

The digital maturity of supply chain technology in South Africa

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ABSTRACT

“The most profound technologies are those that disappear... They weave themselves into the fabric of everyday life until they are indistinguishable from it” wrote computer scientist and visionary Mark Weiser nearly 25 years ago in his essay The Computer for the 21st Century (Facchini, 2020, p.39)

Agility, resilience, and reliability have emerged as increasingly vital factors in supply chain management, particularly in navigating the complexities of a digitalized landscape.

The objective of the study is to assess the digital maturity of supply chain technologies in South Africa, contrasting them with global maturity standards. The study's motivation stems from the need to comprehend the capacity of supply chain networks to meet the growing demand driven by the adoption of e-commerce and other external factors affecting the supply chain.

The study on the digital maturity of supply chain technology in South Africa is crucial as it provides a comprehensive assessment of how advanced and integrated digital technologies are within the country's supply chain sector. It highlights the current state of technological adoption, identifying areas where South African supply chains excel and where they lag. This understanding is vital for enhancing operational efficiency, competitiveness, and resilience against disruptions. Furthermore, the study's insights can inform policy making, guide investments, and support businesses in adopting best practices, ultimately contributing to economic growth and sustainability by optimizing resource use and reducing operational costs.

Employing a qualitative research approach, the study explores patterns of technology adoption in the supply chain and the resulting maturity of the technology, as per the propositions. The conceptual framework provides a clear delineation of the evolution from a traditional supply chain to a digitalized value chain, integrating technology across various segments of the supply chain network. Furthermore, it elucidates the integration of 4IR technologies such as

IoT, robotics, cloud services, and big data analytics and the resultant impact on the efficiencies and effectiveness of the supply chain.

Data was gathered through both focus group sessions and individual interviews involving a diverse range of supply chain experts, including individuals from sales, consultancy, implementation, and support teams.

The primary finding indicates a consensus in adoption between the global patterns and the south African context. However, it is evident that the maturity level of technology utilization remains in its infancy stage in South Africa. Resilience of the supply chain is limited by the siloed implementation approach of technologies that do not function across the full value chain and data inconsistencies across the value chain prohibiting end to end visibility for efficient fulfilment of consumer requirements. Mature digital implementation of supply chain technology can significantly impact businesses in a positive manner by enhancing efficiency, competitiveness, and strategic decision-making.

KEYWORDS

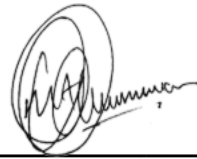
- i. Supply chain
- ii. Digital maturity
- iii. E-commerce
- iv. Maturity models
- v. Digital technologies

DECLARATION

I, Monde Nkwenkwe declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Monde Nkwenkwe

Signature:



Signed at ...Wits business school.....

On the ...29.... day of ...February..... 2024.

DEDICATION

I dedicate the work performed for the fulfilment of the research report to my supervisor Mr Pius Oba and all the lectures involved in disseminating the content.

I dedicate this research report to my boys Mihla and Mayine, all the effort is to ensure I provide a prosperous life for them, predicated in pursuit of academic excellence.

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LIST OF ACRONYMS

4IR – Fourth industrial revolution.

MRP – Material requirements planning.

ERP – Enterprise resource planning

IT – Information technology

IOT – Internet of things

RPA – Robotic process automation

SCM – Supply chain management

BDA – Big data analytics

SC – Supply chain

CHAPTER 1. INTRODUCTION

1.1 Statement of purpose

This research is a qualitative study to examine the digital maturity of supply chain technologies in South Africa.

1.2 Background of the study

The background of the study aims to assess the maturity of supply chain technologies in relation to fast changing demand environment catalysed by hyper adoption of boundaryless technologies that have worldwide reach and high adoption rates. These technologies are mostly adopted on the customer facing component of the value chain and therefore need seamless flow of value and interaction across all aspects of the value chain for fulfilment of customer requirements. The supply chain value chain is comprised of different players that ensure fulfilment of services or materials demand from different platforms, value is created in sequential steps by a set of distinct firms (Holweg, 2014). Supply chain value chains constantly strive to excel on a lot of aspects to improve the competitiveness priorities including quality, cost and speed (Ketchen, 2007). Nowadays due to innovation, global connectivity and rapidly changing needs, supply chains are forced to adopt technologies that will help them meet external expectations and improve customer satisfaction (Heriberto García-Reyes, 2022).

1.3 Research problem

There is evidence of proliferation and adoption of e-commerce technologies in a ubiquitous manner and the trend demonstrates growth in the adoption of these technologies. The delivery times vary from hours to days and weeks and months depending on where the product or service is sourced and located. The current studies focus on internal factors that influence change in the supply chain technology adoption underpinned by business strategy and cost optimisation. The motivation of companies to digitize processes in a supply chain has been

investigated from different angles (e.g., strategic, and operational), limited to traditional information management systems such as MRP/ERP systems. (Dawson et al., 2023). (Wagner & Smyth, 2006) observe that firm size significantly influences supply technology adoption. Smaller organizations tend to stick to traditional supply chain methods, whereas larger firms encounter fewer knowledge and technology barriers, making them more likely to adopt supply chain technologies. This difference is mainly due to larger firms having more resources to invest in and implement advanced technologies. (Wagner & Smyth, 2006) further indicate a positive correlation between technology usage and overall satisfaction with an organization's supply chain performance. Technology helps lower the costs associated with procurement searches. Additional advantages include streamlined order processes, increased supplier transparency, reduced inventory levels, lower product prices, and decreased costs related to purchase orders.

This research aims to evaluate the maturity of digital technologies within the supply chain value chain in South Africa to realise the benefits provided by technology adoption and elucidate the connections between e-commerce and a company's inclination to digitize supply chain processes.

1.4 Research objectives OR research questions

- I. What are the drivers that influence supply chain technology adoption in the South African context?
- II. What is the digital maturity of supply chain technologies in South Africa?

1.5 Rationale

The aim is to analyse how companies adopt and implement technology in the supply chain driven by impetus to cater for factors that influence the digital maturity of the supply chain processes throughout the value chain (Dawson et al., 2023).

The digitalization of supply chain processes is defined here as the application of IT solutions to facilitate the flow of goods and information (Pawlewski et al., 2009). Digitalization enables the improvement of processes in a supply chain, such as procurement, logistics, scheduling, and planning (Arunachalam et al., 2018). A dynamic real-time customer-oriented adaption of the market trends is important to achieving the objectives of logistics processes, decreasing costs, and mitigating the market risks (Hofman et al., 2017).

Adoption studies play a crucial role in understanding the uptake of new technologies and identifying the barriers or constraints to their adoption, this information is particularly valuable for providing valuable insights into the current state of technology adoption, the level of usage, and the factors influencing adoption decisions. Using cross sectional analysis helps in identifying patterns of adoption and abandonment of technology practices and help gain insight on the snapshot of adoption, comparative to other players in the market (Doss, 2006). Technology empowers organizations with expanded strategic choices, enabling long-term flexibility and adaptability to drive their operations towards success (Sarkis et al., 2000). The expansion of e-commerce has led to increased customer expectations for quicker turnaround times and higher levels of customization (Van Hoek, 2001).

1.6 Delimitations of the study

In Scope

- i. Supply chain digital technologies adoption
- ii. Supply chain digital maturity
- iii. 4IR technologies

Out of scope

- i. Impact on sustainability
- ii. Industries outside of fast-moving goods

1.7 Definition of terms

- I. Supply chain management – “is a network of facilities that produce raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system. (Goyal et al., 2011). (Entzer et al. 2001, p.4) describes supply chain as “a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer”.
- II. Digital maturity – “The term “digital maturity” is closely related to digital transformation. We can say that digital maturity is the final stage of digital transformation, which companies aspire to achieve, those companies that have achieved such digital maturity, have now witnessed important improvements in the operation of the company, and have also increased customer satisfaction (Dominguez, 2017).”
- III. E-commerce – “Electronic commerce denotes the seamless application of information and communication technology from its point of origin to its endpoint along the entire value chain of business processes conducted electronically and designed to enable the accomplishment of a business goal (Wigand & Rolf, 1997)”.

