KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

THE MEDIATING ROLE OF SUPPLY CHAIN FLEXIBILITY ON THE RELATIONSHIP BETWEEN IT INFRASTRUCTURE FLEXIBILITY AND SUPPLY CHAIN RESILIENCE IN THE OIL AND GAS INDUSTRY IN GHANA

By

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DECLARATION

I hereby declare that this submission is my work towards the Masters of Science in Logistics and Supply Chain Management and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

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DEDICATION

I dedicate this work to Allah almighty, my parents and Hajia Kubura the CEO of Maltima Enterprise for their continuous support and prayer during my study.

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ABSTRACT

The goal of this study was to investigate the role that supply chain flexibility plays in mediating the relationship between IT infrastructure flexibility and supply chain resilience in the oil and gas companies in Ghana. The study was quantitative, using a cross-sectional survey design and explanatory research approaches. This study used an explanatory research design to investigate the function of supply chain flexibility as a mediator between the flexibility of IT infrastructure and the resilience of the supply chain. Members of the tender committee, procurement officials, and a few handpicked O&G enterprises in Ghana make up the general population. 200 tender committee members and procurement staff were given a well-organised questionnaire. Primary data was collected using a combination of convenient and purposive sampling. Using Structural Equation Modelling, the study's hypotheses were verified with (SmartPLS 4). The research used descriptive statistics, often called summary statistics, to provide a high-level overview of the data. The study revealed that supply chain resilience in the Oil and Gas industry was not significantly affected by the flexibility of IT infrastructure. However, it was shown that the link between IT infrastructure flexibility and supply chain resilience was mediated by supply chain flexibility, which has a significant influence on supply chain resilience. Managers of Oil and Gas companies may improve supply chain resilience by promoting supply chain flexibility, as shown by the findings. Managers are tasked with increasing supply chain flexibility by measures such as increasing the number of suppliers, fostering an environment where employees are encouraged to share ideas, introducing digital technology into the production process, and forming new partnerships.

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CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

The oil and gas (O&G) industry is one of the major industries in terms of dollar value and employs hundreds and thousands of people worldwide (Piya et al., 2022). Despite a substantial burst in the O&G industry with a slowdown in production and a decrease in revenue (Abboud et al., 2021), the industry is still the major contributor to the GDPs of many countries and plays a major role in the generation of significant employment opportunities. As the world economy heads toward renewables, O&G will still play an important role in energy systems (Aastvedt et al., 2021; Piya et al., 2022).

The O&G industry can be categorised into three major sections. The upstream section consists of the exploration and production of hydrocarbon fields by bringing crude oil and natural gas from underground to the surface. The midstream section consists of processes such as setting up gas plants, producing liquefied natural gas, and transporting crude oil and gas from upstream to refineries. The downstream section is concerned with processes such as the refinement, marketing, and distribution of crude oil and related products. As a large number of service and technology companies assist the operation of these three sections (Piya et al., 2022; Yusuf et al., 2014), a high level of cooperation among O&G supply chain (SC) partners and an integration of their capabilities are needed (Piya et al., 2020; Rejeb et al., 2021; Saad et al., 2014; Ebrahimi et al., 2018; Liao et al., 2017). Sudden disruption to any link within the chain will have adverse effects on the entire chain. Therefore, O&G SC needs to be resilient to adapt to the changes orchestrated by market dynamics.

Supply chain resilience (SCR) is defined as the ability of the SC to manage its activities as normally as possible during any form of disruption. Resilience in the SC contributes to improving customer service, market share, and profitability. It is therefore critical for the firm to understand and ensure SCR to mitigate obstacles caused by unforeseen disasters and maintain business growth. This is especially true during the COVID-19 pandemic, where more than 80% of global organizations are severely affected by the crisis (Sujan et al., 2022). The pandemic has affected every facet of human existence and all types of industries, including O&G. One recent example of the effect of the pandemic on an O&G SC was seen in many economies, with severe disruption to the chain to the extent that the government had to take drastic measures to relieve the impact of such a disruption.

In terms of revenue, the oil and gas (O&G) sector ranks among the largest industries and provides jobs for hundreds of thousands of people worldwide (Piya et al., 2022). Despite a significant surge in the O&G sector, which resulted in a slowdown in production and a drop in revenue (Abboud et al., 2021), the sector is still a significant employer and a major contributor to the GDPs of many nations. O&G will continue to be crucial to the world economy's transition to renewable energy sources (Aastvedt et al., 2021; Piya et al., 2022).

Three main divisions can be made in the O&G sector. The upstream phase involves the discovery and development of hydrocarbon fields by bringing subsurface natural gas and crude oil to the surface. The activities in the midstream sector include the construction of gas plants, the creation of liquefied natural gas, and the delivery of crude oil and gas from upstream to refineries. The downstream area is concerned with operations like the distribution, marketing, and refinement of crude oil and related goods. As many service and technology firms support the operation of these three sections (Piya et al., 2022; Yusuf et al., 2014), O&G supply chain (SC) partners must work

closely together and integrate their capabilities (Piya et al., 2020; Rejeb et al., 2021; Saad et al., 2014; Ebrahimi et al., 2018; Liao et al., 2017). Any link in a chain that is suddenly broken will have negative effects on the entire chain. The O&G SC must therefore possess resilience in order to adjust to the changes induced by market dynamics.

The ability of the SC to manage its operations as normally as feasible under any type of disturbance is known as supply chain resilience (SCR). In the SC, resilience helps to increase profitability, market share, and customer satisfaction. Therefore, the company must comprehend and assure SCR to minimise challenges brought on by unplanned disasters and preserve corporate growth. This is particularly true during the COVID-19 pandemic, where more than 80% of international organisations are seriously impacted by the crisis (Sujan et al., 2022; The pandemic has affected every aspect of human existence and all types of industries, including O&G). One recent example of the effect of the pandemic on an O&G SC was seen in many economies, with severe disruption to the chain to the extent that the government had to take drastic measures to lessen the impact of such disruption.

Organisational managers need to identify appropriate strategies, prioritize them, and implement them with the goal of minimising risk and financial impact caused by COVID-19. Despite investment costs, the need for IT infrastructure flexibility within the O&G supply network cannot be ignored as this uncertainty may compensate for building required resilience and contribute to rapidly increasing competitive advantage (Nasir et al., 2021; Das et al., 2022; Sharma et al., 2022; Mahmoudi et al., 2022). To enhance the SC and maintain resilience, a variety of tactics can be used, including reshoring, diversification, boosting inventory level, adding other supply sources, flexibility, agility, IT infrastructure flexibility, etc (Dorsaf et al., 2020). Successfully combining the appropriate tactics can increase SCR (Piya et al., 2020; 2022). The O&G SC needs to invest in

technology in order to become more autonomous and intelligent. By combining strategy with IT infrastructure flexibility, the supply network can detect disruptions and changes more quickly and adjust to them.

Over the last several decades, flexibility has become a focal topic in supply chain research because of increasing irregularity, complexity, uncertainty, and dynamism in most markets and competitive environments (Posen and Levinthal, 2012; Stieglitz, Knudsen, and Becker, 2016). Many strategists and management scholars alike assert that IT infrastructure flexibility is fundamental to flexibility in the supply chain. IT infrastructure flexibility is defined as the degree to which a firm's resources are sharable and reusable (Anwar and Masrek, 2015; Yugo et al.,2016). Consequently, researchers have a sustained and ongoing interest in the topic of IT infrastructure flexibility (Benitez et al., 2018; Makhloufi et al., 2018; Anwar et al., 2018; Chester and Allenby, 2019; Baradziej and Gkikas, 2021; Khoshsima and Jafarnezhad, 2021; Al-Sabaawi and Alyouzbaky, 2022). Despite the growth of the literature on individual concepts, the relationship between firm IT infrastructure flexibility and supply chain resilience remains underexplored. Hence this study examines the effect of IT infrastructure flexibility on supply chain resilience.

1.2 Problem Statement

In recent decades, the role of IT in business has significantly improved – it shifted vastly from a cost center to an investment centre. It is a valuable asset needed to help the organisation survive in this fast- changing environment. As business needs tend to fluctuate in this dynamic setting, a flexible IT infrastructure is a must-to-have so that organisation could be more responsive to the change in business demands. However, this requires no small investments. The urgency to provide a flexible – yet cost-efficient IT infrastructure makes IT infrastructure remains an important issue up to nowadays (Chester and Allenby, 2019; Baradziej and Gkikas, 2021; Khoshsima and Jafarnezhad, 2021; Makhloufi et al., 2018; Makhloufi et al., 2021; Sánchez-Silva and Calderón-Guevara, 2022).

IT infrastructure flexibility is the act of controlling an organisation over its competitive environment and ability to generate better competitive position (Makhloufi et al., 2018). IT infrastructure flexibility is also defined as the ability of existing IT infrastructure to adapt changes from both internal and external to the organisation in order to facilitate information sharing, system development and the continuity of IT operations with minimal effort and time (Sánchez-Silva and Calderón-Guevara, 2022). In essence, a flexible and responsive IT infrastructure within a supply chain will facilitate the SC to fully utilize its information systems for strategic purposes.

IT infrastructure flexibility emerges in an era in which real-time communication and coordination is pursued while many risks arise (Corallo et al., 2020; Khoshsima and Jafarnezhad, 2021; Al-Sabaawi and Alyouzbaky, 2022) which may hinder supply chain resilience (SCR; Colicchia et al., 2019). It implies increasingly mature processes, organisation or even competences (Schumacher et al., 2016; Schuh et al., 2017; Colli et al., 2019) along with digital tools adoption to support data-driven SCM (Buy€ uk€ €ozkan and G€oçer, 2018). IT infrastructure flexibility is attracting significant attention, and the "digital SC" (DSC) is the hottest buzzword in the industry (Buy€ uk€ €ozkan and G€oçer, 2018). The stakes are now focused on IT infrastructure flexibility in a business environment that is now more turbulent than ever (Ivanov et al., 2019a, b), with financial, economic, ecological, and social risks. Of course, IT infrastructure flexibility can be viewed as a solution to managing SC risks (Ivanov and Dolgui, 2019a; Ivanov et al., 2019a, b), but the ongoing "wave" of digitalisation also creates new dynamics that are often difficult to follow in companies (McKinsey and Company, 2015; Deloitte, 2017), leading to new challenges for businesses and society. In such an environment, resilience is desirable in companies. To date, limited evidence, exist on the relationship between IT infrastructure flexibility and SCR (Dubey et al., 2019; Zouari et al., 2020). Though prior studies (Chung et al., 2005; Bush et al., 2010; Bhatt et al., 2010;

Masa'deh, 2013; Isal et al., 2016; Han et al., 2017; Hou, 2020; Qin et al., 2021; Koekemoer et al., 2021) have proved the essential role played by IT infrastructure flexibility in supply chain management and business performance, how IT infrastructure flexibility drives supply chain resilience too remains unclear. Considering the vacuum of knowledge regarding how IT infrastructure flexibility drives supply chain resilience, this study is conducted to answer the question: Does IT infrastructure flexibility drive supply chain resilience?

Despite some encouraging first results on the interplay of SCR with some IT infrastructure (see the example of Procter & Gamble during the COVID-19 outbreak era [1] and the study from Ivanov, 2020), Pettit et al. (2019) recommend further research. Addressing this gap in the literature is of utmost importance, as the emergence of new IT infrastructure alters traditional ways of working and creates disruption across SC processes. This managerial reality needs to be explored by researchers to provide a better understanding of the phenomenon. Adding to the gap in the IT infrastructure flexibility and supply chain resilience relationship, this study introduced supply chain as a mediating variable. Flexibility in the coordination of operations and resources are very important key factor is risk management (Scholten et al., 2010; Kwateng et al., 2022). Supply chain flexibility (SCF) is seen as the ability of members in the chain to adjust their key processes by responding or adjusting to the dynamics in the environment and subsequently deliver value to their customers and ensure that profitability of the chain is guaranteed (Swafford et al., 2006; Merschmann and Thonemann, 2011). Firms must have flexible systems and culture in order to withstand disruption in their environment (Thomas, 2014). Maintaining a rigid and bureaucratic structure could derail the success of the SC (Wise, 2006; Thomas, 2014). It is advisable for managers of aid organisations to adopt flexible competitive style (Wise, 2006). Being flexible will firms to adjust and reconfigure the structure of their supply chain and work collaboratively to

achieve success (Baharmand et al., 2017; Jermsittiparsert and Pithuk, 2019). Though few studies (Dubey et al., 2021; Nikookar and Yanadori, 2021; Rajesh, 2021; Kamalahmadi et al., 2022; Siagian et al., 2021; Koekemoer et al., 2021) have indicated a positive relationship between SCF and SCR. Drawing on the DC theory, SCF remains essential organisational capabilities to achieve superior supply chain resilience, meanwhile, Nikookar and Yanadori (2021) argues that despite research efforts into the organisational capabilities required to develop supply chain resilience, there remains a significant research gap in the supply chain resilience literature. In response to the calls to how SCF may be useful in SCR coupled with the fact that no prior study has examined the indirect role of SCF in the IT infrastructure flexibility and supply chain resilience relationship, this study represents the first attempt to investigate how infrastructure flexibility and SCF may influence supply chain resilience. Though they have been considered individually in different studies, combining these factors in a single model offers a novel insight into SCR literature and practice.

