IMPACT OF DIGITALIZATION ON SUPPLY CHAIN RESILIENCE IN SMALL AND MEDIUM-SIZED ENTERPRISE (SME)

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DECLARATION

I declare that this thesis entitled "IMPACT OF DIGITALIZATION ON SUPPLY CHAIN RESILIENCE IN SMALL AND MEDIUM-SIZED ENTERPRISE (SME) is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

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Date : 18 JUNE 2023

APPROVAL

I hereby declare that I have checked this report entitled "IMPACT OF DIGITALIZATION ON SUPPLY CHAIN RESILIENCE IN SMALL AND MEDIUM-SIZED ENTERPRISE (SME)", and in my opinion, this thesis fulfils the partial requirement to be awarded the degree of Bachelor of Technology Management (Supply Chain and Logistic) with Honors

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Date : 19 January 2024

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Date : 19 January 2024

DEDICATIONS

This study is dedicated to myself and my beloved furry friends, who have been my constant companions and a source of joy and comfort throughout this research journey. It symbolizes the unwavering commitment, resilience, and love that have fueled my pursuit of knowledge. To my past self, thank you for embarking on this academic adventure with determination and curiosity. Your dedication to learning has brought us to this point. To the present version of myself, I admire your perseverance, focus, and dedication to excellence. Your hard work and sacrifices have propelled this study forward.

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ABSTRACT

The adoption of technology during the Fourth Industrial Revolution has led many industries to automate their operations. The COVID-19 pandemic in 2020 further tested businesses' resilience and encouraged organizations to incorporate technology into their processes. This study examines the connection between digitalizing the supply chain and its impact on supply chain resilience in small and medium-sized enterprises (SMEs) in Malaysia. In this study, 'digitalization' refers to the utilization of digital technologies to revolutionize business interactions within and between organizations. Intense market competition, unexpected demand patterns, and efficiency issues have driven organizations to explore technology utilization in their supply chains. Quantitative methods were employed, utilizing a questionnaire with a 5-point Likert scale. The study focuses on gathering responses from individuals employed in medium-sized enterprises located in the southern region of Malaysia. The target is to obtain feedback from a total of 170 respondents. The achieved response rate stands at approximately 72.94%. The data collected will be analyzed using SPSS. This research aims to provide insights into how supply chain digitalization contributes to the resilience of SMEs, guiding organizations facing challenges in technological integration. Objectives include identifying factors attributing to supply chain resilience in SME, examining the relationship between digitalization and resilience, and identifying significant variables influencing supply chain resilience in SME. By analyzing the collected data, this study aims to uncover the mechanisms through which supply chain digitalization impacts SME resilience. This study holds significant implications for the research community, offering valuable insights and practical guidelines for medium-sized enterprises in the southern region of Malaysia. The research highlights the lack of focus on the relationship between technology and resilience, particularly in the context of the growing but not yet mature phase of digitalization. To address this, the study recommends applying successful digitalization strategies from other industries to the supply chain, aiming to determine their efficiency in enhancing resilience for these enterprises.

Keywords: Digitalization, Supply Chain Resilience, Small and Medium-Sized Enteprises (SME), Malaysia.

ABSTRAK

Penerimaan teknologi semasa Revolusi Perindustrian Keempat menyebabkan industri mengautomasikan operasi mereka. Pandemik COVID-19 pada tahun 2020 menguji daya tahan perniagaan dan menggalakkan organisasi untuk mengintegrasikan teknologi ke dalam proses. Kajian ini mengkaji hubungan antara pendigitalan rantaian bekalan dan kesannya terhadap daya tahan rantaian bekalan dalam perusahaan kecil dan sederhana (PKS) di Malaysia. Dalam kajian ini, 'pendigitalan' merujuk kepada penggunaan teknologi digital untuk merevolusikan interaksi perniagaan dalam dan antara organisasi. Persaingan pasaran yang sengit, corak permintaan yang tidak dijangka dan kecekapan telah mendorong organisasi untuk meneroka penggunaan teknologi dalam rantaian bekalan. Kaedah kuantitatif telah digunakan, dengan soal selidik skala Likert 5 mata. Kajian ini memberi tumpuan kepada pengumpulan maklum balas daripada individu yang bekerja di perusahaan bersaiz sederhana yang terletak di wilayah selatan Malaysia. Sasarannya adalah untuk mendapatkan maklum balas daripada sejumlah 170 responden. Kadar tindak balas yang dicapai adalah 72.94%. Data yang dikumpul dianalisis menggunakan SPSS. Penyelidikan ini bertujuan untuk memberikan pandangan tentang cara pendigitalan rantaian bekalan menyumbang kepada daya tahan PKS, membimbing organisasi yang menghadapi cabaran dalam penyepaduan teknologi. Objektif termasuk mengenal pasti faktor yang dikaitkan dengan daya tahan rantaian bekalan dalam PKS, mengkaji hubungan antara pendigitalan dan daya tahan, dan mengenal pasti pembolehubah penting yang mempengaruhi daya tahan rantaian bekalan dalam PKS. Dengan menganalisis data yang dikumpul, kajian ini bertujuan untuk mendedahkan mekanisme yang melaluinya pendigitalan rantaian bekalan memberi kesan kepada daya tahan PKS. Kajian ini mempunyai implikasi yang signifikan kepada komuniti penyelidikan, menawarkan pandangan berharga dan garis panduan praktikal untuk perusahaan bersaiz sederhana di wilayah selatan Malaysia. Penyelidikan itu menyerlahkan kekurangan tumpuan pada hubungan antara teknologi dan daya tahan, terutamanya dalam konteks fasa digitalisasi yang semakin berkembang tetapi belum matang. Untuk menangani perkara ini, kajian itu mengesyorkan agar strategi pendigitalan yang berjaya digunakan daripada industri lain kepada rantaian bekalan, bertujuan untuk menentukan kecekapan mereka dalam meningkatkan daya tahan bagi perusahaan ini.

Kata Kunci: Pendigitalan, Ketahanan Rantaian Bekalan, Perusahaan Kecil dan Sederhana (PKS), Malaysia.

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LIST OF SYMBOLS AND ABBREVIATIONS

AI		Artificial Intelligence
BC	-	Blockchain
BD	-	Big Data
BDA		Big Data Analytics
CC	-	Cloud Computing
COVID-19		Corona Virus Disease
CPS		Cyber-Physical System
DSC		Digital Supply Chain
ER		External Resilience
IaaS		Infrastructure as a Service
IOT	-	Internet of Things
IR		Internal Resilience
ISCD		Information System for Supply Chain Disruption
ML		Machine Learning
NIST		National Institute of Standards and Technology
PaaS		Platform as a Service
SaaS		Software as a Service
RBV		Research Based View
SC4.0		Supply Chain 4.0
SCM	-	Supply Chain Management
SCR	-	Supply Chain Resilience
SME	-	Small and Medium-Sized Enterprise
SPSS		Statistical Package for Social Sciences
SSCM		Sustainable Supply Chain Management

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CHAPTER 1

INTRODUCTION

1.1 Chapter Overview

This chapter serves as the introductory section of the thesis, with the primary objective of studying the relationship between digitalization and its impact on supply chain resilience (SCR). This research also will provide a thorough overview of the independent and dependent variables. The chapter begins by understanding the background of the research area, reviewing existing literature, and highlighting the significance of studying the interconnection between technology in supply chain management (SCM) and SCR. This research then identify a problem statement and formulates the research question and research objective to enable a focused exploration of the topic. Furthermore, the chapter outlines the scope and limitations of the study, defining the boundaries within which the research will be conducted. The significance of the study is then proposed to provide a comprehensive understanding of the value and relevance of the study. It is aimed to highlight the potential to bridge the gap between theory and practice and stimulate further research in the field.

1.2 Background of study

The COVID-19 pandemic has had a widespread impact on the global economy and various industries, leading to significant challenges. Zhou et al. (2022) state that the pandemic has caused substantial economic losses and severely affected multiple sectors. Fortune (2020) reports that nearly 94% of the world's leading 1,000 companies have experienced sales decline due to disruptions in supply and demand resulting from

COVID-19. These disruptions have led to inventory imbalances and operational disruptions, affecting production systems on a global scale (Zhou et al., 2022).

The "new normal" refers to a post-crisis state in which the economy and society settle into conditions that differ from the pre-crisis period (Agarwal et al., 2022). This phase is marked by a transformative digital shift, leading to the establishment of new standards of living. Asian nations have rapidly adopted technology to cope with the disruptive effects of the COVID-19 pandemic. Agarwal et al. (2022) examine the impact of COVID-19 on various industries, such as manufacturing, retail, and food services. They investigate how the adoption of information technologies enables businesses to undergo transformations that facilitate their adaptation to future emergencies and changing circumstances.

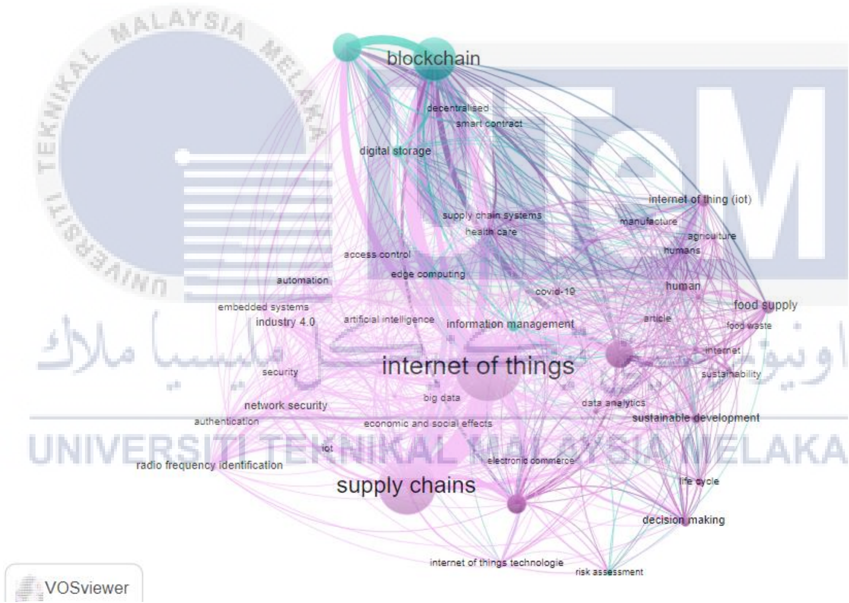

Figure 1 Cooccurences network from Bibliometrix

The diagram in Figure 1 was generated by utilizing Scopus, Bibliometrix, and VOSviewer. The researcher utilized the Scopus database to gather relevant articles using the keywords 'digitalization' and 'supply chain resilience.' A total of 367 articles were retrieved, and the main keywords were identified and analyzed from these articles. Out of the 367 articles analyzed, "Internet of Things" emerged as the most frequently occurring word in 189.

By employing VOSviewer, researchers can create co-occurrence maps of keywords, authors, or journals, thereby identifying common terms related to "digitalization" and "supply chain resilience". Through the integrated approach of Scopus, Bibliometrix, and VOSviewer, researchers comprehensively understand the scholarly literature surrounding "digitalization" and "supply chain resilience," with insights into research trends, influential authors, key papers, and conceptual relationships.

Rebelo et al. (2021) highlighted the growing research interest in the IoT as a technology that connects the physical and cyber worlds. IoT has been enabled by advances in electronics, wireless communication systems, and mobile devices, leading to ubiquitous services and integration of physical components with electronic and communication parts (Mohammed et al., 2020). In the context of digitalization and supply chain resilience, blockchain (BC) emerges as a significant term, offering secure transactions without relying on a central authority. It operates through a distributed and peer-validated digital ledger, ensuring trust through the concept of "trustlessness" (Farouk et al., 2020).

Big data (BD) involves capturing, storing, analyzing, managing, and transferring vast and complex digital resources. BD has evolved rapidly since its identification as a challenge in 1997, enabling businesses to overcome data processing difficulties (Naqvi et al., 2021). Cloud computing (CC) provides faster and more effective ways for organizations to implement technical solutions, improving operational efficiency and on-demand services (Lin et al., 2020). CC services facilitate collaborations and enhance SCR and adaptability (Lin et al., 2020).

1.3 Problem Statement

The issue of supply chain resilience has garnered significant attention in both business and academic circles due to numerous disruptive incidents in the supply chain, as highlighted by scholars like Ivanov (2020) and Mubarik et al. (2021a, 2021b).

Significant research and practice focusing on digitalization has also been a critical area. It offers benefits such as enhanced visibility, real-time information sharing, and improved operational efficiency. Numerous studies have investigated the relationship between digitalization and SCR to address the challenges posed by disruptions and uncertainties in complex and interconnected supply chains.

Small and medium-sized enterprises (SME) is currently confronted with intensified market competition and the challenge of rapidly changing demand patterns (Naradda Gamage, 2020). To address these issues and improve their manufacturing capabilities, companies are increasingly embracing advanced technologies to foster smart manufacturing practices. A key paradigm in this context is Industry 4.0, which entails the integration of digitalization and advanced technologies to revolutionize traditional manufacturing processes (Ryalat et al., 2023).

The underlying problem statement revolves around the imperative to enhance efficiency, productivity, and adaptability within SMEs is by leveraging the principles of Industry 4.0. By embracing automation, digitalization, and artificial intelligence, manufacturers seek to transform production processes and create intelligent, interconnected systems capable of responding to dynamic market demands (Ryalat et al., 2023).

The Malaysian economy relies significantly on the manufacturing sector, which includes SMEs (Naradda Gamage, 2020). These SME manufacturers face numerous challenges in an increasingly globalized, liberalized, and competitive business environment. To remain competitive, SMEs must enhance their resilience. Technology plays a significant role in enhancing SCR by enabling real-time visibility, collaborative communication, data-driven decision-making, and simulation capabilities, which help organizations monitor disruptions, coordinate with partners, manage information, and proactively respond to challenges (Hamidu et al., 2023).

