aims to identify practical solutions to real organisational problems through a participative and collaborative approach (Coghlan and Brannick, 2014; Coghlan, 2011). Unlike other research strategies, action research is distinguished by its emphasis on solving the problems through practical actions and changes within the organisation (Saunders, Lewis and Thornhill, 2019; Silverman, 2015).	It has been one of the traditional strategies that has been extensively utilised in the field of SCM (Mentzer and Kahn, 1995). This strategy is typically employed when researchers seek to investigate the functioning of a system in various scenarios and conditions, to identify optimal operating conditions and explore different possibilities by altering variables such as procedures or conditions without intervening in the real context (AbuKhousa et al. 2014). In SCM, this strategy is commonly used to address questions related to the structure, operation, and integrity of the supply chain, as well as to	Data collected from a survey strategy can be used to suggest possible reasons for relationships between variables and build a model of these relationships.

				explore “what-if” scenarios in relation to strategy.	
Form of research questions	“How” and “Why” questions	“How” and “Why” questions	“How” and “What” questions	“How” and “Why” questions	“Who”, “What”, “Where”, “How much”, and “How many” questions
Required control over behavioural events	No	No	No	Yes	No
Emphasis on contemporary events	No	No	Yes	Yes	Yes
Research philosophy and methodology	Although case study strategy has often been associated with interpretivists and qualitative methods (Näslund, 2002), both qualitative and quantitative methods have been employed in various ways to serve different purposes (Yin, 2017; Soni and Kodali, 2012; Eisenhardt, 1989). Hence, both positivists and interpretivists use case studies for descriptive, exploratory, or explanatory purposes, employing deductive or inductive approaches.	It is a qualitative research approach that is rooted in interpretivism, which emphasises the importance of subjective understanding and interpretation of the social world (Näslund, 2002).	Pragmatism frequently serves as the foundational philosophy in action research, highlighting the significance of practicality and the use of knowledge to address real-world issues. Therefore, both qualitative and quantitative methods can be employed in action research strategy.	This strategy is based on positivism and quantitative model-based methodologies aimed at studying constraint effects (Bell, Bryman and Harley, 2022).	Typically associated with a deductive approach that tests theories or theoretical models with empirical data (Boyer and Swink, 2008; Forza, 2002), survey research involves collecting data from individuals using questionnaires, emails, telephone calls, structured observations, or personal interviews (Rossi, Wright and Anderson, 2013). Hence,

					it is most frequently used by positivists and is primarily based on quantitative data, although there are few cases of data triangulation where both qualitative and quantitative methods are used with the weight and priority given to the quantitative data (Soni and Kodali, 2012).
Advantages	One of the key strengths of case study research is its ability to provide a depth of insights regarding the phenomenon by contextualising the cases (Eisenhardt and Graebner, 2007), leading to rich, empirical descriptions and development of theory (Yin, 1994; Eisenhardt, 1989). Researchers using case study strategy usually collect data via in-depth interviews rather than	This approach allows researchers to gain a deep insight into the shared beliefs, behaviors, language, and rituals that shape the lives of the group members (Cunliffe, 2010).	Through identifying problems, planning, taking actions, and evaluating outcomes, action research promotes organisational learning and practical solutions that benefit both participants and the organisation beyond the research project.	Through formulating a conceptual model and conducting an experiment, researchers can gain insights into real-world problems.	Survey strategy using questionnaires is particularly popular as it allows researchers to collect standardised data from a large number of respondents economically (Saunders, Lewis and Thornhill, 2019; Kotzab, 2005).

	using closed-end questionnaires (Dubois and Araujo, 2007).				
Disadvantages	Its limited ability to serve as a foundation for scientific generalisation, reliability, and theoretical contributions to knowledge due to its extensive focus on a particular situation (Saunders, Lewis and Thornhill, 2019; Yin, 1994). Additionally, case study strategy can be more time-intensive, labor-intensive, and costly in comparison to survey methods, (Daniels and Cannice, 2004; Voss, Tsikriktsis and Frohlich, 2002; Nieto and Pérez, 2000; and Schell, 1992) with inherent research risks (Yin, 2003).	Ethnography is a demanding research strategy that requires a significant investment of time and effort for observation, reflection, and evaluation (Simmons and Smith, 2019; Jeffrey and Troman, 2004; Eckert, 1997).	Due to the intensive time and resources commitment required to facilitate participation and collaboration of participants through multiple stages of research, action research is considered as a quite demanding strategy (Tomal, 2010; Simonsen, 2009). Therefore, it can be suitable to part-time students. Hence, action research strategy is not widely used in SCM research	…..	One potential issue is research findings bias caused by the collection of data from a single source (Näslund, 2002), lack of representation and generalisation due to low response rate, and respondents' interpretation bias due to their limited knowledge and information (Boyer and Swink, 2008). Additionally, there is a limit to the number of questions that can be included in the questionnaires (Saunders, Lewis and Thornhill, 2019), inconsistent comprehension of terms, and an inability to clarify them, which can reduce

the internal validity of data (Grant, Teller and Teller, 2005). Nonetheless, as claimed by Singhal et al. (2008), these shortcomings can be mitigated by employing appropriate statistical techniques, such as the use of random sampling techniques or independent variable test (Bell, Bryman and Harley, 2022; Boyer and Swink, 2008). Moreover, some studies have used data triangulation to overcome the limitations of quantitative data (Soni and Kodali, 2012). By addressing these issues, survey research can be a valuable strategy for advancing scientific

		knowledge in the field of SCM.

Appendix C3 – Mixed-methods Research Designs

Table C3-1: Mixed-methods research designs (Morgan and Hoffman, 2021; Saunders, Lewis and Thornhill, 2019; Creswell and Creswell, 2017; Schoonenboom and Johnson, 2017; Hesse-Biber, 2015; Palinkas et al., 2011; Leech and Onwuegbuzie, 2009; and Morgan, 1998)

Design	Integrated design	Definition and purpose
Convergent	QUAN = QUAL	Quantitative and qualitative data are collected at the same time and analysed separately. After both analyses are complete, the results are compared to draw comprehensive and cohesive conclusions.
Concurrent and Integrated design	QUAN + qual	The simultaneous design combines both quantitative and qualitative methods in a single study, with the dominant component being quantitative and the less dominant or supplemental component being qualitative. In other words, a qualitative design is included within a larger quantitative design. The primary objective of this design is to confirm and test hypotheses using quantitative data while providing additional context and insights through qualitative data.
	QUAL + quan	The simultaneous design that incorporates both qualitative and quantitative methods, with the dominant component being qualitative and the less dominant or supplemental component being quantitative. In other words, a quantitative design is included within a larger qualitative design, The primary purpose of this design is to explore new insights, theories, and generate hypotheses through qualitative data while providing additional quantitative data to support or refute these ideas.

	QUAL + QUAN	Simultaneous design that integrate both qualitative and quantitative studies to gain a more complete understanding of a complex research topic, with equal weight given to both methods.
Sequential design	QUAL → quan	Sequential design that involves conducting a qualitative study as the dominant component, followed by a smaller quantitative study as a less dominant or supplementary component. The primary purpose of this design is to explore new insights, theories, and generate hypotheses through qualitative data while providing additional quantitative data to offer statistical support to the qualitative findings and help to generalise the results to a larger population.
	QUAN → qual	Sequential design that involves conducting a quantitative study as the dominant component, followed by a smaller qualitative study as a less dominant or supplementary component. The primary purpose of this design is to confirm and test hypotheses through the quantitative data while providing additional qualitative data to explain the underlying reasons and motivations behind the quantitative data, especially the poorly understood or unexpected findings such as outliners.
	qual → QUAN	Sequential design that involves conducting a quantitative study as the dominant component, preceded by a smaller qualitative study as a less dominant or supplemental component. The primary objective of this design is to confirm and test hypotheses using primarily quantitative data, complemented by qualitative data that helps to provide valuable insights, generate hypotheses and develop content for questionnaires or interventions used in the quantitative study.
	quan →QUAL	Sequential design that involves conducting a qualitative study as a dominant component, preceded by a smaller quantitative study as the less dominant or supplementary component. The primary purpose is to explore new insights/ theories and generate hypotheses through qualitative data, complemented by quantitative data that helps to guide purposive sampling and establish preliminary results that can be further explored in-depth during the qualitative study.

APPENDIX D – Data Collection Preparation

Appendix D1 – Semi-structured Interview Guide

Empirical investigation on Industry 4.0 technologies adoption in supply chain in Vietnamese firms.

This semi-structured interview aims to explore the diverse views and opinions of management level regarding the inhibiting and driving or supporting factors as well as these factors' impact on the Industry 4.0 implementation in supply chain in Vietnamese firms. Due to the research's mixed method sequential exploratory design, the nature of the qualitative interviews will be dynamic. Some probing questions will emerge after the interviewee's answers to the main interview questions. This will help to explore further the important topics considered by the interviewees.

Pre-Interview Checks

- ✓ Introduction of the interviewer and background information to establish credibility
- ✓ Brief explanation of the research topic, purpose, and its relevance
- ✓ Clear communication of the terms and conditions of the research, ensuring transparency, anonymity and confidentiality of data
- ✓ Explanation of the reasons why the interviewee was selected for the study, highlighting their expertise and relevance to the research
- ✓ Overview of the interview structure, including a description of the interview questions and the expected duration
- ✓ Further discussion or clarification on the research if desired by the interviewees.

The participant has read the participant information sheet
The participant has signed the consent form
The participant has said whether they wish to receive the final report

The participant gives verbal consent for the interview to be recorded (please ensure this is on the recording)

PRESS THE RECORD BUTTON

Time frame	Main Theme	Supplementary Questions / Prompts	Main goal
2 minutes	What are your position and responsibilities in the company?		• Their role/title or level of management within their company • Their general and daily responsibilities in their company's supply chain activities
30s	In which sector is your company active? The sector can be: • Automotive • Seafood processing • Agriculture processing • Pharma • Industrial manufacturing • Software/IT services • Sales/Retail • Chemicals • Aerospace, defence & security • Consulting		

	• Electronics • Oil & Gas • Transportation & logistics • Forest, paper & packaging • Metals • Engineering & construction • Commerce & Tourism • Textile • Others
30s	What size of your company? • Micro enterprises (<10 employees) • Small enterprises (10-200 employees and capital is < 20 billion VN dong) • Medium-sized enterprises (200 to 300 employees and capital is 20-100 billion VN dong • Large enterprises (>300 employees and capital is >100 billion VN dong)
30s	What part of Vietnam is your company in? • North • South • Middle • their company/corporation are located all over Vietnam.

2 minutes	Your years of experience in the Industry and in the company?		• Their years of experience in the current role and in the company in general • Their years of experience in the Industry Their years of experience in the SCM field (note: it can be logistics, procurement, warehouse management, operation, manufacturing
7-10 minutes	Have you heard about Industry 4.0 technologies and what is your understanding of Industry 4.0 in SC?	Do you understand the differences between Industry 3.0 and Industry 4.0? Has your organisation adopted Industry 4.0 technologies in supply chain activities and at what extent has your organisation adopted it?	Describe the concept of Industry 4.0 and its application on supply chain in industries, supply chain and their organisation's operational activities (if applicable) with the aim of investigating and gaining insights into level of Industry 4.0 adoption and the maturity level of digital transformation in Vietnamese organisations. Try not to influence the interviewees' understanding of the concept as we try to have real observation Note: A general non-technical definition and examples of Industry 4.0 concept and clear clarification of the distinction

			between Industry 3.0 and Industry 4.0 would be provided if needed.
10 – 12 minutes	**Organisational factors:** • What organisational factors (organisational resources, organisational structure or infrastructure, etc.) support, drive or push the adoption of digital (I 4.0) technologies into the company's SC? And how can these organisational factors support/drive/enable DSC? 2 What organisational factors (organisational resources, organisational structure or infrastructure, etc.) inhibit or limit the adoption? And how can these organisational factors limit or inhibit DSC?	Are there any organisational factors you can think of can influence your company's DSC adoption?	Provide lists of internal organisational environment factors that can impact the organisation's decision in DSC adoption Specify which factors are current enablers and barriers Describe how these factors drive/support and inhibit the organisation's adoption of digital (Industry 4.0) technologies in their supply chains Note: ask interviewees to describe each factor's impact
10 – 12 mins	**Environmental factors** • What environmental factors (government, Industry or partners, etc.) support, drive or push the adoption of digital (I 4.0) technologies into the company's SC? And how can these environmental factors support/drive/enable DSC? • What organisational factors (government, Industry or partners, etc.) inhibit or limit the adoption? And how can these environmental factors limit or inhibit DSC?	Are there any environmental factors you can think of can influence your company's DSC adoption?	Provide lists of external organisational environment factors that can impact the organisation's decision in DSC adoption Specify which factors are current enablers and barriers Describe how these factors drive/support and inhibit the organisation's adoption of digital

			(Industry 4.0) technologies in their supply chains Note: ask interviewees to describe each factor's impact
10 – 12 mins	**Technology attributes** What evaluation criteria or attributes of the technologies that you consider when implementing these digital (Industry 4.0) technologies?	Are there any technological attributes factors you can think of can influence your company's DSC adoption?	Provide lists of technology attribute factors that can impact the organisation's decision in DSC adoption Specify which factors are current enablers and barriers Describe how these factors drive/support and inhibit the organisation's adoption of digital (Industry 4.0) technologies in their supply chains Note: ask interviewees to describe each factor's impact
10 – 12 mins	**Role of the organisational culture (ex. values, norms or management style etc.) in the digital technology adoption:** • What are the values and norms of your organisational culture (for example: hierarchy focus; teamwork and idea sharing focus, etc.) • How does this culture affect the digital technology adoption**?**		Describe their organisational culture such values, norms, management style Explain how these values, norms and management style influence (support or demotivate) the adoption Note: the interviewee can describe their organisational culture type as follows.

Their culture can be the combination of few

Culture type 1: Hierarchical culture

- Even small matters have to be referred to top management for a final answer
- Any decision made by lower employees has to be approved by the manager
- There can be little action taken here until the manager approves a decision
- Our organisation is very hierarchical
- There are many levels between the lowest level in the organization and top management

Culture type 2: Group culture

- Our organisation encourages employees to work as a team

- Our organisation encourages employees to exchange opinions and ideas
- Our organisation frequently hold group meetings together where employees can really discuss things together
- Generally speaking, everyone in our organisation works well together
- Departments in our organisation communicate frequently with each other

Culture type 3: Rational culture

- Our organisation's incentive system encourages us to vigorously pursue organisational objectives
- In our organisation, goals, objectives and strategies are communicated to me
- Our organisational has a formal strategic planning process, which results in a written mission

			long-range goals and strategies for implementation • Our top management routinely reviews and updates a long-range strategic plan • We encourage employees to work together to achieve common goals, rather than encourage competition among individuals **Culture type 4: Developmental culture** • Our organisation stays on the leading edge of new technology in our Industry • Compared with our Industry, we introduce new products more slowly • We have reduced the time to introduce products by designing product and process together
2 minutes	Any further comments / points	• We're approaching the end of the interview, is there anything you'd like to discuss further?	• Is there anything you'd like to ask me? • Do you know anyone

	• Is there anything you'd like to add?

Appendix D2 – Participant Information Sheet and Consent Form

Participant Information Sheet

Project Title: An empirical investigation into Industry 4.0 technologies adoption in supply chain in Vietnamese firms.

Researcher:

Nguyen Thu Giang

PhD student in Supply Chain Management

Contact Details:

Department: Faculty of Business and Law (FBL)

Email: ….

You are invited to take part in research taking place at the University of the West of England, Bristol. It is funded by **Faculty of Business and Law (FBL), University of the West of England, Bristol.** Before you decide whether to take part, it is important for you to understand why the study is being done and what it will involve. Please read the following information carefully and if you have any queries or would like more information please contact Nguyen Thu Giang, Faculty of FBL, University of the West of England, Bristol via email…..

The research is carried out by Nguyen Thu Giang, supervised by Professor Vikas Kumar who is also Director of Studies and Dr. Anabela Soares. The team's bios and details of their work are available at:

Professor Vikas Kumar…

Dr. Anabela Soares:…

The research aims to identify the inhibiting and supporting or driving factors as well as these factors' impact on the adoption of Industry 4.0's digital technologies (e.g. artificial intelligence, 3D printing, cloud computing and blockchain) into supply chain in Vietnam. Our main research requestions are:

1. What are the inhibiting factors (barriers) and supporting or driving factors (enablers) of Industry 4.0's digital technologies implementation in supply chain (Supply chain 4.0) in Vietnamese firms?
2. How do Technology, Organisation and Environment factors affect this digital technology adoption in supply chain in Vietnamese firms?
3. What is the role of organisational culture in SC 4.0 adoption for Vietnamese firms?