1.8 Assumptions

The assumption is that research is conducted with fast moving goods organisations and individuals that have understanding and participate in the supply chain value chain. The assumption is also that the organisations will have some form of e-commerce presence actively utilised by customers and prospective customers. It is assumed that the market factors that impact other countries are no different to local factors that influence the South African market.

1.9 Chapter Outline

- Chapter 1 outlines the context, background and rationale of the study giving the reader a view on the objectives of the study.

- Chapter 2 covers the literature related to the study of the phenomena and formulated propositions based on the research questions.
- Chapter 3 maps out the research approach and data collection methods.
- Chapter 4 elucidates the research outcomes with empirical evidence from the participants.
- Chapter 5 focuses on analyses contrasting the literature with the research outcomes.
- Chapter 6 converges all aspects of the research and provides a researcher's answers to the research questions.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

Supply chain digital maturity is driven but not limited to by internal and external factors through organisational strategic goals or external factors due to market changes, which necessitate the adoption of new measures to remain competitive in the market. There are general adopted themes in the advent of technology evolution underpinned by continuous improvement based on the monitoring of operational competence and benchmarking against industry best practices.

In the past, business organizations focused on reducing costs and improving quality to gain competitive advantage. Today, however, “companies must be able to innovate at the global frontier, create and commercialize a stream of new products and processes that shift the technology frontier, progressing as fast as their rivals catch up” (Porter & Stern, 2001, p. 28).

2.2 Definition of topic or background discussion

The research explores adoption and maturity in a limited sense to the scope of the research. This encompasses prominent technologies adopted in the other countries for activities involved in the generation, development, and implementation of 4IR technologies (Damanpour, 1991, p. 556).

E-commerce is considered the ultimate embodiment of digital transformation. It surpasses mere digitization for web presence and encompasses the digitalization of sales functions and supply chain integration (Härting et al., 2017). According to (Forbes, 2023) projections indicate that growth in E-commerce sales for 2023 is forecasted to be 10.4%. The global e-commerce market is expected to total \$6.3 trillion.



Figure 1 - Growth of E-commerce sales 2021 - 2023

Source: Forbes 2023

Shortcomings in the fulfilment of the customer orders results in 22% of customers abandoning their carts. Some of the reasons underpinning this behaviour can be addressed through the implementation of digitalization in the supply chain to introduce efficiencies in the value chain. (Forbes, 2023)

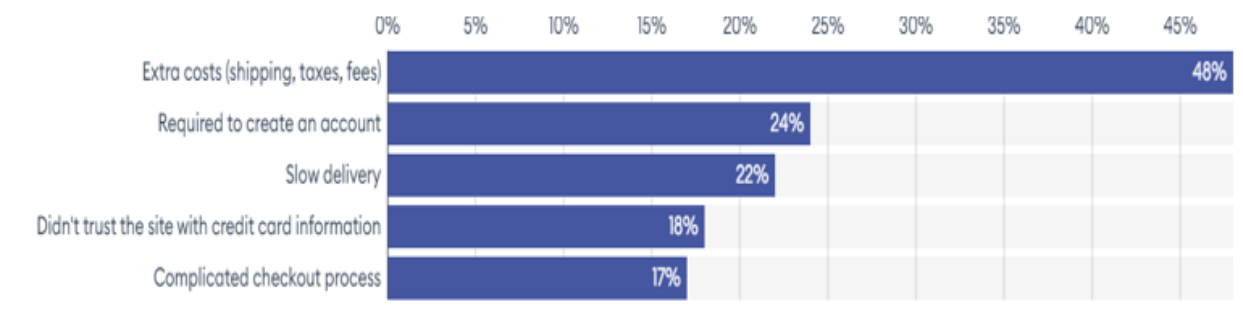


Figure 2 - Why customers abandon their online carts.

Source: Forbes 2023

The adoption of supply chain technologies is instrumental in alleviating some of the new challenges brought about by the evolution in shopping trends and consumer behaviour.

The supply chain value chain comprises of primary and secondary activities as depicted in figure 3. The study focuses on only the primary activities of the supply chain which form part of the workflow of activities for fulfilment of customer orders.

The value chain considers elements related to the creation and capturing of value, while the operational viewpoint of the supply chain focuses on the approaches and resources utilized in the effective management of interconnected networks between companies, to effectively improve these operational and strategic components, operations footprint, risk management, order fulfilment and buffering mechanism (Holweg, 2014).

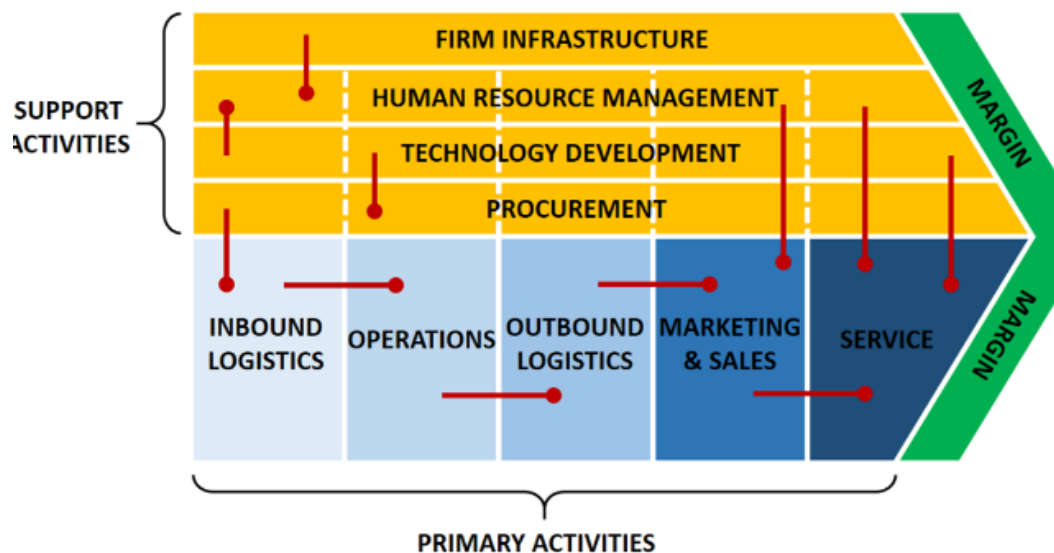


Figure 3 – Supply chain value chain

Source: porter

2.3 What are the drivers that influence supply chain technology adoption in the South African context?

Business organizations today face a more complex and competitive environment than ever before (Ellram, 1991; Srinivasan et al., 1994; Porter & Stern, 2001). As trade barriers crumble and less developed countries enter the competitive marketplace, firms now confront a greater number of competitors able to

introduce new products and services faster and cheaper than ever before (Garten, 1998). Consequently, most industries and firms have entered into a “hyper-competitive” marketplace characterized by an increase in competition, uncertainty, and complexity (D’Aveni, 1994; D’Aveni ,999; Merrifield, 2000).

In the face of market uncertainty and sudden shifts, it becomes crucial to depend on technological advancement that enable prompt and precise responses to dynamic changes. Supply chain therefore need to be resilient, agile, and adaptable to cater for these dynamic changes in demand.