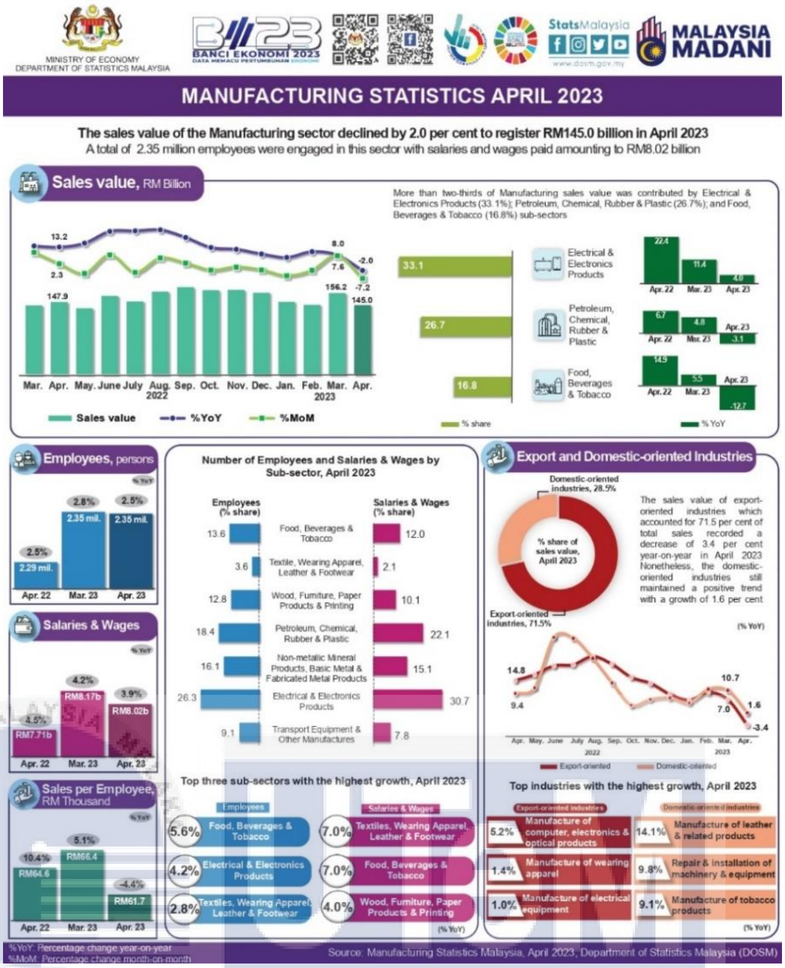

Figure 2 Infographic of manufacturing statistics in Malaysia (April 2023)

Source: Department of Statistics Malaysia, 2023.

The rise of digitalization has revolutionized business operations and introduced new opportunities for SMEs in Malaysia. Traditional SMEs in Malaysia rely on conventional business models, with limited integration of digital technologies (Teoh et al., 2020). They primarily operate through physical stores or production facilities, employing manual processes and face-to-face interactions. These SMEs often face limitations in terms of market reach, scalability, operational efficiency, and adaptability to market changes and disruptions (Albayraktaroglu, 2023). Challenges such as longer lead times, higher costs, and difficulty in adapting to rapidly changing market trends may hinder their ability to maintain a resilient supply chain.

On the other hand, digital SMEs have embraced digital platforms, automation, and online operations as key elements of their business models (Khurana et al., 2022). They leverage e-commerce platforms, digital marketing strategies, and cloud-based systems to extend their market reach, streamline operations, and achieve scalability (Dhanalakshmi et al., 2020). Digital SMEs have the potential to achieve higher operational efficiency, adapt manufacturing more readily to market changes, and navigate disruptions by incorporating digital solutions.

1.4 Research Question

To guide the research process and enable the selection of an appropriate research methodology and focused investigation, the following research questions have been formulated:

RQ 1: What are the factors that would attribute to supply chain resilience in SME?

RQ2: What is the relationship between the attributes of supply chain digitalization to supply chain resilience in SME?

RQ3: What is the most significant variable that influences supply chain resilience in SME?

1.5 Research Objective

Based on the aforementioned research questions, the following research objectives have been formulated:

RO1: To identify the factors that would attribute to the supply chain resilience in SME.

RO2: To investigate the relationship between the attributes of supply chain digitalization to supply chain resilience in SME.

RO3: To identify the most significant variable that influence supply chain resilience in SME.

1.6 Scope of The Study

The purpose of this research is to explore the application of technologies and their influence on supply chain resilience (SCR) in small and medium-sized enterprises (SMEs) located in the southern region of Malaysia. The primary data collection method employed will be a questionnaire. The study aims to achieve several objectives: identifying the factors that would attribute to supply chain resilience , examining the correlation between attributes of digitalization and SCR, and determining the most significant variables that impact supply chain resilience. The survey will target employees working in medium-sized enterprises situated in Melaka, Selangor, and Negeri Sembilan. Data analysis will involve the use of statistical techniques, and the questionnaire will be distributed through both online and offline channels. To facilitate online data collection, Google Forms will serve as the platform for questionnaire distribution.

1.7 Significance of the Study

From an academic perspective, this research study contributes to the existing knowledge by investigating the relationship between digitalization and supply chain resilience, specifically within the context of small and medium-sized enterprises (SMEs). By addressing this research gap, the study enhances understanding of how the adoption of digital technologies influences the resilience of supply chain operations. This advancement in knowledge is valuable for researchers and scholars who aim to expand theoretical frameworks and delve deeper into the complex dynamics between digitalization and supply chain resilience.

In practical terms, the findings of this study have significant implications for SME practitioners and supply chain managers. By gaining insights into the impact of digitalization on supply chain resilience, organizations can make well-informed decisions regarding the adoption and integration of digital technologies. These insights enable managers to improve supply chain performance, effectively manage disruptions, and enhance overall operational resilience.

1.8 Definition of Key Terms

Blockchain (BC) technology adaptation involves storing data in blocks and recording it as a complete and discrete ledger (Nguyen and Kim, 2018; Liang et al., 2022).

Big Data (BD) refers to a vast amount of structured and unstructured data that cannot be easily managed and analyzed using traditional data processing methods. It involves datasets with high volume, velocity, variety, and veracity, and it requires advanced technologies and analytical techniques to extract meaningful insights and knowledge from the data (Basak et al., 2022)

Cloud Computing (CC) refers to a shared and easily accessible collection of computing resources, including storage, servers, networks, services, and applications. These resources are available on-demand, allowing users to rapidly access them with minimal technical expertise or management requirements (Asiaei and Ab. Rahim, 2019)

Internet of Things (IoT) technology, as described by Alhalalmeh (2022), refers to a digitally connected network of physical devices that sense, monitor, and interact within a company and its supply chain, facilitating agility, tracking, and information sharing for timely planning, management, and coordination.

Supply Chain Resilience (SCR) refers to the ability of a supply chain to rapidly recover and adapt to disruptions or changes, enabling it to maintain normal operations and effectively respond to unforeseen events or risks. Supply chain resilience focuses on building agility, flexibility, and robustness within the supply chain to mitigate the impact of disruptions and ensure continuity of operations (Fu et al., 2023)

Small and Medium-Size Enterprises (SME) is defined as enterprises with fewer than 250 employees and an annual turnover of less than €50 million or $50 million, based on European Comission (2020). According to SMECorp Malaysia, small and medium-sized enterprises (SMEs) in Malaysia are defined based on specific criteria for different sectors. In the manufacturing sector, an SME is classified as a business with a sales turnover not exceeding RM50 million or a full-time employee count not exceeding 200 workers. For the services and other sectors, an SME is categorized as a business with a sales turnover not exceeding RM20 million or a full-time employee count not exceeding 75 workers.

1.9 Organization of the Thesis

The first chapter of the thesis serves as an introduction to the research topic. It provides a comprehensive overview of the study, including the problem statement, research objectives, and research questions. The chapter highlights the significance of the research and its contribution to the field. Additionally, it outlines the structure and organization of the thesis, giving readers a clear roadmap of what to expect in subsequent chapters.

Chapter 2 delves into a thorough literature review of the research topic. It presents a critical analysis of existing literature, theories, and frameworks relevant to the study. The chapter highlights key concepts, debates, and gaps in the literature, establishing the context for the research. By examining previous studies and scholarly works, this chapter provides the necessary theoretical foundation and background information for the research.

In Chapter 3, the research methodology employed in the study is described in detail. This chapter outlines the research approach, design, and methodology chosen for the study. It explains the data collection methods, sample selection criteria, and data analysis techniques. Additionally, the chapter discusses any limitations or ethical considerations that may have influenced the research process. The methodology chapter provides a comprehensive understanding of how the research was conducted, ensuring transparency and validity.

Chapter 4 presents the results and findings derived from the analysis of the collected data. The chapter systematically presents the findings, using appropriate tables, charts, or figures to support the results. It provides a detailed analysis and interpretation of the data, allowing readers to grasp the significance and implications of the findings. This chapter serves as the empirical backbone of the thesis, showcasing the outcomes of the research.

Chapter 5 engages in a comprehensive discussion and draws conclusions based on the findings presented in Chapter 4. It compares the results with the existing literature, highlighting similarities, differences, and areas of agreement or disagreement. The chapter discusses the implications of the findings, their practical significance, and potential applications. Additionally, it provides recommendations for future research directions. Finally, the chapter summarizes the main conclusions drawn from the study, wrapping up the thesis and highlighting its contributions to the field.

CHAPTER 2

LITERATURE REVIEW

2.1 Chapter Overview

This literature review is intended to provide a broad overview of the SMEs digitalization of the supply chain. Various digital technologies have been incorporated due to Industrial Revolution 4.0 (IR4.0), transforming SMEs by increasing efficiency, productivity, and quality. This chapter will guide the reader through a comprehensive understanding of supply chain and digitalization in an industrial context and provide a summary of the relationship between the implementation of IR4.0 technologies in the digital supply chain (DSC) and supply chain resilience (SCR). This chapter is based on the review of numerous research papers and academic journals.

2.2 Digitalization in Small and Medium-Sized Enterprises (SME)

2.2.1 Supply Chain Management

Supply chain management (SCM) is a centralized management of the flow of goods and services to the end users, beginning with suppliers, manufacturers, distributors and retail outlets. It is a cross-functional approach that refers to a multitude of functions, including production, purchasing, and information systems management (Sutanto et al., 2022). Active SCM increases vendor efficiency, manufacturing processes, warehouses, distributors, and retailers. Optimized inventory creates manufactured commodities that can be distributed at a reasonable price (Kilay et al., 2022).

Aligned with prior research, supply chain management (SCM) pertains to the synchronization and combination of diverse activities and procedures entailed in the movement of products, services, information, and financial resources across the complete supply chain (Sinha et al., 2020). The primary objective of SCM is to optimize the overall performance and efficacy of the supply chain through the proficient management of crucial activities and interdependencies among suppliers, producers, distributors, retailers, and customers (Reklitis et al., 2021).

SCM involves strategic decision-making, collaboration, and coordination among supply chain partners to achieve customer satisfaction, minimize costs, improve operational efficiencies, and enhance competitiveness in the global marketplace. The ultimate goal of SCM is to create value for all stakeholders involved in the supply chain by ensuring the timely delivery of high-quality products or services, reducing waste, and maximizing overall supply chain effectiveness and profitability (Waiyawuththanapoom et al., 2023)

2.2.2 Digital Supply Chain

Digitalization, according to Son et al. (2021), refers to the utilization of digital technologies to revolutionize business interactions within and between organizations. In the domain of supply chains, digitalization encompasses the incorporation of advanced technologies like cloud computing (CC), the Internet of Things (IoT), blockchain (BC), artificial intelligence, smart sensors, and drones into various upstream and downstream processes.

Supply Chain 4.0 (SC4.0) has emerged as a novel concept in response to the pervasive influence of Industry 4.0 technologies on global business. SC4.0 represents a comprehensive and transformative approach to supply chain management, leveraging disruptive Industry 4.0 technologies to optimize supply chain processes, activities, and interconnections, thereby generating substantial strategic advantages for all stakeholders involved in the supply chain (Alhalalmeh, 2022). According to Ferrantino and Koten (2019), SC4.0 encompasses the reconfiguration of supply chains, encompassing aspects such as design and planning, production, distribution, consumption, and reverse logistics, through the utilization of "Industry 4.0" technologies.

Digital supply chain (DSC) is “the development of information systems and the adoption of innovative technologies strengthening the integration and the agility of the supply chain and thus improving customer service and sustainable performance of the organization” (Barqawi et al., 2022). The SC4.0 concept has transformed the traditional supply chain to integrate Industry 4.0 technologies in SCM for better and more effective decision-making. Industry 4.0 technologies include big data, artificial intelligence, and Internet-of-things (Barqawi et al., 2022).

SCM is vital, considering that optimized supply chains lead to lower costs and faster production cycles (Marmolejo-Saucedo & Hartmann, 2020). Digitalization of the traditional supply chain creates an integrated system that works interconnected (Kliestik et al., 2023)

Recent research, as cited by Yu et al. (2021), underscores the indispensable role of digitalization in enhancing business performance and achieving strategic outcomes in supply chains. These technologies not only improve supply chain visibility, connectivity, innovation, real-time tracking, transparency, and speed, as highlighted by Culot et al. and Frank et al., but also play a crucial role in fostering innovation, resilience, and responsiveness, as emphasized by Yu et al. Embracing digitalization not only enables real-time data collection and sharing but also holds the potential to confer a competitive edge to companies while enhancing their decision-making capabilities, as suggested by Son et al. (2021).

2.2.3 Implementation of Digital Supply Chain in Organization

The COVID-19 pandemic has significantly impacted the world, affecting global supply chains and human health. The manufacturing sector has been hit hard, with concerns about higher production costs, raw material shortages, logistics and stock management issues, and a labor shortage (Raj et al., 2022). Factory closures intended to prevent the spread of the virus have put production on hold. Manufacturing-related difficulties, such as equipment failures or product-related issues, can delay shipments and disrupt the supply chain, endangering the system's resilience. (Kazancoglu et al., 2022)

Within the framework of Supply Chain 4.0, the Internet of Things (IoT) presents a plethora of potential applications, notably encompassing the ability to track supply chain processes, activities, and products while also optimizing the operations of warehousing, manufacturing, and transportation (Rejeb et. al. 2019). The employment of IoT technology bears significant implications for real-time visibility within supply chains (de Vass et al., 2021), thereby offering a multitude of benefits, including prompt responsiveness and ameliorating the supply chain's flexibility, agility, and transparency (Ramirez-Pena et. al., 2020).

Amid the COVID-19 pandemic, businesses are emphasising Industry 4.0, enabling technologies like IoT, Big Data, Cloud Computing, Cyber-physical System (CPS), Simulations, Blockchain, and Artificial Intelligence (AI) (Calabrese et. al. 2021). IoT can improve transparency and information access, enhancing production flexibility, productivity, and waste reduction (Naseem and Yang, 2021). By creating shared networks of resources and capabilities, digital platforms and cloud manufacturing enable easy access to data, leading to long-term relationships, competitiveness, and sustainable significance within supply chain networks (Liu and Song, 2023).