Analysis of supply chain resilience drivers in oil and gas industries during the COVID-19 pandemic using an integrated approach.

1.3 Objective of the study

This study was conducted to examine the mediating role of supply chain flexibility on the relationship between IT infrastructure flexibility and supply chain resilience in the Oil and Gas Industry in Ghana. Specifically, this study intends:

1. To examine the effect of IT infrastructure flexibility and supply chain resilience in the Oil and Gas Industry in Ghana
2. To determine the relationship between supply chain flexibility and supply chain resilience in the Oil and Gas Industry in Ghana.

3. To examine the mediating role of supply chain flexibility on the relationship between IT infrastructure flexibility and supply chain resilience.

1.4 Research Questions

This study was driven by the research questions below:

1. What is the effect of IT infrastructure flexibility and supply chain resilience in the Oil and Gas Industry in Ghana?
2. What is the relationship between supply chain flexibility and supply chain resilience in the Oil and Gas Industry in Ghana?
3. What is the mediating role of supply chain flexibility on the relationship between IT infrastructure flexibility and supply chain resilience?

1.5 Significance of the study

The study was conducted basically on how IT infrastructure flexibility and supply chain flexibility may impact supply chain resilience in the Oil and Gas Industry in Ghana. The outcome of this study made significant practical and theoretical contributions. The practical contribution of this study lied in the attempt to offer suggestions on how the different dimensions of firm flexibility may impact supply chain resilience in the Oil and Gas Industry in Ghana. This study was among the very few attempts to understand how the different dimensions of firm flexibility may impact supply chain resilience in the Oil and Gas Industry in Ghana.

A list of organisational supply chain resilience antecedents has been provided by recent research on the topic (Ambulkar et al., 2015; Blackhurst et al., 2011; G€olgeci and Ponomarov, 2015). In the literature on supply chain management, it is frequently argued that supply chain managers are responsible for making crucial decisions, such as those involving disruptions. In order to deal with supply chain disruptions, businesses rely on their supply chain managers. This study advanced the theory of supply chain resilience by identifying two firm-level factors that affect supply chain resilience. They were classified as managerial supply chain resilience antecedents and are firm-level factors. By examining the mechanisms by which

managerial supply chain resilience antecedents enhance supply chain resilience, this research also contributes to the theory of supply chain resilience. By incorporating the organisational antecedents into the model, this study demonstrated that managerial supply chain resilience antecedents transmit their effects on supply chain resilience through their positive effect on SC flexibility. By simultaneously considering organizational and managerial supply chain resilience antecedents, this first multi-level study demonstrated the significance of individuals as well as organisational capabilities in dealing with supply chain disruptions.

1.6 Organisation of the study

The study was structured into five chapters. Chapter One introduced the background to the study, the research problem, research objectives, research questions, justification or significance of the study, scope of the study, limitations of the research, and an overview of the research methodology. Chapter Two reviewed relevant literature encompassing both theoretical and empirical sections. The various concepts of the study were also reviewed in the Chapter Two. Chapter Three elaborated on the research methodology. The chapter discussed the study design, population of the study, sampling, data collection, data processing, data analysis, and ethical consideration. Chapter Four of the study presented analyses of the data and discussed the result. Chapter Five summarised the research result to make the necessary conclusions and recommended appropriate and feasible policy and managerial measures for improving procurement in Ghana.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Chapter two of this thesis is organised into four main sub-headings. The chapter provides information organised under conceptual review, theoretical review, empirical review and finally the research model and hypotheses development. The Conceptual review section provides definitions, operationalisations and how the constructs have been used in this study. The theoretical review section also provides the theoretical underpinnings of the study. The various prepositions proposed in this study were depicted using a conceptual framework and various relationships were well discussed. The Chapter ends with a summary which also highlights the gap explored in this study.

2.2 Conceptual Review

This section provides definitions of the constructs and how they have been used in the study. The research work was made up of three (3) variables (IT infrastructure flexibility, supply chain resilience, and supply chain flexibility). However, these variables have been operationalised in the subsequent sections below.

2.2.1 Information Technology (IT) Infrastructural Flexibility

Information technology infrastructure flexibility refers to the capacity of the technical physical base, as well as the human component, of the current IT infrastructure to easily diffuse or support a wide range of hardware, software, communication technologies, data, core applications, skills, competencies, commitments, and values (Anwar, et al., 2018). Van de Wetering et al. (2018) suggest that when evaluating the adaptability of IT infrastructure, one should start with the degree of shareability and reusability of IT resources. IT infrastructure flexibility, according to Yasir et al. (2021), is the infrastructure's ability to support a wide range of hardware, software, and other

technologies that can be easily incorporated into the overall technological platform, to distribute any type of information (data, text, voice, image, and video) to anywhere within an organization and beyond, and to support the design, development, and implementation of heterogeneity of business applications. Hou, (2020) claimed that the attributes of connectivity, compatibility, and modularity may be used to characterise IT infrastructure flexibility. Gilrein, et al. (2021) also pointed out that firms are thought to gain high adaptability in their IT infrastructure if their connectivity, compatibility, and modularity are strong. Four important factors; compatibility, the competence of IT staff, and interconnectivity were statistically supported by Yasir et al., (2021). Connectivity may be defined as the hardware's and software's capacity to establish internal and external electronic links. The capacity to distribute any kind of knowledge is known as compatibility. The capacity to quickly alter hardware software and data is known as modularity. Competency in IT personnel refers to both the knowledge and practical experience needed by IT workers to execute IT-related tasks. On the other side, IT infrastructure is described as a collection of common information technology resources that serve as a basis for both internal organization communication and the deployment of existing and future business applications (Anwar, et al., 2018). Schreieck et al. (2022) claim that IT infrastructure is a protracted asset with protracted shareholder value, and it symbolizes an organization's long-term alternatives. The authors also claimed that it is challenging to modify IT infrastructure quickly since it requires a significant financial commitment and has an impact on the entire business. It must thus be able to accommodate change without requiring a fresh start each time a new development is introduced because doing so is too expensive and time-consuming to accomplish (Furrer, 2019; Baradziej, and Gkikas, 2021). The technological and human infrastructures, which are both widely defined, make up the IT infrastructure, according to Moradhaseli and Monfared (2020). The technical

infrastructure consists of real IT resources such as hardware, software, the network, telephony, and applications (Williams, 2021). The ability to manage IT resources inside a company is referred to as human infrastructure (Antoni, et al., 2020). Additionally, flexibility typically allows companies more alternatives to diversify their products and services, enabling them to meet a wider range of market demands and clients, according to Santa et al., (2019). In several managerial disciplines, such as finance (Alsi, 2018), automation (Onyokoko, and Onuoha, 2021), manufacturing (Abdelilah, et al., 2018), health care (Kumar, et al., 2018), and human resources, the word "flexibility" is utilised (e.g., Hsu, et al., 2019). The IT infrastructure, according to Chaudhary et al. (2019), consists of hardware and bandwidth for information technology, as well as skills, knowledge, rules, and standards for human interaction. It also comprises shared applications and IT services for the entire enterprise. The networked organisational structure benefits from IT infrastructure because it lowers transaction costs, which lowers the cost of disseminating information throughout the business (Chaudhary, et al., 2019). This study's definition of IT infrastructure flexibility is that, it is the ability to rapidly diffuse or support a wide range of hardware, software, communication technologies, data, core applications, skills, competencies, commitments, and values within the technical physical base and the human component of the existing IT infrastructure. Anwar and colleagues provided this definition (2018).

2.2.2 Supply Chain Resilience

Supply chain resilience is the capability of a company or group of companies to survive setbacks, adapt, and develop (Fiksel et al. 2015). High-performing businesses will stand out from the competition by having the capacity to predict the effect, which is also a necessary skill set if they want to respond and recover fast before the next big event. Organisations with resilience built into their supply chains should be able to reduce vulnerability to a variety of supply disruptions that

may occur during the next major crisis in addition to minimising exposure to transportation interruptions (Gunasekaran, et al., 2015; Hejazi, 2021; Ivanov, et al., 2019; Tukamuhabwa, Stevenson, and Busby 2015). Resilience is a complicated notion, but its fundamental goal is to maintain a stable state by either adjusting to a new equilibrium stage or going back to a pre-disturbance stage after a disturbance (Hejazi, 2021). According to research by Tukamuhabwa et al. (2015), resilience may be characterised by formative skills including adaptability, speed, visibility, cooperation, etc. (for a comprehensive review see Iftikhar, et al. 2022). Businesses must have resilience if they are to react to disruptive events, recover from them, and maintain their success. You may describe resilience as an adaptive attribute in and of itself (Golgeci and Kuivalainen 2020). It aids in preventing detrimental disruption-related effects, surviving the disruption, and then rapidly and effectively recuperating (Scholten et al., 2020). Therefore, businesses that implement a resilience plan may outperform their competitors in the face of disruptive occurrences (Faruquee et al., 2021). Supply chain resilience is the ability of complex industrial systems to persist, adapt, and develop in the face of disruptive change (Dickens, et al., 2021). Furthermore, supply chain resilience was defined as a proactive, systematic, and integrated investigation of capacities within the supply chain to cope with unpredictable events (Tukamuhabwa et al., 2015; Hohenstein et al., 2015) rather than focusing solely on the capacity to recover from disasters. Wieland and Durach (2021) continued by stating that supply chain resilience is the capacity of a supply chain system to lower the likelihood of disruption, lessen the effects of such disruptions should they occur, and shorten the time it takes to recover normal operation. Another component of supply chain resilience is its adaptability, which allows it to anticipate events, respond to shocks, and recover from them while maintaining the required level of connection and structural and functional control (Massari and Giannoccaro, 2021). To preserve

the supply chain's goals, supply chain resilience must be able to respond to the detrimental consequences of interruptions that take place at a certain time (Barroso et al. 2011). Recent research by Bevilacqua, et al. (2019) suggests that supply chain resilience may be achieved without unduly high operational expenses. The concept of supply chain resilience used in this study, according to Fiksel et al. (2015), refers to an organisation's or group of organisations' capacity to tolerate, adapt, and expand in the face of disturbing change.

2.2.3 Supply Chain Flexibility

Manufacturing flexibility is followed by supply chain flexibility, which expands the idea of penalty-free change beyond the boundaries of a single organisation to include the whole supply chain (Delic and Eyers, 2020; Chirra and Kumar, 2018). Huo et al. (2018) note that supply chain flexibility has emerged as a result of a greater focus on the contribution of supply chains to overall organisational competitiveness and that it addresses manufacturing constraints that prioritise the flexibility of the individual firm over the interdependencies between supply chain partners. Flexibility in the supply chain enables businesses to operate effectively in dynamic contexts (Basheer, et al., 2019) without sacrificing efficiency or competitiveness (Aslam, et al., 2018; Singh, et al., 2019; Seebacher and Winkler, 2015). Supply chain flexibility is a method that may be utilised to adjust to changes in a dynamic environment without experiencing severe performance losses, as claim by Manders et al. (2017). According to Quan et al., (2022) supply chain flexibility has allegedly been considered in terms of vendor flexibility (i.e., flexibility provided by individual businesses) and sourcing flexibility (i.e., the capacity to increase supply chain flexibility through supplier selection and deselection) in (Delic and Eyers, 2020), it is useful to distinguish between internal and external viewpoints of flexibility. Internal perspectives refer to what the production system is capable of, whereas external perspectives refer to what the customer

feels the system is capable of. Flexibility competencies and flexibility capabilities are the internal production system capabilities, according to Nayal et al. (2022). The types of flexibility that manifest as a result of the flexibility competencies. Jafari, et al. (2022) also refer to supply chain flexibility as a multi-dimensional construct made up of internal flexibility, distribution flexibility, and supplier flexibility. This construct would define a firm's ability to successfully adjust to customer changes in the business environment. The ability of an organisation to change its resources and operations in conjunction with its supply chain partners to react to external dynamics is known as supply chain flexibility (Jafari. et al., 2022). On the other hand, Baral, et al. (2022) assert that for businesses to thrive in a disruptive and dynamic environment, they need a well-balanced blend of flexibility types. For instance, Richey et al. (2022) contend that efficient management and coordination of the company and the logistics providers depend on the complementarity of internal and supplier-related external flexibility. To increase company responsiveness, supply chain flexibility encompasses both internal and external (inbound and outbound) flexibilities. According to Acero et al. (2022), supply chain flexibility is a construct made up of the following dimensions: sourcing flexibility, which refers to the availability of goods and services and the capacity to purchase them in response to shifting needs; operating system flexibility, which refers to the capacity to provide goods with a wide range of characteristics, combinations, and volumes to satisfy multiple customer specifications; and distribution flexibility, which refers to the capacity to deliver goods with a wide range of characteristics, combinations, and volumes to satisfy multiple customers. The definition of supply chain flexibility used in this study will be that given by Jafari et al. (2022), who state that it is a firm's capacity to alter, adapt, and transform its resources and procedures in cooperation with its supply chain partners.