To help us answer these questions we will be conducting semi-structured interviews and subsequently a questionnaire to explore a diverse range of managerial experience and views on digital technologies adoption in supply chain context in Vietnam so the interview will ask you about these things. We will not be asking any questions about your personal details such as your name, gender and company's name.

Stage 1: Interview:

You do not have to take part in this research. However, if you do decide to take part in as an interviewee of the research, you will be given a copy of this information sheet to keep and will be asked to sign a consent form. You will also be given a unique identifier which will be used to re-identify you if you choose to withdraw from the study. You are able to withdraw from the research without giving a reason until the point at which your data is anonymised and can therefore no longer be traced back to you. **This point will be 2 weeks from the date you signed your consent form.** If you want to withdraw from the study within this period, please write to Nguyen Thu Giang (….). Deciding not to take part or to withdrawal from the study does not have any penalty and does not affect your and your company's reputation.

The interviews will be conducted by Nguyen Thu Giang and estimated 45-60 minutes. The researcher have knowledge of the subject matter and are sensitive to issues it may raise. The interviews will be held online in Teams. All interviews will be recorded using recording function of the digital platform but the recording will not contain your name. Your answers will be fully anonymised. At the point of anonymised transcription, your Teams interview recording will be destroyed securely immediately. Your data will be anonymised at this point and will be analysed with interview data from other anonymised participants. We will ensure that there is no possibility of identification or re-identification from this point.

As mentioned above, all the information we receive from you will be treated in the strictest confidence. All the information that you give will be kept confidential and anonymised within **two weeks** of your interview. The only circumstance where we may not be able to keep your information confidential is if the information exposes a serious threat to yourself or others, or if there is evidence of criminal offence or professional misconduct that we are legally obliged to report. Hard copy research material will be kept, in a locked and secure setting to which only the researchers will have access in accordance with the University's and the Data Protection Act 2018 and General Data Protection Regulation requirements.

We do not foresee or anticipate any significant risk to you in taking part in this study. If, however, you feel uncomfortable at any time you can ask for the interview to stop. If you need any support during or after the interview then the researcher will be able to put you in touch with suitable support agencies. The interview has been designed with these considerations in mind.

Stage 2: Questionnaire

If you take part in as a questionnaire participant, all of your data collected will be anonymous and used solely for the purpose of statistical data analysis. The anonymised data will be kept in a password protected file in a password protected computer. You have the right to withdraw from the research without giving a reason. Please note that once you press the submit button of the questionnaire, you will be unable to withdraw your answers from the research as your data is completely anonymous. Therefore, we will not be able to identify which questionnaire is yours to withdraw.

If you take part in this research, you will be helping us to gain a better understanding of the reasons why firms in Vietnam are or are not adopting digital technologies into their supply chain. It can then help to offer practical suggestions to the companies and the government about policies, strategies and other changes regarding this adoption in not only Vietnam but also other developing countries where digital technologies have emerged and influenced.

The results of our study will be analysed anonymously and used in the researcher's dissertation made available on the University of the West of England's open-access repository. The anonymised results may also be used in conference papers and peer-reviewed academic papers. A hard copy of the Report will be made available to all research participants if requested. Key findings will also be shared both within and outside the University of the West of England. Anonymous and non-identifying direct quotes may be used for publication and presentation purposes.

The research has been reviewed and approved by the University of the West of England University Research Ethics Committee. Any comments, questions or complaints about the ethical conduct of this study can be addressed to the Research Ethics Committee at the University of the West of England at: Researchethics@uwe.ac.uk

If you have any concerns, queries and/or complaints, please contact in the first instance:

Nguyen Thu Giang

Bristol Business School

Frenchay Campus

Coldharbour Lane

Bristol

BS16 1QY

Thank you very much for agreeing to take part in this study.

You will be given a copy of this Participant Information Sheet and your signed Consent Form to keep.

Consent Form - Interviews

Research title: Empirical investigation of Industry 4.0 adoption in Supply chain in Vietnamese firms.

This consent form will have been given to you with the Participant Information Sheet. Please ensure that you have read and understood the information contained in the Participant Information Sheet and asked any questions before you sign this form.

If you have any questions, please contact the researcher whose details are set out on the Participant Information Sheet.

If you are happy to take part in the interview, please sign and date the form. You will be given a copy to keep for your records.

- I have read and understood the information in the Participant Information Sheet which I have been given to read before asked to sign this form;
- I have been given the opportunity to ask questions about the study;
- I have had my questions answered satisfactorily by the research team;
- I agree that anonymised quotes may be used in the final Report of this study;
- I understand that my participation is voluntary and that I am free to withdraw at any time until the data has been anonymised, without giving a reason;
- I agree to take part in the research

Name (Printed)………………………………………………………………………….

Signature…………………………………………………. Date…………………….

Researcher Details

Nguyen Thu Giang

Appendix D3 - Summary of Research Model Factors' Dimensions, Dimensions' Corresponding Indicators and Definitions

Factors	Dimensions	Definition	Indicators	Definition
Technology	**Perceived risks**	The problems and uncertainties that firms encounter when adopting new technologies (Hsu, Ray and Li-Hsieh, 2014).	Complexity	The perceived complexity of implementing and managing new technologies (Lai, Sun and Ren, 2018; Wei, Lowry and Seedorf, 2015; Oliveira, Thomas and Espadanal, 2014; Tsai, Lee and Wu, 2010; Wang, Wang and Yang, 2010);
			Absence of interconnection standards	The lack of standardised protocols for integrating and connecting different technologies (Arnold and Voigt, 2019; Tsai, Lee and Wu, 2010)
			Cybersecurity risks	Concerns related to the security and protection of digital systems and data (Bienhaus and Haddud, 2018; Haddud et al., 2017; Lai, Sun and Ren, 2018; Chan and Chong, 2013)
			Incompatibility issues	The perceived incompatibility between digital technologies and existing systems or processes (Oliveira, Thomas and Espadanal, 2014; Chan and Chong, 2013)
			High adoption cost	The perceived financial investment required to adopt and implement digital technologies (Wong et al., 2020; Wei, Lowry and Seedorf, 2015; Lian, Yen and Wang, 2014; Tsai, Lee and Wu, 2010)
			Short lifespan of technologies	The limited duration or period of relevance and effectiveness for technological advancements or innovations. It implies that technologies can quickly become outdated or obsolete, necessitating frequent updates, replacements, or upgrades to remain current with evolving trends and user demands. The rapid pace of technological development and the emergence of newer, more advanced technologies contribute to the

			perceived short lifespan of existing technologies (semi-structured interview findings)
		Dependence on the technology providers	The extent to which organisations rely on external technology providers for various aspects, including procurement, updates and maintenance, technical support, expertise, infrastructure, software applications and licensing, and overall functioning of technological solutions or services (semi-structured interview findings)
Perceived benefits	Users' perception of the advantages offered by new technologies (Yacob and Peter, 2022).	Product and/or service customisation	The ability to tailor products and services to meet individual customer needs (Arnold and Voigt, 2019; Arnold, Veile, and Voigt, 2018);
		Productivity and flexibility	The potential for increased productivity and operational flexibility (Arnold and Voigt, 2019; Queiroz and Wamba, 2019; Lin and Lin, 2014; Oliveira, Thomas and Espadanal, 2014)
		Resource savings	The expected reductions in resource usage and associated cost savings (Arnold and Voigt, 2019; Wei, Lowry and Seedorf, 2015)
		Quick data capture and analysis	The ability to efficiently capture and analyse data for decision-making purposes (Chan and Chong, 2013; Wang, Wang and Yang, 2010)
		End-to-end monitoring	The capability to monitor and track activities across the entire supply chain (Chan and Chong, 2013)
		Health and safety of employees	The potential of digital technologies to enhance and safeguard the health and safety of employees by reducing risks associated with manual work (semi-structured interview findings)

			Defects and maintenance reduction	The benefits derived from digital technology adoption in early defect detection that helps minimise the occurrence of faulty products, as well as the ability to predict and prevent equipment failures and breakdowns, thereby reducing the need for reactive maintenance (Dutta et al., 2021; Javaid et al., 2021) (semi-structured interview findings)
Organisation	**Organisational resources**	The tangible (physical assets) and intangible (human resources, skills, and experience) resources that a firm possesses to implement innovations (Lai, Sun and Ren, 2017)	Human resources' competence and willingness for change	The capabilities and readiness of the workforce to embrace and adapt to change (Henao-García, Arias-Pérez and Lozada, 2021; Kumari, Jeble and Patil, 2018; Gupta and George, 2016; Oliveira, Thomas and Espadanal, 2014; Chan and Chong, 2013)
			Financial resources	The availability of financial capital to support innovation initiatives (Lai, Sun and Ren, 2018; Haddud et al., 2017; Chan and Chong, 2013);
			Infrastructure resources	The physical and technological infrastructure necessary for implementing and supporting innovation efforts (Lai, Sun and Ren, 2018; Haddud et al., 2017; Chan and Chong, 2013).
	Top management support and knowledge	The extent to which top managers possess expertise, and provide endorsement, commitment, and resources to facilitate the successful implementation of digital transformation within the organisation (Fernandez-Vidal et al., 2022).	Top management support	The active support and involvement of top managers in driving digital transformation initiatives (Lai, Sun and Ren, 2017; Gangwar, Date and Ramaswamy, 2015; Chan and Chong, 2013)
			Top management knowledge	Level of knowledge and understanding that top managers possess regarding digital technologies and their strategic implications (Lian, Yen and Wang, 2014).
Environment	**Market pressure**	The degree of perceived pressure experienced by firms from their Industry competitors, which stimulates the need	Market uncertainties	The uncertainties and dynamic changes in the market environment that prompt firms to embrace new technologies (Wong et al., 2020; Arnold and Voigt, 2019; Wei, Lowry and Seedorf, 2015)

	to adopt new technology to maintain competitiveness and gain an advantage (Lammers, Tomidei and Trianni, 2019; Tu, 2018; Hsu, Ray and Li-Hsieh, 2014; Zailani, Fernando and Zakaria, 2010).	Pressure from competitors and customers	The competitive and customer-driven pressures that encourage firms to adopt new technologies to meet evolving market demands and stay ahead of their rivals (Lai, Sun and Ren, 2018; Lian, Yen and Wang, 2014; Chan and Chong, 2013; Wang, Wang and Yang, 2010).
Market support	The support that firms receive from various sources, including the government and external organisations such as research institutes, banks and universities, in their pursuit of digital transformation (Rahayu and Day, 2015).	Government support	The support provided by governmental bodies in promoting and facilitating digital transformation initiatives undertaken by firms (Wong et al., 2020; Lai, Sun and Ren, 2018; Wei, Lowry and Seedorf, 2015; Hsu, Ray and Li-Hsieh, 2014)
		Third-party support	The support received from external entities, including research institutes, banks, and universities, which offer resources, expertise, and collaboration opportunities to facilitate firms' digital transformation efforts (Arnold and Voigt, 2019; Lai, Sun and Ren, 2018; Puklavec, Oliveira and Popovič, 2018)
Interorganisational relationships	The collaborative connections and interactions between and among organisations requireee the exchange of resources and information, and capabilities as well as willingness to cooperate and engage in mutual activities to achieve common goals or mutual benefits (Rzepka, 2017).	Trading partners' power	The relative influence and control that trading partners possess within the collaborative relationship to shape and impact the dynamics of the relationship (Wamba, Queiroz and Trinchera, 2020; Chan and Chong, 2013; Wang, Wang and Yang, 2010)
		Trading partners' readiness	The preparedness and willingness of trading partners to engage in collaborative efforts such as the alignment of objectives, commitment, and openness to cooperation to contribute to the relationship's success (Lin and Lin, 2008; Lin, 2008)
		Trust-based Information sharing	The effective information sharing between trading partners based on the foundation of trust, involving the confidence and belief that sensitive and

				valuable information will be shared, protected, and utilized for mutual benefit (Wamba, Queiroz and Trinchera, 2020; Chan and Chong, 2013)
Organisational culture	**Flexibility culture**	The organisational values, norms, and practices that foster adaptability, innovation, risk-taking, agility and tolerance for short-term losses to cope with uncertainty and ambiguity in business conditions and market demands (Hartnell, Ou and Kinicki, 2011; Khazanchi, Lewis and Boyer, 2007). Within a flexibility culture, employees are empowered to make decisions, take ownership of their work, and collaborate across teams and departments to drive innovation and improve processes, leading to higher level of trust and collaboration among employees (Lewis and Boyer, 2002). They are also encouraged and challenged to take risks, explore new ideas and find innovative solutions to problems (Veile et al., 2020).	Loyalty, collaboration and trust	The importance of building strong relationships, fostering cooperation, and establishing trust among employees, enabling effective collaboration and knowledge sharing (Liu et al., 2010).
			Commitment to innovation	Organisation's dedication to embracing and promoting innovation as a core value, encouraging employees to generate and implement creative ideas and solutions (Liu et al., 2010).
			Entrepreneurial spirit	Organisation's support for entrepreneurial behavior and mindset, encouraging employees to be proactive, take initiative, and identify opportunities for growth and improvement (Liu et al., 2010).
			New or improved products and services	Organisation's commitment to continuously develop and enhance its offerings, fostering a culture of ongoing improvement and responsiveness to market needs (Liu et al., 2010).
	Control culture	The set of organisational values, norms, and practices that prioritise productivity, stability, predictability, adherence to	Rules and procedures	Organisation's focus on formalised rules, policies, and procedures that guide employees' behaviours and decision-making processes, ensuring consistency and conformity to established protocols (Liu et al., 2010).

		established rules and procedures (Liu et al., 2010), standardisation, hierarchical authority, and a strict level of control over processes and outcomes (Im, Montoya and Workman Jr, 2013; Uzkurt et al., 2013; McLean, 2005).	Production and tasks-focus	Organisation's emphasis on efficiency, productivity, and task accomplishment, valuing the achievement of tangible outcomes and tangible deliverables (Liu et al., 2010).
			Stability	Organisation's desire for stability and resistance to change, emphasising the maintenance of existing processes, structures, and routines to ensure predictability and minimise disruptions (Liu et al., 2010).
			Results and achievements-focus	Organisation's focus on measurable outcomes, performance indicators, and achieving predefined goals and targets, often associated with a results-oriented and achievement-driven culture (Liu et al., 2010).
Adoption	**Adoption intention**	An individual's or organisation's subjective probability of performing a specific behaviour (Fishbein and Ajzen, 1977). In the context of this research, "DSC adoption intention", therefore, is defined as an inclination or willingness of an individual or organisation to adopt and implement DSC. It represents the expressed intention or planned behaviour of adopting digital solutions and embracing the digital transformation of the SC. DSC adoption intention is an antecedent to the actual adoption	Intention to digitally transform the business	Organisation's plan to digitally transform their entire business operations, encompassing various aspects of the supply chain (adapted from Wong et al., 2020).
			Intention to adopt digital technologies or increase such adoption in the future	Organisation's willingness to adopt digital solutions within their supply chain and their plan to potentially increase the level of adoption in the future (adapted from Wong et al., 2020).
			Intention to explore the potential of digital technologies	Organisation's openness to explore and harness the potential benefits offered by digital technologies within their supply chain activities (adapted from Wong et al., 2020).

	behaviours or actions. It provides insight into the likelihood that individuals or organisations will take tangible steps to integrate digital technologies into their supply chains. However, it is important to note that intention does not always translate into action (Teixeira, 2020; van Koningsbruggen, 2017; Faries, 2016) which suggests that various barriers or challenges may hinder the actual adoption of DSC, and there may be a gap between intention and implementation.		
DSC adoption actions or behaviours	The concrete steps taken by an organisation to incorporate digital solutions and transform traditional supply chain processes using digital technologies.	Development of digital strategy and plan	Organisation's development of a comprehensive strategy and plan to guide the implementation of DSC (adapted from Chan and Chong (2013) and semi-structured interview findings).
		Infrastructure investment	Organisation's allocation of resources and investment in the necessary infrastructure, including hardware, software, and networking capabilities, to support DSC adoption (adapted from Chan and Chong (2013) and semi-structured interview findings).
		Development of training courses	Organisation's designs and delivery of training programs to employees to enhance their digital skills and knowledge, enabling them to effectively utilise and leverage digital technologies in supply chain activities (adapted from Chan and Chong (2013) and semi-structured interview findings).

	Collaboration with third parties	Organisation’s engagement in partnerships and collaborations with external entities, such as technology vendors, consultants, or research institutions, to access expertise and support in implementing digital solutions in the supply chain (adapted from Chan and Chong (2013) and semi-structured interview findings).
	Collaboration with trading partners	Organisation’s establishment of collaborative relationships with its trading partners, including suppliers, distributors, and customers, to jointly explore and adopt digital technologies that improve supply chain visibility, coordination, and efficiency (adapted from Chan and Chong (2013) and semi-structured interview findings).
	Integration of digital technologies in operational processes	Organisation’s implementation of digital technologies into its day-to-day operational processes and activities across the SC, leveraging automation, data analytics, and real-time information exchange to enhance efficiency and decision-making (adapted from Chan and Chong (2013) and semi-structured interview findings).