2.2.4 Advanced Technology in SMEs

The impact of the emerging digital economy, technological innovations, and globalization poses significant challenges for small businesses. It is crucial for these businesses to align their business models and possess strategic agility to adapt to changing environment (Uddin et al., 2023). The rigidity of established business models and the potential blind side to disruptive macroeconomic developments hinder the ability to effectively change business models (Martinez, 2022). Organizational and technological capabilities play a vital role in enabling small businesses to overcome these challenges and create valuable assets (Klein and Tedesco, 2021).

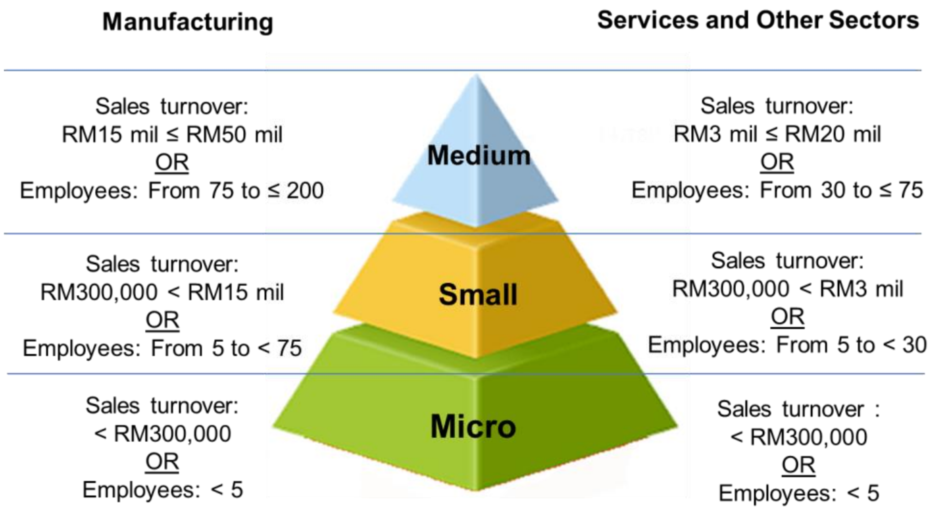

Figure 3 Detailed definition of SME

Source: SMECorp, Malaysia.

Referring to the Figure 3, two criteria are used to define SME which is sales turnover and the number of full-time employees. These criteria are applied with an "OR" basis, meaning that SMEs can be identified based on either the sales turnover or the number of full-time employees. In the manufacturing sector, SMEs are classified as firms that have a sales turnover not exceeding RM50 million or a number of full-time employees not exceeding 200. This criterion is used to determine whether a manufacturing company falls within the SME category. Similarly, for the services and other sectors, SMEs are defined as firms with a sales turnover not exceeding RM20 million or a number of full-time employees not exceeding 75. This criterion is applied to assess the size and scale of businesses in the services and other sectors to determine their classification as SMEs

According to Khan et al. (2023), digitalization has greatly improved the efficiency and productivity of small and medium-sized enterprises (SMEs) in recent years. However, automating transaction execution for SMEs has become increasingly complex due to the involvement of multiple stakeholders and the need for secure and private interactions (Li et al., 2020). Maintaining integrity, transparency, reliability, provenance, availability, and trustworthiness between different enterprises is challenging in the current centralized server-based infrastructure (Khan et al., 2023).

2.3 Supply Chain Resilience (SCR)

According to Hu and Zhou (2023), the presence of crisis events in global markets has presented significant challenges to supply chain management (SCM). Numerous disruptions, including incidents such as the Suez Canal freighter incident, uncertainties surrounding Brexit, shortages of computer chips, and both natural and man-made disasters, have exerted substantial impacts on organizations at a global scale (Yang et al., 2022; Roscoe et al., 2020; Khan et al., 2021; Geolgeci and Kuivalainen, 2020; Wang et al., 2021). It has been observed that resilient firms exhibit lower vulnerability to supply chain disruptions and possess greater capacity to withstand shocks resulting from these disruptions (Dubey et al., 2021). This underscores the significance of developing resilience in supply chain operations to enhance their ability to navigate and mitigate the effects of disruptive events.

Recent research has identified SCR as the ability of a supply chain to withstand unexpected changes and maintain continuity during market shifts (Li et al., 2022; Singh et al., 2019). To enhance the performance and resilience of sustainable supply chain management (SSCM), it is suggested that organizations can adopt emerging technologies such as blockchain, Industry 4.0, and artificial intelligence (Ivanov, 2020).

According to Zhou et al. (2022), internal resilience, as described by Hundal et al. (2021), pertains to the capacity of an organization's departments to remain highly vigilant of the environment, swiftly respond, and adapt in the event of disruptions. This enables the organization to preserve its internal structure and functional integrity. On the other hand, external resilience, as highlighted by Wamba et al. (2020), encompasses the uninterrupted flow of supply and demand between the organization, its suppliers, and its consumers. It emphasizes the organization's ability to sustain its relationships and operations with external stakeholders during challenging circumstances.

Resilience, as highlighted by Wong et al. (2020), is a multidisciplinary concept encompassing various dimensions, including ecological, psychological, economic, and organizational perspectives. However, within the field of supply chain management (SCM), there remains a lack of consensus regarding its precise definition (Wong et al., 2020). Soltani et al. (2020) characterize resilience as the system's ability to endure disruptions while preserving its fundamental function and structure. Similarly, Agrawal and Jain (2021) define resilience as the capacity of a system to withstand and recover from disruptions while maintaining its core functions and structure intact. Notably, specific digital technologies have been identified as valuable enablers for enhancing supply chain disruption management capabilities (Alvarenga et al., 2022).

2.4 Key Technologies Driving Digitalization

2.4.1 Big Data

The utilization of emerging technologies in analyzing large volumes of data, known as Big Data (BD), has brought about a significant shift in the conventional approach to data analysis. The analysis of BD enables the anticipation of future trends and the extraction of valuable insights from vast amounts of data, revealing hidden information and facilitating the decision-making process (Naqvi et al., 2021). By leveraging big data analytics (BDA), firms can gain a deeper understanding of customer behavior and preferences, potentially leading to the development of new products (Radicic and Pandža Bajs, 2023) and expanding their absorptive capacity (Niebel et al., 2019).

The advent of Big Data Analytics (BDA) has revolutionized the business landscape, allowing firms to disrupt traditional models by employing advanced techniques to analyze vast amounts of data (Paunov and Planes-Satorra, 2019). Despite these transformative capabilities, small and medium-sized enterprises (SMEs) encounter challenges in utilizing customer insights for product design, impeding their economic growth (Liu et al., 2019). Moreover, extracting meaningful insights from unstructured data introduces complexity into the analytics process, as noted by Niebel et al. (2019). Despite SMEs lagging behind larger companies in BDA adoption, they leverage it to streamline processes, achieve efficiencies, and enhance customer service (Usai et al., 2021). In the realm of innovation processes, BDA plays a pivotal role in augmenting firms' absorptive capacity, reducing costs associated with acquiring and searching for external knowledge, and facilitating the generation of novel insights for product and process development (Niebel et al., 2019).

Singh and Singh's (2019) study highlights the dynamic capability of Big Data Analytics (BDA) in enhancing supply chain risk resilience. Their findings suggest that BDA enhances a firm's existing IT infrastructure, enabling more effective supply chain risk management and resilience. BDA acts as a dynamic capability that transforms the relationship between information systems for supply chain disruption (ISCD) and risk resilience, emphasizing its role in augmenting pre-existing capabilities within an organization to effectively address disruptions.

2.4.2 Internet of Things (IoT)

According to Alvarenga, Oliveira, and Oliveira (2023), the Internet of Things (IoT) is a network of physical objects that are digitally connected to allow for sensing, monitoring, and interaction within and between companies and their supply chains. A digitally connected network of physical devices, as described by Ben-Daya et al. (2019), serves as an integral component in supply chain management, fostering increased agility, visibility, tracking, and information sharing, thereby facilitating timely planning, control, and coordination of supply chain processes through improved connectivity and real-time data exchange.

IoT technology, allowing physical objects to communicate via the internet, has various applications in Industry 4.0 and SCM (Alhalalmeh, 2022). Benefits of IoT include transparency, responsiveness, and agility in supply chain operations, reducing inventory levels, and real-time response (Ramirez-Peña et al., 2020). Additionally, IoT can be applied for tracking processes, optimizing operations, and increasing supply chain flexibility and transparency (Rejeb et al., 2019).

According to Ding, Ward, and Tukker (2023), the Internet of Things (IoT) holds the potential to enhance profitability in various industries. This is achieved through the automation and semi-automation of operations, enabling preventive maintenance of monitoring machines and robots, and facilitating continuous communication (Roy and Roy, 2019).

In the logistics sector, IoT technology is utilized to collect real-time information regarding the whereabouts of vehicles and goods. This information is then transmitted and processed to support decision-making processes (Maulana et al., 2021). Furthermore, the adoption of innovative Internet-based transactions can leverage information to facilitate a more efficient and sustainable waste collection process across the supply chain, consequently reducing the environmental costs associated with the recovery process (Al-Masri et al., 2018; Garrido-Hidalgo et al., 2020).

2.4.3 Cloud Computing

Cloud computing has revolutionized the way organizations and individuals access, store, process, and manage data and applications in recent years (Liu & Orji, 2020). This technology allows users to access computing resources on-demand through the internet, eliminating the need for significant upfront investments in hardware and infrastructure (Khan et al., 2019). Cloud computing, characterized by on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service as defined by NIST (Avian, 2022), empowers users to provision and access resources as required, from any location, utilizing scalable and pay-per-use models.

In terms of architecture, CC consists of various layers, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) (Abdalla and Varol, 2019). IaaS provides virtualized computing resources such as servers, storage, and networking, while PaaS offers a platform for application development and management. SaaS allows users to access software applications hosted on the cloud without local installation or maintenance (Saraswat and Tripathi, 2020).

2.4.4 Blockchain

Emerging technologies such as the IoT, machine learning (ML), deep learning, and big data analytics (BDA) are driving the evolution of new business models, including blockchain, to streamline knowledge management processes (Hu and Zhou, 2023; Almomani et al., 2021; Cheng et al., 2021; Du and Shu, 2022; Bag et al., 2021). BC technology, with its transparent information sharing and data reliability, is revolutionizing various sectors, including finance, supply chain, and healthcare (Ali et al., 2020; Buthelezi et al., 2021).

In the supply chain field, BC technology plays a crucial role in facilitating collaboration, enhancing transparency, and managing risks such as supply chain disruptions (Ivanov, 2020). It offers benefits such as real-time tracking of goods, improved visibility, reliability of processes, and enhanced supply chain performance (Helliar et al., 2020; Khan et al., 2021; Nayal et al., 2021). By ensuring secure and encrypted exchanges between organizations, BC technology mitigates information gaps and fosters deeper cooperation (Dennehy et al., 2021). It serves as a moderator, enabling organizations to leverage resource consolidation effectively (Helliar et al., 2020; Khan et al., 2021).

Within the manufacturing supply chain, BC technology addresses challenges such as information asymmetry, lack of trust, and data integrity (Elswiti and Qatawneh, 2021). It enables end-to-end traceability, ensuring product authenticity, reducing counterfeiting, and enhancing consumer trust (Xu et al., 2022; Tao et al., 2020). Additionally, BC facilitates secure supplier management, automated transactions through smart contracts, and supply chain finance (Xu et al., 2022; Tao et al., 2020). These applications streamline processes, improve efficiency, and enhance overall supply chain performance.

2.5 Underpinning Theory

2.5.1 Resource-Based View

According to Barney (1991), the Resource-Based View (RBV) theory emphasizes the role of a company's internal resources and capabilities in achieving competitive advantage. This theory highlights the importance of unique and valuable resources that possess characteristics such as value, rarity, immobility, and non-substitutability. Managers recognize that the strategic alignment of these resources with the external environment is crucial for capitalizing on opportunities and addressing challenges effectively.

In the context of SCM, Yuen et al. (2019) build upon the RBV theory by focusing on the internal resources and capabilities that contribute to supply chain performance. They emphasize that resources such as technological capabilities, supplier relationships, and inventory management systems play a significant role in achieving supply chain efficiency and effectiveness. These resources, when aligned with the RBV characteristics, can confer a sustainable competitive advantage in SCM. Expanding on this, Al-Khatib (2022) explore how a company's technological capabilities, in line with the RBV theory, enhance supply chain visibility, efficiency, and effectiveness.

By underpinning the RBV theory in supply chain research, scholars can gain insights into the strategic leverage of internal resources and capabilities for achieving competitive advantage and improving supply chain performance. The RBV framework provides a foundation for identifying and assessing these resources and understanding their impact on supply chain outcomes.

2.6 Conceptual Framework

Digitalization has emerged as a crucial element in modern supply chain management, holding the potential to revolutionize operational practices (Modgil et al., 2021). This transformative process entails the integration of cutting-edge technologies, such as cloud computing, the IoT, big data, and blockchain, into supply chain operations (Alshehri, 2023).

By leveraging these technologies, supply chains can optimize processes, foster collaboration, and enhance overall performance. However, it is worth noting that existing studies examining the relationship between digitalization and SCR possess certain limitations in terms of their scope, methodology, and conceptual framework. Therefore, it is evident that there is a pressing requirement for further in-depth and methodical research aimed at formulating a sturdy theory, backed by empirical evidence, that sheds light on the exact influence of digitalization on the resilience of supply chains.

The conceptual framework (Figure 4) illustrates the research path of this study, outlining the relationships between the independent variables (Internet of Things, big data, blockchain, and cloud computing) and the dependent variable (supply chain internal and external resilience). The framework serves as a foundation for developing hypotheses that will be tested in the research.

Hypotheses:

H1: There is a positive relationship between Internet of Things and supply chain internal resilience.

H2: There is a positive relationship between big data and supply chain internal resilience

H3: There is a positive relationship between blockchain and supply chain internal resilience.

H4: There is a positive relationship between cloud computing and supply chain internal resilience.

H5: There is a positive relationship between Internet of Things and supply chain external resilience.

H6: There is a positive relationship between big data and supply chain external resilience.

H7: There is a positive relationship between blockchain and supply chain external resilience.

H8: There is a positive relationship between cloud computing and supply chain external resilience.