Agility refers to the ability of a supply chain to react quickly to unexpected or rapid shifts in supply and demand (Lee, 2004). Adaptability refers to a willingness to reshape supply chains when necessary, without ties to legacy issues or the way the chain has been operated previously (Lee, 2004)

Competitive prowess is critical in supply chains to ensure total value across cost, speed, and flexibility. At the heart of the Fourth Industrial Revolution (4IR) lies the fundamental concept of operating businesses through the integration of digital technologies. This integration enables companies to establish linkages between their machinery, supply systems, production facilities, end products, and customers, facilitating the seamless collection and exchange of real-time information and data (Bhattacharya & Chatterjee, 2022). The 4IR aims for a viable and sustainable supply chain system with a higher level of complexity for integrating the production and product processes (Bahrin et al.,2022). 4IR is not limited to the internal value chain of a company, it attempts to advance the supply chain management (SCM) “which covers the entire series of manufacturing industry operations from product design to sales and maintenance in order to enable mass-customization” (Asakura, 2016). The goal of 4IR is to achieve greater flexibility, efficiency, adaptability, and improving communication between consumers and producers by integrating and connecting traditional industries.

The aim of 4IR is to enhance flexibility, optimize efficiency, foster adaptability, and facilitate seamless communication between producers and consumers through the integration and interconnection of established industries (Li et al., 2017).

Digital solutions with advanced technological intelligence, well-suited for implementation within a supply chain context, are discussed below.

2.3.1 Robotics

The utilization of Robotic Process Automation (RPA) combines the capabilities of artificial intelligence and machine learning to automate tasks across diverse processes (Van Der Aalst et al., 2018). By incorporating sensors and advanced software functionalities, the intelligence of manufacturing processes is enhanced, facilitating enhanced internal communication within the factory and external interactions with other entities (Kusiak, 2018). Through the utilization of autonomous machines and collaborative robots, manufacturing operations can be carried out autonomously and effectively.

2.3.2 Internet of things

The Internet of Things (IoT) involves the integration of diverse physical entities with digital devices like sensors and actuators, forming a network. Within this network, these interconnected components collect and share data, enabling effective communication among objects, systems, and services.

By leveraging IoT, companies can unlock numerous benefits across various domains, such as expediting product delivery, lowering costs, strengthening customer relationships, and tracking tools or assets (Govindan, 2022). The Internet of Things (IoT) holds significant promise in tackling supply chain challenges associated with control, tracking, and transparency (Dweekat et al., 2017).

2.3.3 Cloud computing

Cloud computing pertains to the provision of scalable and virtualized computational services over the internet (Shukri et al., 2021). The platform offers a flexible environment that enables dynamic allocation of resources within

intricate logistic systems, resulting in reduced delivery times and swift responsiveness to customer need (Zhong et al., 2017).

2.3.4 Big data analytics

In the context of 4IR, big data analytics involves gathering and extensive analysis of data from diverse sources, including customers, operations, and sales. As time progresses, it is anticipated that will evolve into a standard practice for facilitating decision-making processes and optimizing operations in terms of cost and performance coordination (Fernández-Miranda, 2017). By leveraging Big Data Analytics (BDA), manufacturers can utilize information from their own operations as well as their suppliers to enhance the accuracy and timeliness of delivery information provided to customers. Additionally, BDA enables the evaluation of supplier performance based on comprehensive manufacturing data (Strandhagen et al., 2017). Big Data Analytics (BDA) has a wide-reaching impact on various functions within supply chain management (SCM). It influences functions including predicting demand, mitigating risks, planning logistics, enhancing customer service, optimizing network operations, fostering supplier collaboration, and managing inventory levels (Zheng & Wu, 2017).

Proposition 1

Based on research question 1, “what are the drivers that influence supply chain technology adoption in the South African context?”, the formulated proposition is that:

The implementation of e-commerce influences the company’s adoption of supply chain technologies.

2.4 What is the digital maturity of supply chain technologies in South Africa?

Supply chain operations are facing the task of enhancing their intelligence, which involves placing emphasis on their ecological footprint, implementing predictive

learning systems, and enabling autonomous decision-making (Calatayud et al., 2019). Concurrently, industry-level trends like 4IR are emerging, with the adoption of technologies such as robotics, cloud manufacturing, and augmented reality facilitating intelligent information exchange. The adoption of this trend is driving strategic initiatives that encompass the implementation of various technologies aimed at enhancing communication and integrating processes (Pariera et al., 2017). The incorporation of such technological drivers must follow an evolutionary process to reach the desired digital maturity level. The transformation of logistics processes into digitalized systems is a progressive journey, making the maturity theory an appropriate framework for examining this phenomenon (Cichosz et al., 2020). By integrating technology into supply chain operations, businesses are able to undergo a metamorphosis into "intelligent enterprises" through the adoption of platforms that enable real-time management of processes and information (García-Reyes, 2022).

Supply chain trends are leveraging the technological advancements facilitated by 4IR. The adoption of 4IR initiatives can potentially enhance agility, resilience, and reliability within supply chains (García-Reyes, 2022).

The subsequent sections will provide descriptions of these trends.

2.4.1 Supply chain agility

The pursuit of market opportunities and the capability to offer innovative products and services promptly and cost-effectively are integral to supply chain operations. These objectives encompass attributes such as responsiveness, competency, adaptability, and speed. Together with other benefits like flexibility, effectiveness, reliability, and visibility contribute to the agility of the supply chain (Mehralian & Ghatari, 2015). Smart manufacturing has traditionally emphasized productivity and efficiency as key indicators of success. These goals are accomplished by leveraging a well-connected value chain network through digital integration and adopting an intelligent approach to manufacturing. This not only enhances the efficiency of the overall process and supply chain but also ensures prompt fulfilment of customer demands (Fanoro et al., 2021).

2.4.2 Supply Chain Resilience

Supply chain resilience denotes the adaptive capability of supply chains to restore operations to normal levels after a disruption (Mandal, 2014). The advent of covid-19 necessitated that organisations invest in ensuring the resiliency in their supply chain ensuring continuity of supply quick response and recovery from unexpected events. Establishing a supply chain with the ability to adapt and recover from disruptions, known as supply chain resilience, necessitates sustained collaboration between the company and its supply chain partners, coupled with substantial investments in the long run (Ponomarov & Holcomb, 2009). Resilience is no longer solely focused on risk management, but instead, it has evolved into a competitive capability that empowers a company to effectively navigate risks and capitalize on disruptions, setting it apart from its competitors.

2.4.3 Maturity readiness

In today's business landscape, manufacturers and retailers in the consumer products industry are actively pursuing strategies to establish direct connections with consumers and enhance their competitive position. One approach involves providing supplementary services and exploring new avenues for generating revenue (Ghobakhloo, 2018). Companies aiming to advance their 4IR implementation should begin by assessing their current level of maturity. Employing suitable methodologies for maturity assessment allows them to gain insight into their existing capabilities in relation to the maturity of their resources and technologies concerning 4IR (Caiado et al., 2021). Manufacturers and retailers of consumer products are nowadays striving to establish a direct link to consumers and to strengthen their competitive position by offering supplementary services.

The initial stage of the roadmap involves strategically managing the transition to 4IR technologies, commencing with the formulation of short-term, medium-term, and long-term strategies for embracing 4IR. This requires the digital transformation of products, processes, and systems, along with their interconnectivity. This digitalization encompasses not only individual functional areas like the shop floor or IT department but extends across the entire value

chain (Leyh et al., 2016). Adopting 4IR technologies across the value chain defines the critical boundaries and interdependencies between the human and technological resources, it is therefore necessary to appraise the digital skills gap between within the organisation (Ghobakhloo, 2018). The impact of the fourth industrial revolution on supply chain interactions has been profound, primarily driven by the exponential increase in data and the widespread adoption of digitalized processes (Zhong et al., 2016). As the mass-personalization business model continues to gain prominence, future go to market models will shift towards highly specialized and customized strategies. This transformation will necessitate the reconfiguration and integration of the entire supply network to enable a more dynamic approach to manufacturing (Tien, 2011).