2.3 Theoretical Review

To focus the research direction, two underpinning theories were used as a research foundation in supporting and addressing the gap, and as a guide to align this research into an appropriate direction. In this section, the researcher discusses underpinning theories that form the basis to investigate and study the phenomenon of IT infrastructure flexibility, supply chain resilience, and supply chain flexibility. The driving theory of this study was the Dynamic capability theory and information processing theory. Theoretical frameworks provide a clear prism or context through which a subject is studied; it explains the context and the connections between the various factors and dimensions.

2.3.1 Dynamic Capability Theory

The definition of dynamic capacity by Teece, Pisanos and Shuen (1997) is the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments. The dynamic capability view (DCV) is often seen by academics as an extension of the resource-based view (RBV) (Ambrosini and Bowman 2009; Eisenhardt and Martin 2000; Wang and Ahmed 2007). The RBV is largely focused on the firm's present resources, whereas the dynamic capabilities perspective lays greater attention on how resources and organizational capabilities may adapt and change to achieve and retain competitive advantage (Schilke 2014). According to Teece, Pisano, and Shuen (1997), enterprises should depend more on organizational skills and functional competencies than on assets that are easily replicated in the current period of fast technological change.By tacitness, complexity, and specificity in resources and talents, Reed and Defillippi (1990) emphasise the significance of causal ambiguity, or the difficulty for competitors to understand how actions lead to consequences. When discussing how particular supply chain abilities or decision-making criteria are related or how they impact performance in the operations and supply chain management literature, causal ambiguity may be relevant

(Gunessee and Subramanian, 2020). For instance, in their quasi-experimental study at Unilever, Laursen, and Andersen (2016) investigated the effects of causal ambiguity on supplier collaboration during new product development. According to Helfat et al., (2007), a dynamic capability is the capacity of an organisation to actively develop, extend, and adapt its resource base. Sensing, seizing, and reconfiguring are three key components that Teece (2007) takes into account for his dynamic capacity framework. Sensing entails tasks that involve scanning, learning, and analysing the surrounding environment (Fainshmidt et al. 2019). The goal of seizing is to seize fresh business opportunities or eliminate hazards brought forth by tumultuous settings (Blome, Schoenherr, and Rexhausen). 2013). The capacity to reconfigure resources, abilities, and organizational activities in response to variations in tumultuous situations is required for reconfiguration (Eisenhardt and Martin 2000; Wilden, Devinney, and Dowling 2016). It is possible to describe the intra- and inter-firm dynamism of organisations in reaction to change by theorizing dynamic capacities based on sensing, seizing, and reconfiguring (Teece 2018). In the face of uncertainty, businesses reengineer their current competencies and rebuild their supply chain in this manner (Aslam et al. 2020; Chowdhury and Quaddus 2017). Although popular in the literature on strategic management (Barreto 2010, Eisenhardt and Martin 2000, Schilke 2014; Winter 2003), the study of the causes of dynamic capabilities in operations and supply chain management is still in its infancy (Aslam et al. 2020; Brandon-Jones and Knoppen 2018)). Due to the complexity of the structure, worldwide dispersion, and fast shifting consumer behavior, today's supply chains frequently exhibit extremely unpredictable and dynamic tendencies (Azadegan et al. 2019; Hall 2000; Wong and Hvolby 2007). Dynamic capacity is a suitable theoretical framework to describe such behaviors as a result (Sandberg 2021; Beske 2012).

2.3.2 Information Processing Theory

According to IPT, every company is an open information-processing system that must manage a variety of uncertainties and fluctuations. By enhancing their information processing capabilities, businesses may lessen the detrimental effects of uncertainty (Galbraith, 1974). To produce better synchronised decision-making and coordinated activities in the volatile environment, simplified information is required. In other words, if a firm's ability to handle information is weak, it will have conflicting risk management strategies and misinterpretation of external stimuli (Daft and Lengel, 1986). By implementing this idea in supply chain management, businesses will be better able to handle uncertainty and maintain competitiveness (Mason-Jones and Towill, 1997). Two different information processing types were proposed by Wang et al. (2021) as a response to supply chain disturbances. To reduce information distortions and increase the number of solutions, the first kind involves increased information sharing between supply chain parties. Another kind involves standardizing information formats to cut down on the number of information sources and enable quick judgments and responsive actions. IT assists businesses in successfully disseminating information across organizational boundaries as a crucial middleman for information exchange in supply chains (Huo et al., 2015; Iyer, 2011; Li et al., 2009; Patnayakuni et al., 2006; Song et al., 2007; Yu et al., 2017). It links consumers and suppliers with structured language and efficient information flow, facilitating information processing and enabling businesses to rapidly deal with supply chain partners' uncertainties (Srinivasan and Swink, 2015; Yao, 2009). IPT offers a theoretical framework to comprehend how businesses use various IT implementation patterns with suppliers and consumers to strengthen supply chain resilience. This study assumes that by standardizing information formats, the IT infrastructure's flexibility enhances the capacity to process information. Together with their supply chain partners, it enables businesses to respond quickly to unforeseen circumstances, and the flexibility of IT infrastructure promotes open

information exchange. Together with their supply chain partners, businesses develop innovative solutions that help them maintain their competitiveness over time.

2.4 Empirical Review

This section provided the relationship between the constructs by reviewing literatures on the findings from earlier related studies. The relationships included IT infrastructure flexibility, supply chain resilience, and the mediating role of supply chain flexibility in the relationship.

2.4.1 I T Infrastructure Flexibility and Supply Chain Resilience

Gu et al. (2018) undertook research to examine how firms use distinct IT patterns (exploitative vs. explorative) in conjunction with supply chain patterns to achieve supplier and customer resilience. The data was obtained from 206 Chinese firms. The study used structural equation modeling to test the hypotheses. The findings revealed that the exploratory use of information technology had an influence on supply chain resilience. Future studies should focus on intra-firm IT and how intra-firm IT trends improve SC resilience.

Yu et al., (2022) did research to examine the impact of information processing capabilities on supply chain resilience, operational performance, and receptivity to technological innovation. 41 Chinese companies provided the data, which was obtained. The data was examined using structural equation modeling. The results showed that supply chain resilience is significantly impacted by technological innovation. The study concluded that managers widen their responses to disruptive events, therefore avoiding or minimizing any negative effects on organizations.

Cui et al. (2022) investigated the effect of digital technologies on company resilience in the setting of COVID-19. Data was gathered from 332 Chinese industrial companies. The findings revealed that when information complexity is high, digital technologies have a greater influence on company resilience. Future research will be updated to cover all of the current technology.

Belhadi et al. (2022) looked at the direct and indirect impacts of artificial intelligence, supply chain resilience, and performance in the context of the supply chain's dynamic and unpredictability. 279 businesses spanning a range of sizes, industries, and nationalities participated in the survey, providing the data. The results demonstrated that supply chain resilience was improved via artificial intelligence-driven innovation. To get deeper insights, it is advised that future study examined additional linkages and phenomena utilizing a mix of qualitative and quantitative approaches.

Dubey et al. (2021) explored organisational adaptability and data analytics capabilities as a supplement to supply chain resilience. Data were gathered from 213 Indian industrial businesses using a survey-based instrument that had been evaluated beforehand. The hypotheses were assessed using structural equation modeling with variance. The results show that data analytics skills have a significant impact on supply chain resilience. The study recommended using longitudinal data in future studies to improve our current comprehension of data analytics capabilities and their impact on supply chain resilience.

2.4.2 IT Infrastructure Flexibility and Supply chain Flexibility

Gupta et al. (2019) conducted research to clarify the relationship between flexible information systems and smart supply chains in order to achieve supply chain flexibility overall. 150 respondents in the industrial sector of South Africa provided the data. Using structural equation modeling and the partial least square method, the theoretical framework was empirically evaluated. According to the findings, there is a strong correlation between flexible information system modules and smart supply chain management features, leading to a high level of supply chain flexibility. Future studies should look at data from various industries and lower-level managers, the research suggested.

Benitez et al. (2018) carried out a study to look at how mergers and acquisitions are affected by the adaptability of IT infrastructure. The study used a combination of secondary and matched-pair survey data from 100 small businesses in Spain to evaluate this connection. The research showed that mergers and acquisitions are influenced by how flexible the information technology infrastructure is.

Dehgani and Navimipour (2019) looked into how information technology affects supply chain management agility. The questionnaire-based data collection is being carried out by 120 employees of the Golasal Company. The causal model was examined using the structural equation modeling approach, which evaluates the model's validity and reliability. The results showed that the agility of supply chain management is impacted by information technology. The study suggested that more research may examine the connection between customer relationship management, company resource planning, and strategic management.

Al-Lamy et al. (2018) studied the impact of information technology infrastructure on company performance. A survey was sent to 162 SMEs, and the data was analyzed using multiple regression. The study found that information technology infrastructure (IT connection, modularity, and personalization) had a beneficial influence on company performance. According to the report, future research should improve the measures of information technology abilities by incorporating additional criteria.

Huo et al. (2021) conducted research into the effects of information sharing on various supply chain learning models (internal, supplier, and customer learning), as well as how these models affected flexibility performance. Data from 213 Chinese manufacturing companies were utilized in the study's structural equation modeling to test the conceptual model. According to the findings, sharing information enhances supply chain learning in all three dimensions. To increase the

generalisability of the results, future research can gather data from additional industries in more nations and locations.

2.4.3 Supply Chain Flexibility and Supply Chain Resilience

Aslam et al. (2020) conducted research to examine the role of supply chain ambidexterity (SC-Ambidexterity) in the growth of supply chain resilience. Information was acquired through surveying Pakistani manufacturing companies. The results showed that SC-Ambidexterity positively affects SC-Resilience. The study recommended that more research look into operationalizing the key findings of this study and replicating the research design in the service settings.

Yu et al. (2018) explored how supply chain information flexibility and integration affected operational effectiveness. The study used an annual report-based content analysis together with a sample of 84 food companies that had been listed in China for three years. To analyse the data, hierarchical regressions were employed. The results show that integrating external information results in proactive and reactive flexibility, which enhances operational effectiveness. Future studies may examine the multifaceted nature of information integration, for example, by separating supplier information integration from consumer information integration when examining interactions across supply chains with information integration.

Kazancoglu et al. (2022) looked on the role of flexibility, agility, and responsiveness in maintaining supply chain resilience. The partial least squares (PLS) model is used to examine the study hypotheses, which are based on 200 replies from organisations with complicated supply chain systems. Supply chain flexibility has been demonstrated to have a direct impact on supply chain agility. The study indicated that future research might benefit from new factors in addition to flexibility, agility, and reactivity.

Rojo et al. (2018) examined the effectiveness of two dynamic capabilities—operational absorptive ability and organisational learning—in the trade-off between environmental dynamism and supply chain flexibility. By combining structural equation modeling and data from 302 Spanish manufacturing companies, hypothesized linkages are put to the test. The results demonstrated that supply chain flexibility is strongly correlated with organizational learning and operational absorptive capacity, and that both dynamic capabilities support environmental dynamism. Future research should, if feasible, gather longitudinal data on supply chain flexibility.

2.4.4 The mediating role of Supply Chain Flexibility

Khanuja and Jain (2021) conducted analysis to determine how supply chain flexibility affects the relationship between supply chain integration and performance. The 187 data points collected from Indian companies utilising survey methodologies were examined using the structural equation modeling method. The results show that both partial and full supply chain flexibility mediates the link between customer and supplier integration and supply chain performance. The study recommended that more investigation be done in order to include the opinions of other stakeholders, such as clients and suppliers.

Thongrawd et al. (2020) explored the link between ties between suppliers and customers and competitive advantage. Additionally, research is being done on the mediating effects of supply chain agility and flexibility. The data for the present study came from customers of Indonesian textile enterprises. The Statistical Package for Social Sciences (SPSS) version 23 and Smart PLS 3.0 were both used to analyse the data. The findings showed that there is little proof to back up supply chain flexibility as a significant mediator between suppliers' performance and competitive advantage.