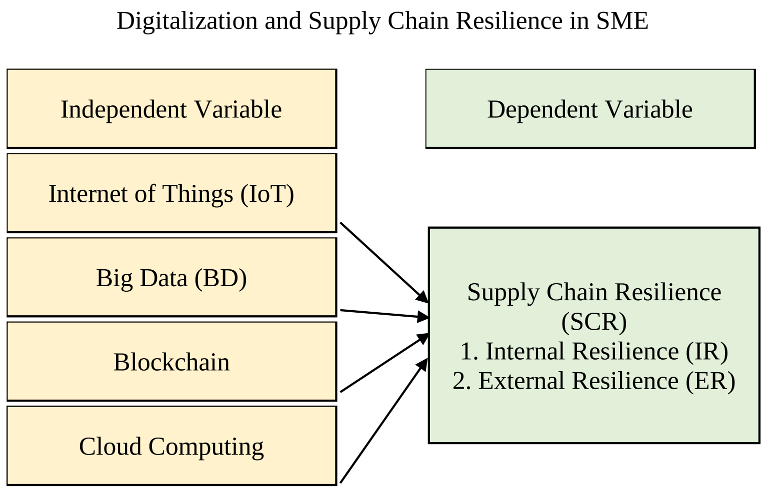

Figure 4 Conceptual framework of the study

CHAPTER 3

METHODOLOGY

3.1 Chapter Overview

In Chapter 3, the focus is on the research methodology employed to conduct the study. This chapter provides a detailed explanation of the methods and procedures used to collect and analyze data, as well as the rationale behind these choices. The chapter begins with an introduction, setting the context and purpose of the chapter. It provides a brief overview of the research questions or objectives that guide the study. Next, the research design is described, outlining the overall approach and design employed. The chapter justifies the chosen research design based on the research questions and objectives and discusses any limitations or potential biases associated with the design.

The sampling techniques used in the study are then explained. The process of selecting participants or subjects for the study is described, along with details on the sampling method employed and sample size. The rationale behind the chosen sampling technique is also discussed. The chapter proceeds to describe the specific data collection methods utilized. The chapter provides information on the development or adaptation of these instruments and discusses measures taken to ensure data validity and reliability.

The analysis of the collected data is then explained. The chapter describes the analytical techniques used, how the data was organized, coded, and processed for analysis. It may mention any statistical or qualitative analysis methods employed, as well as any software or tools used for data analysis. Finally, the chapter provides a summary of the research methodology, emphasizing how the chosen methodology aligns with the research objectives. It briefly mentions the upcoming chapters and how they relate to the methodology.

3.2 Research Design

3.2.1 Type of Study

The research design chosen for this study is quantitative, aiming to obtain numerical data for analysis and drawing statistical inferences. Quantitative research focuses on objective measurements, numerical data, and statistical analysis to establish patterns, relationships, or causality among variables. Causal research is a type of quantitative research that aims to establish a cause-and-effect relationship between variables. In this study, the researcher has chosen a quantitative data collection method to investigate causal relationships among the variables of interest (Bloomfield and Fisher, 2019)

The quantitative data collection method allows the researcher to gather numerical data on various variables in a structured manner. This could involve conducting surveys, experiments, or utilizing existing datasets (Mohajan, 2020). The data collected will typically involve measurements of independent and dependent variables, as well as potential confounding variables. The researcher will carefully design the data collection process to ensure that causal inferences can be made. This includes implementing appropriate control measures, randomization techniques, and ensuring the reliability and validity of the collected data.

3.2.2 Unit of Analysis

The unit of analysis for this study is organization within SME industry, specifically focusing on medium-sized enterprises. In this research, employees from the mentioned industry will serve as the respondents and key informants for their respective organizations.

3.2.3 Population

Despite the challenging economic environment in 2019, SMEs in Malaysia displayed diversified characteristics and achieved higher resilience and performance, leading to a significant contribution to the economy. In that year, SMEs accounted for 38.9% of the overall Gross Domestic Product (GDP), 48.4% of total employment, and 17.9% of total exports.

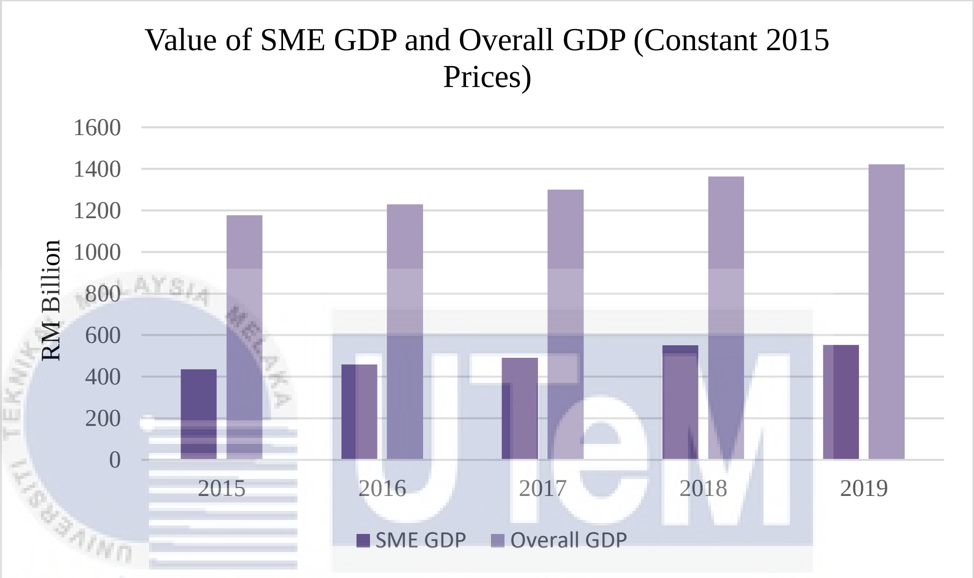

Figure 5 Value of SME GDP and overall GDP

Department of Statistics, Malaysia (2019) and SME Corp, Malaysia (2019)

3.2.4 Sampling Method

In this research, the simple random sampling method will be adopted, as it ensures that all participants in the population have an equal opportunity to be chosen for the sample. This approach requires minimal knowledge about the population and is relatively easier to analyse compared to other probability sampling techniques (Acharya et al., 2013). By employing simple random sampling, the research aims to obtain an unbiased and representative sample of participants for the study.

3.2.5 Sampling Frame

For the study titled "Impact of Digitalization on Supply Chain Resilience in the Small and Medium-Sized Enterprises (SME)" in Malaysia, a sampling frame can be constructed to ensure representation from the medium-sized enterprises while considering the required sample size of 170 respondents. The sampling frame will encompass the medium-sized enterprises in southern region of Malaysia. It will include various types of companies involved in manufacturing in the SMEs.

Considering geographical constraints, the sampling frame will particularly focus on physically distributing questionnaires in southern region of Malaysia, namely Johor, Melaka and Negeri Sembilan. These areas can provide a more concentrated representation of respondents due to the researcher's accessibility. For respondents who are not available for offline distribution, the questionnaires will be administered online to reach employees in those areas.

3.2.6 Sample Size

G* Power stands out as a tool for calculating sample sizes, offering a convenient alternative to intricate formulas and simulation applications. It simplifies the process of determining sample sizes, providing an accessible solution for individuals to address this aspect without the need for extensive expertise. This program, as highlighted by Yenipinar et al. (2019), serves as an easily applicable resource in resolving the challenge of sample size determination.

To calculate the necessary sample size, the desired population effect size (0.15), significance level (0.05), and statistical power (0.8), as suggested by Cohen (1988), were inputted into the G*Power software (Figure 6). Based on the software output, this study determined that a minimum sample size of 85 is appropriate in the context of the research, considering three selected predictors.

Nevertheless, in light of the anticipated low response rate, the research made the decision to increase the required sample size, as proposed by Baruch (1999). The rationale behind this decision is that a larger sample size, even with a constant response rate, will yield a higher number of responses compared to a smaller sample size. According to Babbie (1990), a 50 percent response rate is considered sufficient in social science surveys to effectively represent the behaviour of the population. Consequently, the number of questionnaires distributed will be doubled to approximately 170 respondents, aligning with the recommendation provided by Babbie (1990).

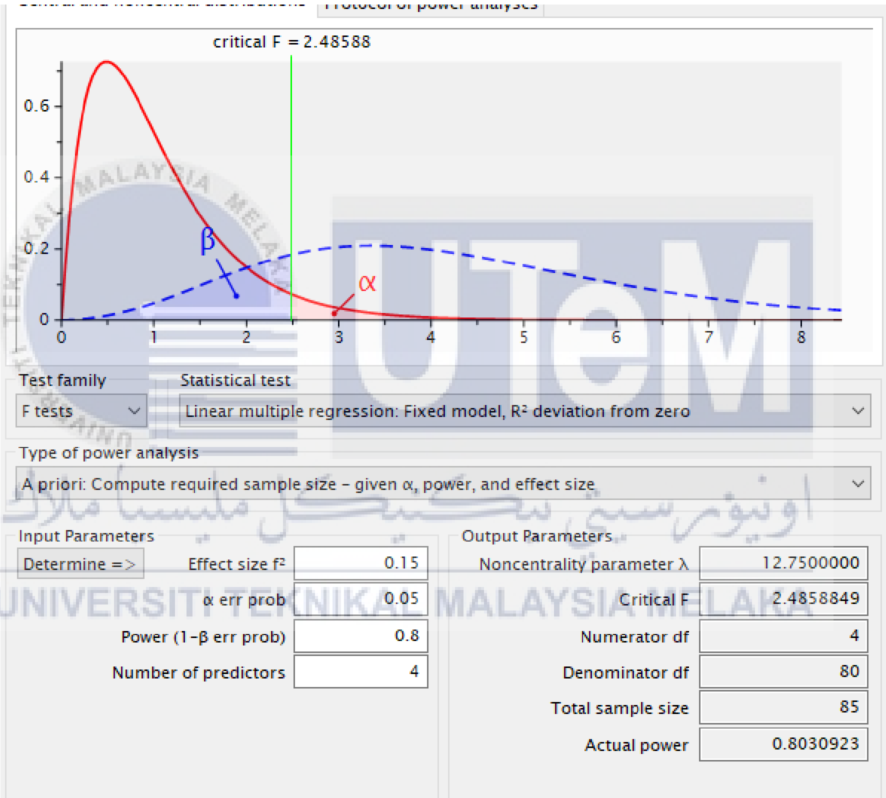

Figure 6 Sample size obtained by G*Power

3.2.7 Data Collection Method

For this research on the SMEs in Malaysia, primary data will be collected using a Likert scale questionnaire. The questionnaire will consist of five Likert scale questions, allowing respondents to indicate their level of agreement or disagreement with statements related to the variables of interest, namely digitalization and supply chain resilience.

By utilizing the adapted Likert scale questionnaire as the primary data collection method, this research project aims to efficiently gather targeted data from the SMEs in Malaysia. The utilization of a previously validated questionnaire enhances the reliability and comparability of the findings while providing valuable insights into the variables of interest.

3.3 Survey Instrument

For this study, the survey instrument has been developed by referring to several research journals related to the topic. The construction of the survey questionnaire draws upon insights and methodologies presented in these scholarly works to ensure its relevance and appropriateness for the research context.

3.3.1 Measurement of Variables and Construct

3.3.1.1 Nominal Scale

In the survey questionnaire, the demographic section (Section A) will utilize the nominal scale of measurement for data collection. The nominal scale is the lowest level of measurement, primarily used to categorize variables into distinct categories or groups without any inherent order or numerical value (Burkholder et al., 2020). This scale will be employed to collect demographic information such as age groups, gender, educational attainment, occupation, and other categorical variables.

Using the nominal scale for the demographic section ensures that the data collected is appropriate for understanding the characteristics of the survey participants without implying any numerical significance or order among the categories (Kitchenham and Pfleeger, 2003). This enables researchers to gain insights into the demographic composition of the sample and potentially identify any patterns or associations between demographic factors and the variables under investigation in the study.

3.3.1.2 Likert Scale

In the survey questionnaire, the Likert scale will be used for data collection in Section B. The Likert scale is a commonly employed measurement tool for assessing respondents' attitudes, opinions, or perceptions towards specific constructs (Joshi et al., 2015). It involves a series of statements or items to which respondents indicate their level of agreement or disagreement on a scale.

The Likert scale typically consists of multiple response options, such as "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." Respondents select the option that best reflects their viewpoint for each statement. The use of the Likert scale allows for the quantification of respondents' subjective assessments, enabling researchers to analyze and interpret the collected data quantitatively. The scale facilitates the measurement of the intensity or strength of respondents' opinions or attitudes towards the constructs of interest.

Section B of the survey questionnaire will present a series of statements related to the variables under investigation. Respondents will indicate their agreement or disagreement with each statement using the Likert scale response options. By utilizing the Likert scale, researchers can obtain valuable insights into the perceptions, attitudes, or opinions of the respondents regarding the constructs being measured.

3.3.2 Survey Questionnaire

A survey questionnaire is a structured set of questions designed to collect information directly from respondents. It is a commonly used data collection instrument in research studies. The questionnaire is carefully crafted to address research objectives and cover relevant aspects of the topic. It can include multiple-choice, Likert scale, open-ended, or demographic questions. The collected data can be analyzed using statistical techniques. Ethical considerations, such as confidentiality and informed consent, are important in survey research.

3.3.2.1 General Questions

The research questionnaire comprises two sections: Section A and Section B. Sectio n A is designed to collect demographic information from the respondents. This section aims to gather data regarding the characteristics of the participants. By collecting this information, researchers can gain a better understanding of the sample composition and explore any potential relationships between demographic factors and the variables under investigation.

3.3.2.2 Independent Variables Construct

Section B of the questionnaire comprises questions related to digitalization, specifically focusing on the areas of big data, IoT (Internet of Things), cloud computing, and blockchain. Each of these variables consists of a set of 4 to 6 mandatory questions that participants are required to answer.

Table 1 IoT construct

Variable	Number of items
Internet of Things (IOT) IOT1. IoT enables improved monitoring and management of inventory. IOT2. IoT improve fleet and transportation management IOT3. Production adjustments based on real-time information of the demand and capacity availability with IoT IOT4. IoT enhances just-in-time manufacturing by enabling more efficient production scheduling.	6

IOT5. IoT reduce Bullwhip effect within supply chain IOT6. IoT leads to enhanced efficiency in utilizing company assets, resulting in reduced machinery loss and downtime.	
Source: (Lee et al., 2021)	

Table 2 Big data construct

Variable	Number of items
Big Data (BD) BD1. Big data helps management capabilities in terms of examining innovative opportunities BD2. My organization's big data analytics (BDA) capabilities adequately plan the utilization of big data BD3. Communication and information sharing inside the organization is effective with big data BD4. The organization provide clear and well-defined responsibility in relation to big data BD5. Big data utilization improve employee productivity inside the organization BD6. Big data enables quick and data-driven decision making inside the organization	6
Source: (Edwin Cheng et al., 2021)	

Table 3 Blockchain construct

Variable	Number of items
Blockchain (BC)	5

BC1. Blockchain is useful in my company operation BC2. Using blockchain can enhance the efficiency of firm's operation BC3. Using blockchain is convenient for management activities BC4. Using blockchain can eliminate processing cost and increase firm's profits BC5. Blockchain helps me accomplish duties more quickly	
Source: (Nguyen et al. 2023)	

Table 4 Cloud computing construct

Variable	Number of items
Cloud Computing (CC) CC1. Work processes undergo regular checks to prevent product defects and service errors. CC2. Standards for process improvements are periodically raised to enhance overall performance. CC3. Newly introduced work processes are designed to be more user-friendly compared to previous ones. CC4. Work processes are continuously improved or established to facilitate smooth coordination of activities within the organization. CC5. Work processes are continuously improved or established to enhance the coordination of activities with external organizations.	5
Source: (Kim et al., 2019)	

3.3.2.3 Dependent Variables Construct

Section C of the questionnaire focuses on assessing supply chain resilience (SCR) within the organization as a result of implementing digitalization practices. SCR encompasses two distinct dimensions: internal resilience and external resilience. To operationalize these dimensions, the measurement items employed in this study were adapted from Gu et al. (2020) and Golgeci and Ponomarov (2013).