2.4.4 Maturity models

“A maturity model defines different levels of maturity in order to be able to assess the extent to which an object (an organization, a process etc.) fulfils the defined requirements” (Ahlemann et al., 2005). (Fraser et al., 2021) attributes that the maturity model should have a hierarchy of detail comprised of main dimensions that define the area of focus, sub-dimensions should also be defined to provide the granular detail of the component being interrogated.

Within the different stages of maturity, it is important to emphasize the significance of integration, whether it be vertical or horizontal in nature, as well as the importance of both intra- and inter-company collaboration. Digital supply chains offer numerous benefits compared to conventional ones. Employing a maturity model serves as a valuable instrument for evaluating the existing level of digitalization in supply chains and providing guidance to companies in implementing digital solutions (Hellweg et al., 2021). While several maturity models exist that focus on aspects of supply chain management or specific digital technologies, there have been initial attempts to create a maturity model for the overall digitalization of an entire supply chain, there is currently no agreement on the specific structure and

components such a maturity model should encompass (Reis et al., 2018). This lack of research and variable constraints that impede the realisation of a uniform view of the optimal maturity model necessitates that the general digitalisation maturity matrices are examined to identify the relevant applicability to supply chain metrics. This approach however has its limitations due to the minimal consideration of supply chain factors in the general technology maturity models.

Maturity models in the main appraise several key areas in the organisation:

- Competency (De Bruin et al. 2005)
- Capability (De Bruin et al., 2005; Kohlegger et al., 2009)
- Implementation and sophistication levels (De Bruin et al., 2005; Mettler et al., 2009)

The environmental dimension concentrates on the organization's context and its surrounding environment (Tornatzky et al., 1990). It encompasses external factors such as market positioning, opportunities for technological innovation arising from new technologies, and the regulatory framework and funding opportunities (Raj et al., 2020).

Table 1 - Literature review of maturity models

Author (Year)	SC Function	Dimensions of Digitalization				Methodology
		Business	Organizational	Process & Method	Technological	
Aimi et al. (2017)	Deliver		X	X	X	1
Akdil et al. (2018)	General	X		X	X	2
Anderson and Ellerby (2018)	General	X	X		X	1
Arunachalam et al. (2018)	General		X		X	3
Asdecker and Felch (2018)	Source, Deliver			X	X	3
Barata and Cunha (2017)	Make			X	X	2
Bibby and Dehe (2018)	Make	X	X			2
Blatz et al. (2018)	General	X	X	X	X	2
de Carolis et al. (2017)	Make		X	X	X	3
Ellefsen et al. (2019)	Make, Deliver	X		X	X	1
Frederico et al. (2019)	General		X		X	2
Ganzarain and Errasti (2016)	Make	X				1
Gaur and Ramakrishnan (2019)	Make	X		X	X	2
Geissbauer et al. (2016)	General	X			X	1
Gustafsson et al. (2019)	General				X	2
Hausladen and Schosser (2020)	Plan	X	X		X	3
Issa et al. (2018)	General	X				1
Klötzer and Pflaum (2016)	Make	X	X	X	X	2
Krowas and Riedel (2019)	Make		X	X	X	2
Leyh et al. (2016)	General				X	1
Mendes Junior et al. (2016)	General	X		X	X	3
Oleśków-Szłapka and Stachowiak (2018)	Source, Deliver				X	1
Schuh et al. (2017)	Make		X		X	2
Schumacher et al. (2016)	Make	X	X		X	2
Solis (2017)	General	X				1
Uhl and Gollenia (2014)	General	X	X			1
Wang et al. (2018)	Make	X		X	X	1
Weber et al. (2017)	Make			X	X	2

1: No / 2: Basic / 3: Detailed

Source: Literature review on maturity models for digital supply chains (Hellweg, 2021, p.41).

The aspect of the supply chain most frequently highlighted is the "make" function. Eleven papers exclusively focus on the digitalization of this function. For instance, they discuss digitalization within the production processes of individual

companies but overlook the connections with customers and/or suppliers (Hellweg, 2021, p.41).

2.4.5 Maturity levels

The sequence of levels, from initial to ideal, allows an assessment of the current state with respect to give a maturity level description thus, it is possible to identify improvement guidelines considering building an action plan capable of reaching the desired level (Mayr et al., 2018; Ruiz-benitez et al., 2019). For this study, the following maturity level descriptions for supply chain technology adoption readiness perspective are proposed:

Level 1: Discovery

Initially, there is enthusiasm for integrating technologies, with a few undergoing pilot testing alongside the supply chain. There is recognition of the requisite technological skills among employees, although training initiatives remain sporadic. The organization implements isolated programs to incorporate technologies as part of its efforts to align with supply chain trends. Initial positive results are recorded and shared with employees.

Level 2: Awakening

At this stage, the organization acknowledges the importance of adopting technologies and staying abreast of supply chain trends. Various technologies are integrated into process enhancements aimed at embracing supply chain advancements. However, these technologies and the accompanying systems remain isolated or only partially integrated with the supply chain. Employees receive periodic training on the adoption of new technologies and the requisite technological skills.

Level 3: Developed

Concepts and technologies are continuously included in improvement projects along with the SC. Changes in processes to face market uncertain behaviour are part of the work culture. Top management systematically promotes the definition

of projects to advance the adoption of a SC trend. There are established formal training programs aimed at developing technological and technical skills related to the technology initiative in company employees. The first integrations of systems and applications technologies are ongoing.

Level 4: Integrated:

Technologies are synchronously integrated into SC, so that the decision-making process is done with real-time information, resulting in continuous improvement actions. Best practices related to the 4IR, and SC trends are identified and customized to the organizational work culture. Employees are promoters of the inclusion of the technologies and concepts. A general vision of the supply chain technologies is defined and communicated among SC members.

Based on the literature review for research question 2, “what is the digital maturity of supply chain technologies in South Africa?” the proposition formulated is that:

Companies that have high regard for e-commerce have better supply chain digital maturity.

2.5 ANALYTICAL FRAMEWORK

Effective research stems from a logical initial premise or theoretical framework that provides a conceptual basis (Sullivan, 2011). The basis of this study is defined by using a conceptual framework. The framework aims to define linkages of empirical evidence to this study through published literature and the thesis of this study. The conceptual framework gives a schematic view of interrelations between interactions between the various technologies and the supply chain value chain mapping the transition from traditional supply chains to agile, flexible, and resilient digital supply chains.

2.5.1 Conceptual Framework

Literature indicates that there is evidence that economic, political, social, technological, and environmental factors impact customer behaviour and change

the way that customers interface with the market environment. Evident in the Covid force majeure, there was a big shift in customer behaviour due to the change in mobility limitations and shortage of goods. The change in the market environment has lasting effects and can change the consumer behaviour for good. There have been exponential developments in shopping behaviour in customers underpinned by technological developments that facilitated marketplace access to products and services during the restricted trade periods. Post the pandemic these alternative means were adopted due to their efficiencies like,

- Access to worldwide market,
- reduction of emissions due to less travelling by utilising e-commerce platforms
- Technology advancement in the value chain from make to deliver processes.
- Lower cost of transacting

The change in customer behaviour necessitates that the value chain and touchpoints for servicing the customer need to adapt to the changes brought about by the customer needs. Empirical evidence denotes that organisations normally focus their change initiatives based on revenue drivers, optimisation, and the available capital to execute the strategies. Historically there has been silo approach and hyper competitiveness between the players in the market which offsets the benefits of vertical and horizontal integration. The changes in customer shopping expectations like speed of delivery and the tailored services or goods offerings puts pressure on the organisations to evolve and advertently initiate conversations with partners across value chain to identify areas of value generation to the benefit of the customers.