Appendix D4 – Measurement Items

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
Technological factor	**Perceived risks**	Complexity	My company believes that RFID development is a complex process	Digital transformation is a complicated and long process	Wang, Wang and Yang (2010, p. 809)
			My company believes that RFID is complex to use.	Digital tech adoption needs complex skills and experience	
		Absence of interconnection standards	IIoT adoption is associated with establishment of standards	Digital tech adoption lacks unified standards for information sharing	Arnold and Voigt (2019, p.10)
		Cybersecurity risks	My company believes that data transmitted in a mobile SCM are secure.	Digital technologies are prone to security and privacy issues	Chan and Chong, (2013, p.1211)
			My company believes that data stored and used in the mobile SCM are private.		
			We are not concerned with potential security and privacy issues related to mobile SCM as we trust that it is secure and private		

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
		Short lifespan of technologies	*Not available in literature*	Digital technologies may have a short lifespan and be obsolete quickly	Semi-structured Interviews
		Incompatibility issues	The use of cloud computing fits the work style of the company.	Digital technologies are incompatible with existing work practices and business environment characteristics	Oliveira, Thomas and Espadanal, (2014, p.507)
			The use of cloud computing is fully compatible with current business operations		
			Using cloud computing is compatible with your company's corporate culture and value system		
			The use of cloud computing will be compatible with existing hardware and software in the company	Digital technologies are incompatible with existing IT systems	
			It is easy to integrate a mobile SCM system with our existing systems (for example, finance, ERP, CRM, SCM)	Digital tech adoption requires integration with our existing operational system and working environment	Chan and Chong, (2013, p.1211)
			Not available in literature review	Digital tech incompatibility with existing IT system generates poor data quality and low reliability	Semi-structured Interviews
		High adoption cost	The cost of adopting INDUSTRY 4.0 tech in supply chain	Adoption costs of digital technologies are greater than its short-term benefits	Wong, et al. (2020, p.16)

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
			(establishment, training, maintenance etc) is unclear and not easily understandable		
			The cost of adopting INDUSTRY 4.0 tech in supply chain is high for my firm		
			The cost of adopting I.4 tech in supply chain is greater than the benefits		
		Dependence on the technology providers	*Not available in literature*	Continuous upgrade and maintenance, training and after-sale support of digital technologies are highly dependent on external technology providers	Semi-structured Interviews
			Not available in literature	There is a lack of industrial tech providers within the country	
	Perceived benefits	Product/service customisation	IIoT adoption is associated with the offering of customised solutions	Digital tech adoption improves product/service customisation	Arnold and Voigt (2019, p.10)
		Productivity and flexibility	IIoT adoption is associated with increased production flexibility	Digital tech adoption improves productivity and flexibility to market changes	
		Resources savings	IIoT adoption is associated with increased resource efficiency.	Digital tech adoption increases resource efficiency/ savings (e.g. labour, energy, materials)	

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
		Health and safety	*Not available*	Digital tech adoption improves employees' health and safety	Semi-structured Interviews
		Quick data capture and analysis	Mobile SCM helps quick data capture and analysis Mobile SCM provides accurate information for decision making in a timely manner.	Digital tech adoption allows timely market data capture and analysis for faster decision making	Chan and Chong, (2013, p.1211)
		End-to-end monitoring	The introduction of mobile SCM entails increased visibility and transparency of business operations amongst trading partners	Digital tech adoption allows effective information sharing and monitoring to improve supply chain visibility	
		Defects and maintenance reduction	*Not available in literature*	Digital tech adoption reduces product/service defects and breakdown maintenance for better product/service quality	Semi-structured Interviews
Organisational factor	**Organisational resources**	Human resources' competence and willingness for change	My company is dedicated to ensuring employees are familiar with mobile SCM. My company has good knowledge of mobile SCM	Our company has necessary skills and knowledge (e.g. management, digital tech knowledge, English) and trainings to understand application of digital technologies	Chan and Chong, (2013, p.1212)

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
			Employees' resistance to new technologies and practices	Our company's employees are willing and welcome new working methods, ideas and technologies	Haddud et al. (2017, p.1076)
		Financial resources	My company has the financial resources to purchase hardware and software required for mobile SCM.	Our company has adequate financial resources to support digital tech adoption	Chan and Chong, (2013, p.1212)
			My company has the financial resources to make work-flow changes to accommodate the implementation of mobile SCM		
		Infrastructure resources	The technology infrastructure of my company is available to support mobile SCM	Our company has an adequate technology infrastructure (e.g. wireless Internet, databases, security system) to support digital tech adoption	Chan and Chong, (2013, p.1212)
	Top management knowledge and support	Top management support	Top management would provide resources necessary for the adoption of big data analytics	Top management communicates a sense of digital transformation urgency to the whole organisation	Lai, Sun and Ren (2017, p.699)
			Top management would provide necessary support for the adoption of big data analytics (BDA)		

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
			Top management would support the use of BDA		
			Top managers would be enthusiastic about adopting BDA		
			Top management actively participates in establishing a vision and formulating strategies for utilising mobile SCM	Top management actively establishes a clear vision, strategies and roadmap for digital transformation	Chan and Chong (2013, p.1212)
			Top management is likely to take risk involved in implementing mobile SCM	Top management is willing to take potential risks such as financial and operational risks involved in digital transformation	
			Top management communicates its support for the use of mobile SCM		
			The company's top management provides strong leadership and engages in the process when it comes to information systems company	Top management engages, guides and supports employees in digital transformation process	Gangwar, Date and Ramaswamy (2015, p.129)
		Top management knowledge	Top managers understand the benefits of cloud computing technology.	Top management has adequate knowledge and experience in digital transformation	Lian, Yen and Wang (2014, p.35)

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
Environmental factor	**Market pressure**	Market uncertainties	Customer preferences or requirements are always changing in my Industry	Changes in market demand are difficult to predict	Wong et al. (2020, p.16)
			My Industry is sensitive to changes in the marketplace		
			In my Industry, change is difficult to predict		
		Pressure from competitors and customers	My company experiences competitive pressure to implement mobile SCM	Our company is under pressure from competitors and/or customers to adopt digital technologies	Chan and Chong (2013, p.1212)
			My company will have competitive disadvantage if we do not implement mobile SCM	Our company will gain competitive advantage from digital transformation	
	Market support	Government support	BOSCM development receives financial support from the government or relevant authorities	The government provides incentives to support digital transformation (e.g. financial subsidies, tax rebates, investment into national infrastructure)	Wong et al. (2020, p.16)
			There is legal support in the use of BOSCM		
			The laws and regulations that exist nowadays are sufficient to protect the use of BOSCM	The government has devised sufficient laws and policies to support digital	

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
			Relevant policies are introduced by the government to boost BOSCM development	transformation (e.g. labour policies, technical standards, data protection)	
		Third-party support	There is a sufficient number of experts that could help us to implement the IIoT	There is third party support within the country for digital transformation (e.g. business associations, funding programs, research institutes)	Arnold and Voigt (2019. p.11)
			We could get outside support to help us troubleshooting with little effort.	It is easy to access to and obtain financial support for digital transformation from local banks/ other financial institutions within the country	
			Not available in literature	Vietnamese universities are preparing the graduates with the skills and knowledge for digital transformation	Interviews
			Not available in literature	Independent training providers in Vietnam offer trainings on digital skills	
			Not available in literature	Basic Information and Communication Technology infrastructure such as fast broadband and 4G,5G network are available in our business area	
	Interorganisational relationships	Trading partners' readiness	Majority trading partners recommended implementation of e-business	Our trading partners are willing to adopt digital technologies	Lin and Lin (2008, p.140)

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
			Majority trading partners requested implementation of e-business		
			Trading partners contain considerable technical expertise	Our trading partners have HR, technical and financial resources for adopting digital technologies	
			Trading partners are generally very knowledgeable regarding technical matters		
		Trading partners' power	Incentive from trading partners will encourage us on mobile SCM implementation	Our trading partners provide incentives and support (e.g. training, sharing best practices) to encourage our company to adopt digital technologies	Chan and Chong, (2013, p.1212)
			Trading partners of my company encourage the implementation of mobile SCM.		
			If a company has more bargaining power, it is able to demand its trading partners to implement mobile SCM	Our major trading partners with high bargaining power demand/pressure our company to adopt digital technologies	
		Trust-based Information sharing	Our organisation trusts that confidential proprietary information shared with trading partners through mobile SCM will be kept confidential	Our company and our trading partners ensure information sharing is confidential	Chan and Chong, (2013, p.1212)

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
			One must have a previous business relationship with my organisation in order to conduct business using mobile SCM		
			Mobile SCM implementation requires trusting our trading partners as we have to share information online		
			Your firm prefers to share know-how, innovations and blockchain-enabled supply chain knowledge with supply chain partners.	Our company shares information with our trading partners frequently.	Wamba, Queiroz and Trinchera (2020, p.11)
			Your firm prefers to share relevant market knowledge and blockchain-enabled supply chain knowledge with supply chain partners.		
			Your firm openly shares knowledge on blockchain-enabled supply chain applications with your supply chain partners		
			Your firm and supply chain partners share knowledge on blockchain-		

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
			enabled supply chain applications that help in the establishment of business planning		
Organisational culture types	**Flexibility culture**	Loyalty, collaboration and trust	The glue that holds our organisation together is loyalty and tradition. Commitment runs high	The glue that holds our company together is loyalty, teamwork and mutual trust. This means for our company, commitment to the company runs high.	Liu et al. (2010, p.382)
		Commitment to innovation	The glue that holds our organisation together is commitment to innovation and development. There is an emphasis on being first with products and services.	The glue that holds our company together is commitment to innovation in products/ services/ processes.	
		Entrepreneurial spirit	Our organisation is a very dynamic and entrepreneurial place. People are willing to stick their necks out and take risks	Our company is a very dynamic and entrepreneurial place. This means our company's employees are willing to stick their necks out and take risks.	
		New or improved products and services	Our organisation emphasizes growth through developing new ideas. Generating new products or services is important.	Our company emphasises growth through developing new ideas. This means for our company, generating new or improved products/ services/ processes is important	
	Control culture	Rules and procedures	The glue that holds our organisation together is formal rules and policies. Following rules is important.	The glue that holds our company together is formal rules and policies. This means for our company, following rules is important	

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
		Production and tasks-focus	Our organisation is a very production oriented place. People are concerned with getting the job done	Our company is a very production-oriented place. This means in our company, people are concerned with getting the job done.	
		Stability	Our organisation emphasizes permanence and stability. Efficiency is important.	Our company emphasises permanence and stability. This means for our company, control and efficient and smooth operations are important.	
		Results and achievements-focus	Our organisation emphasizes outcomes and achievement. Accomplishing goals is important	Our company emphasises outcomes and achievements. This means for our company, accomplishing goals is important.	
DSC adoption	**Adoption intention**	Intention to transform the business	My firm intends to digitally transform operations and supply chain management through BOSCM	Our company plans to digitally transform the business	Wong et al. (2020, p.16)
		Intention to adopt or increase adoption in the future	I predict my firm would adopt BOSCM in the future	Our company plans to adopt or increase adoption of more digital technologies in the next 5 to 10 years	
			I predict I would use BOSCM in the future		
		Intention to explore the potential of digital technologies	The organization plans to evaluate and adopt cloud computing.	Our company plans to explore and evaluate the potential of digital technologies	
	Adoption actions	Development of digital strategy and plan	My company invests resources to adopt mobile SCM.	Our company has a clear strategy and plan for digital transformation	Chan and Chong

Factor	Dimensions	Indicators	Measurement items used in prior studies	Final re-worded measurement items used in the research survey	Sources
		Infrastructure investment		Our company invests in technology infrastructure to prepare for digital transformation	(2013, p.1213)
		Development of training course		Our company designs training courses or use external training providers to equip employees with digital knowledge & skills	
		Collaboration with third parties	Mobile SCM is being implemented together with our trading partners and customers	Our company has a close collaboration with third parties (e.g: consultancy firms, technology providers, universities) to digitally transform the business	
		Collaboration with trading partners		Our company collaborates with trading partners to implement digital technologies	
		Integration of digital technologies in operational processes	We have integrated mobile SCM with existing backend/legacy/ supply chain systems.	Our company has integrated digital technologies into the whole operational processes	
			Real time distribution information is collected by integrating distribution systems with mobile SCM applications.		
			Real time inventory information is collected by integrating inventory systems with mobile SCM applications.		

Note: Measures and measurement items in italic in this table are the items identified from the findings of semi-structured interviews

Appendix D5 – Questionnaire in English and Vietnamese

ENGLISH VERSION

DIGITAL TECHNOLOGY APPLICATION OR DIGITAL TRANSFORMATION OF COMPANIES WITHIN SUPPLY CHAINS IN VIETNAM

You are invited to take part in a research project taking place at the University of the West of England, Bristol. It is funded by College of Business and Law (CBL), University of the West of England, Bristol, UK. The research is carried out by Nguyen Thu Giang, and supervised by the Director of Studies: Professor Vikas Kumar, Dr. Anabela Soares and Dr. Linh Duong.

This study aims to understand what factors are inhibiting, driving or supporting companies in adopting Industry 4.0 digital technologies as well as digital transformation of Supply chains in Vietnam.

(**Industry 4.0** is defined as the 4th Industrial revolution that embraces digital technologies such as Artificial Intelligence, Big Data, Blockchain, Cloud computing, ERP or Virtual Reality).

(**A supply chain** is a network of individuals, organisations, resources, information and processes involved in delivering products/services to the customers).

If you take part, you will be helping us to gain a better understanding of the reasons why firms within supply chains in Vietnam are or are not adopting digital technologies. The data collected will be used to offer practical suggestions to the companies and the government about policies, strategies and other changes regarding this adoption.

All data collected will be anonymous and used solely for the purpose of this study. The anonymised data will be kept in a password protected file in a password protected computer. You can withdraw from the research whilst you are completing the survey. However, once you press the submit button, it is impossible to withdraw because the data is completely anonymous.

The survey includes 15 questions that will take you around 10 minutes to complete. If you do not know the answer to the questions, please try to answer the questions at the best of your knowledge.

If you want to find out more or need any further details regarding this research project or if you want to have a copy of the final report of this research, please contact the researcher: **Nguyen Thu Giang**

Thank you very much for your time and collaboration!

After reading this, would you like to take part in this research questionnaire?

O Yes

O No

Q1: What is your position in the company

- ○ Junior management (e.g. Assistant manager, Supervisor)
- ○ Middle management (e.g. Head of department, Factory manager)
- ○ Senior management (e.g. Director, Chairman, General manager)
- ○ Others (if others, please specify your position)

Q2: What part of Vietnam is your company based?