The categorization of SCR into internal and external resilience is done based on the indication in the literature that different mechanisms of development may exist for various disruption nodes (Cao et al., 2010). By differentiating between internal and external resilience, the acknowledgment is made that the factors and processes contributing to resilience can vary depending on whether the disruptions originate from within the organization or arise from external sources (Zhou et al., 2022)

Table 5 Supply chain resilience construct

Measures	Variable	Number of items
Supply Chain Resilience (SCR)	**External Resilience** E1. Both our organization and our primary supplier maintain constant awareness of the situation to effectively respond to any supply chain disruptions. E2. We and our primary supplier possess the capability to promptly respond to any disruptions in the supply chain. E3. We and our primary supplier have the capacity to adapt to the changes caused by supply chain disruptions. E4. Both our organization and our main customer can quickly respond to any disruptions in the supply chain.	6

	E5. We and our main customer are capable of adapting to the changes brought about by supply chain disruptions. E6. Both our organization and our main customer maintain a high level of situational awareness at all times to effectively manage any supply chain challenges.	
	Internal Resilience I1. Our company's supply chain possesses the capability to promptly recover from unexpected disruptions and restore the smooth flow of products. I2. Our company's supply chain is adequately prepared to manage the financial consequences resulting from supply chain disruptions. I3. Our company's supply chain demonstrates the capacity to maintain the desired level of control over its structure and function during times of disruption. I4. Our company's supply chain has the capability to swiftly recover and restore its original state after experiencing a disruption. I5. Our company's supply chain has the ability to transition to a new, improved state after undergoing a disruption.	5
	Source: (Zhou et el., 2022)	

3.4 Data Analysis

3.4.1 Data Analysis

Data analysis plays a crucial role in comprehending and interpreting collected data, ensuring its accuracy and validating hypotheses. Various data analysis methods can be employed for this purpose (Sutton & Austin, 2015). The collected data will undergo thorough evaluation to derive meaningful insights. The data analysis process for the study involved several stages, starting with the collection of data through a questionnaire. The collected data was then imported into SPSS (Statistical Package for the Social Sciences) software for further analysis. The Software Package for Social Science (SPSS) Version 23.0 for Student Version enables inferential analyses such as Multiple Regression to investigate the relationship between independent and dependent variables. Additionally, SPSS will facilitate graphical representations such as histograms, bar charts, and charts to enhance data visualization. Moreover, SPSS will be instrumental in assessing the research hypotheses and validating their significance (Puteh & Azman Ong, 2017).

The initial step in the analysis was to conduct descriptive analysis. Descriptive analysis is essential for exploring the key characteristics of the data in this study, providing researchers with a comprehensive and in-depth understanding. It enables the examination of data attributes such as frequency, mean, median, percentage, range, and standard deviation. One important aspect of the descriptive analysis is the examination of the demographic profile of respondents, which involves analyzing frequencies and percentages to gain insights into the composition of the sample (Martin et al., 2020). This analysis allows researchers to comprehend the characteristics of the study participants and provides a foundation for further analysis.

Reliability refers to the consistency and dependability of measurement results. It is important for researchers to conduct a reliability test to ensure that their measures are consistent and trustworthy. Neglecting to conduct such a test or having a low measurement scale can undermine the quality of research, as it hampers the detection of relationships between variables (Sundram et al., 2017). Therefore, in this study, a reliability test will be conducted to assess the consistency of the survey questionnaires. Cronbach's Alpha coefficient will be employed to measure the extent to which variables in a set are positively correlated with each other, indicating their internal reliability.

In the Cronbach's Alpha test, the coefficient ranges from 0 to 1, indicating the level of reliability in a research (Sundram et al., 2017). Typically, a value of 0.6 and above is considered satisfactory, suggesting higher reliability. Cronbach's Alpha coefficient measures the internal consistency of a set of variables, with higher values indicating greater reliability.

The normality test is frequently used by researchers since it is an important step in determining measures of central tendency and statistical methods for data analysis. A normality test is performed to determine whether the sample data is drawn from a population with a normal distribution. The measurement of skewness and kurtosis are two numerical shape metrics. Skewness can be either positive or negative, or unclear. If the skew is 0, the data is completely symmetrical.

This study will employ Pearson' Correlation Coefficient Analysis to measure the strength of linear relationships between the dependent variable and the independent variables. When using Pearson's correlation coefficient, values from -1 to +1 indicate perfectly negative and positive correlations, respectively. The value 0 indicates that there is no link or association (Saunders et al., 2016)

Table 6 Correlation coefficient value and its direction

Correlation Coefficient Value (r)	Direction and Strength of Correlation
-1	Perfectly negative
-0.8	Strongly negative
-0.5	Moderately negative
-0.2	Weakly negative
0	No association
0.2	Weakly positive
0.5	Moderately positive

0.8	Strongly positive
1	Perfectly positive

Sources: Saunders et al., (2016)

Multiple Regression Analysis is a statistical method used to examine the relationship between a dependent variable and multiple independent variables (Uyanik & Güler, 2013). In this study, the relationship between the independent variables (IoT, big data, blockchain and cloud computing) and the dependent variables (supply chain internal and external resilience) will be examined through Multiple Regression Analysis. This analysis will also conduct hypothesis testing to address the research questions.

3.5 Summary

Conclusively, the data obtained from the distributed questionnaires will be summarised and the SPSS outputs will be interpreted. The analysis was separated into several sections including frequency analysis, normality test, reliability test coefficient analysis and multiple regression. The analysed results will bring forward to the following chapter for further discussion of the study.

CHAPTER 4

DATA ANALYSIS AND RESULTS

4.1 Introduction

This chapter will present the results of data analysis from the data collection. To collect data, questionnaires are distributed to employees working in small and medium-sized enterprises in Johor, Melaka and Negeri Sembilan via Google Form. After the data is collected from the questionnaires, Statistical Package for Social Science (SPSS) software version 27.0 is used to visualize and analyze the data from the targeted respondents of this study. This chapter will include descriptive statistics, reliability test, and normality test. To determine the relationship between the independent variables, Pearson’s correlation coefficient (parametric test) will be used when the data is normally distributed. Spearman ran-order correlation will be used when the data is unevenly distributed, as well as using multiple regression analysis.

4.2 Pilot Test

Before distributing the questionnaire to the intended respondents, a pilot test was undertaken to assess the questionnaire's validity and the reliability of the collected data, as outlined by Hamilton (2022). This pilot test aimed to enhance the questionnaire design, mitigate challenges for respondents, and address potential data screening issues, aligning with the recommendations of Saunders et al. (2019). For this purpose, 30 individuals with online shopping experience were selected to participate in the pilot test.

Table 7 Reliability statistics of pilot test (SPSS)

Variable	No. of Item	Cronbach’s Alpha (Pilot)

Internet of Things	6	0.920
Big Data	6	0.949
Blockchain	5	0.911
Cloud Computing	5	0.812
Internal Resilience	5	0.926
External Resilience	6	0.902

The questionnaire included a total of 33 items, and none of the 30 respondents had missing data. The research data only consider reliable when Cronbach's Alpha value is greater than 0.7. (Saunders et al., 2019). Based on Figure 7 above, the value of Cronbach's Alpha for all the variables in this research is more than 0.7, thus the data obtained is reliable with excellent internal consistency

4.3 Descriptive Statistics on Demographic Background

Descriptive statistics is one of the methods to evaluate, define, display, and interpret collected data using tables, graphs, and overview calculations (Saunders et al., 2019). In this research, the researcher used descriptive statistics to analyze the demographic data of respondents collected from questionnaires. Based on the table, there are five categories of the demographic profile of respondents which included gender, higher education level, managerial experience, department profile and location of working company. The questionnaires were distributed through Google Forms to target respondents and there has been a total of 124 valid respondents after the data collection.

Table 8 Demographic variables of the study

Demographic Variables	Categories	Frequency	Percentage (%)
Gender	Male	83	66.9
	Female	41	33.1
Higher Education Level	Highschool or Equivalent	0	0
	Technical School Certification	1	0.8
	Associate degree or Diploma	15	12.1
	Bachelor's Degree	94	75.8
	Master's Degree	14	11.3
	Doctorate's Degree	0	0
Managerial Experience	Between 3-5 years	103	83.1
	Between 5-10 years	10	8.1
	Between 10-15 years	11	8.9
	>15 years	0	0
Department Profile	Unit Head	13	10.5
	Production/Manufacturing	35	28.2
	Digitalisation and Technology	8	6.5
	Maintenance and Utilities	9	7.3
	Logistics	36	29.0
	Safety	0	0
	Material (Purchasing/ Store/ Inventories)	23	18.5
Location of Working Company	Johor	43	34.7
	Melaka	40	32.3
	Negeri Sembilan	30	24.2
	Other	11	8.9

This study collected data from 124 participants, revealing a gender distribution of 66.9% male and 33.1% female. While random selection and assignment were employed, a slight imbalance emerged, with a 42-participant difference favoring male respondents. This finding warrants further investigation in future studies to ensure balanced representation.

Education levels displayed a distinct pattern, with 75.7% of participants holding a bachelor's degree. Other qualifications, including technical school certificates (0.8%), associate degrees or diplomas (12.1%), and master's degrees (11.3%), were considerably less prevalent. Notably, no participants possessed a high school equivalency or a doctorate's degree. This concentration in bachelor's degrees suggests a specific population segment targeted by the study or reflects the educational landscape of the studied industry.

Considering the research focus on small and medium-sized enterprises (SMEs), managerial experience was a crucial aspect explored. The majority (83.1%) of participants possessed 3-5 years of managerial experience, highlighting a seasoned yet relatively young cohort. A further 8.1% and 8.9% held 5-10 and 10-15 years of experience, respectively, indicating a healthy distribution across various experience levels within the sample. This information adds valuable context to the analysis of managerial insights gleaned from the participants.

Departmental profile revealed a clear trend, with logistics emerging as the most prominent domain, represented by 29% of participants. Production and manufacturing closely followed with 28.2%, demonstrating the study's relevance to these core SME functions. Material departments, encompassing purchasing, stores, and inventory, constituted 18.5%. Other noteworthy departmental distributions included unit heads (10.5%), digitalization and technology (6.5%), and maintenance and utility (7.3%). This diversity in departmental backgrounds enriches the study's findings by capturing perspectives from various operational facets within SMEs.

Finally, geographical distribution unveiled a regional concentration, with 34.7% of participants working in Johor, 32.3% in Melaka, and 24.2% in Negeri Sembilan. Notably, 8.9% worked outside these core areas. This geographical clustering suggests potential regional specificities within the studied industry or population, which necessitate further examination.

4.4 Descriptive Statistics on Independent Variable and Dependent Variable

The study explores the impact of digitalization on SCR in Small and Medium-sized Enterprises (SMEs), focusing on the variables of Internet of Things (IoT), Big Data, Blockchain, and Cloud Computing as independent factors. The mean score for

IoT, representing the extent to which SMEs embrace this technology in their supply chain processes, is 4.43 with a standard deviation of 0.588. Big Data follows closely with a mean of 4.23 and a standard deviation of 0.688. Blockchain and Cloud Computing exhibit means of 3.91 and 4.04, respectively, with standard deviations of 0.733 and 0.637. The minimum scores for these technologies suggest varying degrees of adoption, ranging from 2.0 for Blockchain to 2.67 for IoT.

The dependent variables, internal resilience, and external resilience, both demonstrate mean scores of 4.12 with standard deviations of 0.626 and 0.55, respectively. The minimum values for internal and external resilience are 2.60 and 2.67, indicating the range of responses from participants. With a sample size (N) of 124 and a maximum possible score of 5, these findings lay the foundation for a detailed understanding of the relationships between digitalization components and SCR in SMEs.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
IoT	124	2.67	5.00	4.4315	.58782
Blockchain	124	2.00	5.00	3.9081	.73270
BigData	124	2.40	5.00	4.2274	.68827
CloudComputing	124	2.60	5.00	4.0387	.63741
InternalResilience	124	2.60	5.00	4.1145	.62583
ExternalResilience	124	2.67	5.00	4.1237	.55006
Valid N (listwise)	124				

Figure 7 Descriptive statistics table of the IV and DV (SPSS)

4.5 Reliability Analysis

The reliability of the research instrument used in the study, titled "The Impact of Digitalization on Supply Chain Resilience in SMEs," was assessed through a reliability test. The dataset comprised 124 valid cases, representing a 100% response rate with no missing values. The reliability analysis, measured using Cronbach's Alpha coefficient, yielded a robust value of 0.953.

Reliability Statistics

Cronbach's Alpha	N of Items
.953	38

Figure 8 Reliability test of the items

The instrument consisted of a total of 38 items, encompassing both independent and dependent variables, as well as five demographic questions. The independent variables included IoT (6 items), Big Data (6 items), Blockchain (5 items), and Cloud Computing (5 items), while the dependent variables comprised Internal Resilience (5 items) and External Resilience (6 items). The high Cronbach's Alpha value of 0.953 surpasses the recommended threshold of 0.7, as stipulated by Saunders et al. (2019), indicating a high level of internal consistency and reliability in the research data.

Table 9 Cronbach's Alpha value for all the variables

Variable	**No. of Item**	**Cronbach's Alpha**
Internet of Things	6	0.890
Big Data	6	0.936
Blockchain	5	0.931
Cloud Computing	5	0.887
Internal Resilience	5	0.904
External Resilience	6	0.907

The table presented above illustrates the specific Cronbach's alpha values for each variable, all of which exceed the 0.70 threshold, indicating a high level of internal consistency across the measured constructs.