This study aims to ascertain whether the adoption of the e-commerce influences the decision to adopt technology in the supply chain environment and proceeds to measure the degree to which the supply chains are technologically mature to cater for the adoption of these technologies.

The framework distils the interrelation between the most adopted technologies in the supply value chain in the process of customer requirements fulfilment. There is a myriad of other utilised technologies that are excluded for the scope of this research. Most of the technologies cut across the process flow like big data analytics, cloud computing, robotics and IOT, however for this purpose we only focusing on the dominant technologies on each phase of the process. The literature review extensively discussed the functionality of these technologies and role they play in the technological advancement of the supply chain to cater for e-commerce adoption.

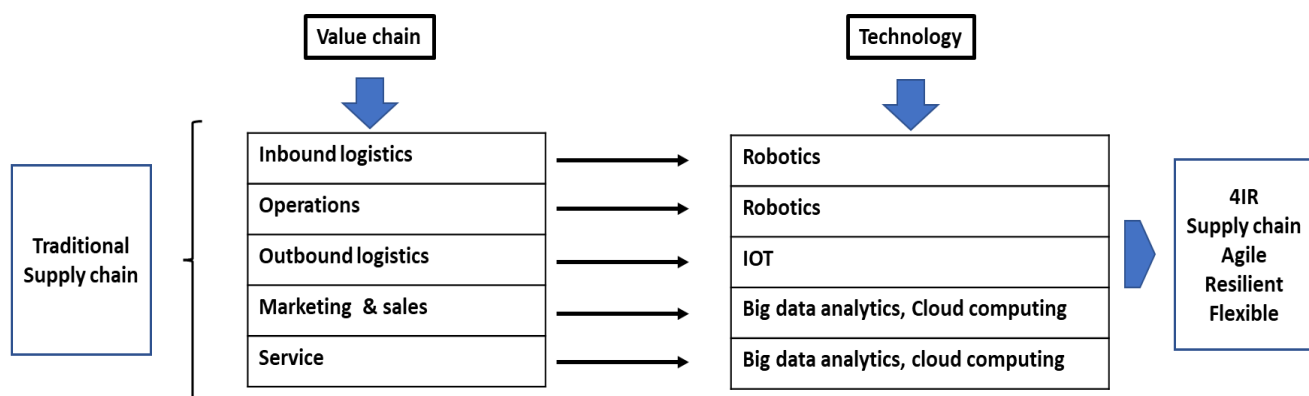


Figure 4 - Transformation from traditional to digital supply chain

Source: Author

2.6 Conclusion of Literature Review

In their quest for market share, expedited time to market, and improved profitability, organizations are actively seeking diverse avenues to boost their competitive edge. The escalating integration of technology throughout the different phases of the technology adoption lifecycle unmistakably indicates that technology assumes a crucial position in propelling business strategies to align with ever-changing market dynamics.

4IR has evolved from a mere future trend and is now a focal point in the strategic agendas of numerous leading organizations. The organisations who can keep up with this transformation will gain significant competitive advantages like those enjoyed by early adopters. 4IR necessitates not only innovative capabilities but

also demands fresh strategies, organizational models, and comprehensive changes in physical infrastructure, manufacturing operations, technologies, and human resources throughout the entire organization (Ghobakhloo, 2018).

Existing literature clearly demonstrates the widespread implementation of Fourth Industrial Revolution (4IR) technologies across the value chain, however, there is a lack of standardized criteria for technology adoption, and the selection of specific technologies by different organizations is varied and solely based on their own discretion. There is minimal literature that interrogates the e-commerce impact on supply chains and the technology adoption thereof. There is no convergence of effort from the players in the market to map out digitisation strategies that incorporates technical capabilities, supply chain teams and external organisations.

2.6.1 Proposition 1

The implementation of e-commerce influences the company's adoption of supply chain technologies.

2.6.2 Proposition 2

Companies that have adopted e-commerce have better supply chain digital maturity.

CHAPTER 3. RESEARCH METHODOLOGY

For this study, a qualitative methodology has been chosen to investigate the proposition and gain deeper insight into the phenomenon. Data will be gathered from individual professionals and focus groups engaged in e-commerce and the supply chain value chain. Consequently, the study seeks to advance understanding by comprehensively examining the digital maturity of supply chains within the South African context.

3.1 Research approach

(Van Maanen, 1979, p.520) defines qualitative research as “an umbrella term covering an array of interpretive techniques which seek to describe, decode, translate, and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world.” The thorough review of literature emphasizes that quantitative research is the prevailing approach found in most papers and supplementary materials pertaining to the topic. This preference is largely driven by the scarcity of existing research conducted on the relationship between supply chain technology adoption and its maturity. Consequently, synthesizing the topic through qualitative research has emerged as the preferred method for delving into this seldom-explored area.

(Carol, 2021) highlights these benefits for qualitative research:

- Participants demonstrate greater engagement when employing interactive methods like interviews and group discussions.
- The opportunity to inquire further enables the researcher to acquire deeper insights beyond simple initial responses and explanations.
- Additionally, it helps mitigate discomfort that may result in hasty or superficial replies.

3.2 Research design

The research assumes case study approach, “Case study research is an increasingly popular approach among qualitative researchers” (Thomas, 2011) “Current qualitative case study approaches are shaped by paradigm, study design, and selection of methods, and, as a result, case studies in the published literature vary. Case study research has a level of flexibility that is not readily offered by other qualitative approaches such as grounded theory or phenomenology” (Hyett et al., 2014).

The dimensions of technology adoption and maturity identified in the literature were utilized to assess the level of supply chain technology maturity. This approach was considered appropriate due to the limited existing research in this field, both globally and specifically within the South African context. The correlation among the various aspects examined in this study is still in its early stages, as indicated by the literature. Only a few early adopters have begun to explore and implement technology, with their efforts somewhat constrained. Many of these technology adopters are newly established businesses that emerged during the COVID-19 pandemic or are swiftly embracing technology as part of the Fourth Industrial Revolution (4IR). Typically, these businesses implement technology primarily within their own organizational environments at the enterprise resource planning (ERP) level, without involving other market players.

3.3 Data collection methods

The research design utilizes a combination of structured focus group sessions and individual interviews to gather data from supply chain experts. As qualitative researchers typically offer thorough depictions of individuals and occurrences within their authentic contexts, interviews have traditionally been considered a pivotal element in research design (Weiss, 1994).

Advantages of the research design include:

1. Real-time information: Interview approach enable the collection of up-to-date information from participants.
2. Testing the applicability of existing literature and maturity models: The research design allows for the assessment of how well existing literature and maturity models apply to the current context.
3. Insights into real implementation issues: The research design provides valuable insights into the practical challenges and issues faced during technology implementation.

3.4 Population and sample

The study population consists of supply chain experts who hold pivotal roles within the value chain. These individuals exhibit a diverse range of expertise, spanning from supply chain systems support to sales consultancy, as well as supply chain executives. This broad spectrum of individuals represents expertise across all segments of the supply chain.

3.4.1 Sample and sampling method

Maximum variation sampling involves gathering a diverse range of perspectives on the specific phenomenon being studied and is considered a form of purposive sampling (Neergaard et al., 2009).