- ○ North
- ○ Middle
- ○ South

Q3: To what extent do you agree/disagree with the following statements regarding the benefits of digital technology adoption (e.g. AI, Big Data, ERP...) for your company's supply chain (e.g. inventory and demand planning, logistics)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Digital tech adoption improves product/service customisation	○	○	○	○	○
Digital tech adoption improves productivity & flexibility to market changes	○	○	○	○	○
Digital tech adoption improves employees' health & safety	○	○	○	○	○
Digital tech adoption increases resource efficiency/ savings (e.g. labour, energy, materials)	○	○	○	○	○
Digital tech adoption allows timely market data capture and analysis for faster decision making	○	○	○	○	○
Digital tech adoption allows effective information sharing and monitoring to improve supply chain visibility	○	○	○	○	○
Digital tech adoption reduces product/service defects and breakdown maintenance for better product/service quality	○	○	○	○	○

Q4: To what extent do you agree/disagree with the following statements regarding the barriers of digital technology adoption (e.g. AI, Big Data, ERP) to your company's supply chain (e.g. inventory and demand planning, logistics)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Digital transformation is a complicated & long process	○	○	○	○	○
Digital tech adoption requires integration with our existing operational system & working environment	○	○	○	○	○
Digital tech adoption <u>lacks</u> unified standards for information sharing	○	○	○	○	○
Digital tech adoption needs complex skills & experience	○	○	○	○	○
Digital techs are prone to security & privacy issues	○	○	○	○	○
Digital techs may have a short lifespan and be obsolete quickly	○	○	○	○	○
Digital techs are <u>incompatible</u> with existing work practices & business environment characteristics	○	○	○	○	○
Digital techs are <u>incompatible</u> with existing IT systems	○	○	○	○	○
Digital tech <u>incompatibility</u> with existing IT system generates poor data quality & low reliability	○	○	○	○	○
Adoption costs of digital techs are <u>greater</u> than its short-term benefits	○	○	○	○	○

Continuous upgrade & maintenance, training & after-sale support of digital techs are highly dependent on external technology providers	○	○	○	○	○
There is a lack of industrial tech providers within the country	○	○	○	○	○

Q5: To what extent do you agree/disagree with the following statements regarding your company's resources availability in support of digital technology adoption

	Strongly disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
Our company has an adequate technology infrastructure (e.g. wireless Internet, databases, security system) to support digital tech adoption	○	○	○	○	○
Our company has adequate financial resources to support digital tech adoption	○	○	○	○	○
Our company has necessary skills & knowledge (e.g. management, digital tech knowledge, English) and trainings to understand application of digital techs	○	○	○	○	○
Our company's employees are willing & welcome new working methods, ideas & techs	○	○	○	○	○

Q6: To what extent do you agree/disagree with the following statements regarding your company's top management support towards digital transformation?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Top management communicates a sense of digital transformation urgency to the whole organisation	○	○	○	○	○
Top management actively establishes a clear vision, strategies & roadmap for digital transformation	○	○	○	○	○
Top management has adequate knowledge & experience in digital transformation	○	○	○	○	○
Top management engages, guides & supports employees in digital transformation process	○	○	○	○	○
Top management is willing to take potential risks such as financial & operational risks involved in digital transformation	○	○	○	○	○

Q7: To what extent do you agree/disagree with the following statements regarding your company's market and Industry environment

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Changes in market demand are difficult to predict	○	○	○	○	○
Our company is under pressure from competitors and/or customers to adopt digital techs	○	○	○	○	○
Our company will gain competitive advantage from digital transformation	○	○	○	○	○
The government provides incentives to support digital transformation (e.g: financial subsidies, tax rebates, investment into national infrastructure)	○	○	○	○	○
The government has devised sufficient laws & policies to support digital transformation (e.g. labour policies, technical standards, data protection)	○	○	○	○	○
Vietnamese universities are preparing the graduates with the skills & knowledge for digital transformation	○	○	○	○	○
Independent training providers in Vietnam offer trainings on digital skills	○	○	○	○	○
It is easy to access to & obtain financial support for digital transformation from local banks/ other financial institutions within the country	○	○	○	○	○
There is third party support within the country for digital transformation (e.g. business associations, funding programs, research institutes)	○	○	○	○	○

Basic Information& Communication Technology infrastructure such as fast broadband & 4G,5G network are available in our business area					

Q8: To what extent do you agree/disagree with the following statements regarding your company's relationship with trading partners (e.g. suppliers or clients)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Our trading partners are willing to adopt digital techs					
Our trading partners have HR, technical and financial resources for adopting digital techs					
Our trading partners provide incentives & support (e.g. training, sharing best practices) to encourage our company to adopt digital techs					
Our major trading partners with high bargaining power demand/pressure our company to adopt digital techs					
Our company & our trading partners ensure information sharing is confidential					
Our company shares information with our trading partners frequently.					

Q9: To what extent do you agree/disagree with the following statements regarding your organisational culture

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The glue that holds our company together is loyalty, teamwork & mutual trust. This means for our company, commitment to the company runs high	○	○	○	○	○
The glue that holds our company together is formal rules & policies. This means for our company, following rules is important	○	○	○	○	○
The glue that holds our company together is commitment to innovation in products/ services/ processes	○	○	○	○	○
Our company is a very dynamic & entrepreneurial place. This means our company's employees are willing to stick their necks out & take risks	○	○	○	○	○
Our company is a very production-oriented place. This means in our company, people are concerned with getting the job done	○	○	○	○	○
Our company emphasises growth through developing new ideas. This means for our company, generating new or improved products/ services/ processes is important	○	○	○	○	○
Our company emphasises permanence & stability. This means for our company, control & efficient and smooth operations are important	○	○	○	○	○
Our company emphasises outcomes & achievements. This means for our company, accomplishing goals is important	○	○	○	○	○

Q10: To what extent do you agree or disagree with the following statements regarding your company's intention towards digital technology adoption?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Our company plans to digitally transform the business	○	○	○	○	○
Our company plans to explore and evaluate the potential of digital techs	○	○	○	○	○
Our company plans to adopt or increase adoption of more digital techs in the next 5 to 10 years	○	○	○	○	○

Q11: To what extent do you agree/disagree with the following statements regarding your company's actions of adopting digital technologies?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Our company has a **clear strategy & plan** for digital transformation	○	○	○	○	○
Our company has a **close collaboration with third parties** (e.g: consultancy firms, technology providers, universities) to digitally transform the business	○	○	○	○	○
Our company **collaborates with trading partners** to implement digital techs	○	○	○	○	○
Our company **invests in technology infrastructure** to prepare for digital transformation	○	○	○	○	○
Our company **designs training courses** or **use external training providers** to equip employees with digital knowledge & skills	○	○	○	○	○
Our company has **integrated** digital techs into the **whole operational processes**	○	○	○	○	○

Q12: In which sector is your company active? (You can choose more than 1)

☐ Wholesale/ Retail trade

- ☐ Textiles & Garment
- ☐ Postal & Telecommunication services
- ☐ Professional services (Real estate agent, Insurance, IT services, etc)
- ☐ Hotels, Catering & Tourism
- ☐ Financial services
- ☐ Transportation & Logistics
- ☐ Construction
- ☐ Health services
- ☐ Education
- ☐ Mining (Coal, Minerals, etc)
- ☐ Forestry (Paper, Pulp, & Wood)
- ☐ Agriculture (plantation, farming, crops production such as rice, cashew, coffee etc)
- ☐ Transport equipment manufacturing (Motor vehicles and Auto parts, Motorcycles and Bicycles, Aircraft equipment, Railroad equipment, etc)
- ☐ Oil & Gas production

- [ ] Electronics (Computers & Laptops, Mobile phones, TVs, Electrical appliances, etc)
- [ ] Chemicals (Plastics, Cleaners, Paints, Agricultural chemicals, Rubber, Pharmaceutical, etc)
- [ ] Metals production (Iron, Steel, etc)
- [ ] Food, Drink & Tobacco
- [ ] Utilities (Water, Gas and Electricity)
- [ ] Media & Graphics (Newspapers, Books, Television, etc)
- [ ] Others ____

Q13: How is your company classified (You can choose more than 1)

- ☐ State-owned
- ☐ Foreign-domestic partnership
- ☐ 100% Foreign-owned
- ☐ 100% Domestic-owned
- ☐ Others ____

Q14: Please rate level of autonomy in terms of adopting digital technologies (for example: your local branch from your parent company if applicable)? Put into the scale with 1: lowest level and 5: highest level.

	1	2	3	4	5
Level of decision-making autonomy					

Q15: We are now going to ask you about the number of employees, capital and revenue in the past year in your company. This is solely for the purpose of categorising the company into micro, small, medium or large enterprise to help us complete statistical data analysis.

How do you classify your company? (See the table below)

<table>
<tr><th>Business size</th><th colspan="2">Micro-sized business</th><th colspan="2">Small-sized business</th><th colspan="2">Medium-sized business</th><th colspan="2">Large business</th></tr>
<tr><th>Sectors</th><th>Annual revenue</th><th>Number of employees</th><th>Annual revenue</th><th>Number of employees</th><th>Annual revenue</th><th>Number of employees</th><th>Annual revenue</th><th>Number of employees</th></tr>
<tr><td>Agriculture, forestry and fishery</td><td rowspan="3">< 3 billion VND</td><td rowspan="3">< 10 employees</td><td rowspan="2">From 3 to 50 billion VND</td><td rowspan="2">From 10 to 100 employees</td><td rowspan="2">From 50 to 200 billion VND</td><td rowspan="2">From 100 to 200 employees</td><td rowspan="2">> 200 billion VND</td><td rowspan="2">> 200 employees</td></tr>
<tr><td>Industry & construction</td></tr>
<tr><td>Services</td><td>From 3 to 100 billion VND</td><td>From 10 to 50 employees</td><td>From 100 to 300 billion VND</td><td>From 50 to 100 employees</td><td>> 300 billion VND</td><td>> 100 employees</td></tr>
</table>

- ○ Micro-sized company
- ○ Small-sized company
- ○ Medium-sized company
- ○ Large company

This is the end of the survey! Thank you very much for your precious time and participation! If you have any comments or suggestions, please comment in the text box below.
Otherwise, please **press the SUBMIT button** to submit your answers!

VIETNAMESE VERSION

ỨNG DỤNG CÔNG NGHỆ SỐ (CNS) HAY CHUYỂN ĐỔI SỐ CỦA CÁC DOANH NGHIỆP TRONG CHUỖI CUNG ỨNG TẠI VIỆT NAM

Anh/chị được mời tham gia vào dự án nghiên cứu khoa học của trường **Đại học West of England, Bristol, Vương quốc Anh.** Dự án được tài trợ bởi Khoa Kinh Doanh và Luật và được thực hiện bởi Nguyễn Thu Giang với sự hướng dẫn của Giáo sư Vikas Kumar, Tiến sĩ Anabela Soares và Tiến sĩ Linh Duong.

Bài khảo sát này nhằm tìm hiểu những thách thức và điều kiện thuận lợi tác động lên việc áp dụng CNS 4.0 hay việc Chuyển đổi số của các doanh nghiệp (DN) trong Chuỗi cung ứng tại Việt Nam, từ góc nhìn của những nhà quản lý DN.

Trong đó:

- **Công nghệ số 4.0 (CNS)** được hiểu là những CN như AI (Trí tuệ nhân tạo), Blockchain (Chuỗi khối), in 3D, IoT (Internet vạn vật), ERP (Hoạch định tài nguyên doanh nghiệp) hay Big Data (Dữ liệu lớn).
- **Chuỗi cung ứng** bao gồm các cá nhân, tổ chức, nguồn lực, thông tin và quy trình để đưa sản phẩm/dịch vụ từ nhà cung cấp/sản xuất đến người tiêu dung

Nếu anh/chị đồng ý tham gia, anh/chị sẽ giúp đỡ chúng tôi trong việc tìm hiểu lý do vì sao các doanh nghiệp (DN) trong Chuỗi cung ứng tại Việt Nam đã, đang hoặc vẫn chưa ứng dụng CNS trong các hoạt động của họ.

Kết quả của nghiên cứu cũng sẽ **đưa ra những phương hướng thiết thực, giúp ích cho những nhà hoạch định chính sách trong việc xây dựng chiến lược**, **cũng như chính phủ Việt Nam trong việc hỗ trợ các doanh nghiệp (DN) xây dựng lộ trình Chuyển đổi số.**

Tất cả dữ liệu thu thập sẽ ẩn danh và chỉ được sử dụng cho mục đích nghiên cứu của dự án. Các thông tin bảo mật sẽ được lưu giữ trong hồ sơ được bảo vệ bằng mật khẩu trong máy tính cài mật khẩu. Anh/chị có thể từ chối tham gia dự án bất kì lúc nào bằng cách đóng bài khảo sát. Xin hãy lưu ý, một khi anh/chị nhấn nút Gửi, anh/chị sẽ không thể rút câu trả lời ra khỏi dữ liệu nghiên cứu vì tất cả dữ liệu hoàn toàn bị ẩn danh.

Bài khảo sát bao gồm 15 câu hỏi và mất khoảng 10 phút để hoàn thành. Với những câu hỏi nào anh/chị không biết câu trả lời, xin hãy cố gắng đưa ra đáp án gần nhất với hiểu biết của anh/chị.

Nếu anh/chị có câu hỏi gì hoặc muốn biết thêm thông tin, hoặc muốn nhận được kết quả của bài nghiên cứu, xin hãy liên hệ **Nguyễn Thu Giang,** Khoa Kinh Doanh và Luật, trường đại học West of England, Bristol qua email...

Cảm ơn anh/chị rất nhiều vì đã dành thời gian quý báu tham gia dự án nghiên cứu!

Anh chị có đồng ý tham gia dự án nghiên cứu không ạ?

○ Có

○ Không

Câu 1: Vị trí của anh/chị trong doanh nghiệp?

- ○ Quản lý cấp dưới (Trợ lý giám đốc, Quản đốc, Giám sát viên, v.v)
- ○ Quản lý cấp trung (Trưởng phòng, Giám đốc nhà máy, v.v)
- ○ Quản lý cấp cao (Giám đốc điều hành, Tổng giám đốc, Chủ tịch, v.v)
- ○ Khác (Nếu khác, xin hãy nêu rõ vị trí của anh/chị vào ô dưới đây)

____

Q1: What is your position in the company

- ○ Junior management (e.g. Assistant manager, Supervisor)
- ○ Middle management (e.g. Head of department, Factory manager)
- ○ Senior management (e.g. Director, Chairman, General manager)
- ○ Others (if others, please specify your position) ____

Câu 2: Doanh nghiệp anh/chị nằm ở vùng miền nào của Việt Nam?

- ○ Miền Bắc
- ○ Miền Trung
- ○ Miền Nam

Câu 3: Quan điểm của anh/chị về lợi ích của việc ứng dụng CNS (AI, ERP...) vào Chuỗi cung ứng của Doanh nghiệp (DN) anh/chị (như quản lý nhà máy, lên kế hoạch sản xuất và hàng tồn kho, quản lý đơn hàng...)

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý
Ứng dụng CNS cho phép **tăng mức độ cá nhân hóa sản phẩm/dịch vụ**	○	○	○	○	○
Ứng dụng CNS làm **tăng năng suất và tính linh hoạt** với sự thay đổi của thị trường	○	○	○	○	○
Ứng dụng CNS cho phép **nâng cao mức độ an toàn & sức khỏe của nhân viên**	○	○	○	○	○

Ứng dụng CNS **tiết kiệm nguyên & nhiên liệu** cho các hoạt động vận hành	○	○	○	○	○
Ứng dụng CNS cho phép **thu thập & phân tích dữ liệu kịp thời** để đẩy nhanh việc đưa ra quyết định	○	○	○	○	○
Ứng dụng CNS cho phép **chia sẻ & quản lý thông tin, dữ liệu một cách hiệu quả** nhằm cải thiện tính minh bạch trong chuỗi cung ứng	○	○	○	○	○
Ứng dụng CNS làm **giảm thiểu lỗi sản phẩm/dịch vụ, đảm bảo chất lượng** sản phẩm/dịch vụ	○	○	○	○	○

Câu 4: Quan điểm của anh/chị về những thách thức của việc ứng dụng CNS (AI, Big Data, ERP...) vào Chuỗi cung ứng của Doanh nghiệp (DN) anh/chị (như quản lý nhà máy, lên kế hoạch sản xuất và hàng tồn kho, quản lý đơn hàng...)

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý
Chuyển đổi số là một **quá trình lâu dài & phức tạp**	○	○	○	○	○

Ứng dụng CNS **cần tích hợp** với hệ thống vận hành & môi trường kinh doanh hiện tại của DN chúng tôi	○	○	○	○	○
Ứng dụng CNS **thiếu** các **tiêu chuẩn về chia sẻ** dữ liệu & thông tin	○	○	○	○	○
Ứng dụng CNS đòi hỏi những **kỹ năng phức tạp, kiến thức & kinh nghiệm chuyên sâu**	○	○	○	○	○
CNS **dễ gặp** phải vấn đề về **quyền riêng tư & bảo mật dữ liệu**	○	○	○	○	○
CNS có thể có **vòng đời khá ngắn** và **nhanh lỗi thời**	○	○	○	○	○
CNS **không phù hợp** với **thực tiễn công việc** & **đặc điểm môi trường kinh doanh** hiện tại của DN chúng tôi	○	○	○	○	○
CNS **không tương thích** với **hệ thống CN thông tin** hiện tại của DN	○	○	○	○	○

<u>Việc không tương thích</u> của CNS với hệ thống CN thông tin hiện tại của DN chúng tôi tạo ra **dữ liệu chất lượng kém & độ tin cậy thấp**	○	○	○	○	○
Chi phí ứng dụng CNS **<u>lớn hơn</u>** những **lợi ích ngắn hạn** chúng tôi đạt được	○	○	○	○	○
Việc nâng cấp & bảo trì CNS liên tục, đào tạo sử dụng & dịch vụ hỗ trợ CNS **phụ thuộc vào các nhà cung cấp CN**	○	○	○	○	○
Có sự **<u>thiếu hụt</u> các nhà cung cấp CNS** trong nước	○	○	○	○	○

Câu 5: Quan điểm của anh/chị về nguồn lực của doanh nghiệp (DN) anh/chị trong việc hỗ trợ ứng dụng CNS?