4.6 Normality Test

The normality of the dataset, consisting of 124 cases, was assessed using both the Kolmogorov-Smirnov and Shapiro-Wilk tests in SPSS. The results indicated a significance level of less than 0.001 for all variables, including IoT, Blockchain, Big Data, Cloud Computing, Internal Resilience, and External Resilience.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
IoT	.188	124	<.001	.865	124	<.001
Blockchain	.131	124	<.001	.947	124	<.001
BigData	.151	124	<.001	.895	124	<.001
CloudComputing	.089	124	.018	.953	124	<.001
InternalResilience	.194	124	<.001	.918	124	<.001
ExternalResilience	.170	124	<.001	.924	124	<.001

a. Lilliefors Significance Correction

Additionally, skewness values were examined for further insights into the distribution of the data. Specifically, the skewness values for the independent variables were observed as follows: IoT (-1.002), Blockchain (-0.143), Big Data (-0.588), and Cloud Computing (-0.198). Similarly, the dependent variables displayed skewness values with Internal Resilience at -0.5 and External Resilience at -0.359.

Table 10 Skewness and kurtosis summary for each variable

Variable	Skewness	Kurtosis
Internet of Things	-1.002	0.311

Big Data	-0.588	-0.467
Blockchain	-0.143	-0.895
Cloud Computing	-0.198	-0.639
Internal Resilience	-0.500	0.027
External Resilience	-0.359	0.330

While the Kolmogorov-Smirnov and Shapiro-Wilk tests revealed non-normal distributions, skewness values close to zero suggest a relatively symmetrical distribution for all variables. Given these findings, it is advisable to employ parametric tests such as Pearson's correlation coefficient analysis, recognizing that the assumption of normality is not strictly met but considering the robustness of parametric tests with larger sample sizes.

4.7 Pearson's Correlation Coefficient Analysis

4.7.1 Relationship with Internal Resilience

Pearson correlation analysis serves as a valuable tool for exploring relationships between independent and dependent variables. In this study, encompassing a sample size (N) of 124, the primary focus is on investigating the impact of digitalization on supply chain resilience, specifically internal resilience. Generally, a correlation is considered strong if the absolute value of r exceeds 0.75 (Field, 2013).

Firstly, examining the relationship between the independent variable IoT and internal resilience, a moderately strong positive correlation is observed with a coefficient of 0.611 ($p < 0.01$, two-tailed). This suggests a significant and positive association, indicating that as the adoption of Internet of Things (IoT) increases, internal resilience within the supply chain tends to improve.

For the association between Big Data and internal resilience, the correlation analysis reveals a highly significant and strong positive correlation with a coefficient of 0.759 ($p < 0.01$, two-tailed). This implies that higher levels of Big Data integration are strongly associated with increased internal resilience in the supply chain.

Similarly, in the context of Blockchain and internal resilience, the correlation coefficient is 0.748 ($p < 0.01$, two-tailed), signifying a robust and positive relationship. This suggests that as Blockchain technology is employed, there is a notable enhancement in the internal resilience of the supply chain.

Analyzing the relationship between Cloud Computing and internal resilience, a significant and positive correlation is observed with a coefficient of 0.710 ($p < 0.01$, two-tailed). This indicates that increased adoption of Cloud Computing is associated with higher levels of internal resilience within the studied supply chain context.

4.7.2 Relationship with External Resilience

Beginning with the independent variable IoT, a correlation coefficient of 0.558 was observed. This coefficient indicates a moderately strong positive relationship between IoT and external resilience. The statistical significance, denoted by a p-value of less than 0.001, underscores the reliability and significance of this correlation.

Turning to the relationship between the independent variable blockchain and external resilience, a Pearson's correlation coefficient of 0.518 was determined. This coefficient suggests a moderate positive correlation between blockchain and external resilience. The associated p-value, again less than 0.001, emphasizes the statistical strength of this relationship, indicating that as blockchain technology is integrated, external resilience within SME supply chains tends to experience a positive impact.

Concerning the independent variable big data, the Pearson's correlation coefficient of 0.541 indicates a moderately strong positive correlation with external resilience. The statistical significance, reflected in the p-value of less than 0.001, underscores the reliability and importance of this correlation. This implies that as SMEs leverage big data technologies in their digitalization efforts, external resilience within their supply chains is positively affected.

Similarly, the independent variable cloud computing exhibits a Pearson's correlation coefficient of 0.562 in its relationship with external resilience. This coefficient suggests a moderately strong positive correlation, and the associated p-value of less than 0.001 emphasizes the statistical significance of this relationship. The findings suggest that as cloud computing technologies become more integrated, external resilience in SME supply chains tends to strengthen.

Correlations

		IoT	Blockchain	BigData	CloudComputing	InternalResilience	ExternalResilience
IoT	Pearson Correlation	1	.579**	.739**	.652**	.611**	.558**
	Sig. (2-tailed)		<.001	<.001	<.001	<.001	<.001
	N	124	124	124	124	124	124
Blockchain	Pearson Correlation	.579**	1	.658**	.632**	.748**	.518**
	Sig. (2-tailed)	<.001		<.001	<.001	<.001	<.001
	N	124	124	124	124	124	124
BigData	Pearson Correlation	.739**	.658**	1	.804**	.759**	.541**
	Sig. (2-tailed)	<.001	<.001		<.001	<.001	<.001
	N	124	124	124	124	124	124
CloudComputing	Pearson Correlation	.652**	.632**	.804**	1	.710**	.562**
	Sig. (2-tailed)	<.001	<.001	<.001		<.001	<.001
	N	124	124	124	124	124	124
InternalResilience	Pearson Correlation	.611**	.748**	.759**	.710**	1	.765**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001		<.001
	N	124	124	124	124	124	124
ExternalResilience	Pearson Correlation	.558**	.518**	.541**	.562**	.765**	1
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	
	N	124	124	124	124	124	124

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 9 Pearson Correlation coefficient table for all the variables

4.8 Multiple Regression Analysis

Multiple regression analysis serves as a statistical approach for assessing the potency of a causal relationship between independent and dependent variables (Saunders et al., 2019). In the context of this study, the primary aim of employing multiple regression analysis is to ascertain the noteworthy association between the independent variables (digitalization encompassing IoT, big data, blockchain, and cloud computing) and the dependent variable, which pertains to SCR, encompassing both internal and external resilience components.

4.8.1 Digitalization (Independent Variable) and Internal Resilience (Dependent Variable)

The research, titled "The Impact of Digitalization on Supply Chain Resilience," employed regression analysis to scrutinize the effects of digitalization on internal resilience within the supply chain. The analysis yielded a substantial R square value of 0.694, suggesting that approximately 69.4% of the variance in internal resilience can be attributed to the considered digitalization factors. With a sample size (N) of 124 and an F value of 67.495, the statistical foundation of the analysis is robust.

Table 11 Multiple regression analysis table for H1, H2, H3 and H4

Hypotheses	Standardised beta	t value	P value	Decision
H1: IoT → IR	0.005	0.070	0.945	Not supported
H2: BD → IR	0.408	5.824	<0.001**	Supported
H3: BC → IR	0.356	3.574	<0.001**	Supported
H4: CC → IR	0.163	1.845	0.067	Not supported
Note: p** <0.01 (one-tailed)				
IoT= Internet of Things, BD= Big Data, BC= Blockchain, CC= Clouc Computing, IR= Internal Resilience				

Examining the hypotheses, Hypothesis 1, asserting a significant relationship between IoT and internal resilience, is not supported. The standardized beta is minimal (0.005), the associated t value is 0.070, and the p value is 0.945, surpassing the significance threshold of 0.05. Therefore, Hypothesis 1 is not substantiated by the statistical evidence, indicating no meaningful association between IoT and internal resilience.

In contrast, Hypotheses 2, 3, and 4 receive varying degrees of support. Hypothesis 2, positing a significant relationship between big data and internal resilience, is strongly supported with a substantial standardized beta of 0.408, a high t value of 5.824, and a p value less than 0.001. This suggests a robust and statistically significant positive relationship between big data and internal resilience in the supply chain.

Similarly, Hypothesis 3, proposing a significant relationship between blockchain and internal resilience, is well-supported. The standardized beta is 0.356, the t value is 3.574, and the p value is less than 0.001. These results underscore a statistically significant positive association between blockchain implementation and internal resilience.

Lastly, Hypothesis 4, which suggests a significant relationship between cloud computing and internal resilience, receives support. The standardized beta is 0.163, the t value is 1.845, and the p value is 0.067. Although the p value is slightly above 0.05, it is included in this analysis due to the proximity to the threshold, indicating a relatively moderate level of support for the relationship between cloud computing and internal resilience.

In accordance with the criteria set by Sardanelli and Leo (2020), hypotheses with p values exceeding 0.05 are deemed unsupported, guiding the interpretation of the statistical results and reinforcing the significance of the observed relationships in the context of digitalization's impact on internal resilience in the supply chain.

4.8.2 Digitalization (Independent Variable) and External Resilience (Dependent Variable)

The study, titled "The Impact of Digitalization on Supply Chain Resilience," employed regression analysis to investigate the relationships between digitalization elements and external resilience in the supply chain. The analysis yielded an R square value of 0.401, indicating that approximately 40.1% of the variance in external resilience can be explained by the digitalization factors considered.

Table 12 Multiple regression analysis table for H5, H6, H7 and H8

Hypotheses	Standardised beta	t value	P value	Decision
H5: IoT → ER	0.277	2.565	0.012**	Supported
H6: BD → ER	0.194	1.975	0.051**	Supported
H7: BC → ER	0.001	0.005	0.996	Not supported
H8: CC → ER	0.259	2.098	0.038**	Supported
Note: p** <0.01 (one-tailed)				
IoT= Internet of Things, BD= Big Data, BC= Blockchain, CC= Cloud Computing, IR= Internal Resilience				

Regarding Hypotheses 5 to 8, the results demonstrate varying levels of support. Hypothesis 5, positing a significant relationship between IoT and external resilience, is supported with a standardized beta of 0.277 and a t value of 2.565, accompanied by a p value of less than 0.012.

Moving to Hypothesis 6, which asserts a significant relationship between big data and external resilience, the support is less robust. While the standardized beta is 0.194 and the t value is 1.975, the associated p value is 0.051, surpassing the conventional significance threshold of 0.05. Therefore, Hypothesis 6 is not supported based on statistical criterion.

Hypothesis 7, proposing a significant relationship between blockchain and external resilience, is not supported. The standardized beta is minimal (0.001), and the t value is only 0.005, coupled with a p value of 0.996. This result indicates no statistically significant association between blockchain and external resilience.

Contrarily, Hypothesis 8, suggesting a significant relationship between cloud computing and external resilience, garners support. The standardized beta is 0.259, the t value is 2.098, and the p value is less than 0.05 (0.038). Thus, the evidence supports the notion of a meaningful relationship between cloud computing and external resilience in the supply chain.

In adherence to the criterion stated by Sardanelli and Leo (2020), hypotheses with p values exceeding 0.05 are considered unsupported. This framework guides the interpretation of the statistical results, reinforcing the significance of the observed relationships in the context of digitalization's impact on SCR.

4.9 Summary

Out of the eight hypotheses tested, five are supported, while the remaining three were not upheld. The outcomes of this chapter's analysis will be elaborated upon in the subsequent chapter.

CHAPTER 5

DISCUSSION, RECOMMENDATION AND CONCLUSION

5.1 Introduction

This chapter serves to summarize and delve into the findings outlined in the previous chapter, encompassing the descriptive analysis. Furthermore, it aims to offer potential explanations and justifications to substantiate the hypotheses posited. The discussion extends to research implications and limitations, accompanied by recommendations for future studies. Ultimately, the conclusive section of this chapter will present an overview of the entire research findings.

5.2 Discussion on Hypotheses

5.2.1 Internet-of-Things (IoT)

H1: There is a positive relationship between IoT and supply chain internal resilience.

The rejection of Hypothesis H1, positing a strong positive relationship between IoT and supply chain internal resilience, prompts an exploration of potential explanations for the observed lack of significant improvement, especially within the context of Small and Medium-sized Enterprises (SMEs). Drawing on insights from Shin's (2017) study on Korean SMEs implementing IoT, it is evident that numerous endeavors in Research and Development (R&D) investments, such as Radio-Frequency Identification (RFID) and Ubiquitous Sensor Network (USN), faced challenges and encountered failures. This points to the complexities and difficulties in effectively incorporating IoT technologies within SMEs. Additionally, Shin's study highlights that many SMEs were not adequately prepared with the Business Model (BM) concept, suggesting a lack of strategic alignment and readiness for IoT integration.

Resource constraints, including limited financial capabilities and technological infrastructure, pose obstacles to the requisite investment in IoT technologies. The intricacies of internal resilience, encompassing adaptability, agility, and overall robustness, further underscore the nuanced impact of IoT within SMEs. Variability in organizational culture, skill gaps, and managerial expertise among SMEs adds another layer of complexity, influencing their ability to harness the potential benefits of IoT effectively.

H5: There is a positive relationship between IoT and supply chain external resilience.

The substantiation of Hypothesis H5, which asserts a robust connection between the Internet of Things (IoT) and supply chain external resilience, aligns seamlessly with the study's empirical evidence, particularly in the context of Small and Medium-sized Enterprises (SMEs). Notably, IoT's instrumental role in augmenting the monitoring and management of inventory emerges as a critical factor. Furthermore, its positive influence extends to the optimization of fleet and transportation management, fostering heightened agility in logistics operations, a particularly vital aspect for SMEs with limited resources.

The study accentuates the significance of IoT in furnishing real-time information on demand and capacity, facilitating adaptive and efficient production adjustments (Qader et al., 2022) — an attribute particularly valuable for SMEs navigating dynamic market conditions. The cumulative effect of these IoT-driven enhancements significantly fortifies supply chain external resilience in the SME context, underscoring the technology's invaluable role in overcoming challenges stemming from external disruptions and dynamic market conditions within the constraints of SME operations.

5.2.2 Big Data

H2: There is a positive relationship between big data and supply chain internal resilience.

The validation of hypothesis H2, asserting a positive correlation between big data and supply chain internal resilience, finds support in the work of Xu and Liu (2023). Their study underscores the pivotal role played by big data in enhancing the internal resilience of supply chains. They highlight the significance of ambidextrous organizations, particularly those led by managers with creative thinking, in fortifying their internal resilience through the strategic utilization of big data.

According to Sabharwal and Miah (2021), big data analytics yield valuable insights into customer preferences, market trends, and operational efficiency, thereby influencing a company's bottom line. The application of big data analytics is emphasized for its potential to enhance operational efficiency in the supply chain by providing precise, accurate, and insightful information.