Interview type	Participant identity	Participants	Occupation
Focus group	Focus group 1	4	Supply chain sales and support
Focus group	Focus group 2	2	Supply chain sales and support
Individual interview	Interviewee 1	1	Supply chain consultant
Individual interview	Interviewee 2	1	Supply chain executive

3.5 The research instruments.

The methodology utilizes interviews as a means to achieve thorough data collection, enabling analysis of the outcomes' impact and relevance to the research inquiries. During these interviews, participants provide data on their experiences with supply chain technology trends, usage patterns, and

satisfaction levels, incorporating specific metrics tailored to the South African context. The interviews seek to obtain information on the extent of technology adoption within supply chains, as well as aspects of horizontal and vertical integration, which are commonly discussed in existing literature. The main objective is to gain insights into the maturity of trend adoption and its impact on supply chain dynamics.

3.6 Procedure for data collection

To gain an in-depth understanding of perceptions or opinions on a topic, verbally ask participants open-ended questions in individual interviews or focus group discussions (Bhandari, 2023).

“The data collection provides the basis for reliability estimations. Thus, a good data collection procedure is crucial to ensure that the reliability estimate is trustworthy. A prediction is never better than the data on which it is based. Thus, it is important to ensure the quality of the data collection” (Wohlin et al., 2003).

3.7 Data analysis strategies and interpretation

After conducting research on the most suitable tools for data analysis, emerged as relevant is inductive thematic network model. According to (Braun and Clarke, 2006) thematic analysis is highly adaptable, diverse, and compatible with a wide range of methodologies because it is not limited to theory or epistemologies.

The inductive thematic network model provides a valuable feature of visualizing the interconnectedness between themes. This facilitates analysis of themes and data patterns derived from transcribed interviews, allowing for a deeper understanding of the relationships within the data.

(Delve et al., 2023) enlists the benefits and disadvantages of inductive thematic analysis as:

- Deductive content analysis provides a structured approach to analysing data.

- It allows for a systematic and efficient analysis process.
- It can be useful in testing previous research or theories.
- It allows the comparison of findings across studies that use similar categories or codes.
- It may be less prone to researcher bias, as the categories or codes used are predetermined.

Disadvantages are:

- It may miss important content that does not fit into the pre-existing categories or codes.
- Inflexible compared to inductive content analysis.
- Easy to overlook new insights or ideas that emerge from the data.
- It may limit the depth of analysis by focusing on predetermined categories or codes.
- Less suitable for exploratory research questions that require an inductive approach.

3.8 Possible limitations and challenges of the study

Based on the findings from the literature review and market analysis, several limitations are identified:

1. Limited awareness among potential participants: The individuals who could potentially take part in the research may have limited knowledge or understanding of the subject matter.
2. Potential reluctance to participate due to concerns about intellectual property: Participants might be hesitant to engage in the study, fearing that their intellectual property or sensitive information could be compromised.
3. Verification challenges for participant inputs: Ensuring the accuracy and reliability of the information provided by participants may pose difficulties, potentially affecting the overall quality of the collected data.

3.9 Quality Assurance

Quality assurance is obtained by ensuring purposeful selection of the population with specific roles in the value chain. As previously indicated, the interviewees will be interviewed on a uniform approach following a structured set of questions.

3.9.1 *External validity OR transferability*

The research heavily relies on recent literature spanning from 2019 to 2022, with a particular emphasis on the latest developments in supply chain and technology adoption, influenced by the transformative effects of the COVID-19 pandemic on the market. Given the research's focus areas and alignment with prevalent topics addressed in the literature, it is assumed that the findings can be transferrable and applicable to confront various environments within supply chain and technology assessment.

Moreover, considerable effort has been dedicated to prioritizing the inclusion of common trends identified in the literature, aiming to ensure consistency and conformity across the research.

3.9.2 *Internal validity OR credibility*

The research fulfils the internal criteria for credibility by implementing rigorous measures to maintain uniformity in both the methodology and content of the questionnaires and interviews. Considerable effort has been made to ensure consistency throughout the research process.

3.9.3 *Reliability OR dependability*

The study demonstrates reliability by incorporating widely accepted frameworks in supply chain management and adhering to best practices in the field. It draws upon an extensive body of literature from both local and international sources, focusing on identifying common themes and trends regarding the challenges and advantages of technology adoption in the supply chain. These efforts are driven

by the increasing presence of e-commerce technologies, ensuring that the study captures the key aspects related to this pervasive trend.

3.10 Ethical considerations

Ethical considerations for the study include:

1. Privacy: participants contribution is at their discretion to decide information that they are willing to share.
2. Voluntary participation: participants will participate at their own volition without any coercion.
3. Information protection: ensure participants understand that the information they share will be used for academic purposes and shared with the university.

CHAPTER 4. PRESENTATION OF RESULTS / FINDINGS

4.1 Introduction

The data collection process followed a structured methodology that included both one-on-one interviews and focus groups. Incorporating the focus group approach aimed to encourage interactive discussions among participants, fostering the exploration of diverse perspectives. This method allowed respondents to contribute additional insights related to topics raised by others or introduce entirely new phenomena based on their individual experiences, thus broadening the scope of the conversation during the research.

Conversely, one-on-one interviews were conducted with individuals identified as having exposure to various organizations and possessing some level of international experience. It was assumed that these individuals would bring a diverse knowledge base to the research, thereby offering a range of valuable insights. This dual approach, utilizing both focus groups and one-on-one interviews, was selected to ensure a thorough and nuanced examination of the subject matter.

The questions posed during the interviews were tailored to address the defined proposition outlined in the preceding chapters of the research. This proposition centres around understanding the driving factors for technology adoption and how they influence the maturity of supply chain technology adoption.

The word map was created to visually represent the prevalent insights observed during the interviews.



Figure 5 - Prevalent interview insights

4.2 The implementation of e-commerce influences the company's adoption of supply chain technologies.

Proposition one proclaims that, regard for e-commerce importance, influences company's adoption of supply chain technologies. This proposition stems from an extensive literature review examining the adoption patterns of e-commerce and how they correlate with the adoption of supply chain technologies across the value chain. In a series of interviews with various experts exploring the prioritization of e-commerce within specific organizations, the first question posed was: What would you attribute as the main drivers or detractors for adoption of technology in supply chain?

The purpose of posing this question in an open-ended manner was to obtain impartial perspectives from the interviewees regarding what they perceive as the primary drivers for technology adoption in the supply chain. This approach was intended to precede a more targeted and detailed inquiry into the prioritization of e-commerce within organizations and its implications for technology adoption.

4.2.1 Detractors for technology adoption in supply chain

Interviewees were lucid in defining both the technological and non-technological detractors of technology prioritisation and adoption in organisations. This gave a great view of the factors beyond just the technological aspects that underpin and impair technological advancement in organisations.

I. Cost and human resources

Interviewee 1: provided a clear elucidation of both the technological and non-technological barriers to technology prioritization and adoption within organizations. This comprehensive insight offered a holistic view of the multifaceted factors influencing and hindering technological progress within organizations, extending beyond purely technological considerations. Interviewee 1: pointed out that *“The cost of adoption, that's it, also look at the human capital. That's quite key because, it's going to cost you money to get that skill set to start building such technologies, so it's cost of adoption and human capital in my view”*.

Focus group 2: concurred that cost and human resources stand out as the predominant factors hindering the prioritization of technology implementation within organizations. Their collective sentiment underscored the significant challenges posed by financial constraints and the shortage of skilled personnel, both of which impede effective technological advancement within the organizational context: *“the management has a problem with the cost, they definitely do because, some of these technologies are very expensive and that's my past experience with some of the products and then also the understanding of the integration, between these technologies because sometimes they think one solution will cater for all their requirements, but then some of these technologies have got add-ons or another module that you need to purchase and stuff to get the full end to end view.*

Interviewee 2: emphasized the human resource aspects and the shortage of skills. However, focus group 2: perceived the human resource challenges differently, characterizing them as stemming from the management team's

insufficient comprehension of the technologies, including their end-to-end integration and the accompanying costs.