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý
DN chúng tôi có **đầy đủ cơ sở hạ tầng CN** (Internet không dây, cơ sở dữ liệu & hệ thống bảo mật, v.v.) để hỗ trợ ứng dụng CNS	○	○	○	○	○

DN chúng tôi có **đầy đủ nguồn lực tài chính** để hỗ trợ cho chuyển đổi số	○	○	○	○	○
DN chúng tôi **có các kĩ năng & kiến thức** (kiến thức về CNS, kỹ năng quản lý, kỹ năng tiếng Anh...) cùng các **buổi đào tạo cần thiết** để nắm rõ việc ứng dụng CNS	○	○	○	○	○
Nhân viên DN chúng tôi **sẵn sàng tiếp nhận ý tưởng, phương thức làm việc & CN mới**	○	○	○	○	○

Câu 6: Quan điểm của anh/chị về sự hỗ trợ của Ban lãnh đạo doanh nghiệp (DN) anh/chị đối với việc chuyển đổi số

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý
Ban lãnh đạo **truyền đạt về tính cấp bách** của chuyển đổi số đến toàn bộ DN	○	○	○	○	○

Ban lãnh đạo tích cực **xây dựng tầm nhìn, chiến lược & đường lối** cho việc chuyển đổi số	○	○	○	○	○
Ban lãnh đạo **có đủ kiến thức & kinh nghiệm** trong việc chuyển đổi số	○	○	○	○	○
Ban lãnh đạo **tham gia, hướng dẫn & hỗ trợ nhân viên** trong quá trình chuyển đổi số	○	○	○	○	○
Ban lãnh đạo **sẵn sàng chấp nhận rủi ro** (rủi ro tài chính, rủi ro vận hành...) từ việc chuyển đổi số	○	○	○	○	○

Câu 7: Quan điểm của anh/chị về điều kiện thị trường & môi trường ngành công nghiệp của doanh nghiệp (DN) anh/chị

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý
Những **thay đổi về nhu cầu** của thị trường **khó dự đoán**	○	○	○	○	○

DN chúng tôi **chịu áp lực từ đối thủ cạnh tranh/ khách hàng** trong việc ứng dụng CNS	○	○	○	○	○
DN chúng tôi sẽ **có lợi thế cạnh tranh** từ việc chuyển đổi số	○	○	○	○	○
Chính phủ cung cấp các ưu đãi để hỗ trợ DN trong việc chuyển đổi số (trợ cấp tài chính, giảm thuế, xây dựng các trung tâm CN, đầu tư vào cơ sở hạ tầng quốc gia, v.v.)	○	○	○	○	○
Chính phủ ban hành đầy đủ những chính sách & luật lệ để hỗ trợ DN chuyển đổi số (chính sách lao động, tiêu chuẩn kỹ thuật, bảo vệ dữ liệu, v.v.)	○	○	○	○	○
Các trường đại học Việt Nam đang **trang bị cho sinh viên các kỹ năng & kiến thức** để sẵn sàng cho việc chuyển đổi số	○	○	○	○	○
Các tổ chức đào tạo tại Việt Nam **cung cấp các khóa đào tạo kỹ năng & chuyên môn về CNS.**	○	○	○	○	○
Dễ dàng tiếp cận & nhận được sự hỗ trợ tài chính từ các ngân hàng/các tổ chức tài chính khác trong nước cho việc chuyển đổi số	○	○	○	○	○

Hiện có sự **hỗ trợ từ các tổ chức & DN ở Việt Nam** (Hiệp hội DN, Chương trình viện trợ, Viện nghiên cứu, v.v) cho việc chuyển đổi số					
Cơ sở hạ tầng CN & thông tin cơ bản (Đường truyền nhanh, băng thông rộng, mạng 4G, 5G...) **có sẵn** trong khu vực kinh doanh của chúng tôi					

Câu 8: Quan điểm của anh/chị mối quan hệ của doanh nghiệp (DN) với đối tác kinh doanh (khách hàng, nhà cung ứng,..) của DN anh/chị

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý
Các đối tác thương mại của DN chúng tôi **sẵn sàng ứng dụng CNS**					
Các đối tác thương mại của DN chúng tôi **có nguồn tài chính, CN và nhân lực** cho việc ứng dụng CNS					

Các đối tác thương mại của DN chúng tôi **đưa ra các ưu đãi và hỗ trợ** (đào tạo, chia sẻ ý tưởng & CN,...) để **khuyến khích** DN chúng tôi ứng dụng CNS.	○	○	○	○	○
Các đối tác thương mại **chính** của DN chúng tôi **yêu cầu/ gây áp lực** buộc DN chúng tôi phải ứng dụng CNS.	○	○	○	○	○
DN chúng tôi & các đối tác thương mại **đảm bảo thông tin chia sẻ được bảo mật**	○	○	○	○	○
DN chúng tôi **thường xuyên chia sẻ thông tin** với các đối tác thương mại	○	○	○	○	○

Câu 9: Quan điểm của anh/chị về văn hóa doanh nghiệp (DN) của DN anh/chị

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý
Điều gắn kết DN chúng tôi là sự **trung thành, tinh thần đồng đội & niềm tin tưởng lẫn nhau**. Với DN chúng tôi, **cam kết cống hiến cho DN** đóng vai trò quan trọng.	○	○	○	○	○

Điều gắn kết DN chúng tôi là những **quy tắc, luật lệ & chính sách**. Với DN chúng tôi, **tuân theo quy tắc, luật lệ** đóng vai trò quan trọng.	○	○	○	○	○
Điều gắn kết DN chúng tôi là sự **cam kết đổi mới sáng tạo** trong các sản phẩm, dịch vụ và quy trình hoạt động.	○	○	○	○	○
DN chúng tôi rất **năng động & có tinh thần khởi nghiệp cao.** Trong DN chúng tôi, mọi người **sẵn sàng thử thách & chấp nhận rủi ro.**	○	○	○	○	○
DN chúng tôi rất **hướng đến kết quả cuối cùng**. Trong DN chúng tôi, mọi người **quan tâm đến việc hoàn thành công việc.**	○	○	○	○	○
DN chúng tôi tập trung phát triển bằng cách **đưa ra những ý tưởng mới.** Với DN chúng tôi, **tạo ra hoặc cải thiện các sản phẩm/ dịch vụ/ quy trình hoạt động** đóng vai trò quan trọng.	○	○	○	○	○
DN chúng tôi tập trung vào **tính lâu dài & ổn định**. Với DN chúng tôi, **kiểm soát, hoạt động trơn tru & hiệu quả** đóng vai trò quan trọng.	○	○	○	○	○
DN chúng tôi nhấn mạnh vào **kết quả & thành tích đạt được.** Với DN chúng tôi, **hoàn thành mục tiêu** đóng vai trò quan trọng.	○	○	○	○	○

Câu 10: Quan điểm của anh/chị về ý định của doanh nghiệp (DN) anh/chị trong việc ứng dụng CNS?

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý
DN chúng tôi **dự định chuyển đổi số**	○	○	○	○	○
DN chúng tôi **dự định tìm hiểu và đánh giá** về tiềm năng của CNS	○	○	○	○	○
DN chúng tôi **dự định ứng dụng hoặc tăng cường việc ứng dụng CNS** trong 5 - 10 năm tới	○	○	○	○	○

Câu 11: Quan điểm của anh/chị về hành động thực tế của doanh nghiệp (DN) anh/chị trong việc ứng dụng CNS?

	Hoàn toàn không đồng ý	Không đồng ý	Không đồng ý cũng không phản đối	Đồng ý	Hoàn toàn đồng ý

DN chúng tôi **có chiến lược & kế hoạch cụ thể** cho việc chuyển đổi số	○	○	○	○	○
DN chúng tôi **hợp tác chặt chẽ & sâu rộng với các bên thứ ba** (Công ty tư vấn, Nhà cung cấp CN, Học viện nghiên cứu hay các Trường đại học, v.v) để giúp DN chúng tôi chuyển đổi số.	○	○	○	○	○
DN chúng tôi **hợp tác với các đối tác thương mại** để triển khai ứng dụng CNS	○	○	○	○	○
DN chúng tôi **đầu tư vào cơ sở hạ tầng kỹ thuật** để chuẩn bị cho quá trình chuyển đổi số	○	○	○	○	○
DN chúng tôi **thiết kế các khóa đào tạo/ tìm kiếm những nhà cung cấp các khóa đào tạo** để trang bị cho nhân viên kiến thức & kỹ năng số	○	○	○	○	○
DN chúng tôi **đã tích hợp CNS** vào **toàn bộ các quá trình vận hành**	○	○	○	○	○

Câu 12: Doanh nghiệp anh/chị hoạt động trong lĩnh vực nào? (Vui lòng chọn từ danh mục dưới đây)

- [ ] Bán buôn/ bán lẻ
- [ ] Dệt may
- [ ] Dịch vụ Bưu chính & Viễn thông
- [ ] Dịch vụ Chuyên nghiệp (Bất động sản, Bảo hiểm,...)
- [ ] Dịch vụ Khách sạn, Ăn uống & Du lịch
- [ ] Dịch vụ Tài chính
- [ ] Dịch vụ Vận tải & Logistics
- [ ] Dịch vụ Xây dựng
- [ ] Dịch vụ Y tế & Sức khỏe
- [ ] Giáo dục
- [ ] Khai thác (Than, Khoáng sản,...)
- [ ] Lâm nghiệp (Giấy, Bột gỗ,...)

- [ ] Nông nghiệp (Trồng trọt, Canh tác, Sản xuất cây trồng như gạo, điều, cà phê,...)
- [ ] Sản xuất (Thiết bị) vận tải (Ô tô & Phụ tùng ô tô, Xe máy & Xe đạp, Thiết bị máy bay, Thiết bị đường sắt,...)
- [ ] Sản xuất Dầu khí
- [ ] Sản xuất Hàng điện tử (Máy tính & Máy tính xách tay, Điện thoại, TV, các thiết bị điện tử dân dụng,...)
- [ ] Sản xuất Hóa chất (Nhựa, Chất tẩy rửa, Sơn,
- [ ] Sản xuất Kim loại (Sắt, Thép,...)
- [ ] Thực phẩm, Đồ uống & Thuốc lá
- [ ] Tiện ích (Nước, Khí đốt & Điện)
- [ ] Truyền thông (Báo chí,
- [ ] Ngành khác ____

Câu 13: Hình thức sở hữu của doanh nghiệp anh/chị là gì? (Anh/chị có thể chọn nhiều hơn 1 đáp án)

- [ ] Doanh nghiệp nhà nước
- [ ] Doanh nghiệp liên doanh (với nước ngoài)
- [ ] Doanh nghiệp 100% vốn nước ngoài
- [ ] Doanh nghiệp 100% vốn trong nước
- [ ] Khác ____

Câu 14: Vui lòng đánh giá mức độ tự chủ của DN anh/chị trong việc ứng dụng CN số? (ví dụ: so với công ty mẹ, nếu có) ? **Từ 1 (mức độ thấp nhất) đến 5 (mức độ cao nhất)**

	1	2	3	4	5
Mức độ tự chủ ra quyết định					

Câu 15: Đây là câu hỏi về số lượng nhân viên & doanh thu trong năm qua của doanh nghiệp (DN). Điều này chỉ nhằm mục đích phân loại DN thành các loại Siêu nhỏ, Nhỏ, Vừa hoặc Lớn để giúp chúng tôi hoàn thành phân tích dữ liệu thống kê.

Quy mô DN anh/chị? (Dựa vào bảng dưới đây)

- ○ Doanh nghiệp siêu nhỏ
- ○ Doanh nghiệp nhỏ
- ○ Doanh nghiệp vừa
- ○ Doanh nghiệp lớn

Đến đây là kết thúc của cuộc khảo sát. Cảm ơn rất nhiều vì sự tham gia và thời gian quý báu của anh/chị. Nếu anh/chị có bất kỳ nhận xét hoặc đề xuất nào, xin vui lòng bình luận vào ô dưới đây.

Nếu không, vui lòng **nhấn nút GỬI (Submit)** để gửi câu trả lời của anh/chị!

Appendix D6 – Ethics Approval

Faculty of Business and Law
Frenchay Campus
Coldharbour Lane
Bristol BS16 2QY

Tel: 0117 328 1170

UWE REC REF No: FBL.22.02.025

16th March 2022

Giang Nguyen

Dear Giang

Application title: Empirical investigation of Supply chain 4.0 implementation in Vietnamese organisations

Thank you for responding to the conditions raised in my letter to you of 11th March 2022.

I can now confirm full ethics approval for your project, but please note that despite the easing of lockdown in England and across the devolved nations, you must continue to follow guidance as set by the UK Government and the relevant devolved administrations. If you have any questions about how this may affect starting your research project or for further information, please contact res.admin@uwe.ac.uk.

In the UK, face-to-face research and fieldwork can be undertaken but there should still be consideration of whether the activities could be delivered in an alternative way. There must still be appropriate mitigations related to Covid-19 risks included within risk assessments, including account taken of requirements from stakeholders.

From Tuesday 1 March, the moratorium on UWE Bristol international travel has been lifted and travellers are now able to request permission to travel through a new online approval process. All applications for international travel must follow the new process with bookings to be made in liaison with the Finance Services team through the University's designated travel management company. Please see the guidance at https://intranet.uwe.ac.uk/tasks-guides/Guide/travelling-on-university-business.

The following standard conditions apply to all research given ethical approval by a UWE Research Ethics Committee:

1. You must notify the relevant UWE Research Ethics Committee in advance if you wish to make significant amendments to the original application: these include any changes to the study protocol which have an ethical dimension. Please note that any changes approved by an external research ethics committee must also be communicated to the relevant UWE committee.
2. You must notify the Faculty Research Ethics Committee if you terminate your research before completion.
3. You must notify the Faculty Research Ethics Committee if there are any serious events or developments in the research that have an ethical dimension.

Please ensure that before proceeding with your research:

- you have sought contractual advice from the UWE Contracts Team Amy.Charles@uwe.ac.uk if your research involves external funding and/or contracts with partner organisations;
- You have sought advice from the UWE Data Protection Team (dataprotection@uwe.ac.uk) if, in relation to collecting and/or sharing personal data, a third party (i.e. any person or institution extraneous to UWE) is involved in the research project.

Please note: The Research Ethics Sub-Committee (RESC) is required to monitor and audit the ethical conduct of research involving human participants, data and tissue conducted by academic staff, students and researchers. Your project may be selected for audit from the research projects submitted to and approved by the RESC and its committees.

We wish you well with your research.