Hou, (2020) looked into how supply chain capabilities affected the linkages between the integration and flexibility of information technology infrastructure and business performance. The Partial Least Squares approach was used to examine the relationships indicated in the framework after data from 270 businesses in the Taiwanese electronics sector were obtained for the study. The results demonstrated that information technology infrastructure integration and flexibility indirectly and favorably impact organisational performance through the mediating influence of supply chain capabilities. The study made the suggestion that more research should gather longitudinal data throughout time and at various stages in order to improve the conclusions of causal inferences.

Jajja et al. (2018) looked at how supply chain integration affects the link between agility performance and supply chain risk. Structural equation modeling was used to assess the assumptions using data from 770 manufacturing companies from the sixth International Manufacturing Strategy Survey. The findings demonstrated that supplier and customer integration acts as a mediator in the relationship between a firm's supply chain risk and agility performance. Future research may be able to examine the relationship between internal integration and supply chain risk in greater detail.

Pinheiro et al. (2020) examined how manufacturing flexibility functions as a mediating element in the relationship between knowledge development, technological upheaval, and performance. The study looks at a survey from 370 manufacturing companies. In the study, structural equation modeling with covariance was used to examine the data. The research results showed that manufacturing flexibility acts as a mediator between operational performance and knowledge development. Future researchers will consider innovation as a prerequisite for industrial flexibility.

2.5 Hypotheses Development

This section discusses the four key hypotheses as shown in Figure 2.1 below. Subsections have been created and discussed for each of the hypotheses as illustrated by the research model.

2.5.1 Effect of IT Infrastructure Flexibility on Supply Chain Resilience

Information technology infrastructure flexibility is the capability of the infrastructure to distribute any type of information (data, text, voice, image, and video) anywhere within an organisation and beyond, to assist in the design, improvement, and execution of a diversity of software platforms, and to assist in the of hardware, software, and other technological advances that can be comfortably diffused into the overall technological platform. Yasir and others (2021). The use of information technology promotes supply chain partners to provide comprehensive and in-depth information for unstructured jobs (Jean, et al., 2021). Through experimentation and creativity, it enables the production of new information and ideas for distinctive situations. Im et al., (2019) and Qrunfleh and Tarafdar's, (2014). When surroundings are dynamic, this knowledge and skill help people to be more responsive and are therefore more valued (Yeniyurt, et al., 2021; Gu, et al., 2021). The environment becomes extremely volatile when disturbances take place. To be able to take quick action, businesses and their supply chain partners need to have access to enough information about their shared operations and external environment. The use of information technology stimulates more active information exchange. As a result, businesses may dynamically reconfigure their internal processes in response to changing environmental demands, increasing supplier and customer resilience. Consequently, this study hypothesised that:

H_1. I T infrastructure flexibility positively and significantly influences supply chain resilience.

2.5.2 Effect of IT Infrastructure Flexibility on Supply Chain Flexibility

A source of value in an organisation, IT infrastructure has been highlighted as a crucial organisational competency (Syailendra, G.D., 2019; Chiu, and Yang, 2019). According to Chiu and Yang (2019), IT infrastructure is made up of shareable and reusable IT resources that serve as the basis for current and future business applications for organizations using supply chain network architecture. They make it possible for data to be shared between various application systems, guarantee consistency, and efficiently take advantage of business possibilities to enable rapid and flexible answers that satisfy the demands of the organisations. According to Butaney (2020), poor information systems and a lack of communication are the main reasons for production and sales issues. The corporation has individual computerised systems for each department. Long wait times and sluggish approvals led to consumer discontent and ongoing dispute between multiple departments since the various databases were not connected and few communications were transferred within them. As a result, integrating and adapting information technology enhances communication and collaboration across many departments. Supply chain partners can reduce the issue of data entry mistakes and information delays by eliminating the need to repeatedly type the same transaction data in multiple systems by using flexible IT infrastructures (Ul-Hameed, et al., 2019). The adaptability of cross-functional applications also improves the supply chain's transparency and synchronises the execution of cross-organisational tasks and business operations. Therefore, the study proposes that:

H_2. I T infrastructure flexibility positively and significantly influence supply chain flexibility.

2.5.3 Effect of Supply Chain Flexibility on Supply Chain Resilience

Supply chain flexibility is a measurement of a supply chain's capacity to respond to shifting consumer demands and market conditions. Supply chains must become more flexible if they want to improve and preserve their competitiveness (Kazancoglu, et al., 2022). Furthermore, supply networks can respond quicker to unforeseen interruptions and changes because of their flexibility (Shekarian et al., 2020). According to Pettit et al. (2019), a supply chain has to be adaptable to provide resilience in the face of issues that develop in supply networks. Supply chain resilience is also impacted by supply chain flexibility. The sustainability and resilience of supply chains in a complex environment are impacted by alternative supplier options and operational flexibility, according to Tukamuhabwa et al. (2015) and Kazancoglu et al. (2022). In the context of the dynamic capability viewpoint and contingency theory, flexibility is an indication of the responsiveness of supply networks, according to Pettit et al. (2019). It is also one of the variables that enable supply chains to adapt fast. From a different angle, flexibility in supply chains is ensured by putting speed and versatility on the front burner (Kazancoglu, et al., 2022; Gligor et al., 2019). One of the most crucial prerequisites for flexibility is resilience (Ivanov, 2020b). According to Liao (2020), supply chain flexibility gives a corporation the ability to adapt to environmental changes and advances the development of high-quality goods and services. Due to the literature, this study also hypothesised that:

H_3. Supply chain flexibility significantly influences supply chain resilience.

2.5.4 The mediating Role of Supply Chain Flexibility

Supply chain flexibility is defined and assessed in relation to a company's operating capacity (Gligor, 2018). With various production lines, improved changeover, and the ability to schedule a time to react to clients, the company can precisely modify output volume (Khanuja, and Jain,

2021). Past studies have found that supply chain flexibility helps firms accomplish their goals. For instance, Rashid et al. (2021) discovered that flexibility aids in enhancing the firm's performance in terms of quality and resilience. According to Khanuja and Jain (2021), the ability of the supply chain to produce the proper product and make it accessible for processing in the downstream supply chain adds to the value chain. IT infrastructure flexibility cannot be seen just as a means of bridging the gap between channel partners, claim Khanuja and Jain (2021). Nevertheless, it aims to create supply networks that are stronger and more adaptable, which improves supply chain resilience. Research from the past has also shown how the supply chain's flexibility helps the firm's capacity to respond. For instance, flexibility efforts improve the robustness of the supply chain, according to Khanuja and Jain (2021), and information and knowledge exchange among partners is a key driver of flexibility, according to Liao and Barnes (2015). According to Jin et al. (2014), supply chain flexibility fosters transparency and confidence among partners, which boosts the robustness of the supply chain. For businesses to provide a flexible environment and effectively address client demands, information technology infrastructure is essential (Khanuja, and Jain, 2021). For instance, different client requests are communicated to manufacturers through channel partners, such as the range of items, quality, and enhancements to current products (Zhang and Cao, 2018). The literature suggests that:

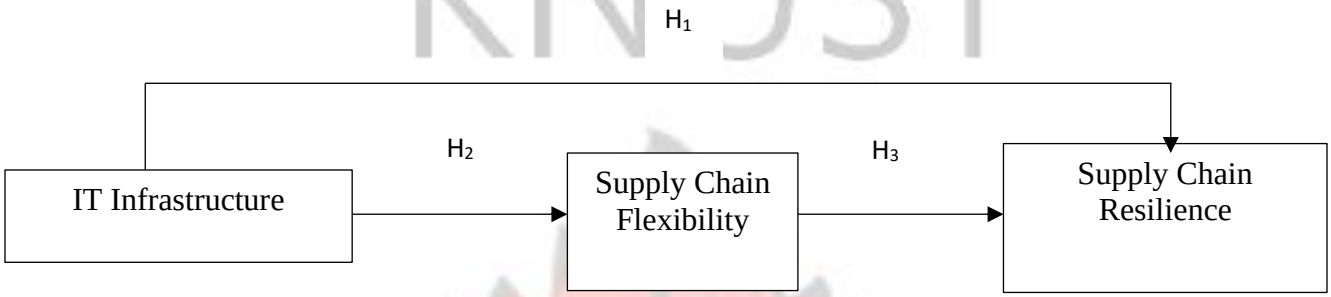
H_4. Supply chain flexibility mediates the relationship between IT T infrastructure flexibility and supply chain resilience.

2.6 Conceptual Framework

The section explains the conceptual framework and underlying assumptions that relate the IT infrastructure flexibility and supply chain resilience as well as how supply chain flexibility affects the relationship. The study examined the direct effect of IT infrastructure flexibility on supply

chain resilience and the indirect role of supply chain flexibility in the IT infrastructure flexibility and supply chain resilience link.

Figure 2.1 Conceptual Framework



2.7 Literature Gap

Author/Year	Country	Purpose	Theory	Method	Findings	Future Studies
Gu et al. (2018)	China	To look at how businesses apply various Supply chain patterns and IT patterns (exploitative vs. explorative) to achieve supplier and customer resilience.	Information processing theory (IPT)	Quantitative	Supply chain resilience is impacted by the exploratory use of information technology.	Future research should address intra-firm IT and investigate how intra-firm IT patterns enhance SC resilience.
Gupta et al. (2019)	South Africa	To describe the relationship between flexible information systems and smart supply chains in order to achieve overall supply chain flexibility	Information processing theory (IPT)	Quantitative	Favorable association between smart supply chain management features and modules of information system flexibility,	Future studies examine data from different industries as well as lower-level managers.
Yu et al., (2022)	China	To examine the connection between operational effectiveness, supply chain resilience, and receptivity to technological innovation.	No Theory	Quantitative	Technological innovation has a major impact on supply chain resilience	None
Cui et al. (2022)	China	to look into how digital technologies affect business resilience in the COVID-19 environment.	Information processing theory	Quantitative	Digital technologies have a greater influence on company resilience.	Future research will be updated to cover all of the current technology.

Belhadi et al. (2022)	North Africa, South Europe, and Southern Asia	To examine the effects of artificial intelligence, supply chain performance, and resilience	Information processing theory (OIPT)	Quantitative	Supply chain resilience was improved via artificial intelligence-driven innovation.	Future study examines additional linkages and phenomena utilizing a mix of qualitative and quantitative approaches.
Dubey et al. (2021)	India	To research organizational adaptability and data analytics skills as a supplement to supply chain resilience.	Information processing theory (OIPT).	Quantitative	Data analytics capabilities has a major influence on supply chain resilience.	Future research uses longitudinal data to enhance our present understanding of data analytics capabilities and its influence on supply chain resilience.
Benitez et al. (2018)	Spain	To investigate how the flexibility of information technology (IT) infrastructure influence mergers and acquisitions	No Theory	Mix method	Flexibility of information technology infrastructure influences mergers and acquisitions.	None
Hou, (2020)	Taiwan	To look into how supply chain capabilities affected the linkages between the integration and flexibility of information technology infrastructure and	Resource-based theory	Quantitative	Supply chain capabilities mediate the relationship between information technology infrastructure organisational performances.	More research should gather longitudinal data throughout time and at various stages to improve the conclusions of causal inferences

		business performance				
Dehgani and Navimipour (2019)	East Azerbaijan	To look into how information technology affects supply chain management agility.	No Theory	Quantitative	Information technology has an impact on the agility of supply chain management	More research may examine the connection between customer relationship management, company resource planning, and strategic management
Al-Lamy et al. (2018)	Iraq	To investigate the impact of information technology infrastructure on company performance.	Resource based view theory	Quantitative	Information technology infrastructure (IT connection, modularity, and personalization) had a beneficial influence on company performance.	Future research should improve the measures of information technology abilities by incorporating additional criteria.
Huo et al. (2021)	China	To investigate the effects of information sharing on several supply chain learning models as well as how these models affected flexibility performance.	Absorptive capacity theory	Quantitative	Sharing information enhances supply chain learning in all three dimensions	Future research can gather data from additional industries in more nations and locations

Aslam et al. (2020)	Pakistan	To research the impact of supply chain ambidexterity (SC-Ambidexterity) on the development of supply chain resilience (SC-Resilience).	Dynamic capabilities view (DCV)	quantitative	SC-Ambidexterity has a beneficial influence on SC-Resilience.	Future research examines operationalizing the primary dimensions of this study and duplicating the research methodology in the context of services.
Yu et al. (2018)	China	To look into how the flexibility and integration of supply chain information affect operational effectiveness.	Information processing theory	Quantitative	External information integration leads to both reactive and proactive flexibility, which improves operational performance.	Future research may explore the multidimensionality of information integration when investigating supply chain information integration interactions.
Kazancoglu et al. (2022)	Turkey	To look at the role that flexibility, agility, and responsiveness play in maintaining supply chain resilience during COVID-19.	Contingency theory	Quantitative	Supply chain flexibility has been demonstrated to have a direct impact on supply chain agility	Future research might benefit from new factors in addition to flexibility, agility, and reactivity
Rojo et al. (2018)	Spain	Examined the link between supply chain flexibility and environmental dynamism.	No Theory	Quantitative	Supply chain flexibility is strongly correlated with organizational learning and operational absorptive capacity	Future research should, if feasible, gather longitudinal data on supply chain flexibility.