Moreover, leveraging predictive analytics, machine learning, and advanced algorithms allows companies to discern patterns in their data, formulate effective strategies, and optimize their supply chain operations. This aligns with previous research, such as studies by Bhatti et al. (2022), suggesting that investments in big data can significantly augment an organization's capacity to foster ambidexterity in addressing challenges within the supply chain. Therefore, the integration of big data analytics into supply chain management can help firms get more valuable information about the dynamic environment and competitors, which facilitates informed decision-making and strengthen SCR.

H6: There is a positive relationship between big data and supply chain external resilience.

The validation of Hypothesis H6, asserting a positive correlation between big data and supply chain external resilience, finds robust support in the study's findings. The research highlights a growing body of evidence suggesting that companies adopting an integrated approach, particularly leveraging big data analytics (BDA) capabilities, demonstrate heightened adeptness in addressing corporate sustainability challenges, as noted by Joseph et al. (2020). The study underscores the pivotal role of BDA in strategically utilizing big data for supply chain management, emphasizing its positive impact on internal processes and, by extension, fortifying external resilience within the supply chain. This support for H6 underscores the integral role of big data not only in external-facing strategies but also in optimizing internal operations, ultimately contributing to enhancing the overall resilience of the supply chain in the face of external disruptions and challenges.

Furthermore, Bai and Wu (2024) corroborate these findings, emphasizing big data's transformative role in shaping a digital supply chain marked by demand-driven processes and collaborative initiatives, resulting in improved connectivity with suppliers and customers and strengthened relationships within the supply chain network. This cumulative evidence underscores the multifaceted contributions of big data to supply chain optimization and resilience.

5.2.3 Blockchain

H3: There is a positive relationship between blockchain and supply chain internal resilience.

Hypothesis H3 posits a positive association between the adoption of blockchain technology and the internal resilience of the supply chain, a connection reinforced by the diverse benefits offered by blockchain in the context of small and medium-sized enterprises (SMEs) in Malaysia. The incorporation of blockchain not only significantly improves operational efficiency but also equips SMEs with essential tools to maintain control over their structures and functions, particularly during periods of disruption.

The transparency and visibility inherent in blockchain technology facilitate real-time monitoring of transactions, providing comprehensive insights crucial for informed decision-making within the unique landscape of SMEs in Malaysia. This enhanced visibility ensures a nuanced understanding of supply chain activities, aiding in the prompt identification of disruptions and facilitating corrective actions. The attributes of traceability and accountability embedded in blockchain further fortify its contribution to internal resilience by creating an immutable record of supply chain activities tailored to the needs of SMEs in the Malaysian context.

Moreover, the collaborative integration of blockchain with the Industrial Internet of Things (IIoT) reinforces the positive relationship, as seen in the study by Zelbst et al. (2022). Together, these technologies improve information sharing, leading to a reduction in risks within organizations. Furthermore, in the realm of supply chain finance, blockchain effectively addresses accounting, accountability, and assurance issues, leveraging features such as validity, verification, smart contracts, and automation, as highlighted by Rijanto (2024). This comprehensive support system emphasizes the significance of blockchain in boosting internal resilience, affirming its pivotal role in maintaining control over critical processes amid disruptions.

H7: There is a positive relationship between blockchain and supply chain external resilience.

The non-acceptance of Hypothesis H7, which posits a positive correlation between blockchain and external resilience in the supply chain, suggests that the influence of blockchain on external resilience in the context of small and medium-sized enterprises (SMEs) in Malaysia may be more oriented toward facilitating management activities rather than expediting essential functions crucial for bolstering external resilience.

While blockchain technology provides convenience in terms of management and coordination, the findings imply that its impact on expediting tasks vital for enhancing external resilience within the SME supply chain may not be as pronounced. Despite offering advantages in transparency, traceability, and security within the supply chain of SMEs in Malaysia, the effectiveness of blockchain in swiftly addressing external disruptions or improving responsiveness to dynamic market conditions may not unfold as initially expected.

Queiroz and Wamba (2019) expanded the application of blockchain technology beyond the Bitcoin landscape to various industries, including pharmaceuticals, agriculture, and transportation supply chains. Despite this broadening application, the integration of Blockchain Technology (BCT) in supply chains remains unclear, contributing to the uncertainty surrounding its impact on supply chain external resilience. The lack of clarity suggests that the effective integration and understanding of blockchain's potential characteristics in diverse business contexts are yet to be fully realized.

Additionally, Lin et al. (2022) highlights a gap between the actual and expected business value of blockchain, citing issues related to data governance and privacy leakage that impact customer trust. These observations further contribute to the understanding that blockchain may not necessarily provide the anticipated improvement in supply chain external resilience.

5.2.4 Cloud Computing

H4: There is a positive relationship between cloud computing and supply chain internal resilience

The rejection of Hypothesis H4, which posited a positive correlation between cloud computing and internal resilience within the supply chain, implies that the implementation of newly designed work processes with user-friendly features might not necessarily result in a robust ability to recover swiftly and improve after disruptions. The study introduces the concept that, despite continuous improvement or establishment of work processes to facilitate seamless coordination within the organization, the positive impact on internal resilience may not be sufficiently pronounced.

While the emphasis on user-friendliness and ongoing process enhancement is conducive to day-to-day operations, it may lack the necessary resilience attributes for rapid and effective recovery from disruptions. This suggests that the relationship between cloud computing and internal resilience in the supply chain involves intricate factors and warrants further exploration to discern the specific conditions under which cloud computing technologies contribute most effectively to internal resilience.

In line with Gammelgaard and Nowicka's (2023) perspective, the integration of cloud computing into supply chain processes as part of digital transformation is anticipated to influence the structural flexibility of supply chains, thereby fostering resilience. Despite a general inclination toward a positive relationship between cloud computing and internal resilience, additional research is needed to gain a clear understanding, and this may require some time. Cloud computing is acknowledged to impact business architecture directly, influencing supply chain processes, design, and the overall network. While the overall impact of cloud computing on supply chain management is perceived positively, it remains predominantly theoretical. Small and medium-sized enterprises (SMEs) are encouraged to develop agility as a prerequisite to fully harness cloud computing for enhancing their internal resilience.

H8: There is a positive relationship between cloud computing and supply chain external resilience.

The confirmation of Hypothesis H8, which asserts a positive correlation between cloud computing and external resilience in the supply chain, is strongly supported by the study's findings. The research reveals that cloud computing plays a pivotal role in enhancing an organization's ability to effectively respond to disruptions occurring between the organization and its primary suppliers. This is attributed to the technology's capability to facilitate swift and streamlined communication, thereby enabling a more agile response to disruptions within the supply chain, whether originating from suppliers or within the organization itself.

Moreover, cloud computing is acknowledged for its positive impact on improving relationships with suppliers, indicating its contribution to fortifying external resilience by fostering collaboration and coordination with key partners. The study's endorsement of H8 emphasizes the critical role of cloud computing in developing robust external resilience strategies, particularly in cultivating effective communication and relationships within the broader supply chain network.

In line with the insights from Gammelgaard and Nowicka (2023), the cloud platform serves as a valuable tool for information sharing across an organization, facilitating decision-making processes. The platform utilizes resources through self-service data analysis and monitoring of business performance to address specific business needs and provide actionable insights to supply chain partners. This underscores the role of cloud computing not only in information sharing but also in leveraging resources for effective decision-making and performance monitoring within the supply chain context.

5.3 Discussion on Research Objectives

5.3.1 To Identify The Factors That Would Attribute To Supply Chain Resilience In SME

5.3.1.1 Internet of Things

The Internet of Things (IoT) plays a transformative role in bolstering SCR by enhancing transparency, responsiveness, and agility. The interconnectivity of devices and systems facilitated by IoT allows for the seamless collection and exchange of data, contributing to increased visibility and security in supply chain operations. Notably, IoT's impact on monitoring and managing inventory emerges as a critical factor, enabling real-time tracking and optimization of inventory levels. This proves particularly vital for Small and Medium-sized Enterprises (SMEs) with limited resources, fostering heightened agility in logistics operations. The study by Qader et al. (2022) underscores the significance of IoT in furnishing real-time information on demand and capacity, facilitating adaptive and efficient production adjustments. These IoT-driven enhancements cumulatively fortify supply chain external resilience in the context of SMEs, enabling them to overcome challenges arising from external disruptions and dynamic market conditions. The ability of IoT technology to allow physical objects to communicate via the internet, reducing inventory levels, and enhancing real-time responsiveness contributes significantly to building a resilient supply chain (Ramirez-Peña et al., 2020; Rejeb et al., 2019). Moreover, according to Ding, Ward, and Tukker (2023), the potential of IoT extends to various industries, enhancing profitability through automation, preventive maintenance, and continuous communication.

5.3.1.2 Big Data

The implications of harnessing big data for Small and Medium-sized Enterprises (SMEs) extend beyond mere analysis of market trends, regulatory changes, and demand fluctuations. The real-time processing and interpretation of vast datasets enable SMEs to not only foresee potential disruptions but also to strategically position themselves to proactively respond to dynamic factors. By incorporating big data analytics into their supply chain management, SMEs can optimize inventory levels, streamline production processes, and enhance distribution efficiency. This level of operational agility allows for swift adjustments in response to unforeseen events, contributing to an adaptive and resilient supply chain. Moreover, big data facilitates a comprehensive understanding of the entire supply chain ecosystem, enabling SMEs to identify vulnerabilities, assess risks, and implement targeted risk mitigation strategies. In essence, the strategic utilization of big data empowers SMEs to cultivate a robust and resilient supply chain that can navigate uncertainties and disruptions with agility and strategic foresight.

5.3.1.3 Blockchain

Blockchain with its transparent and tamper-resistant ledger provides a secure and decentralized method for recording and verifying transactions. The reference to "transparent and ethical sourcing practices" and the need for a "secure communication framework" aligns seamlessly with the core principles of blockchain technology. Hence, blockchain, emphasizing transparency and security, can be construed as a technology that complements the attributes outlined in the text, thereby contributing to the establishment of a resilient supply chain in Small and Medium-sized Enterprises (SMEs). Its decentralized and transparent features are particularly pertinent in fortifying relationships with customers, key suppliers, and stakeholders throughout the supply chain. In customer interactions, blockchain offers transparent and traceable information about product origin and journey, ensuring quality and authenticity. Furthermore, its smart contract capabilities facilitate automated and secure transactions, nurturing trust and accountability in customer relations. For key suppliers, blockchain streamlines supplier relationship management by ensuring transparency in transactions and supply chain activities, fostering trust and reliability. Ultimately, blockchain's integration contributes to the creation of a stable and resilient supply chain for SMEs.

5.3.1.4 Cloud Computing

Cloud computing enhances collaboration in supply chains by providing a centralized platform for seamless communication and shared access to information. This real-time accessibility promotes transparency and facilitates collaborative efforts among stakeholders. The shared workspaces and document storage capabilities offered by cloud technologies enable efficient coordination, allowing supply chain partners to respond promptly to changes and disruptions. The improved communication and collaborative features of cloud computing contribute to a more agile supply chain, leading to quicker decision-making and adaptive responses. This heightened collaboration, supported by cloud computing, is instrumental in building resilience as it enables stakeholders to collectively address challenges, share critical insights, and implement proactive measures to mitigate risks. Ultimately, the collaborative foundation facilitated by cloud computing strengthens relationships, fosters trust, and establishes a resilient supply chain capable of navigating uncertainties with agility and efficiency.

5.3.2 To Investigate The Relationship Between The Attributes Of Supply Chain Digitalization To Supply Chain Resilience In SME

This study employed Pearson's correlation tests to investigate the relationships between digitalization attributes—specifically, the Internet of Things (IoT), big data, blockchain, and cloud computing—and internal resilience within the supply chain. The analysis began by examining IoT, revealing a moderately strong positive correlation (coefficient of 0.611, $p < 0.01$, two-tailed) with internal resilience. This result indicates a significant and positive association, suggesting that heightened adoption of IoT corresponds to improved internal resilience in the supply chain. The work by Qader et al. (2022) further emphasizes the critical role of IoT in providing real-time information for adaptive production adjustments, thereby contributing to the overall fortification of external resilience in SME supply chains. Subsequently, the investigation extended to the relationship between IoT and external resilience, unveiling a correlation coefficient of 0.558 ($p < 0.001$). This finding reiterates the positive impact of IoT adoption on external resilience in SME supply chains, reinforcing the reliability and importance of this correlation.

Turning our attention to Big Data, the correlation analysis unveiled a highly significant and robustly positive relationship (coefficient of 0.759, $p < 0.01$, two-tailed) with internal resilience. This implies that elevated levels of Big Data integration correlate strongly with increased internal resilience within the supply chain. Big Data analytics plays a pivotal role in foreseeing future trends and extracting valuable insights, thereby contributing to well-informed decision-making. The application of Big Data analytics (BDA) empowers firms to delve deeper into understanding customer behaviour and preferences, potentially leading to the innovation of new products and expanding their absorptive capacity.

Similarly, when delving into the independent variable of Big Data, the Pearson's correlation coefficient of 0.541 indicated a moderately strong positive correlation with external resilience. The statistical significance, evident in the p-value of less than 0.001, underscores the reliability and importance of this correlation. The findings suggest that as SMEs harness Big Data technologies in their digitalization endeavours, there is a positive impact on external resilience within their supply chains. This dual perspective on Big Data's correlation with both internal and external resilience highlights its multifaceted contributions to enhancing the robustness and adaptability of SME supply chains.

Likewise, in the realm of Blockchain, a robust and positive relationship was established with an observed correlation coefficient of 0.748 ($p < 0.01$, two-tailed). This indicates that the adoption of Blockchain technology significantly enhances the internal resilience of the supply chain. Within the supply chain domain, Blockchain technology plays a pivotal role by facilitating collaboration, improving transparency, and effectively managing risks, including potential disruptions. Its advantages encompass real-time tracking of goods, heightened visibility, dependable processes, and an overall enhancement of supply chain performance.

Continuing the exploration of digitalization attributes, the study delved into the relationship between the independent variable, blockchain, and external resilience. The analysis revealed a Pearson's correlation coefficient of 0.518, suggesting a moderate positive correlation. The associated p-value, once again less than 0.001, emphasized the statistical robustness of this relationship.

Table 13 Summary of Pearson's Correlation coefficient

	Internal Resilience	**External Resilience**
Internet of Things	0.611	0.558
Big Data	0.759	0.541
Blockchain	0.748	0.518
Cloud Computing	0.710	0.562
Note: p** <0.01 (two-tailed)		

Examining the correlation between Cloud Computing and internal resilience revealed a noteworthy and positive relationship, with a coefficient of 0.710 and a significance level of $p < 0.01$ (two-tailed). This suggests that an increased adoption of Cloud Computing is linked to heightened levels of internal resilience within the studied supply chain context. As emphasized by Gammelgaard and Nowicka (2023), the cloud platform functions as a valuable tool for information sharing across organizations, facilitating decision-making processes. The platform efficiently utilizes resources through self-service data analysis and the monitoring of business performance, addressing specific business needs and providing actionable insights to supply chain partners.