Yours sincerely

Hazel Conley

Professor Hazel Conley
Chair, Faculty Research Ethics Committee

c.c. Professor Vikas Kumar
Dr. Anabela Soares

APPENDIX E – Data Analysis Results

Appendix E1 – Interviewees' Supporting Quotes

Themes	Subthemes	Content	Supporting Quotes
7.3.1.1. Understanding of Industry 4.0		Vague or unclear understanding	"*My understanding would be it is about data usage, it is about innovation, it is about automation and using data for an end to end, let's say supply chain improvement.*" (P2) "*From what I understand, Industry 4.0 refers to investing in technology within the company, increasing productivity on an individual level. All the tasks that used to be done manually are now perhaps being transitioned into a system in order to increase productivity.*" (P.6) "*Since I am not an IT expert or a technician, I am unable to provide a technical definition of digital technologies. Nor do I understand how to build, develop, or apply digital technologies*". "*At the era of Industry 3.0, despite IT applications in the computers, employees still had to work manually at an intensive level such as detecting products' defects manually; whereas, under Industry 4.0's digital technologies, there is a high level of automation, connectivity and communication among machines and equipment; therefore, products' defects can be identified and sent to control tower automatically for company's decision-making*." (P7)

	Robust understanding	“*Industry 4.0 involves integrating AI into machines, equipment lines and robots, enabling these machines and equipment to communicate, share information, and automate the production process. The data generated is collected and transmitted back to the control tower.*” (P7) “*In the 4th industrial revolution, digital technologies such as AI, robotic automation, 5G and more are employed to streamline worldwide real-time data collection, analysis and sharing; and allow end-to-end monitoring and control of supply chain activities such as forecasting, production, warehousing and distribution which increase level of supply chain visibility*.” (P11) “*Industry 4.0 has to be built on a standardised data platform and intelligence. Concerning the term Intelligence, it is not about preprogramed automation. Here, Intelligence refers to AI, where machines learn, comprehend and replicate humans’ behaviours through data input to generate decisions. So that in the future, humans can make more accurate decisions based on real-time data analysis. In the past, without Industry 4.0 technologies, we could still analyse data but the data analysis faced challenges such as restricted data access and unstandardised data. Therefore, data usage required individual analysis of each data segment to facilitate conclusive decisions. It is really time-consuming. However, Industry 4.0 provides a unified and interconnected data that is stored on Cloud computing that allows users to access it easily*.” (P3)
	Understanding of differences between	“*Industry 3.0 is the industry revolution where .com, Internet connection, Uber, Grab were born. Industry 3.0 as an online data landfill where everyone freely dumps or takes out the information. This information or data can also be controlled and utilised by few entities or*

	Industry 3.0 and Industry 4.0	*companies such as Amazon, Google and Facebook which can turn this raw data into valuable information. They analyse customers' behaviours and communication in order to produce products or provide services that meet customers' demand. However, Industry 4.0 is a place where everyone can make use of the data and protect their personal information through data protection regulations such as Privacy Act*". (P3)
		"During Industry 3.0, real-time data was not available and communication was fast. In order for the companies to make the decisions, it took lots of effort and time to collect data from different places and review them to make final decisions. However, with Industry 4.0 technologies, data becomes visible and available that support the managers to make faster decisions. Now, we can be anywhere and still can see the performance indicators of factories and logistics and sales data. Those data is fast, easy, accessible and clear." (P4)
		"*The 3rd industrial revolution is the era of computerisation when operational processes were computerised whereas 4th industrial revolution is the era of digitalisation where the supply chain activities, operational processes, machines and equipment are integrated and communicate with each other with the support of digital technologies. In Industry 4.0, machines and equipment or robots do not operate independently like in Industry 3.0, but they are integrated into a control system. Therefore, the difference between Industry 3.0 and Industry 4.0 is in Industry 3.0, things work independently and separately but in Industry 4.0, things are communicated and integrated with the support of IoT.*" (P5)
		"*At the era of Industry 3.0, despite IT applications in the computers, employees still had to work manually at an intensive level such as detecting products' defects manually;*

		whereas, under Industry 4.0's digital technologies, there is a high level of automation, connectivity and communication among machines and equipment; therefore, products' defects can be identified and sent to control tower automatically for company's decision-making." (P7)
7.3.1.2. Implementation of Industry 4.0 in Vietnamese companies and their supply chain activities	Extensive application of Industry 4.0 in SCM	"*Comparing to other Vietnamese business, our business has adopted a considerable amount of digital technologies in supply chain activities, from forecasting, production planning, outsourcing, manufacturing and distribution activities and is still on digital transformation journey. We view digital transformation as our competitive advantage*" (P12)
	Limited application of Industry 4.0 in SCM	"*Despite the large size of our business, the level of digital technology implementation is still limited as the firm is still relatively young in the market and adheres to traditional working method. However, our business has recognised the benefits of digital transformation or digital technology adoption, prompting us to embrace change*." (P11) "*Our level of digitalisation is relatively high, primarily utilising barcode scanner, a digital control system, Big Data analytics and few more. However, despite our large scale in chemicals Industry, digital technologies are primarily employed in logistics and warehouse management. Overall, within the chemicals sector, the adoption of digital technologies remains at a low rate. This is mainly due to the potential dangers associated with conducting online control of chemical plants from the central control tower. Therefore, despite having sufficient financial resources, our business does not fully digitalise our business. Instead, we have only automated few stages of production processes and incorporated real-time data analytics to monitor the factory emissions in compliance with the government environmental regulations and to track the vehicle location, manage energy and speed, and employ an ERP for operational management*." (P13)

			“*In the textile Industry, the adoption of digital technology is relatively low, with technologies being only minimally incorporated at a few stages of the production line. Moreover, the machinery and equipment within this sector cannot be seamlessly integrated with digital technologies, resulting in a lack of interconnectedness*.” (P7) “*In Vietnam, Industry 3.0 is not yet fully developed and completed; therefore, planning for Industry 4.0 is still too early. Additionally, artificial intelligence (AI) and Big Data are still in the research and experimental stages, and there has not been substantial implementation*.” (P3) “*Real-time big data analysis does not currently exist in Vietnam; moreover, achieving an integrated and digitally controlled supply chain with the assistance of digital technologies is impossible*.” (P10) “*Digital technologies like AI and Blockchain are prevalent in the service Industry and are employed at some production stages in factories. However, it is challenging to integrate digital technologies across the entire production line*.” (P14)
7.3.2.1. Technological determinants	a. Perceived risks	(1) Unclear return on investment (ROI)	“*Every investment in technologies requires justification in terms of ROI, even if it is a cheap technology. Even a low-cost technology can be considered expensive and a waste of financial resources if it does not bring benefits*” (P5) “*It is challenging to justify the financial benefits from investments in digital initiatives. The outcomes often appear doubtful, uncertain and invisible*.” (13)

		“The biggest question is whether the adoption of technologies truly holds financial value for the company…Apart from higher profitability, it is important to ensure increased market demand and improved operational and managerial efficiency. These incentives serve as the driving factors for our business’s digitalisation adoption.” (P14) “*all top managers realise the value of digital transformation or digital technology implementation*” (P9) *“businesses are reluctant to embrace this disruptive change due to a lack of sufficient business cases to prove the feasibility*” (P11) “*due to the failure to justify projected financial returns*” (P12). “*despite substantial support from our company’s top management and abundant resources, digital technology adoption is deemed impractical as our organisation cannot sufficiently demonstrate the expected financial gains*” (P7)
	(2) Dependence on external technology providers	• **There exists a dependence on external technology providers.** “*There are numerous technology providers in the market, each offering varying levels of service quality. This can significantly impact the success of businesses’ adoption of digital technologies, as low-quality technologies or technology services can lead to the failures or slow down the process of technology adoption*”. (P9)

“*Our business faces challenges during the technology adoption journey due to the absence of communication between our company and the technology vendor, especially when our efforts to seek support from the technology provider have not been successful*”. (P10)

“*When faced with minor technical issues such as system breakdowns or maintenance, it is not convenient to reach out to external technical experts*. *Our business can be at considerable risk if the technology provider offers poor after-sale service, has limited technical knowledge, experiences company closure, or discontinues their service*.” (P7)

“W*hen evaluating any technology, it is imperative for technology providers to demonstrate reliability, offer exceptional after-sales service, possess a dedicated support team to address both technical and operational challenges, provide adept technical guidance, commit to technology deployment roadmaps, and offer flexibility to tailor services to meet the specific needs of the firms. Consequently, the trustworthiness of technology providers is commonly assessed based on their technological solutions and services. This thorough evaluation of the technology provider's creditability plays a pivotal role in the selection process*”. (P8)

“*The biggest barrier facing our company in digital transformation is the absence of domestic technology providers within the Industry, which compels us to outsource very expensive technologies from overseas sources. Moreover, we have partnered with various prominent IT providers in Vietnam, such as FPT, CMC, and Viettel corporations to develop a digital transformation plan. However, no significant progress has been made*.” (P7)

- **Dependence on external technology providers does not exist.**

		"*There are numerous online technology learning courses and programs available that offer organisations a flexible and cost-effective means to acquire digital skills. As long as organisations possess the necessary financial resources, access to digital technologies becomes feasible*." (P11) "*There are numerous technology service providers in the market, particularly in the domain of e-commerce technology services. Therefore, it is not a concern for our company*" (P10)
	(3) Short lifespan of digital technologies	"*One of the criteria for evaluating technologies is its life span. A short lifespan of digital technologies can lead to tremendous waste and inefficiency, as older digital devices and machines become unusable, sluggish or incompatible with other equipment. This may necessitate upgrading the devices and machines to more advanced versions. The lifespan of technology should be sufficiently long to justify the investment. Our business would face great financial risk if the applied digital technologies quickly become obsolete*." (P5)
	(4) Data privacy and security concerns	"*Given the expansive scope of our business, a system malfunction can potentially cause massive data breach, thus prioritising data safety and operational system security becomes our paramount concern and having robust data protection system in place is critical*" (P9) "*For technology products and tech-based service industries, risks of data privacy can ruin their competitive advantage as they do not want the competitors to be able to obtain their valuable organisation information*." (P13)

		"*Although a few organisations acknowledge the importance of data privacy and security, in comparison to European data privacy and security standards, the matter is still not given much seriousness in Vietnam. This has led to numerous cases of data breaches.*" (P10)
	(5) Incompatibility issues	"*Vietnamese firms often encounter significant compatibility issues between their internal IT systems and the technologies developed by foreign technology vendors*….. *The technologies that we outsource from abroad need to be customised and developed to suit the Vietnamese market. However, these technologies often face difficulties in communicating effectively with our operational system due to their applications' inability to integrate into our existing operational systems. Consequently, this situation necessitates our firm and the technology vendor to collaborate to make necessary adjustments or modifications to the technical components, which ultimately leads to significant additional costs for the adoption process.*" (P9) "*When choosing a technology, our business has to customise it to match the scale and the size of the business. This incompatibility with IT systems is closely related to the adoption process. Additionally, the expenses associated with customising the technology to align with the organisations' operational environment can be substantial. Therefore, it is not necessary to adopt the latest technologies, but it is crucial to choose the technologies that are suitable and compatible with the organisational environment*" (P6) "*It was challenging for our business to identify compatible technologies with our existing machines and equipment*" (P7)

		"*Our company cannot integrate digital technologies into its transportation management system due to the lack of advanced and qualified vehicles. Many transport vehicles do not adhere to national standards, making it impossible for our company to implement digital technologies on a large scale*." (P8) "*Technologies must be compatible with needs and solutions of our organisation.*" (P11)
	(6) Complexity issues	• **Complexity is not an issue** "*I occasionally take complexity into consideration. However, most of the time, technologies are not overly complicated*." (P10) "*I do not believe technologies are complex, especially considering that young generations nowadays are fast learners.*" (P6) • **Complexity is an issue** "*In my opinion, no technology is inherently complex while still being suitable for you. When you invest in a technology, it needs to be convenient and user-friendly. That is when technology becomes genuinely beneficial. However, if a technology is excessively complex, we do not invest in it. The primary principle of investing in technology is that it should bring benefits and efficiency. The second principle, which is just as important, is that it should be easy to use. After all, there will likely be software that fits your purpose. If someone finds it difficult to use, it means it is not a good fit. People refer to this as being user-friendly*." (P11) "*... If the technology is overly complicated, it also has an impact on the users. For instance, in our context, workers with different levels of expertise might not be skilled in using*

		complex information technology. They typically require straightforward actions and simple steps. When things become overly intricate, it tends to discourage people." (P7) "*In my view, if a technology is complex, it should not be utilised because it will not bring effectiveness. Whatever it is, it must be simple for it to truly function efficiently."* (P12) • **Suggestions to mitigate degree of complexity** "*In my personal opinion, when my company is still at a small scale like this, I prefer to implement technologies gradually and then scale them up. This approach is easier and less complex compared to trying to implement technologies on a large scale immediately*." (P6) "*To reduce complexity and ensure the success of the digital transformation journey, it is important to break it down into smaller stages of digitalisation and take incremental steps to digitise daily operational activities. This approach can help simplify the process of digital transformation.*" (P5) *"It is crucial for top management to provide guidance and encouragement to employees, fostering a digital mindset and data-based working habits. This approach ultimately helps overcome resistance to digital changes…. When employees are given frequent opportunities to practice and train with technologies, these technologies become relatively simple.*" (P9)
	(7) Cost concerns	• **Cost is concern**

"*Only a few organisations are prepared to embrace digital transformation, given the high costs associated with technology infrastructure development, such as investments in fast broadband, databases, training, and the development of IT human resources*." (P14)

"*We offer a wide range of products, spanning from high-end to mid-range and even low-end, as well as various other categories. As a result, the R&D expenses are higher…. Due to our company's complex business structure and operations across diverse Industry sectors, maintaining our leading position requires substantial investments in acquiring various technologies and recruiting diverse personnel. Consequently, our R&D and innovation adoption costs are notably higher compared to other companies*." (P3)

"*Certainly, the perpetual concern of innovation adoption costs has become even more evident, particularly in the aftermath of Covid*." (P1)

- **Cost is not a concern**

"*In Vietnam, I believe that the adoption of innovation largely depends on the willingness of business owners. Financially speaking, the cost is not excessively high. There are certainly affordable management software options available. I am of the opinion that the cost is not necessarily a significant barrier; it's more about whether they choose to invest or not*" (P5)

"*We do not mind the costs of technology adoption since we view these expenses as long-term investments that will yield benefits for our business in the future.*" (P6)

	b. Perceived benefits		“*Digital technologies have allowed us to minimise our organisation’s heavy dependence on human resources, provided better protection for employees’ health and safety by automating hazardous manual work*” (P3) “*Thanks to automation and real-time market data analysis, numerous processes can now be automated. As a result, productivity and team collaboration are enhanced, leading to substantial time savings, which in turn are allocated to critical business activities….The saying “data is money” holds true; therefore collecting real-time market data enriches our database, empowering us to make informed decisions and respond promptly to market dynamics*.” (P6) “*One of the primary benefits that motivated our business to embark on digital transformation is the potential to achieve substantial revenue through cost reduction, resource saving, and increased productivity…The adoption of digital technologies has enabled our business to enhance customer service by efficiently handling a high volume of customer orders, improving communication between operational systems, and increasing the speed of product and service delivery…. Additionally, the pandemic has helped our business to realise the potential of digital technologies in reducing our business’s reliance on labor force*” (P9) “*Incorporating technologies into our operational system enables our business to reduce the number of employees and save on human resources costs, all while enhancing work productivity, particularly during the Covid-19 pandemic*.” (P10)
	a. Organisational resources	(1) Financial resources	“*If you have the financial resources, you can invest in technologies and hire the right personnel for those technologies*.” (P3)

7.3.2.2. Organisational determinants		"*If we have funds, we can access to advanced technologies and qualified personnel easily*" (P11) "*Financial capability is a prerequisite for organisations' adoption of digital technologies. Therefore, without sufficient financial resources, technology transformation cannot be achieved, regardless of the efforts of top management*." (P12) "*Our organisation has a sufficient budget allocated to digital transformation.... Financial concern is not an issue...Budgets for digital transformation have been approved by the leadership, but the results of Industry 4.0 have not been demonstrated or proven yet*." (P7) "*Our company has allocated budgets and human resources to prepare the organisation's digital transformation*." (P9)
	(2) Employees' skills, knowledge and willingness for change	• **Importance of employees' skills and knowledge** "*Recruiting a skilled team with expertise in change management to oversee the digital transformation process and transition activities within the company is essential. Profound changes, like the adoption of new technologies, demand not only the integration of these technologies into the operational systems but also the implementation of effective governance practices and models. This, in turn, necessitates business leaders to possess both management and digital competencies and to challenge the organisation's conventional mindset in order to effectively guide the transformation process*." (P11) • **There exists a shortage of employees' skills and knowledge** "*One of the challenges with the organisations is the gap in awareness, knowledge and understanding of digitalisation between top management and employees…Despite*

leadership's good understanding and knowledge of INDUSTRY 4.0, the digitalisation visions might not be achieved or the plan is not executed successfully due to the knowledge gap between management levels and even middle management and employee level." (P5)

"*Knowledge gaps among employees or between employees and managers can jeopardise the digital transformation process; thus, ensuring that all employees are equipped with sufficient digital knowledge is critical*" (P6)

"*…gaps in leaders' digital expertise are having a significant impact on our ability to drive the transformation, leading to incorrect decisions for the organisation. This is also a common challenge that many businesses face*" (P11)

"*Our employees have limited access to technology-related training materials and document, as they are only available in English, which our employees do not have English skills to comprehend. Furthermore, the translated documents are in Vietnamese are scarce and not easily accessible….Even if the technology training documents are translated into Vietnamese, the full content cannot be fully captured. Therefore, English-based trainings from the company's headquarters cannot be effectively conducted at all levels of employees and in a wider context, it is mostly limited to the top management level*". (P1)

- **There is no challenges in acquiring IT skilled employees**

"*I do not think acquiring IT skilled employees can become a barrier, as you can access to such employees if the company has sufficient financial resources. So I believe that financial* *resources are the most critical facto*r… *With sufficient funds, you can obtain individuals with different level of knowledge and degrees, even the desired patents" (P3)*

"*IT and management skills can be outsourced*." (P4)

"*Well, our team is relatively young which means that the implementation of new technologies does not encounter many obstacles. Our management team is also young, therefore we do not face many issues in terms of innovation adoption*." (P9)

- **Employees' resistance for change**

"*Employees in our business are not strongly adaptive to the market changes, which hamper our change initiatives*" (P7)

"*Our employees are resistant to changes. They have established routines and prefer the traditional work methods as they are not given incentives to make changes, meanwhile changes always involve challenges and difficulties*". (P9)

"*Firms have a tendency of basing strategies on the past successful experience, making it unlikely for them to introduce drastic changes…Most of employees and even certain managers are accustomed to traditional and predictable routines since introducing changes demand them to acquire more advanced skills…. As employees are unwilling to give up their traditional work methods for more skill-demanding tasks, providing appropriate education, training, and guidance becomes are crucial*." (P11)