The table above summarises the results of earlier studies that have been conducted on the topic area. The results in the table show that although studies have been conducted on the subject area, very little research has been done on the link between the constructs in the study. Also, little research has been done on the mediating role of supply chain flexibility in I T infrastructure flexibility and supply chain resilience effect. The table also shows that many previous researchers use quantitative research design to evaluate the constructs in the study. The study was also rarely conducted in the sub-Saharan African continents. These findings have created a gap in research in the topic area which makes this study imperative and an urgent response to recent calls on the need to critically identify ways to achieve supply chain resilience through effective I T infrastructure flexibility and supply chain flexibility. This research added to the literature by examining the mediating effect of supply chain flexibility in the relationship between I T infrastructure flexibility and supply chain resilience

CHAPTER THREE

RESEARCH METHODOLOGY AND PROFILE OF ORGANISATION

3.0 Introduction

This section presents and justifies the research design and the methodology used in testing the hypothesis stated in the preceding chapter. The tools, methods, techniques, and strategies employed to help achieve the stated objectives of this study are presented in this chapter. It encapsulates the Research Design, Population, Sampling Techniques, Sample Size, Respondents of the study, Analytic Method, Research Instruments, Validity, and Organisational Profile. The entire chapter describes the methods and techniques implemented to obtain the right data from the right respondents for quality analysis.

3.1 Research Design

The quantitative research approach was chosen on the basis that it produces accurate and measurable data that can be generalized to a broader population (Goertzen, 2017). Aside from that, it is ideal for evaluating and verifying already known concepts about how and why events occur by testing hypotheses developed before data collection. In general, quantitative research is regarded as a deductive approach to the investigation (Ragab and Arisha, 2018). The study will combine both descriptive and explanatory research types. While the descriptive provides description of the relationship between IT infrastructure flexibility and supply chain resilience, the mediating role of supply chain flexibility. The explanatory research will also aid in examining the relationship between IT infrastructure flexibility and supply chain resilience, the mediating role of supply chain flexibility.

This study used explanatory research design and quantitative methods. An explanatory research design is generally appropriate for this investigation because of its capacity to assess some variable or variables of interest at more than one moment in time which corresponds to the study's

population. The explanatory design has the benefit of allowing the researcher to explain and draw conclusions between multiple variables. The study, therefore, employed an explanatory research design to understand the relationship between IT infrastructure flexibility and supply chain resilience, the mediating role of supply chain flexibility.

3.2 Population of the Study

This is considered to be the totality of elements through which sampling can be selected Bryman and Bell, 2018). This general population often contains elements or units or individuals whose inclusion would violate the goals, context, and/or assumptions of the study as this population is characteristically crude (Asiamah, Mensah and Oteng-Abayie, 2017). The two refined research populations defined from the general population are the target and accessible. Target population refers to all individuals or groups of individuals to which researchers are interested in generalising the conclusions (Asiamah, Mensah, and Oteng-Abayie, 2017). This is the refined part of the general population. The target population which is also known as the theoretical population normally has varying characteristics. Thus, a refined form of the target population is the accessible population. The accessible population is the population in research to which the researchers can apply their conclusions. This form of the population is defined by excluding all individuals of the target population that are not accessible to the researcher during the period of the study (Bartlett et al., 2001). This population which is termed as study population serves as the source of the study sample. In the context of this study, the general population constitutes members of the tender committee, procurement Officers, and selected O&G firms in Ghana.

3.3 Sampling Technique and Sample Size

Sampling is mainly about choosing individuals as a subset of a defined population to evaluate the characteristics of the entire population (Collis and Hussey, 2009). It can also be used to designate the process of selecting a section from the entire population (Bryman, 2012). It is very suitable in situations where the researcher cannot reach the whole sample or population due to challenges

such as time constraints and cost (Saunders et al., 2007). There are two (2) main techniques used in sampling, they are; probability (random) and non-probability sampling. With probability or random sampling, every participant in the population has an equal chance of selection. However, in the instance of non-probability sampling, not all the subjects in the population have the chance of being selected (Bhattacherjee, 2012; Kothari, 2004). The subject of sample size in research remains a dilemma. Different views have been said by different authors. Some authors argue that a smaller sample size is well suited for larger populations while others also believe that it should be representative (Krejcie and Morgan, 1970), relatively homogeneous, or heterogeneous in the population. In the view of Gorsuch (1990) and Kline (1979), the sample size should be at least 100. Others also advise that researchers should get the maximum sample size possible (Rummell, 1970; Humphreys, Ilgen, McGrath, and Montanelli, 1969; Guertin and Bailey, 1970; Press, 1972). Thus, if the sample size is unsuitable or insufficient it may harm the outcome or findings of the research (Bartlett, Kotrlik, Higgins, 2001). To achieve an appreciable statistical test power and avoid the tendency of using few sample cases, which will affect the results, (Habib, Magruder-Habib, Kupper, 1987) the study targeted procurement officers in the public sector organisations in Ghana. The study, therefore, sampled two (2) respondents from each of the 100 sampled organizations, making a total sample of 200. The study further employed purposive and convenience sampling techniques to select the participants in the study.

3.4 Data Collection Procedure

Primary data refers to the data originated by the research for the first time. Primary data is real-time data and is collected by addressing the problem at hand and it also involves a process. Primary data sources include surveys, observations, experiments, questionnaires, and personal interviews (Saunders et al., 2007). Primary data for this study were through a questionnaire. The questionnaire was well-structured and was designed in line with the posited objectives of the study. The questionnaire will be designed based on existing measures in the literature. To ensure the quality

of its design, the researcher employed Saunders et al. (2009), an indication that underscores instrument design. According to Saunders et al. (2009), data obtained from respondents through the use of a questionnaire can be considered stable, constant, and has a uniform measure of variation. It also reduces the researcher's preconceived notion or idea concerning the presentation of study variables. The questionnaire was sourced from studies.

The questionnaire was presented to respondents at their offices considering their position in the organization. Respondents utilized not less than 30 minutes the filling out the questionnaire. The researcher adopted one-on-one data collection administration to make clarifications and explanations when the need arose. The researcher personally collected the questionnaire after it has been filled out by the respondents.

The purpose of pilot testing is to identify the flaws in the questionnaires and instruments to be used for the study and do the necessary corrections before using them for the actual research. The pilot study gives a clear picture of the estimation of cost and logistics needed for data gathering and analysis. According to Hertzog (2008), the ideal sample size for pilot testing is 35-40, Lackey and Wingate (1998) propose 10 percent of the population for the study whereas Nieswiadomy (1998) suggests 10 respondents. Others, like Israel (1992) and Krejcie and Morgan, (1970), are of the view that the sample size provided should be the same or near value. This research has resorted to Hertzog (2008) where a sample size of 35 respondents will be enough to perform the pilot testing.

There are several methods from which a researcher can adopt to collect data depending on the type of research being conducted (qualitative, quantitative, and mixed methods). Saunders et al. (2016) posit that the two main questionnaires are the self-completed and the interview completed. Face-to-face and telephone questionnaires, according to Saunders et al. (2016), form part of the interviewer questionnaire. Zikmund (2013) has given questionnaires, interviews, and observation

as the main instruments for the methods survey. Data for this research was collected through face-to-face interaction using a questionnaire. The Face-face approach enabled the researcher to obtain timely responses, especially during data collection. Face-to-face data collection helped the researcher build rapport and seek clarification of ambiguous responses, enhancing the data collected (Szolnoki and Hoffmann, 2013).

Studies have shown that face-to-face administered questionnaires work better than posted and phone surveys (Szolnoki and Hoffmann, 2013). However, it can be expensive and requires a lot of time. With an introductory letter obtained from the school, the researcher visited firms selected for the study with a questionnaire. This assisted the researcher to obtain the needed responses for the study. A self-administered questionnaire technique has been adopted because the number of sampling frame are considered high and they are located in different parts of the region.

3.6 Data Analysis

The method of data analysis forms an essential component of any research such that the choice of the method of analyzing data plays important role in the quality of findings, conclusions, and recommendations that are drawn from the data. Being a quantitative study, this study employed multiple quantitative techniques in analysing the data to fulfill the goal outlined in chapter one. After gathered was gathered, all the data was compiled in excel for scrutiny. After the scrutiny, a few questionnaires that were found incomplete were discarded. The analysis employed both Statistical Package for Social Sciences (SPSS) version 26.0 and Smart PLS 3. The Statistical Package for Social Sciences (SPSS) was used for the analysis such as frequencies, means, standard deviations, independent sample t-test, correlation, and exploratory factor analysis. Smart PLS-SEM was used for Confirmatory Factor analysis, Structural Model evaluation, and other model fit indices that were explored in this study. The next section provides a detailed discussion on the

justification of the use of Partial Least Square-Structured Equation Modelling (PLS-SEM) and the various tests that were conducted.

3.7 Validity and Reliability

To ensure external validity, the participants were randomly selected to avoid selection bias. The selected participants were assured of the benefits of the study to the organisation to ensure a minimum dropout rate. Both the content and the construct validity of this study were also ensured. The validity and reliability of a research study are two research criteria for consistency (Straus, 2017). Alpha coefficient of 0.70 is used as a cut-off point for assessing the internal consistency of the research item and scales to guarantee study reliability (Singh, 2017; Hair, Biasutti, and Frate, 2017)). To eliminate logical flaws and biases in the study, the researcher emphasises the validity and reliability of the results. This was done by adopting all of the constructs and conducting a pilot study using ten employees from the company.

3.8 Ethical Consideration

Consent was sought from the authorities of all respondents to inform them of all benefits and risks involved in the participation and further sought their consent for their inclusion in the study. Selected farmers had the right to decline their participation in the study. The researcher indicated all forms of anonymity and confidentiality would be observed. Privacy of farmers in terms of freedom to define the time, extent, and conditions of sharing information was also observed. The researcher avoided any form of action in their relation with participants that amounts to deception. All forms of plagiarism and falsification of data were also avoided by the researcher.

3.9 Profile of the Oil and Gas Industry in Ghana

Ghana is a rising oil and gas operator with operations in the upstream (exploration and production), midstream, and downstream sectors. After the discovery of commercial quantities of oil and gas in 2007, Ghana made tangible moves to establish a viable oil and gas industry. The Jubilee field began commercial production in 2010, and the Ghanaian government established the Petroleum

Commission in 2011 to manage the upstream business. Currently, Ghana produces 126,000 barrels of oil per day, with the possibility of an increase shortly. Consequently, numerous multinational corporations have established a foothold in the upstream industry.

Despite its emergence as a major oil and gas producer, Ghana has been severely impacted by the recent spike in international fuel and energy costs. Ghana continues to import five times as much oil and gas as it exports. It lacks significant downstream value addition in sectors like refining. The infrastructure must also be improved so that Ghana's natural gas can reach its domestic power plants. Ghana may also be in a better position to capitalise on the predicted increase in global demand for liquid natural gas (LNG). Moreover, Ghana is the leading importer of chemical fertilizers in West Africa. Domestic production is limited to the blending of imported fertilizer. The global shortage of chemical fertilizer creates incentives for Ghana to develop a downstream ammonium nitrate and urea business using its natural gas to meet domestic fertilizer needs.

There is an urgent demand for oil and gas service companies capable of partnering with indigenous Ghanaian firms to assist the offshore operations of foreign oil majors. Despite local content laws mandating a minimum amount of local participation, Ghanaian enterprises lack the capacity to deliver a comprehensive range of services. Joint venture companies in which international partners contribute technology and expertise to a partnership with a reputable local firm will be in great demand.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, AND DISCUSSION OF RESULT

4.1 Introduction

Findings from the data analysis are presented in this chapter. Descriptive statistics, an exploratory factor analysis, and a confirmatory factor analysis were all used. The hypotheses were analyzed using SmartPLS 4. In the discussion, the author provides a more in-depth analysis of the key results and draws parallels to related research.

4.2 Exploratory Factor Analysis

In order to guarantee the maximum level of precision, exploratory factor analysis (EFA) with Promax rotation was utilised in this research. When the loading is more than 0.6, then it is high; when it is less than 0.4, then it is low (Hair et al. 1998). In this study, the researcher employed a cut-off of 0.5 to ensure that the factor loadings weren't too low. All items in the approved levels

had Item loadings greater than 0.5. The sample size was adequate, as shown by the KMO of 0.913 and Bartlett's test of sphericity score of 0.000 in Table 4.2. (This test is typically performed at a significance level of 0.7) (Kaiser et al., 1970). High levels of consistency were found between the items and the study's primary constructs, with factor loadings ranging from 0.907 to 0.922 for IT infrastructure flexibility, 0784 to 0.914 for supply chain flexibility, and 0.866 to 0.958 for supply chain resilience (see table 4.6).