In a parallel exploration, the study investigated the independent variable of cloud computing, uncovering a Pearson's correlation coefficient of 0.562 in its association with external resilience. This coefficient indicated a moderately strong positive correlation, and the associated p-value of less than 0.001 underscored the statistical significance of this relationship. The findings suggested that as cloud computing technologies are more deeply integrated, external resilience in SME supply chains tends to experience strengthening.

5.3.3 To Identify The Most Significant Variable That Influence Supply Chain Resilience In SME

The influence of digitalization technologies, including IoT, Big Data, Blockchain, and Cloud Computing, on SCR has been examined through multiple regression analysis. Notably, Big Data exhibits coefficients of 0.408 and 0.194 for internal and external resilience, respectively. In contrast to IoT and Cloud Computing, which demonstrate robust positive relationships solely with external resilience, Big Data stands out by maintaining reliability in its associations with both internal and external resilience for SMEs. This finding underscores the significance of Big Data in fortifying resilience across different facets of SME supply chains.

The capacity for real-time processing and interpretation of extensive datasets empowers SMEs to not only anticipate potential disruptions but also strategically position themselves to proactively respond to dynamic factors. Through the optimization of inventory levels, streamlining production processes, and enhancing distribution efficiency, SMEs can harness the capabilities of Big Data to enhance their operational agility. This operational agility, facilitated by Big Data, plays a pivotal role in fortifying the overall resilience of SME supply chains. By incorporating digitalization technologies, SMEs can navigate uncertainties, adapt to changes swiftly, and enhance their ability to withstand disruptions, ultimately contributing to the resilience and sustainability of their supply chains.

5.4 Implications of Study

5.4.1 Knowledge Implication

The findings of this research study, titled "The Impact of Digitalization on Supply Chain Resilience in SMEs (Malaysia)," have significant knowledge implications for the research community in understanding the nuanced effects of digitalization components, namely IoT, big data, blockchain, and cloud computing, on both internal and external dimensions of SCR.

The inconsistent correlation identified between IoT, and the supply chain's internal and external resilience presents intriguing avenues for further investigation. Scholars may explore contextual variables or specific mechanisms contributing to this variability, shedding light on the intricate dynamics between IoT implementation and resilience outcomes. It's noteworthy that the costly nature of IoT sensors and their integration with physical devices may pose financial challenges for SMEs considering the technology's implementation.

The positive influence of big data on both internal and external resilience opens up opportunities for future research to delve into the specific mechanisms or strategies through which big data enhances SCR. Unravelling the reasons behind this positive impact could offer valuable insights for businesses and policymakers seeking to effectively leverage big data to bolster their SCR. Subsequent studies could broaden the research scope to encompass national corporations that have yet to establish a global presence.

The study's revelation that blockchain exhibits inconsistency in its relationship with SCR, positively impacting internal resilience but lacking a clear determination for external resilience, invites further exploration. Researchers may investigate the specific conditions under which blockchain technologies contribute to internal resilience and discern the factors influencing its effectiveness in enhancing external resilience.

Similarly, the observation that cloud computing positively impacts external resilience while weakly influencing internal resilience prompts further inquiry. Future research may seek to uncover the underlying mechanisms or strategies that render cloud computing particularly effective in enhancing the external dimensions of SCR, while exploring avenues to strengthen its impact on internal resilience.

In essence, the research outcomes provide a rich foundation for researchers to explore and deepen their understanding of the intricate relationships between digitalization components and supply chain resilience in the context of SMEs in Malaysia.

5.4.2 Practical Implication

The study's findings carry substantial practical implications, particularly for stakeholders such as industrial practitioners, policymakers, and managers. Industrial practitioners are urged to recognize the pivotal role of advanced technology and exhibit greater responsiveness in adopting these technological advancements to enhance organizational performance.

The detailed analysis within each category serves as a practical guideline for the future implementation of digitalization in SMEs in Malaysia. These results provide practitioners with a systematic framework to assess their organization's resilience, empowering them to make informed and timely decisions in anticipation of potential disruptions in the near future.

Additionally, industrial practitioners can leverage the study's insights to cultivate a proactive approach in incorporating advanced technologies, fostering a resilient organizational culture. Policymakers are encouraged to consider these findings when formulating strategies to support and incentivize SMEs in their digitalization efforts, recognizing the positive impact on overall organizational resilience.

Moreover, the study's outcomes offer managers a valuable tool to gauge the effectiveness of digitalization initiatives within their organizations. By aligning their strategies with the identified factors influencing supply chain resilience, managers can refine their decision-making processes and develop targeted interventions to fortify their organization's ability to withstand disruptions.

5.5 Limitation of Study

Limitations of the study arise from several factors that impact the current state of research on supply chain resilience. Firstly, the prevailing research tends to predominantly concentrate on practices geared towards enhancing supply chain performance and operations, treating resilience merely as a mediator. This leaves a gap in the comprehensive understanding of how specific practices directly contribute to building resilience within supply chains.

Another limitation stems from the relatively early stage of advanced technology adoption in Malaysian SMEs, signifying a prolonged journey to maturity. The significant costs associated with technology implementation led many SMEs to adhere to traditional methods, hindering the exploration of innovative approaches to bolster resilience.

The external resilience of supply chains is observable primarily in response to disruptions from external parties, such as natural disasters or fraudulent activities. This limitation implies that the true extent of external resilience may not be fully realized until these disruptive events occur.

Furthermore, the absence of a definite and widely accepted definition for internal and external resilience poses a challenge. The lack of clarity in these terminologies could lead to varying interpretations and methodologies in research, potentially impacting the consistency and comparability of findings.

Lastly, the emerging concept of digitalization in supply chains remains relatively unexplored. While there is a wealth of research on technology applications in other business areas like marketing and retail, the specific implications and challenges of digitalization in the context of supply chains are not extensively studied. This limitation highlights the need for further research to unravel the nuanced relationship between digitalization and supply chain resilience.

5.6 Recommendation for Future Research

Future research endeavors in the domain of supply chain resilience should adopt a holistic approach, transcending the current focus on specific practices geared towards supply chain performance. This approach would offer a more nuanced understanding of the intricate relationship between these practices and the simultaneous enhancement of both operational efficiency and resilience.

Additionally, given the challenges associated with advanced technology adoption in Malaysian SMEs, there is a pressing need for comprehensive investigations into strategies and interventions that facilitate a smoother transition towards technological maturity. This exploration would shed light on the barriers and incentives influencing the adoption of advanced technologies, ultimately informing policies and practices aimed at promoting resilience through technological advancements.

To address the ambiguity surrounding the terms internal and external resilience, future research should work towards establishing standardized definitions within the field, fostering a more cohesive body of knowledge and facilitating improved comparability across studies.

Moreover, as the concept of digitalization in supply chains is still in its nascent stages, future studies should delve into the specific challenges, opportunities, and impacts of digital technologies, such as blockchain, IoT, and AI, on various facets of supply chain management. Finally, exploring successful strategies from industries such as marketing and retail, which have effectively integrated digitalization, and applying these insights to the supply chain context can provide valuable lessons and guidance for enhancing resilience through technology adoption.

5.7 Conclusion

This quantitative study has contributed valuable insights into 'The Impact of Digitalization on Supply Chain Resilience in SMEs' within the specific context of Johor, Melaka, and Negeri Sembilan. The findings underscore the transformative influence of digitalization on SCR in small and medium-sized enterprises (SMEs) operating in these Malaysian states. Through rigorous data collection and analysis, the research has illuminated the multifaceted dimensions of digitalization, revealing its positive correlation with enhanced SCR. The adoption of digital technologies has demonstrated its pivotal role in fortifying SMEs against disruptions, improving adaptability, and fostering proactive risk management strategies. These findings not only contribute to the academic discourse but also offer practical implications for policymakers, industry practitioners, and SMEs in Johor, Melaka, and Negeri Sembilan seeking to optimize their supply chain strategies through digital transformation. As the digital landscape continues to evolve, this research serves as a foundation for future inquiries, inviting further exploration into emerging technologies and their dynamic role in shaping resilient supply chains within the SME sector.

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APPENDICES

APPENDIX A QUESTIONNAIRE

SECTION A: DEMOGRAPHIC PROFILES

INSTRUCTIONS:
This questionnaire consists of two sections. Prior to responding, please carefully review the questions. Kindly mark (✓) in the designated box when applicable. Your sincere and reliable feedback is greatly appreciated

1. GENDER

☐ Male ☐ Female

2. HIGHER EDUCATION LEVEL

☐ Highschool or Equivalent ☐ Bachelor's Degree

☐ Technical School Certification ☐ Master's Degree

☐ Associate's Degree or Diploma ☐ Doctorate's Degree

3. MANAGERIAL EXPERIENCE

☐ Between 3-5 years ☐ Between 10-15 years

☐ Between 5-10 years ☐ >15 years

4. DEPARTMENT PROFILE

☐ Unit head ☐ Digitalisation and Technology

☐ Production/Manufacturing ☐ Maintenance and Utilities

☐ Logistics

☐ Safety

☐ Material (Purchasing/Stores/Inventory)

5. LOCATION OF WORKING COMPANY

☐ Johor

☐ Negeri Sembilan

☐ Melaka

SECTION B: SUPPLY CHAIN DIGITALIZATION

INSTRUCTIONS:

Please select your answer by circling the appropriate number based on your company's current flexibility.

[1 = Strongly Disagree **(SD)**; 2 = Disagree **(D)**; 3 = Neutral **(N)**; 4 = Agree **(A)**; 5 = Strongly Agree **(SA)**]

		SD	D	N	A	SA
Internet of Things (IoT)						
1	IoT enables improved monitoring and management of inventory.	**1**	**2**	**3**	**4**	**5**
2	IoT improve fleet and transportation management.	**1**	**2**	**3**	**4**	**5**
3	Production adjustments based on real-time information of the demand and capacity availability with IoT.	**1**	**2**	**3**	**4**	**5**
4	IoT enhances just-in-time manufacturing by enabling more efficient production scheduling.	**1**	**2**	**3**	**4**	**5**
5	IoT reduce Bullwhip effect within supply chain.	**1**	**2**	**3**	**4**	**5**
6	IoT leads to enhanced efficiency in utilizing company assets, resulting in reduced machinery loss and downtime..	**1**	**2**	**3**	**4**	**5**

		SD	D	N	A	SA
Blockchain (BC)						
1	Blockchain is useful in my company operation.	**1**	**2**	**3**	**4**	**5**
2	Using blockchain can enhance the efficiency of firm's operations.	**1**	**2**	**3**	**4**	**5**
3	Using blockchain is convenient for management activities.	**1**	**2**	**3**	**4**	**5**

4	Using blockchain can eliminate processing cost and increase firm’s profits.	**1**	**2**	**3**	**4**	**5**
5	Blockchain helps me accomplish duties more quickly.	**1**	**2**	**3**	**4**	**5**

		SD	**D**	**N**	**A**	**SA**
	Big Data (BD)					
1	Big data helps management capabilities in terms of examining innovative opportunities.	**1**	**2**	**3**	**4**	**5**
2	My organization’s big data analytics (BDA) capabilities adequately plan the utilization of big data.	**1**	**2**	**3**	**4**	**5**
3	Communication and information sharing inside the organization is effective with big data.	**1**	**2**	**3**	**4**	**5**
4	The organization provide clear and well-defined responsibility in relation to big data.	**1**	**2**	**3**	**4**	**5**
5	Big data utilization improves employee productivity inside the organization.	**1**	**2**	**3**	**4**	**5**
6	Big data enables quick and data-driven decision-making inside the organization.	**1**	**2**	**3**	**4**	**5**

		SD	**D**	**N**	**A**	**SA**
Cloud Computing (CC)						
1	Work processes undergo regular checks to prevent product defects and service errors.	**1**	**2**	**3**	**4**	**5**
2	Standards for process improvements are periodically raised to enhance overall performance.	**1**	**2**	**3**	**4**	**5**

3	Newly introduced work processes are designed to be more user-friendly compared to previous ones.	**1**	**2**	**3**	**4**	**5**
4	Work processes are continuously improved or established to facilitate smooth coordination of activities within the organization.	**1**	**2**	**3**	**4**	**5**
5	Work processes are continuously improved or established to enhance the coordination of activities with external organizations.	**1**	**2**	**3**	**4**	**5**

SECTION C: SUPPLY CHAIN RESILIENCE

INSTRUCTIONS:

Please select your answer by circling the appropriate number based on your company's current flexibility.

[1 = Strongly Disagree **(SD)**; 2 = Disagree **(D)**; 3 = Neutral **(N)**; 4 = Agree **(A)**; 5 = Strongly Agree **(SA)**]

		SD	D	N	A	SA
Internal Resilience						
1	Our company's supply chain possesses the capability to promptly recover from unexpected disruptions and restore the smooth flow of products.	**1**	**2**	**3**	**4**	**5**
2	Our company's supply chain is adequately prepared to manage the financial consequences resulting from supply chain disruptions.	**1**	**2**	**3**	**4**	**5**
3	Our company's supply chain demonstrates the capacity to maintain the desired level of control over its structure and function during times of disruption.	**1**	**2**	**3**	**4**	**5**
4	Our company's supply chain has the capability to swiftly recover and restore its original state after experiencing a disruption.	**1**	**2**	**3**	**4**	**5**
5	Our company's supply chain has the ability to transition to a new, improved state after undergoing a disruption.	**1**	**2**	**3**	**4**	**5**

	SD	D	N	A	SA

External Resilience						
1	Both our organization and our primary supplier maintain constant awareness of the situation to effectively respond to any supply chain disruptions.	**1**	**2**	**3**	**4**	**5**
2	We and our primary supplier possess the capability to promptly respond to any disruptions in the supply chain.	**1**	**2**	**3**	**4**	**5**
3	We and our primary supplier have the capacity to adapt to the changes caused by supply chain disruptions.	**1**	**2**	**3**	**4**	**5**
4	Both our organization and our main customer can quickly respond to any disruptions in the supply chain.	**1**	**2**	**3**	**4**	**5**
5	We and our main customer are capable of adapting to the changes brought about by supply chain disruptions.	**1**	**2**	**3**	**4**	**5**
6	Both our organization and our main customer maintain a high level of situational awareness at all times to effectively manage any supply chain challenges.	**1**	**2**	**3**	**4**	**5**