Interviewee 1: shared the same sentiment with regards to cost but viewed it from a lense of cost of change from legacy systems and the associated risk of migrating to new technologies which brings forward the next point which is risk. *“So, I think the single biggest issue is legacy and the cost to change from the legacy systems is probably one of the biggest detractors as well as I would say purely the risk to adopt these new technologies.”*

II. Risk of adopting 4IR technology

As stated earlier, interviewee 1: pointed out risk as a notable obstacle to technology adoption. This risk entails the apprehension of disrupting current business operations by integrating new technologies. *“So sometimes companies are so invested in the legacy and the risk to move away from that legacy is just so big that adopting these new technologies, as part of the core business is probably the biggest detractor.”* Hinging on the risk is also the hyper evolution of technology without demonstrable benefits, Interviewee 1 highlighted that there has been an influx of technology innovations where historical implementation has demonstrated little to no value realised from implemented technologies.

III. 4IR technology Integration

Interviewee 1: raised an intriguing point regarding the interdependence of supply chain technologies, emphasizing that they cannot function in isolation. Instead, integration with other business applications and systems on a broader scale is essential to achieve effectiveness and efficiency throughout the entire business. Over and the above the integration with the internal system to achieve fully visibility in the supply chain there must be integration with external partners in the value chain.

This introduces a major challenge in realising the full benefits of the implemented technologies in the absence of this end-to-end integration. *“Supply chain technology works off your base_systems, and if your base systems are not, easy to integrate and doesn't work that well, then you have a challenge with the*

technology.”

Focus Group 1: also cited instances of partial integration within specific aspects of the procurement function. For example, the customer-facing front end is seamlessly integrated for invoicing purposes, and suppliers extensively leverage this functionality. This serves as a tangible illustration of the smooth acceptance and adoption of technology when it adds value to the organization. In this context, suppliers consider invoicing crucial, as it directly contributes to their revenue. Furthermore, the group expanded on the demonstration of integration in customer-facing applications, where orders are placed through the application, and fulfilment occurs through an ERP system. They perceive the application as an upper layer interfacing with the foundational ERP system deployed throughout the organization. *“Well, I think in certain aspects it's integrated in certain aspects it's not, where supplies can capture their own invoices. That's super advanced, you know, and super beneficial on a nice front-end tool, however, when you go to contract management, it's not so advanced, so you've still got to flip the contract and then manually process the contract.”* *“Let's say your basic transaction is through the ERP, most of them has been in the ERP. Now you bring order placement as an application which is like a layer on top of your ERP system.”*

4.2.2 Drivers for technology adoption in supply chain

Contrary to the detractors stifling the adoption of technology there is a myriad of factors that organisations consider valuable and some critical for their competitiveness, driving the adoption of e-commerce technologies in their environments. The decisions are primarily underpinned by major events bordering on implicit events that threaten business existence instead of innocuous day to day operations and efficiencies.

I. Fundamental shift in strategy to adopt 4IR technologies.

Individual 2: highlighted shift in strategy fundamental to adoption of technology driven by competition and other factors that threaten business existence. Organisations that are leaders in the market are mostly resistant to adopting

technology due to their evident leadership in the markets that they operate, it is only when external factors emerge that threaten the business existence or profitability that necessitate the shift in the business strategy and technology approach. *“So, the drivers are typically fundamental shift in strategy or business model”.*

II. Catastrophic events promoting adopting of 4IR technologies.

Individual 2: proceeded to highlight another business threatening factor that promotes the adoption of technology, to be unforeseen catastrophic events case in point the covid pandemic and other natural events that threaten business continuity. *“It is catastrophic negative events that forces company to adopt technology”.*

These sentiments were echoed by focus group 1: highlighting covid disruption as one of the catastrophic events that impaired trade. *“When we look at when there was disruption in terms of COVID you know a lot of our customers feedback, you know being in the IT solution space, most of our customers did indicate that if the solutions were not available, they would not have been able to transact with their suppliers and be able to source materials as soon as possible.”*

III. Cost savings by implementing 4IR technologies.

Focus group 2: identified cost saving as one of the factors that drive adoption of technology in organisations due to faster processing, limited use of human resources and less mistakes in production and distribution of goods to the right place the first time eliminating the cost of reverse logistics and goods that are not fit for purpose. Individual 1: also attributed cost savings as the driver for technology adoption citing technology that allows courier companies to bid for deliveries bundling them with other deliveries therefore reducing the cost of delivery compared to singularly sourcing a courier to deliver their goods. *“So, these systems that we call, I think transport management systems, which is basically a simple software, where you basically throw your goods onto that system to say guys, I need to deliver this to these guys that actually bid to tell you I can deliver it at this cost at this rate.”*

4.2.3 Would you say e-commerce is the biggest driver of the adoption of supply technologies?

Following an in-depth exploration of the factors influencing technology adoption, participants were posed with a crucial question aimed at gauging their perspective on whether they consider e-commerce to be the primary catalyst for the adoption of supply chain technologies. This inquiry aimed to directly address the proposition that the perceived significance of e-commerce plays a pivotal role in influencing a company's decision to adopt supply chain technologies.

Individual 2: concurred that e-commerce stands out as the foremost catalyst for the adoption of technology in the supply chain. This acknowledgment acknowledged the impact of drivers previously examined, such as catastrophic events and competition, in fostering the adoption of e-commerce. Furthermore, Individual 2: introduced another element influencing e-commerce adoption within organizations – the demographics of the country. According to their perspective, younger, technology-savvy generations are more inclined to utilize e-commerce for both every day and luxury shopping, contributing to its widespread adoption.

“The reason e-commerce drives the adoption of supply chain, technology is due to the generation demographics categories and the way that they operate contrary to the silent generation and if you look at also what people buy, as I said, even groceries are now being delivered as a run of the mill thing, let's not forget the COVID pandemic that's made a huge impact in essential services and online delivery.”

Individual 1: brought a different dimension into the proliferation of e-commerce and the resultant adoption of supply chain technologies thereof. He alluded to environmental factors driving the adoption of e-commerce and technology adoption in supply chain at large.

“We can't be doing paper now, talks to the environmental awareness, and stuff like that to say you have to clean the environment, you know, so we talk about paperless, whether it's in store or not.”

The follow through question was to ascertain the interviewee's perception on whether most transactions are processed online or processed via the traditional means of shopping. Here there were varying views on the landscape of shopping behaviour primarily based on industry and access to technology. Again, some of the factors as aforementioned as demographics play a major role in consumer shopping behaviour.

Individual 2: had a multifaceted view in that he believes that most of the sales still are processed traditionally with evident uptake on e-commerce propositions. He did however indicate that be that as it may, the e-commerce adoption is influencing and changing the traditional shopping landscape. This is due to the residual benefits to traditional shopping that are driven by e-commerce initiatives. An example is that the adoption of supply chain technologies driven by e-commerce shopping also benefits the traditional shopping due to the efficiencies introduced in the value chain.

"So traditional shopping is still the largest. But the behaviour change is forced through e-commerce, the benefits for e-commerce adoption flow back to traditional shopping. Traditional sales channels also improve because of the adoption of technologies driven by e-commerce."

Individual 1: had a differing view, he believed that the majority of transactions are now executed on e-commerce platforms post the covid pandemic and with the new focus on environmentally friendly business operations. He is observing an upward trend of more customers moving to digital platforms whereas there are still customers that prefer traditional shopping.

"E-commerce drives more traffic, I've seen that already within our own business The shift is going online and digital, there are still those later adopters into e-commerce, that still want to go into a store."