In order to collect information, a questionnaire was sent to key experts in the field. Every one of these surveys has to carefully assess the possibility of common method bias. So, the research provides a brief justification for the study's goal and, at prominent areas throughout the survey, includes paragraphs outlining the features (IT infrastructure flexibility, supply chain flexibility, and supply chain resilience). The survey was designed with simplicity for the users in mind. Podsakoff et al. (2003) proposed using Harman's one-factor test to assess the common method bias. Four factors with eigenvalues of one or above account for 69.284% of the total variance, as shown in Table 4.1, based on the factor analysis. Due to the fact that the first component accounted for 48%, or less than 50%, of the variance, the problem of common method bias in the dataset was fixed.

Table 4.1 Common Method Bias

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.501	47.919	47.919	11.501	47.919	47.919
2	2.255	9.395	57.313	2.255	9.395	57.313
3	1.704	7.102	64.415	1.704	7.102	64.415
4	1.169	4.869	69.284	1.169	4.869	69.284
5	0.82	3.416	72.700			
6	0.731	3.045	75.745			
7	0.611	2.546	78.291			
8	0.508	2.118	80.409			
9	0.451	1.88	82.289			
10	0.446	1.857	84.146			

11	0.423	1.762	85.908			
12	0.397	1.655	87.562			
13	0.375	1.563	89.126			
14	0.329	1.37	90.496			
15	0.314	1.309	91.805			
16	0.296	1.234	93.039			
17	0.262	1.094	94.133			
18	0.254	1.06	95.193			
19	0.241	1.003	96.196			
20	0.212	0.882	97.078			
21	0.204	0.849	97.927			
22	0.192	0.801	98.728			
23	0.156	0.65	99.379			
24	0.149	0.621	100			
Extraction Method: Principal Component Analysis.						

Table 4.2 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.913
Bartlett's Test of Sphericity	Approx. Chi-Square	7581.231
	df	276
	Sig.	0.000

4.2.1 Response Rate

Researchers were able to gauge the severity of non-response bias by comparing the actions of early and late respondents. It is possible to assess the magnitude of non-response bias by contrasting the mean model estimates of early and late responders. Comparing two groups of respondents across all variables using the F-test (Levene's test of equality of variances) provides a p-value that is not

statistically significant (Table 4.3). The assumption is that the two sets have similar degrees of variability. The t-test p-values reveal that there are no statistically significant differences between the groups. There is no statistically significant difference between the first 100 survey respondents and the final 100.

Table 4.3 Response Bias

Levene's Test for Equality of Variances					
Constructs	**Group**	**Mean**	**F**	**Sig.**	**T**
Supply Chain Resilience	1.00	13.89	0.428	0.514	-2.298
	2.00	15.49			
Information Technology Infrastructure Flexibility	1.00	18.86	0.287	0.593	-1.871
	2.00	20.23			
Supply Chain Flexibility	1.00	56.66	0.006	0.94	-2.069
	2.00	60.92			

4.3 Demographic Information

Demographic information about the study's participants is shown below. The findings are presented in Table 4.4 below. The participants were asked to indicate their gender, as can be seen from the results, the participants were made up of 38.5% females and 61.5% males. They were also asked to indicate their age, the results show that 20.5% were in the age range of 18 and 30 years, 50.5% were also in the age range of 31 and 40 years, 15.5% were in the age range of 41 and 50 years and 13.5% of the remaining were also above 50 years. Also, when asked about their level of education, 8.0% of them indicated they had Junior High School certificate, 10.5% also indicated they had Senior High school certificate, 17.0% indicated they had diploma certificate, 43.5% indicated they had bachelor's degree, 16.0% indicated master's/Ph.D., and 5.0% of the remaining indicated other certificates. When asked about their position in the firm, 21.0% indicated they were

business owners, 39.0% also indicated they were business owners and managers, 20.5% indicated managers, 12.5% also indicated production managers and 7.0% of the rest indicated other positions. For the number of years their firms have been in operation, 11.5% of the participants indicated 1-5 years, 17.0% indicated 6-10 years, 43.5% indicated 11-15 years, and 28.0% also indicated 16 years and above. For the number of employees in their firms, 8.5% of the participants indicated less than employees, 28.0% indicated 5-29 employees, 47.5% indicated 30-99 employees and 16.0% also indicated more than 100 employees.

Table 4.4 Demographic Information

Variables	Dimension	Frequency	Percentage
Gender	Female	77	38.5
	Male	123	61.5
Age	18-30 years	41	20.5
	31-40 years	101	50.5
	41-50 years	31	15.5
	Above 50 years	27	13.5
Level of Education	Junior High School	16	8.0
	Senior High School	21	10.5
	Diploma	34	17.0
	Bachelor Degree	87	43.5
	Graduate Studies (Master / Ph.D.)	32	16.0
	Others	10	5.0
Your Position in the Firm	Business Owner	42	21.0
	Business Owner & Manager	78	39.0
	Manager	41	20.5

	Production Manager	25	12.5
	Others	14	7.0
How many years has your firm been in operation?	1 - 5 years	23	11.5
	6 - 10 years	34	17.0
	11 – 15 years	87	43.5
	16 years and above	56	28.0
How many employees are in the firm?	Less than 5 employees	17	8.5
	5 – 29 employees	56	28.0
	30 – 99 employees	95	47.5
	More than 100	32	16.0
	Total	**200**	**100.0**

4.4 Measurement Model Assessment

Hair et al. (2019), criteria were used to assess the quality of the measurement model. The data was analyzed using the PLS-SEM software SmartPLS version 4 (Ringle et al., 2015). Before beginning the study, the researcher made sure that all indicator loadings were more than 0.70. This is encouraging since it implies the construct is robust enough to account for more than half the variation in the indicator, indicating that its parts may be trusted. Table 4.5 shows that the researcher retained only the outer loading components that achieved a score greater than or equal to 0.700.

4.4.1 Reliability

There are two basic approaches to verifying the reliability of a construct's internal consistency. Composite reliability (CR) and Cronbach's alpha (CA) are two widely used instances of such metrics. Unlike composite reliability (CR), which evaluates the accuracy with which one set of items predicts another set's latent variable, Cronbach's alpha is a measure of reliability based on correlations across apparent indicator constructs. Once both the CA and CR for a construct are between 0.70 and 0.95, it is assumed that the constructs are reliable. Table 4.5 displays the values of the model's consistency tests, which reveal that the CR ranges from 0.958 to 0.980 and the CA ranges from 0.941 to 0.978 for IT infrastructure flexibility, supply chain flexibility, and supply

chain resilience. This result suggested that the model is unidimensional, such that it will always provide the same result if run again.

4.4.2 Validity

Constructs are regarded to have high convergent validity when they can be evaluated in a consistent manner by a large number of indicators. If it corresponds well with other tests that use the same or comparable criteria, it is said that the test is convergently valid (Jensen, 2003). Empirical or theoretical methods may be used to evaluate the level of convergent validity. The results of several tests used to assess the same attribute of an item may be compared with one another. Most people agree that two standardized exams are quantitatively equal to one another. A strong to moderate correlation is one indication of convergence. Common measurements of convergent validity include factor loading (FL) on a scale and average variance extracted (AVE). Table 4.5 displays the results of the analysis of the convergent validity. (Both AVE and FL) Loading levels over 0.7 are recommended, whereas values below 0.7 are discarded. Indicators with loadings between 0.4 and 0.7 need to be watched if CA, CR, or AVE are over the threshold. Eliminating markers that have been shown to decrease CA, CR, and AVE is unnecessary. In most cases, a score of 0.5 or above on the AVE scale signifies satisfactory. As can be seen from the outcomes, all of the indicators had loadings greater than 0.7. The AVE was consistently greater than 0.5, proving the validity of the model.

Discriminant validity was used to assess the degree to which one independent variable differed from the rest of the model's independent variables. Effective discriminant functions have input variables with correlations less than the square root of the average variance (AVE) (Fornell & Larcker, 1981). In contrast to the square roots of the AVE, which are shown with clear diagonals, Table 4.6 use non-diagonal figures to demonstrate the link between the variables. The discriminant power of the constructs is enhanced by the fact that diagonal values surpass those of non-diagonal elements.

Since the Fornell-Larcker criteria do not provide a uniform means of assessing discriminant validity, the HTMT ratio of correlations was created as an alternative measure (Hair et al., 2019; Henseler et al., 2015; Voorhees et al., 2016). The vast majority of studies have shown that HTMT values under 0.90 are optimal. Calculating this might be as simple as reducing the average value of the items' correlations across constructs by the geometric mean of the average correlations for scales measuring the same variable (Henseler et al., 2015). The maximum HTMT is 0.893, as shown in Table 4.7.

Table 4.5 Reliability and Validity

Constructs	Items	Loadings	CA	CR	AVE	VIF
IT Infrastructure Flexibility	ITF1	0.910	0.951	0.962	0.836	2.593
	ITF2	0.921				3.145
	ITF3	0.910				3.072
	ITF4	0.907				3.064
	ITF5	0.922				2.822
Supply Chain Flexibility	LF1	0.825	0.978	0.980	0.766	2.101
	LF2	0.831				2.156
	LF3	0.784				1.867
	LF4	0.904				1.782
	LF5	0.871				2.543
	MF1	0.869				1.595
	MF2	0.877				2.647

	MF3	0.914				1.896
	MF4	0.885				3.081
	MF5	0.912				1.520
	SF1	0.909				1.855
	SF2	0.908				2.710
	SF3	0.898				2.847
	SF4	0.826				2.859
	SF5	0.901				8.795
Supply Chain Resilience	SCRES1	0.921	0.941	0.958	0.851	9.708
	SCRES2	0.942				1.434
	SCRES3	0.958				3.098
	SCRES4	0.866				1.823

Table 4.6 Fornell-Larcker test

Constructs	**1**	**2**	**3**
IT Infrastructure Flexibility	**0.914**		
Supply Chain Flexibility	0.734	**0.875**	
Supply Chain Resilience	0.752	0.806	**0.922**

Table 4.7 HTMT Test results

Constructs	**1**	**2**	**3**
IT Infrastructure Flexibility			
Supply Chain Flexibility	0.767		
Supply Chain Resilience	0.893	0.838	

4.5 Model Fit Indices

Valid values and ranges may be determined for the Fitness of Extracted-Index, SRMR, Root Mean Square of Approximation, and Chi-Square (Table 4.8). Both the extracted and rare indices fall below 0.9, the threshold at which permission is given. In most cases, a residual is not infinitely tiny if it has a finite value that can be written as the square root or the common root. This emphasizes the need of ensuring that all relevant factors and points of view are taken into consideration in any future research.

Table 4.8 Fit Summary

Indices	Saturated model	Estimated model
SRMR	0.054	0.054
d_ULS	0.876	0.876
d_G	2.422	2.422
Chi-square	2019.024	2019.024
NFI	0.746	0.746

4.6 Initial Description of the Data

The first stage of SmartPLS is a high-level description of the data. The major purpose of this analysis is to provide insight for the researcher about how thoroughly survey items have been completed by respondents. Each of the pre-set markers (mean, median, maximum, standard deviation, excess kurtosis, and skewness, for example) are given a numerical value using descriptive statistics. The dispersion of data is measured by its standard deviation. Table 4.9 displays the reporting format for descriptive analysis used in the research. Means for the constructs are 3.97, 3.91, and 3.92 and their standard deviations are 1.345, 1.106 and 1.117. Findings demonstrate that the calculated or statistical mean corresponds to the true value across all indicators.

Table 4.9 Descriptive Statistics

Constructs	Mean	Standard Deviation
Supply Chain Resilience	3.67	1.345
IT Infrastructure Flexibility	3.91	1.106
Supply chain Flexibility	3.92	1.117

4.7 Coefficient of Determination and Predictive Power of the PLs Model

Initially, the researcher ensured the measurement model was correct before evaluating the validity of the structural model and the anticipated linkages. By testing for collinearity before analyzing the structural relationships, the study rules out the possibility of false positives. Therefore, VIF were calculated for the hidden latent factors. VIF values were between 1.051 and 3.004, which is much below the minimum acceptable value of 3.3 (Hair et al., 2019). Several researchers Check the R2 values of the endogenous variables to allow assess to how well the model represented the data available in the sample. R2 values between 0.75 and 0.50 indicate a high degree of correlation; values below 0.25 indicate a low degree of connection (Hair et al., 2011). Table 4.10 and Figure 4.1 show R2 values of 0.872 and 0.820, respectively, for supply chain flexibility and supply chain resilience, indicating excellent explanatory power for both.