"*I believe that our advantage in innovation adoption lies in young personnel who tend to adapt quickly*." (P10)

- **Employees' willingness for change**

"*There are also other employees who are willing and welcome new working methods, operational systems, and technologies*". (P6)

"*In reality, no company functions in a way where suggestions are made and everyone instantly agrees. Or there is no immediate resistance like "I'm not doing it, I'm not doing that". It's consistently about exchanging ideas, sharing insights, and mutually challenging one another. This dynamic is prevalent everywhere... It is a common situation where some individuals, particularly those from the older generation, disagree or resist technological changes. Whereas, younger-generation employees are more open and enthusiastic about adopting new ideas and technologies. Hence, it becomes imperative to offer additional technology training for employees from the older generations."* (P11)

- **Training for employees and development of employee engagement strategies**

"*Investing in employees' skills and knowledge is crucial, as HR represents the core resource that can accelerate the technology adoption process*." (P6)

"*With proper instructions and guidance, employees will be able to effectively adopt technologies*." (P10)

		"*Technologies can be acquired, but it is essential to train and invest in human resources…Over the past few years, our corporation has developed various training programs related to digitalisation for different levels of management*." (P4) "*Offering training is one of the future objectives of our organisation... It is imperative to provide comprehensive and ongoing training in digital skills for both top management and employees in preparation for the digital transformation journey*" (P9) "*Incorporating the adoption of technologies and innovations into employee performance evaluations, and rewarding them with financial incentives based on their efforts to learn and apply technologies, can help incentivize employees to feel more responsible and interested, enhancing their willingness to integrate technology into their daily work habits"* (P2) "*The collection and analysis of up-to-date data through the utilisation of technologies are integral components of our company's operational routine... Importantly, leaders should highlight the economic and rational benefits of technology adoption for employees, such as reduced physical workload, enhanced safety, early salary payments, promotions, or other financial incentives... It is also crucial to involve employees in weekly meetings, providing them with the opportunity to share their challenges and achievements within the new culture. This approach can significantly improve the acceptance of disruptive technology adoption among employees."* (P9)
	(3) Technical infrastructure	• **Absence of robust IT infrastructure** "*Slow network connection in our business's area significantly affected our work progress*." (P1)

	“*Existing technology infrastructure in our company greatly constrains our business’ long-term digital technology investment plan*.” (P11) “*The pace of digital transformation within the organisation is very slow... Because in addition to investing in software, we also have to build databases and maintain the human workforce to sustain the company's digital foundation*.” (P14) • **IT infrastructure is not a concern** “*I don't think IT infrastructure concerns are too significant*.” (P8) “*We have gradually and significantly built and invested in our IT infrastructure... Our early investment in technical infrastructure has become an advantage that enables our company to implement technologies.”* (P9)
b. Top management knowledge and support	“*In fostering innovation adoption, leadership stands out as the crucial factor. When leaders are not only convinced but also understand the significance of integrating innovation within the company, they proactively restructure the organisational systems to support the deployment of the innovation and ensure policy compliance. This principle holds true for all facets, not solely limited to innovation adoption, that must start from top management…The company’s cultural foundation is built upon the cumulative habits of its members, shaped by repetitive actions and practices, which ultimately define the overall organisational culture. This process of building a transformative organisational culture must begin with leadership… Thus, it is important that the top management must embrace changes, then the rest of the organisation will follow suit.”* (P4)

"*Whatever transformation you embark upon, it all hinges on leadership*" (P5)

"*It is all about the mindset of leadership. Without their conviction, it is nearly impossible to achieve anything. Once leadership is determined, the implementation of digital transformation can move forward."* (P7)

"*Top managers with the capability and knowledge, as well as a desire to scale the business, are likely to follow the technology market trends. In addition to having sufficient knowledge of digital transformation, it is crucial for top management to recognise the urgency of this radical change and effectively communicate this urgency to their employees*." (P11)

"*If top managers possess limited understanding, commitment, or knowledge, they are less likely to endorse digital transformation. Moreover, if they assume full responsibility for technology adoption due to the company's top-down approach, there is a risk of making incorrect decisions*." (P10)

"*If top managers exert their power and control over employees in the pursuit of digital transformation, employees are left with no choice but to either comply with the orders or leave the organisation…. It is essential for top managers not only show the commitment to technology adoption but also to practically apply these changes and involve employees in the process of change. Thus, the top management team should be proactive in driving company-wide changes and empowering employees to facilitate these changes…Digital transformation should not be isolated from employees. Therefore, it is crucial for leaders to clearly communicate their needs and tasks to their subordinates, ensuring that the work required for digital transformation is appropriately planned. Additionally, identifying qualified employees* *who can lead various parts of the process is critical to successfully facilitate the necessary changes… It is important for top management to cultivate employees' habits of collecting and utilising real-time data, while also rewarding them for their innovative achievements*" (P9)

"*It is important that the top management to formulate a clear digital strategy and roadmap to direct the whole organisation towards the digitalisation goal*." (P5)

"*Despite the modest size of our business, our top management is willing and enthusiastic to make significant investments in digital technology adoption in order to expedite the growth of the business. We align technological reform with the business strategy and objectives to underpin success in the market, particularly helping the organisation in quickly controlling things, responding to the market changes and accurately planning resources to enhance our business' competitive advantage*." (P6)

"*As a single top manager alone cannot drive a significant change, it is crucial to have the full support and effort of the entire top management team or the governance board*." (P9)

"*One of the primary barriers to technology adoption is that many businesses leaders do not prioritise digital transformation or have a sense of urgency. They are also unwilling to take on potential risks involved in the journey of digital transformation*" (P10)

"*Although our business's top management is determined and proactive in pursuing digital transformation, allocating budgets and teams to explore the potential of digital technologies, promoting digital transformation among employees, and recognising it as a vital survival strategy in the Industry, our organisation is still struggling to start the journey due to*

			the lack of clarity regarding the approaches and methods required to formulate a detailed plan and establish a clear direction towards for the process of digital transformation." (P7)
7.3.2.3. Environmental determinants	a. Market pressure	(1) Competitor pressure	"*The logistics Industry constantly changes, pressuring logistics companies to continuously improve and adapt in response to market demands*." (P8) "*Facing the increasingly fierce low-cost competition, businesses must redefine their operational and management methods, which can be achieved with the support of digital technologies...The pace of digital transition is accelerating across all Industry sectors in Vietnam, as companies increasingly perceive digital transformation as a competitive advantage*" (P12) "*Our industry characteristics involve rapidly changes, ambiguity, and shorter product life cycle*." (P3) "*Without digitalisation, our business would not remain competitive*". (P9) "*Recent initiatives by competitors to adopt digital transformation have put our business under significant pressure to embrace digital technologies in order to survive. Thus, the effort for digitalisation is even greater especially when Vietnamese local firms with limited resources are threatened by foreign firms that possess more abundant financial, HR, and technical resources to compete in the Vietnamese market*." (P11) "*With the evolution of technologies, competitors can enter the market more rapidly and inconspicuously*". (P5)

	(2) Customer pressure	"*If there is a shift in customers' mindset towards innovation, for example, considering innovation as an important factor for evaluating companies, then profit-driven companies will certainly establish digitalisation as a goal*". (P2) "*Customers essentially do not concern themselves with the quantity or extent of technologies a company is adopting; they are primarily concerned with whether the service is fast, transparent, and efficient. This, in turn, has prompted companies to pursue the adoption of digital technology*". (P11) "*The customer's desire for fast, transparent, efficient, and cost-effective services indirectly compels companies to adopt digital technologies to achieve the desired level of customer service quality*." (P3) "*The international requirements or customers' demands for sustainable and environmentally-friendly products, recycled or biodegradable materials, and energy-saving production processes also serve as encouragement and motivation for today's firms to adopt digital technologies"* (P9) "*Covid has significantly impacted the business environment and accelerated digital transformation process for businesses*". (P4) "*Before Covid 19, our business partners had not realised the potential of adopting digital technologies as there was no compelling force to encourage organisations to think outside of the box. Thus, it was an arduous task for our company to call for change from our business partners. Only when Covid-19 impacted every company did our business partners*

come under pressure to implement digital transformation in order to maintain competitiveness in the market…Covid-19 also provided our business with the opportunity to recognise the importance of reducing reliance on labour force to mitigate operational risks which therefore drive our business to embrace technological reform." (P9)

"*Covid 19 has compelled our business to accelerate the speed of digital transformation, particularly to promote commerce and business interactions with other countries*." (P7)

"*During the pandemic, our business found technology adoption to be extremely valuable, as it enables organisations to monitor business health by collecting and analysing real-time data, and facilitates more efficient and effective management of operational activities. Additionally, the pandemic has prompted a significant shift in consumer behaviours towards online shopping habits. This requires businesses to engage with customers through digital channels and adopt digital solutions to address customers' needs."* (P6)

"*Our business had already embraced a certain extent of digital transformation before this crisis event. Given the characteristics of the chemical Industry that requires onsite control of factories, chemical companies are advised not to implement a full digital transformation*" (P13)

"*Despite the impact of Covid 19, digital technologies cannot be fully implemented into transport management due to the substantial reliance on human resources. Therefore, market uncertainties such as Covid may not have significant impact on these companies*." (P8)

		"*The pandemic has only stimulated Internet penetration, e-commerce, e-government, e-banking, online work, e-learning, and more which is evident by the fact that Covid 19 crisis prompted companies to quickly invest in software platforms such as Zoom and Microsoft Teams to facilitate online meetings and communications*." (P3) "*The market has not yet achieved full digitalisation, and Covid 19 has only raised everyone's awareness about Industry 4.0. However, businesses are still struggling or progressing slowly in their digital transformation efforts*." (P4)
b. Market support	(1) Government policies and support	• **Government does not pose any barriers to businesses' digital transformation** "*The government is also aiming for development of Industry 4.0. The government is not only advancing 5G networks but also exploring the possibilities of 6G networks…When looking at administrative processes, customs procedures, import and export protocols, as well as legal documentation, substantial digitisation efforts have been undertaken. These have also been integrated onto the government's website, enhancing accessibility and interactions with government entities through this platform. I do not think the government is creating any obstacles; rather, they are striving to support businesses in enhancing their competitiveness by developing the IT infrastructure…Notably, innovation awards such as "Vietnamese Talent" or "Vietnamese Entrepreneurs" are all greatly aided by the government. The government's capital accumulation is not as high as in other countries, which is one of the difficulties for Vietnamese start-ups…Presently, the government acknowledges private enterprises as the backbone of Vietnam's economy…Now businesses can secure loans from banks and access fundings*" (P1)

"*In order to promote the development of high technology Industry, the government is also encouraging local companies to invest in the high technology sector while offering open and favourable investment conditions, such as reduced requirements for technology transfer or tax rebates, to attract foreign high technology companies*." (P3)

- **Government poses challenges to businesses' digital transformation**

"*However, the Vietnamese government's understanding and awareness of digital transformation remain vague. There is little understanding about the benefits and contributions of digital technologies towards the economy and their applications*. *Despite significant investment, innovation projects and innovation centres have not achieved success. Some innovation centres fail to attract sufficient technology businesses, innovators, and entrepreneurs. Vietnam has been unsuccessful in meeting the needs of foreign investors when it comes to establishing innovation centres. The transition from detailed plans to concrete actions remains challenging. Therefore, the government needs to significantly enhance its capacity to coordinate and implement digital transformation plans. When compared to other regional countries, Vietnam's development of 3G and 4G is still slower and the progress of 4G has also faced significant delays. Hence, the Vietnamese government must expedite the process of 5G development to stay competitive in the region and to ensure robust Internet connectivity for Industry 4.0 development. 5G can be described as a crucial and pivotal infrastructure component, particularly within the context of the Industry 4.0 revolution …Currently, the government is limited to only encouraging and issuing general guidance and policies, such as clean, environmentally friendly, and sustainable technologies. The support is mainly given to SMEs and start-ups, such as building national innovation centres to provide* *funding and support for SMEs' product tests, launch, marketing, etc… The access to national funding is difficult with complex and costly administrative processes'*" (P3)

"*Despite the government's constant discourse on digital transformation, frequent meetings, and the Minister of Information and Communications calling for digital transformation action from businesses, the detailed digital transformation pathway remains uncertain and the term "digital transformation" itself remains ambiguous for businesses…The government has taken few initial steps…However, when it comes to the implications of Industry 4.0 in manufacturing, I find these efforts insufficient... This is my perspective... In essence, I believe that individual enterprises must take the initiative rather than solely relying on the government funding…Our survival depends on taking action ourselves, not waiting for government intervention. The government primarily focuses on policies and legal frameworks, but in reality, there is not much... I believe the current role of the government is more about legal frameworks, which are already in place; the critical aspect is the lack of substantial support for Industry 4.0*." (P7)

"*Numerous documents, countless official letters, and many calls for changes – yet, there is no comprehensive plan in place. Thus, I truly feel that the current role of the state remains too restricted, not yet evident or present somewhere that I do not know. Simply put, it appears that the state is not taking significant actions to catalyse digital transformation within businesses. I have not seen such endeavours being implemented*." (P11)

"*In terms of general logistics infrastructure, I believe better planning is required. Theoretically, numerous projects have been proposed, including discussions about regional* *planning and logistics centres at different levels…However, the reality is that Vietnam lacks interconnected logistics hubs that can serve as access points for air routes and various transportation modes. I believe more advanced and logically developed countries have established such hub centres*." (P8)

- **Suggestions to businesses and government**

"*We cannot expect the government to hold our hand; that is only feasible through the leadership of businesses themselves. Businesses need to formulate their own strategies, develop products that meet market demands, and then channel investments in the right direction…The self-sufficiency of Vietnamese businesses is not particularly robust. So I believe the government manages at the macro level. It might be necessary for them to implement policies such as ranking mechanisms to assess the degree of businesses' digitalisation or provide financial incentives or capital access for businesses with a high level of digitalisation*." (P1)

"*In order for Vietnamese businesses to capitalise on the opportunities presented by the evolution of digital technology, it is important for the government to enhance the effectiveness of governance at all levels, along with improving the business and investment environment, such as executing administrative reforms, streamlining or simplifying administrative processes or procedures related to the business sector.*" (P14)

"*It is imperative for the government to accelerate the finalisation of supportive programs, detailed policies, and guiding circulars for businesses. This will help create a*

		favourable environment and incentives for businesses on their digitalisation journey, ensuring that the country does not miss out on this opportunity." (P5) "*The government should delegate the task of developing local or national management software tools, such as warehouse, logistics, and transport management software, to IT firms that are either state-owned or privately-owned. Because outsourcing from external technology providers is extremely costly and often not compatible with the characteristics of the Vietnamese market*." (P8) "*The role of the government here should involve understanding the needs and challenges of businesses, creating a supportive legal framework and mechanisms, as well as providing businesses access to financial funding for implementing digital transformation. The government should not blindly apply the same digital strategies and roadmaps from other countries. Instead, it should focus on understanding the national economic characteristics and market challenges, and how technologies can solve current market problems, rather than simply trying to keep up with other countries' technology advancements*". (P3)
	(2) Third-party support	"*The success of our business's digital transformation heavily relies on technology providers that are currently unavailable in the market. As a result, our organisation has partnered with large IT firms like FPT to prepare for digital transformation. However, due to the complex production nature of the textile and clothing Industry, digital transformation and the adoption of digital technology are exceedingly challenging. Consequently, not much progress has been achieved*." (P7)

	"*The availability of external financial resources is limited. Additionally, businesses face high financing costs due to high interest rates and difficulties in accessing capital from banks or the government. Companies seeking government subsidies are required to navigate complex and challenging administrative procedures. (P9)* "*While accessing funding from external sources such as banks or government funds is easy, the cost of financing remains relatively high for businesses in Vietnam*." (P1) "*Rarely did our business rely on external companies, and these external entities only played a subordinate role in adopting digital technology*." (P13)
c. Interorganisational relationships	"*In the last 3 - 4 years, establishing partnerships within the supply chain has become critical for the mutual success and competitive advantage of all supply chain stakeholders. Even suppliers now collaborate with each other to provide the best service to clients, rather than competing against each other as in the past*." (P5) *"The key to a successful digital transformation that benefits everyone lies in building strategic partnerships and fostering collaboration among all parties which is essential to as no single party can accomplish this alone. Obviously, by involving implementation partners or technology partners, the likelihood of reaching mutual visions and strategies for adopting digital technologies increases. Additionally, the early identification of major obstacles that impede digital technology adoption by all supply chain stakeholders can help mitigate risks of failure in later stages"* (P9) "*Nowadays, supply chain stakeholders actively support each other in embracing digital changes*". (P11)