The predictive accuracy of the PLS path model may also be evaluated using Q2. (Geisser, 1974; Stone, 1974). At the point when Q2 becomes statistically significant, an endogenous structural model's capacity to predict outcomes may be evaluated (Hair et al., 2019). Table 4.10 displays the model's predictive performance based on Q2 scores of 0.870 and 0.722 for supply chain flexibility and supply chain resilience, respectively.

Table 4.10 Coefficient of Determination and Predictive Power of the PLs Model

Endogenous Constructs	R-square	Q^2predict
Supply Chain Flexibility	0.872	0.870
Supply Chain Resilience	0.820	0.722

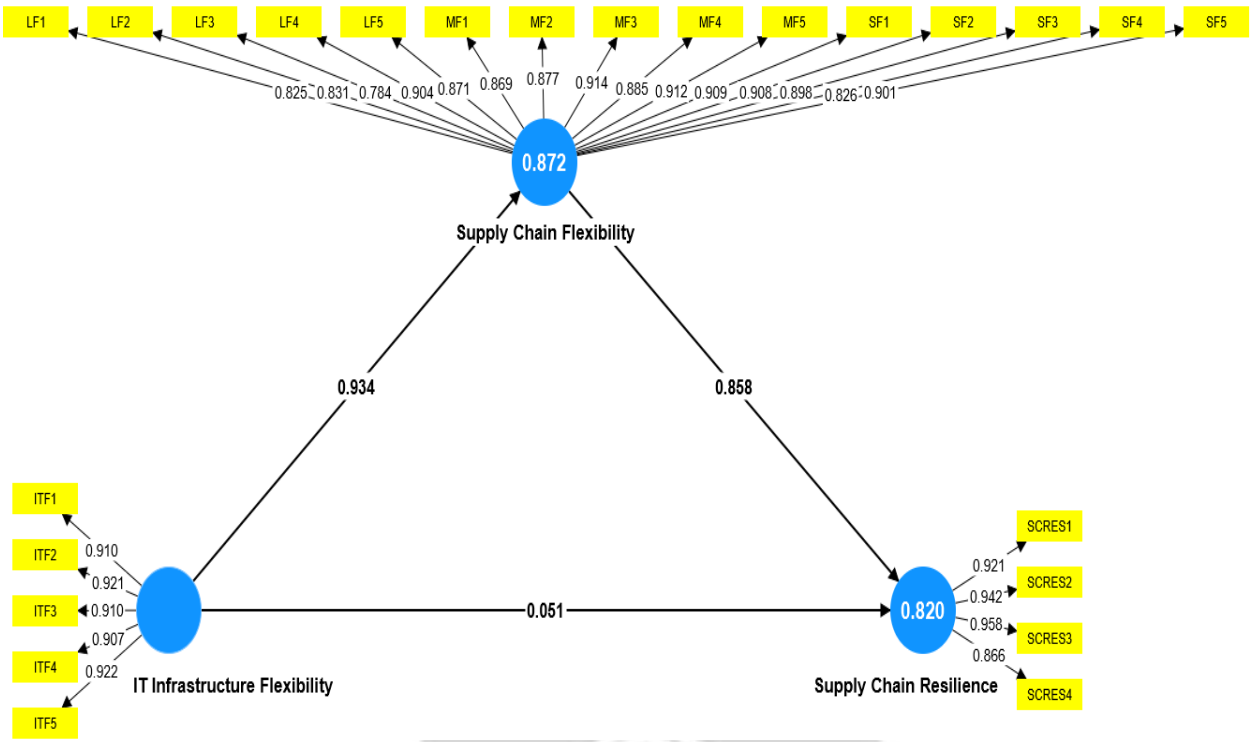


Figure 4.1 Measurement Model Assessment

4.8 Hypotheses for Direct and Indirect Relationship

With the help of smartPLS 4, the researcher checks the validity of the four hypotheses proposed in the study. The purpose of this research was to analyze how supply chain flexibility mediates the connection between IT infrastructure flexibility and supply chain resilience in Ghana's oil and gas sector. The findings are summarized in the table 4.11 below.

The first purpose of this research was to analyze how supply chain resilience in Ghana's oil and gas industry relates to the flexibility of its IT infrastructure. Table 4.11 shows that there is no statistically significant relationship between the IT infrastructure flexibility and supply chain resilience used by oil and gas industries (B=0.051; t=0.314; p-value=0.754> 0.05). This study's results do not lend credence to the idea of a link between the factors postulated by the researcher. Further, it demonstrates that changes in supply chain resilience across oil and gas companies may not be attributable to changes in the degree to which IT infrastructure flexibility is controlled (assuming all other variables are equal). The research indicates that even if the management of oil

and gas businesses places a premium on the requirement for flexibility in their IT infrastructure, this may not improve supply chain resilience.

The research also looks at the connection between IT infrastructure flexibility and oil and gas supply chain flexibility. Companies' ability to embrace IT infrastructure flexibility has a major impact on oil and gas supply chain flexibility, as shown in Table 4.11 (B=0.934; t=71.278; p-value=0.000 <0.05). This study's results provide credence to the hypothesis linking the two constructs. The results show that if no other independent factors change, a single unit change in IT infrastructure flexibility accounts for 93.4% of the change in supply chain resilience. According to the findings, if the oil and gas sector wants to see an improvement in supply chain resilience, firm leadership should emphasize the organization's capacity to expand IT infrastructure flexibility.

The second goal of the research was to see whether the rise of supply chain flexibility has had any effect on the resilience of supply chains in the oil and gas sector. Table 4.11 shows a positive and statistically significant relationship between supply chain flexibility and resilience in the oil and gas sector (B=0.858; t=5.470; p-value=0.000 <0.05). The results of the research lend credence to the idea that two constructs are related. This further illustrates how changes in the oil and gas industry's backing of supply chain flexibility may be tied to shifts in supply chain resilience. 85.8% of the overall changes in supply chain resilience may be attributed to this. These findings suggest that managers in the oil and gas industry who practice supply chain flexibility get the advantages of increased supply chain resilience.

The third purpose of the research was to ascertain whether the link between IT infrastructure flexibility and supply chain resilience in oil and gas enterprises may be mediated by the flexibility of the supply chain. Table 4.11 shows that the link between IT infrastructure flexibility and supply

chain resilience is mediated by supply chain flexibility (B=0.801; t=5.536; p-value=0.000 <0.05). The study's findings provide evidence to the postulated relationship of cause and effect between the factors. The results also show that the impact of IT infrastructure flexibility on supply chain resilience may be explained (80.1%) by supply chain flexibility (after controlling for other factors). The results of this research indicate a strong association between IT infrastructure flexibility and supply chain resilience when supply chain flexibility is addressed at the top levels of the oil and gas companies.

Table 4.11 Hypotheses for Direct and Indirect Relationship

Hypotheses	Path Coefficient	Error	T Statistics	P Values	Decision
IT Infrastructure Flexibility -> Supply Chain Resilience	0.051	0.164	0.314	0.754	Not Supported
IT Infrastructure Flexibility -> Supply Chain Flexibility	0.934	0.013	71.278	0.000	Supported
Supply Chain Flexibility -> Supply Chain Resilience	0.858	0.157	5.470	0.000	Supported
IT Infrastructure Flexibility -> Supply Chain Flexibility -> Supply Chain Resilience	0.801	0.145	5.536	0.000	Supported

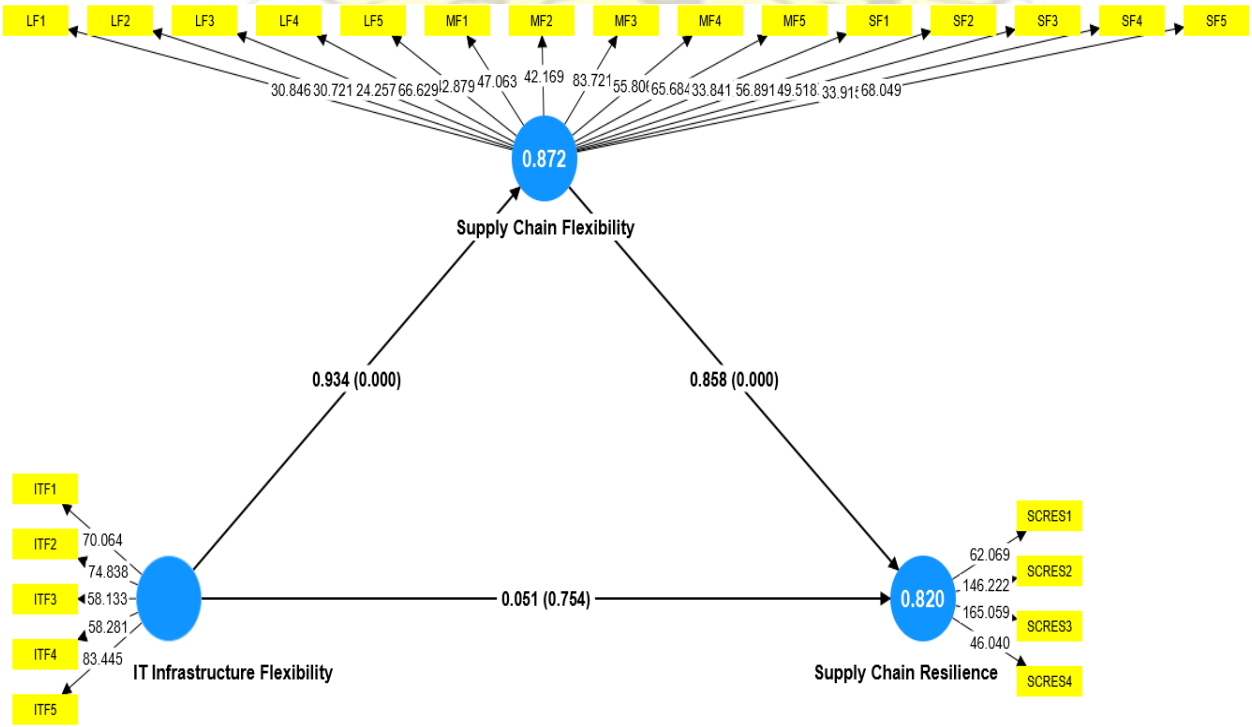


Figure 4.2 Structure Model Evaluation

4.9 Discussion of Major Findings

In this part, the study will review the relevant literature and highlight the most important results. The purpose of this research was to analyse how supply chain flexibility mediates the connection between IT infrastructure flexibility and supply chain resilience in Ghana's oil and gas sector. The results may be organized into the several categories that are provided in the following paragraphs.

The first purpose of this research was to analyze how supply chain resilience in Ghana's oil and gas industry relates to the flexibility of its IT infrastructure. The result showed that there is no statistically significant relationship between the IT infrastructure flexibility and supply chain resilience used by oil and gas industries (B=0.051; t=0.314; p-value=0.754> 0.05). This study's results do not lend credence to the idea of a link between the factors postulated by the researcher. Further, it demonstrates that changes in supply chain resilience across oil and gas companies may not be attributable to changes in the degree to which IT infrastructure flexibility is controlled (assuming all other variables are equal). The research indicates that even if the management of oil and gas businesses places a premium on the requirement for flexibility in their IT infrastructure, this may not improve supply chain resilience. The findings contradict information processing theory (IPT), which provides a theoretical framework for understanding how companies employ different IT deployment patterns with suppliers and customers to fortify supply chain resilience. These also findings run counter to the work of Gu et al. (2018), who investigated if and how organisations use two separate IT patterns (exploratory and exploitative) in collaboration with supply chain patterns to ensure the resilience of their suppliers and customers. Using IT for research purposes was shown to affect supply chain robustness. The findings contradict those of Yu et al. (2022), who investigated the effect of information processing capabilities on supply chain resilience, operational performance, and receptivity to technological innovation and discovered

that the latter three factors are significantly influenced by the former. The findings also contradict those of Cui et al. (2022), who studied the impact of digital technologies on business resilience in the context of COVID-19 and found that the impact is more when information complexity is higher.

The second goal of the research was to see whether the rise of supply chain flexibility has had any effect on the resilience of supply chains in the oil and gas sector. The findings revealed a positive and statistically significant relationship between supply chain flexibility and resilience in the oil and gas sector (B=0.858; t=5.470; p-value=0.000 <0.05). The results of the research lend credence to the idea that two constructs are related. This further illustrates how changes in the oil and gas industry's backing of supply chain flexibility may be tied to shifts in supply chain resilience. 85.8% of the overall changes in supply chain resilience may be attributed to this. These findings suggest that managers in the oil and gas industry who practice supply chain flexibility get the advantages of increased supply chain resilience. The findings support Kazancoglu et al. (2022), who examined on the importance of flexibility, agility, and responsiveness in sustaining supply chain resilience and concluded that supply chain flexibility has a direct influence on supply chain resilience. Findings from this study corroborate those of Yu et al. (2018), who investigated the effects of supply chain information integration and flexibility on operational efficiency. These findings demonstrate that flexibility, both proactive and reactive, is increased by the incorporation of external information, leading to better overall operational performance. The findings are consistent with the dynamic capacity theory's tenet that a company's ability to integrate, grow, and reconfigure internal and external competencies to respond to quickly changing surroundings is crucial to the company's survival (Teece, Pisano and Shuen 997).

The third purpose of the research was to ascertain whether the link between IT infrastructure flexibility and supply chain resilience in oil and gas enterprises may be mediated by the flexibility of the supply chain. The result showed that the link between IT infrastructure flexibility and supply chain resilience is mediated by supply chain flexibility (B=0.801; t=5.536; p-value=0.000 <0.05). The study's findings provide evidence to the postulated relationship of cause and effect between the factors. The results also show that the impact of IT infrastructure flexibility on supply chain resilience may be explained (80.1%) by supply chain flexibility (after controlling for other factors). The results of this research indicate a strong association between IT infrastructure flexibility and supply chain resilience when supply chain flexibility is addressed at the top levels of the oil and gas companies. The results are consistent with those found by Khanuja and Jain (2021), who studied the impact of supply chain flexibility on the connection between integration and performance. The findings demonstrate that both partial and complete supply chain flexibility mediates the relationship between customer and supplier integration and supply chain performance. The findings are at odds with those of Thongrawd et al. (2020), who investigated the mediating role of supply chain agility and flexibility as a mediator between suppliers, customers, and competitive advantage. Based on the results, supply chain flexibility does not play a pivotal role in bridging the gap between suppliers' performance and competitive advantage. These results are consistent with those found by Pinheiro et al. (2020), who investigated the role of manufacturing flexibility as a mediator between the spread of information, the introduction of new technologies, and increased productivity. Findings indicated that manufacturing flexibility mediates the relationship between operational efficiency and newfound knowledge.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

5.1 Introduction

This chapter concludes the study with a brief discussion of the study's findings and recommendations for further inquiry. The study's limitations as well as some suggestions for further research are discussed.

5.2 Summary

The purpose of this research was to analyze how supply chain flexibility mediates the connection between IT infrastructure flexibility and supply chain resilience in Ghana's oil and gas sector. In the following lines, the author presents a brief overview of the study's key findings based on experiments and the existing literature. The findings are presented in a sequence that makes sense in light of the aims of the research.

5.2.1 The relationship between IT Infrastructure Flexibility and Supply Chain Resilience

The first purpose of this research was to analyse how supply chain resilience in Ghana's oil and gas industry relates to the flexibility of its IT infrastructure. The result showed that there is no statistically significant relationship between the IT infrastructure flexibility and supply chain resilience used by oil and gas industries. This study's results do not lend credence to the idea of a link between the factors postulated by the researcher. Further, it demonstrates that changes in supply chain resilience across oil and gas companies may not be attributable to changes in the degree to which IT infrastructure flexibility is controlled (assuming all other variables are equal). The research indicates that even if the management of oil and gas businesses places a premium on the requirement for flexibility in their IT infrastructure, this may not improve supply chain resilience

5.2.2 The relationship between Supply Chain Flexibility and Supply Chain Resilience

The second goal of the research was to see whether the rise of supply chain flexibility has had any effect on the resilience of supply chains in the oil and gas sector. The findings revealed a positive and statistically significant relationship between supply chain flexibility and resilience in the oil and gas sector. The results of the research lend credence to the idea that the two constructs are related. This further illustrates how changes in the oil and gas industry's backing of supply chain flexibility may be tied to shifts in supply chain resilience. Changes in supply chain resilience may

be attributed to changes in supply chain flexibility. These findings suggest that managers in the oil and gas industry who practice supply chain flexibility get the advantages of increased supply chain resilience.

5.2.3 The mediating role of Supply Chain Flexibility on the relationship between IT Infrastructure Flexibility and Supply Chain Resilience

The third purpose of the research was to ascertain whether the link between IT infrastructure flexibility and supply chain resilience in oil and gas enterprises may be mediated by the flexibility of the supply chain. The result showed that the link between IT infrastructure flexibility and supply chain resilience is mediated by supply chain flexibility. The study's findings provide evidence to the postulated relationship of cause and effect between the factors. The results also show that the impact of IT infrastructure flexibility on supply chain resilience may be explained by supply chain flexibility (after controlling for other factors). The results of this research indicate a strong association between IT infrastructure flexibility and supply chain resilience when supply chain flexibility is addressed at the top levels of oil and gas companies.

5.3 Conclusion

The goal of this study was to investigate the role that supply chain flexibility plays in mediating the relationship between IT infrastructure flexibility and supply chain resilience in the oil and gas companies in Ghana. The study was quantitative, using a cross-sectional survey design and explanatory research approaches. This study used an explanatory research design to investigate the function of supply chain flexibility as a mediator between the flexibility of IT infrastructure and the resilience of the supply chain. Members of the tender committee, procurement officials, and a few handpicked O&G enterprises in Ghana make up the general population. 200 tender committee members and procurement staff were given a well-organized questionnaire. Primary data was collected using a combination of convenient and purposive sampling. Using Structural Equation Modeling, the study's hypotheses were verified with (SmartPLS 4). The research used descriptive

statistics, often called summary statistics, to provide a high-level overview of the data. The study revealed that supply chain resilience in the Oil and Gas industry was not significantly affected by the flexibility of IT infrastructure. However, it was shown that the link between IT infrastructure flexibility and supply chain resilience was mediated by supply chain flexibility, which has a significant influence on supply chain resilience. Managers of Oil and Gas companies may improve supply chain resilience by promoting supply chain flexibility, as shown by the findings.

5.4 Recommendation

The goal of this study was to investigate the role that supply chain flexibility plays in mediating the relationship between IT infrastructure flexibility and supply chain resilience in the oil and gas companies in Ghana. The study revealed that supply chain resilience in the Oil and Gas industry was not significantly affected by the flexibility of IT infrastructure. However, it was shown that the link between IT infrastructure flexibility and supply chain resilience was mediated by supply chain flexibility, which has a significant influence on supply chain resilience. Managers of Oil and Gas companies may improve supply chain resilience by promoting supply chain flexibility, as shown by the findings. The study suggests the recommendations below based on the findings.

- The study found that supply chain resilience was not greatly impacted by the flexibility of IT infrastructure. These results go contrary to the conclusions of several other research which concluded that increasing efforts to develop a more flexible IT infrastructure would suffice to improve the resilience of supply chains. One possible explanation for the results is the level of priority given to IT infrastructure in the oil and gas industry. Managers in the oil and gas industry would do well to upgrade their IT systems by migrating to cloud computing, adding more servers and storage space, backing up their data, and training their employees to properly use computers.
- Given the evidence suggesting that increased supply chain flexibility enhances supply chain resilience, it stands to reason that doing so would have the same effect. Managers are

tasked with increasing supply chain flexibility by measures such as increasing the number of suppliers, fostering an environment where employees are encouraged to share ideas, introducing digital technology into the production process, and forming new partnerships.

- According to the findings, the link between IT infrastructure flexibility and supply chain resilience was mediated by supply chain flexibility. The influence of IT infrastructure flexibility on supply chain resilience is amplified when supply chain flexibility is prioritized by management at oil and gas companies. Leaders in the oil and gas industry must spend heavily on supply chain flexibility to ensure their company's supply chain resilience and continued profitability. When it comes to bolstering the company's ability to adapt to supply chain changes, managers must spend heavily on supply chain flexibility.

5.5 Limitations and Future Research Directions

These are some of the study's flaws. Subjective responses to a questionnaire served as the basis for the data gathered in this research. Since only two people from each firm are chosen to take part, the study was able to gather only 200 samples in total. Consequently, the subjective awareness of certain respondents may introduce measurement bias. Next, the scope of this study encompasses a wide variety of disciplines, including IT and SCM, among others. Therefore, it's possible that some respondents made mistakes because they had trouble grasping the big picture, despite the fact that they are middle- and high-level managers and department heads. The study findings may also have been skewed if respondents gave the wrong answers because they misread the questions or did not fully comprehend them. This study employed a cross-sectional research design, in which data were collected all at once, at a single moment in time, due to time restrictions. Therefore, unlike the longitudinal research approach, it is not feasible to track how the study design evolves over time. Consequently, it is recommended that future studies gather longitudinal data at several time periods to bolster the outcomes of causal inferences. Furthermore, as this study was limited to a

specific sector, its findings may not be applicable to other sectors. There is a need for further investigation to see whether the findings of this one can be applied to other fields.

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APPENDIX

SURVEY QUESTIONNAIRE

Dear Sir/ Madam,

My name is ……., a postgraduate student at the Kwame Nkrumah University of Science and Technology, Kumasi, Department of Supply Chain and Information Systems. This survey instrument has been designed to enable me to carry out research on the topic: **"The Mediating Role of Supply Chain Flexibility on the Relationship Between IT Infrastructure Flexibility and Supply Chain Resilience in The Oil and Gas Industry in Ghana "**. Any information provided will be used for academic purposes ONLY. There are no risks associated with your participation, and your responses will remain confidential and anonymous.

SECTION A: RESPONDENT'S BIOGRAPHY AND COMPANY PROFILE

When completing this questionnaire, please tick **[√]** in the applicable box or provide an answer as applicable.

Please answer the following questions:

1. *Gender*: Male ☐ Female ☐
2. *Age*

   18-30 years ☐ 31-40 year's ☐ 41-50 years ☐ Above 50 years ☐
3. *Level of Education*

   Junior High School ☐ Senior High School ☐ Diploma ☐ Bachelor Degree ☐ Graduate Studies (Master / Ph.D.) ☐ Others ☐ For Others, please specify……
4. *Your Position in the Firm*

   Business Owner ☐ Business Owner & Manager ☐ Manager ☐ Production Manager ☐ Others ☐……
5. *How many years have your firm been in operation?*

   1 - 5 years ☐ 6 - 10 years ☐ 11 – 15 years ☐ 16 years and above ☐
6. *How many employees are in the firm?*

   Less than 5 employees ☐ 5 – 29 employees ☐ 30 – 99 employees ☐ More than 100 ☐

SECTION B: RESILIENCE (Brandon-Jones et al., 2014)

To what extent do the following statements apply to your company by checking the appropriate number from 1 to 5, using the following scale:

SECTION C: RESILIENCE (Brandon-Jones et al., 2014)

Indicate the extent to which you agree or disagree that your firm attaches importance to these activities by checking the appropriate number from 1 to 5 using the following scale:

Item		**1**	**2**	**3**	**4**	**5**
SCRES1	Material flow would be quickly restored					
SCRES	It would not take long to recover normal operating performance					
SCRES3	The supply chain would easily recover to its original state					
SCRES4	Disruptions would be dealt with quickly					

SECTION D: IT Flexibility (Bhatt, G., Emdad, A., Roberts, N., & Grover, V. (2010))

Indicate the extent to which you agree or disagree that your firm attaches importance to these activities by checking the appropriate number from 1 to 5 using the following scale:

Item		**1**	**2**	**3**	**4**	**5**
ITF1	Our information systems are scalable					
ITF2	Our information systems are compatible					
ITF3	Our information systems are adopted to share information					
ITF4	Our information systems are modular					
ITF5	Our information systems can handle multiple business applications					

SECTION E: SUPPLY CHAIN FLEXIBILITY (Swafford et al., 2006; Jin et al., 2014; Jin et al., 2014; Naim et al., 2010)

Indicate the extent to which you agree or disagree with each statement by checking the appropriate number from 1 to 5 using the following scale:

Item	**Manufacturing flexibility**	**1**	**2**	**3**	**4**	**5**
MF1	We are capable of incorporating a wide range of products in manufacturing planning					
MF2	We are capable of accommodating uncertain market demand					
MF3	We can accommodate market demand as and when required					

MF4	We can operate at a high and low production volume					
SCIN5	We motivate supply chain members to suggest new ideas					
Item	**Sourcing flexibility**	**1**	**2**	**3**	**4**	**5**
SF1	We have a wide range of suppliers that provide major materials/components/ products					
SF2	Our suppliers can respond efficiently to changes in an order quantity					
SF3	Our suppliers can respond efficiently to changes in the order in terms of range, specifications, etc.					
SF4	Our suppliers respond quickly to changes in order quantity in asked time					
SF5	Our suppliers respond quickly for any changes desired from them in terms of range, specifications in asked time					
Item	**Logistics flexibility**	**1**	**2**	**3**	**4**	**5**
LF1	We/Our logistics service provider (LSP) have different ranges and sufficient no. of the fleet to meet customers requirement					
LF2	We/Our LSP is capable of providing different modes of transport					
LF3	We/Our LSP is capable of accommodating variations or changes in demand uncertainty					
LF4	We have extensive distribution coverage for our flagship brand/critical product where we serve or planned to serve					
LF5	We/Our LSP can deliver the right products to all customers when and where they need them					

Thank you for participating in the survey.