	(1) Trading partners' pressure	"*We have a vendor evaluation criteria dashboard. For a company to become our primary vendors, the companies need to invest at least 15 to 20% of their human resources into R&D.*" (P3) "*Our partners exerted pressure on us to operate with greater speed, precision (without errors), and transparency throughout our operational processes. They also demanded real-time updates and tracking for products. Therefore, we were compelled to adopt digital technologies to meet these demands*." (P6) "*Our trading partners required suppliers to showcase products virtually, leading to pressure on our company to adopt digital technologies such as Virtual Reality and 3D printing. Failure to do so would have resulted in losing this partner*". (P7) "*Our company could lose contracts to other competitors if we fail to meet the conditions specified in the contracts*." (P8) "*A few years ago, our large business encouraged our partners to embrace digital transformation; however, more recently, our business has had to exert pressure on our partners to expedite this process.*" (P12) "*When business partners demand adherence to specific digital standards for products and services, businesses are motivated to adopt digital technologies as they clearly recognize the value and ROI from such technology adoption.*" (P14)

			“*In the chemical Industry, we neither influence nor are influenced by our partners to adopt digital technologies or implement digital transformation*”. (P13)
		(2) Trading partners’ readiness	*“Due to different sizes, market power, and business sectors, each organisation possesses a distinct level of financial and technical resources, as well as a willingness to undertake digital reform. Therefore, even with sufficient resources and a strong commitment to embracing digital transformation, certain organisations find themselves constrained, slowed down, or unable to fully harness the potential of digital technologies due to the lack of readiness on the part of their trading partners*.” (P2) “*At times, our company needs to provide education to our business partners about technology adoption*” (P9)
		(3) Trust-based information sharing with supply chain partners	“*It is crucial to have a mutual information-sharing platform or standards for supply chain stakeholders that allows continuous, flexible and up-to-date information exchange for effective decision-making*.” (P5) “*Nonetheless, businesses are reluctant or find it unnecessary to share information with their trading partners due to the scope and size of their operations.*” (P6). “*For our firm, it is unnecessary for us to share extensive information and data with partners, only some information about orders, products, and business transactions need to be shared*” (P13)
	a. Organisational structure		• **Importance of flexibility-oriented culture and flat and decentralised structure**

7.3.2.4. Organisational culture	"*The culture that focuses on teamwork, discussions, arguments and debates can foster creativity and bring forth the best ideas; however, the digital transformation progress can be slowed down if it involves too many stakeholders in the decision-making process*". "*Digital transformation necessitates organisations to review and redefine their business processes and organisational structures, making them more flexible and flatter that enable faster and smoother information sharing and communication…Thus, we aim to decentralise our organisational structure, granting a high level of autonomy to employees…placing a strong emphasis on fostering discussions among employees*" (P1) "*We follow a very flat and decentralised structure... We are very pragmatic.*" (P2) "*In order for us to adopt the technology system, our company had to undergo restructuring to become more flexible*". (P6) *"If the governance processes and procedures are not optimised, and the structure is too hierarchical, centralised, inflexible and complex, the flow of information and decisions is slowed down, significantly impacting the digital transformation effort. On the other hand, a simple and flexible organisational structure and processes can facilitate the adoption process …The process of digitalisation requires our organisation to restructure its systems to be simpler and more flexible in management, effective in communication, and easier to guide employees through technology adoption."* (P8) • **Importance of integrated flexibility and control-oriented culture with hybrid structure**

	“*The organisational culture centered around values of discipline and innovation is likely to accelerate the digitalisation process. On the other hand, an innovative culture without discipline can slows down the process, and a culture focusing solely on discipline may result in employee resistance to changes.”* (P12) “*Indeed, decentralisation allows fast and easy communication, information sharing, flexibility, and the freedom to be innovative and creative… In our organisation, we focus more on hierarchy, orders…top-down approaches...Our organisation is making an to shift towards a more decentralised and flexible structure. However, a large firm’s decentralised structure can also become a hinderance, especially for multinational corporations with business units lacking sufficient knowledge about digital transformation.…Our firm’s leadership style, which used to be dictatorial and controlling, along with its high hierarchical structure and limited inter-departmental collaboration have paradoxically facilitated rapid innovation by strictly enforcing it to all levels of employees. Therefore, in order to remain the leading position in the industry and accelerate digital transformation, it requires employees to obey rules, procedures, processes and “do what they are told”…However, it is important to note that the organisational culture is influenced by national culture, thus difficult to change completely…*” (P3)
b. Organisational strategies and goals	• **Integration of both flexibility and control-oriented culture** “*We aim to create the latest and world-leading products, while focusing on continuous improvement*.” (P1) “*We engage in sharing ideas and best practices with other countries and focus on continuous improvement for our operational system… We ensure that our objectives and goals are clearly communicated to everyone …While we are not the first mover in the market,*

	we strive to catch up quickly with the market by developing and implementing new services that we do not offer in other countries." (P2) *"We have built global and regional team as well as R&D department dedicated to digitalisation and innovation adoption, with the aims of assessing the IT quality, managing cyber security risks and other technological risks, and facilitating the sharing of best practices and* experiences" (P3) "*The pillars of our success lie in teamwork, the exchange of ideas, and the sharing of best practices among our members…Additionally, we aspire to lead the Industry in which we operate*" (P4) "*Our primary aim is not Industry leadership; rather, we focus on achieving operational excellence through digital transformation. In this context, operational excellence means meeting customer needs, reducing costs, and delivering greater value to our customers. For us, effective teamwork and the exchange of information and ideas are foundational.*" (P9) "*Teamwork, functional collaboration, and information sharing are fundamental prerequisites for our business to thrive*." (P11) "*We want to invest strongly in manufacturing technologies and product quality…We aspire to take a leading position the Industry*" (P13) "*We consider the utilisation of data as an essential component of the innovation process, contributing to enhanced decision-making and risk management. Therefore, we are*

	making efforts to instill a data-driven and innovative culture at all levels of management and among employees, aligning this culture with the digital goals of the company…One of our organisation's Widely Important Goals is to enhance the utilisation of data in decision-making from 0% to 100%... We aim to shift employees' habits towards frequent data usage and change their mindset regarding the significance of using data on a daily basis for business purposes…Furthermore, engaging employees in the digital transformation journal is also of paramount importance." (P9) "*To align employees to the organisation's digital goals, ensuring that employees recognise the direct correlation between their dedication and the overall performance of the organisation, and engaging them in the change process, establish a strong connection between them and the organisation. We proactively communicate our digital transformation goals to employees across all levels, involve employees in discussion and strategy revisions during regular company meetings, and ensure a solid understanding of their valuable contribution in achieving digital goals as well as guide them towards fulfilling these goals by developing KPI, dashboards and training initiatives*." (P9)
c. The link between organisational culture and top management	• **Top management drives and intertwines with organisational culture** "*I believe that despite the organisation's long-standing development of its culture, a change in top management could potentially shift the corporate culture to align with the new values introduced by the incoming leadership*." (P4)

"*Corporate culture mirrors the leadership style of the top management; therefore, decision regarding digital transformation must originate from the top management level, and then be disseminated to middle and lower management levels*." (P6)

"*Although both culture and top management play equal roles in the technological transformation journey, the changes should first take root at the leadership level before permeating the organisational culture level…In the context of large organisations, if a newly hired corporate leader brings in external values and visions that conflict with the organisation's internal culture and strategies, it can trigger resistance within the organisation, especially among employees*." (P9)

"*If top management is decisive and determined, but the culture remains stagnant, unadaptable, rigid and inflexible, or if the culture is dynamic and flexible but leaders lack vision and earnest commitment to digital transformation, this massive change cannot be implemented effectively. Therefore, for technological reform to take root and develop, both corporate culture and top management need to go hand in hand… Top managers must act as role models to enforce the corporate culture, and in return, the corporate culture will ensure employees execute top management's strategies*." (P9)

"*It is a chicken-or-the-egg causality dilemma. It is not necessary that the leaders influence and create the corporate culture, but the corporate culture can also tremendously affect and shape the top managers' leadership style and their business goals; thus, this relationship is closely intertwined*." (P11)

- **Top management cannot drive organisational culture change**

	"*Corporate culture plays a more significant role than top management, especially in large organisations…In many cases, the efforts of top managers may not suffice to drive a substantial change throughout the entire organisation if a majority of employees are resistant to change. This is where organisational culture steps in*." (P12)
Firm size	• **Large firms have advantages over SMEs in digital transformation journey** "*Since my company is a large enterprise, we have abundant financial resources. In fact, if you do not have money, you cannot adopt technologies. What does technology mean? It is about the latest advancements, the finest innovations*" (P3) "*Being a large corporation, our company consistently strives to stay ahead of the curve by anticipating significant global shifts through up-to-date market data analysis so that our company can develop strategic long-term plans for its development*." (P4) *"I believe that digital transformation might not yield substantial benefits for smaller businesses due to the substantial investment required*" (P9) • **Large size of firms do not pose digital transformation barriers** *"Despite our large organisational structure, we have not encountered significant challenges in our digital transformation journey thanks to our early adoption of technology during the company's initial growth stage. By integrating technologies into our operations at*

early stage, our company has faced less substantial obstacles when the business has expanded in size." (P9)

- **SMEs have advantages over large firms in digital transformation journey**

"*Due to the complex organisational structures with a broad business scope, including multiple divisions and various businesses, engaging in different products and service types, our organisation has to adopt various technologies instead of relying on a single technology for all purposes. As a result, this leads to a considerable cost of technology adoption, involving a substantial number of individuals with diverse IT skills and knowledge, as well as a series of training sessions. In addition, it requires substantial effort of research, experiment, and an extended implementation period. This cost and effort are even more substantial, particularly for leading technology product companies like us*" (P3).

"*Despite making substantial investments in innovation, a number of large firms face challenges when it comes to adopting digital technologies like ERP due to their complex organisational structures and the higher adoption costs that come with large-scale implementations, especially when compared to small businesses*" (P6). Furthermore, the interviewee asserted, "*Even though we run a small business, we are enthusiastic about investing in technology adoption. We firmly believe that technologies can bring about significantly positive impacts on our small enterprise, enabling us to expedite business growth in a more systematic manner and enhance overall productivity*" (P6)

	"*Small organisations possess a significant advantage over their larger competitors, namely the ability to remain flexible and swiftly adapt to market changes because small firms have a smaller number of employees, more compact facilities, fewer information-sharing requirements, and a simpler hierarchy or management structure. These attributes collectively make it easier and quicker for small firms to adopt technologies. On the other hand, changes within large organisations may face slowdowns due to their greater organisational inertia and complex organisational structure… Furthermore, concerning technology training for digital adoption, in small firms, the responsibility would likely fall on senior managers, such as company directors and/or founders, who are eager to drive this profound change for their business, thereby expediting the digital transformation process. In contrast, in larger firms, this task would be assigned to middle or junior managers who have the responsibility of executing strategies given by the senior managers. The pace of the change process can be hindered if these middle or junior managers do not recognise the importance of digital goals or if they lack the financial incentives to implement changes*." (P10) *"Big firms definitely face challenges when it comes to embracing digital transformation*" (P13)
Industry characteristics	*"Depending on the industry characteristics of the business, success is measured by different values. For technology-based products or services such as the electronics Industry including mobile phones, laptops, cars, software, etc. a company's success is intricately tied to the rapid development of cutting-edge technology-driven products and services. Thus, technologies stand as both the cornerstone of achievement and the source of profitability*" (P11)

"*As a leading figure in technology products, in order to maintain a competitive advantage in the market, our company has to consistently adopt digital technologies and needs to act as pioneers in digital technology adoption to retain our dominant position. The greater the integration of technologies and automation, the stronger our competitive advantage becomes …It is crucial that all departments and supply chain partners are interconnected and collaborate seamlessly. The supply chain must be agile, robust and has no disruptions in order for us to deliver products quickly. Especially, following Just-in-time management model restricts our business from stockpiling excess products, thus, implementing the latest digital technologies becomes critical for our business to expedite product deliveries*." (P3)

"*Due to the nature of the chemical industry where full digitalisation is unachievable, our company has reached an adequate level of automation. Therefore, I do not find it urgent to adopt many digital technologies for my company, nor do I perceive any challenges that inhibit us from undergoing digital transformation*." (P13)

"*As we produce consumer goods, the success of a new product is not reliant on technologies but expertise and competence of people. Therefore, those businesses do not set the goals of being the first in the market with leading technologies*." (P11)

"*Due to the complex production nature of the textile and clothing Industry, in which technology maturity is relatively poor, digital transformation and the adoption of digital technology are more challenging. As a result, the adoption of digital technology is still in the research stage*" (P7).

	"*Due to the nature of the logistics Industry, logistics providers collaborate with numerous clients, each with distinct operational systems and products, often under short-term contracts. Consequently, employing a single technology that is universally applicable and compatible across all businesses poses a challenge. Such an approach would necessitate logistics companies to modify their own operational systems to align with their partners…Additionally, the logistics Industry is still in a state of immaturity, with some transportation systems being outdated and not in alignment with vehicle standards, such as the absence of GPS installation. Consequently, this limitation hampers the integration of digital technologies into transport management. Lastly, the logistics Industry is highly competitive in terms of pricing strategy. This means that if our service quality is higher than the norm, we might struggle to sell our service due to the perception of a high-price offering. Meanwhile, the cost of technology investment is enormous, which drives up the logistics price, causing the company to lose its competitive advantage in the market. For these reasons, despite receiving substantial support from top management, logistics companies continue to face challenges in fully digitising their business operations. As a result, there is a low level or almost no adoption of digital technologies among SMEs, particularly within the logistics sector. Even for large logistics organisations, they are only adopting fundamental technology tools and systems*." (P8)

Appendix E2 – Pearson's Correlation Analysis Outcome (without control variables)

	TechFact	Risks	Benefits	OrgFact	OrgRes	TopMa	EnviFact	MarSup	MarPres	PartRela	OrgCult	AdoptIntent	AdoptAct	Adoption
TechFact	1													
Risks	.452**	1												
Benefits	.691**	-.332**	1											
OrgFact	.321**	-.172**	.479**	1										
OrgRes	.348**	-.117*	.463**	.895**	1									
TopMa	.209**	-.190**	.375**	.865**	.550**	1								
EnviFact	.019	-.258**	.230**	.453**	.398**	.401**	1							
MarSup	-.063	-.093	.009	.288**	.243**	.266**	.753**	1						
MarPres	.092	-.298**	.338**	.272**	.256**	.222**	.743**	.260**	1					
PartRela	.007	-.178**	.152**	.485**	.415**	.441**	.751**	.436**	.338**	1				
OrgCult	.331**	-.203**	.515**	.611**	.491**	.593**	.468**	.289**	.341**	.435**	1			
AdoptIntent	.255**	-.174**	.411**	.548**	.418**	.555**	.400**	.164**	.356**	.387**	.566**	1		
AdoptAct	.192**	-.131*	.310**	.674**	.570**	.621**	.555**	.404**	.326**	.546**	.563**	.623**	1	
Adoption	.249**	-.170**	.401**	.678**	.548**	.652**	.529**	.314**	.378**	.517**	.627**	.904**	.898**	1

***. Correlation is significant at the 0.01 level (2-tailed).*

**. Correlation is significant at the 0.05 level (2-tailed).*

TechFact: Technological Factor

OrgFact: Organisational Factor

OrgRes: Organisational Resources

TopMa: Top Management Support and Knowledge

EnviFact: Environmental Factor

MarSup : Market Support

MarPres : Market Pressure

PartRela : Partner Relationships or Interorganisational Relationships

OrgCult: Organisational Culture

AdoptIntent : Adoption Intention

AdoptAct : Adoption Actions

Appendix E3 – Regression Analysis Result (with control variables)

	Overall DSC adoption		**DSC adoption intention**		**DSC adoption actions**	
	Beta	**t value**	**Beta**	**t value**	**Beta**	**t value**
Constant		-.650		.345		-1.593
Respondent's company position	-.002	-.051	.014	.303	-.018	-.455
Company's location	-.056	-1.337	-.053	-1.095	-.047	-1.125
Company's level of decision-making autonomy	.057	1.373	.045	.929	.058	1.389
Company's size	**.097***	**2.275**	**.057**	**1.149**	**.118****	**2.769**
Company's type	-.029	-.687	-.034	-.686	-.018	-.431
Company's industry	.014	.350	.024	.499	.002	.042
Perceived benefits	.137*	2.704	.200	3.396	.044	.868
Perceived risks	.042	.957	.035	.682	.041	.927
Organisational resources	.120*	2.246	.020	.330	.197***	3.693
Top management knowledge and support	.390***	7.667	.373	6.275	.330***	6.462
Market support	.049	1.072	-.053	-.985	.144***	3.125
Market pressure	.151**	3.261	.177	3.271	.094*	2.030
Interorganisational relationships	.196***	3.917	.142	2.434	.212***	4.222

*p < 0.05; **p< 0.01; ***p≤ 0.001