Focus group 1: shared the same sentiment as individual 2: in that e-commerce fosters quick adoption of supply chain technologies due to its instant nature requiring real time visibility thorough the value chain at the time of order placement. It also enables collaboration between all players in the value chain

suppliers, buyers, and manufacturers. *“I can say it does help in terms of trading between the suppliers and customers, you get faster information without pain. I think you get suppliers to respond to information with ease of visibility, there's transparency and you know you can really track what's happening with that particular transaction from order to payment. You know you can see who are the players that were involved, you know, if a transaction was equivalent to this amount at a purchase order level, did we pay that amount?”*

4.3 Companies that have adopted e-commerce have better supply chain digital maturity.

Proposition 2 posits that companies embracing e-commerce exhibit enhanced supply chain maturity. In the absence of explicitly defined models for gauging supply chain maturity, we will assess specific characteristics to formulate a reasonable prognosis regarding supply chain maturity. In this study, our examination of supply chain digital maturity will centre on the incorporation of Fourth Industrial Revolution (4IR) technologies and their impact on enhancing the efficiency and effectiveness of the supply chain.

The evaluation aims to understand how supply chains transition from traditional to digital, the driving technologies behind this evolution, and the resultant advantages. Success will be measured by the agility and resilience of supply chains in addressing the complexities introduced by the adoption of e-commerce and the ever-changing needs of customers. Additionally, emphasis will be placed on developing maturity models to assess supply chain digital maturity, drawing from existing technology adoption models, and exploring their adaptation for evaluating the maturity of supply chain technology adoption. The succeeding chapter brings to detail the view of the interviewees on these aspects.

4.3.1 4IR Technology maturity

Individual 2: adopted a very interesting view on how to go about appraising the maturity, by opting to assess the technology maturity independently and then proceeding to appraise the technology implementation in supply chains. This

approach proved to be very instrumental in that, it shows technology capabilities across a wide spectrum and then bringing to bare the gap between the maturity of technologies and that of supply chain technology adoption.

“So, in terms of the technology itself the maturity is very high If you look at it end to end, but the application of the technology not so much. When you look into end to end, for example we've got technology right now that's being used by companies to do their planning to do their forecasting and even on the forecasting algorithms. The technology has matured significantly many years ago, with use of machine learning to look at social media comments on certain products and services and how that influenced the actual forecasting.

So, if you look at how, for example, people comment on Twitter or X these days, it was already in 2015, they already had this technology and so people would comment on Twitter, back then and based on the sentiments of those comments, they would use machine learning to teach the engine to adapt the forecast up or down based on the comments they had from social media. The level of forecasting all the way to materials requirement planning down to distribution requirements planning, software is probably you know the most mature in my opinion.”

Even though not as lucid as interviewee 2 all the other participants also reflected on the gap between the maturity of the technologies indicated that the technologies far supersede the maturity of implementation in the supply value chain.

Individual 1: believes that *“with the use of technology now, I think it's more a bit sophisticated and I think to a point the element of analytics and data science has come into play alright, which obviously brings the fuelling to the innovation within supply chain.”*

4.3.2 Supply chain technology implementation maturity

After exploring technology capabilities, our attention shifted towards the practical implementation and utilization of technology within the supply chain, thoroughly

examining each segment of the supply chain. The interviews revealed diverse perspectives and opinions from participants, prompting a comprehensive review of the adoption and implementation levels of various technologies across all facets of the supply chain.

The initial query presented to the interviewees was: How do you characterize the existing maturity level of supply chain technologies?

Individual 1: *"I think it is mature from my own view, I think yes, definitely things have evolved to a great extent. It's not the usual traditional supply chain we used to have where it's a warehouse pick and pack and then drop it off to end consumer kind of thing."*

Individual 2: *"Ok, so a lot of the US companies would lead in maturity, I would venture to say Asia uh specially with the likes of you look at the whole Alibaba group in terms of adoption of technology in terms of Europe, umm the European adoption is slow based on what I've seen some ability on some layers and then when it gets to South Africa, you'd be amazed you know some of our leading companies are backward so you know in terms of maturity we need to get to technology maturity"*

Focus group 1: *"I hope I'm not biased, but I believe that supply chain technology has really matured in terms of, if you had to put one to five for scale and then I would put like a four and a half."*

"Well, I think we fully implemented, I would say in certain spaces, but we're not necessarily fully compliant or fully implemented, I think you got to look at it from both ends it is a massive change management for suppliers because they need to adopt to start working towards a computer, not necessarily individual."

"I mean, when I started in supporting procurement at that time, they still had the tender box and I think the technology that they've implemented from the e-sourcing now, I would say yeah, from what the current solutions are offering really, i would say mature from a technology perspective you know."

"I would say emerging so some level of implementation. The thing again it depends on the company. There are companies that go big on supply chain and atomisation and then there are others that are running the basics so but probably emerging is where we are."

I. ERP systems

The interviewees pointed out that Enterprise Resource Planning (ERPs) serve as the initial step in adopting technology across both the supply chain and the entire organization. While ERPs provide a foundational level of technology adoption, they are notably restricted in terms of adaptability and optimization due to their one-size-fits-all approach.

Individual 2 *"In the past it used to be, you know, everybody was like you must have an ERP system and the ERP system then controls everything, that notion has changed ERP is not dead, but the old way of ERP management and looking at it is definitely changing."*

Individual 1: *"Going back ten years, the way those systems were designed to what we have now, I think we getting to a more satisfactory and a user friendly systems and I think the ERPs are now built into one, it's not you have to swivel chair process to say oh log in this in this particular systems we will share to this to get to 1 endpoint it's all bucketed into one"*

Focus group 2: *I think ARUBA still very immature in South Africa So, looking at it as well and there are companies using it, but I think to use the full suite of ARUBA you must be very mature company. And I think you must have the mindset of adopting full technology and then the other thing as well, your ERP system, we still be using SAP ECC and the compatibility between ECC and ARUBA is not really great.*

As per the insights from the interviewees, there is a discernible change in the strategy for deploying and overseeing ERPs throughout the value chain. A substantial trend is emerging, favouring the adoption of modular solutions designed for specific areas within the value chain. This shift relies on seamless

integration and the active utilization of Application Programming Interfaces (APIs).

II. Visibility

The supply chain comprises various segments, including manufacturing, storage, logistics, procurement, sales, and marketing, among others. Achieving end-to-end visibility and seamless data transfer for customer order fulfilment requires extensive integration among the systems housed in these segments. Given the challenges associated with modifying ERPs, there is a growing inclination to transition from rigid, off-the-shelf solutions to more adaptable modular alternatives.

Individual 2: What we've seen is the shift to ERP systems like NetSuite, which is part of Oracle, or which is an Oracle solution type that can integrate easily into a whole bunch of other applications". A very interesting concept of multiple apps, so not necessarily a full-blown ERP, but multiple apps that have different functionality and those then integrate through an integration platform to talk to each other. Now these solutions offer integrated platforms, and you can literally hook up any software with any software, and everybody tends to move to this cloud-based environment."

Individual 1: I think one of the points that we probably touch on in terms of how all those systems are integrated end to end and what I mean by end to end is from a point of planning to a point of consumption all those systems need to obviously talk to each other, so you can't have a silo system talking to planning, which does not even read into the consumption of the product, which is your point of sale".

Focus group 1: I've seen most of the solutions, even you know ARUBA and competitors, the areas of pain has been integrations, we have a native integration layer that we had to improve. We now have a cloud integration layer even that was still not good enough because we didn't have like several services and criteria of items that could integrate well."

The implementation of the integrated systems brings about visibility across the value chain, in that users can have an end-to-end view of the status on processing of transactions.

Individual 2: *"We are now looking from a, let's call it the visibility point of view and visibility has always been the holy grail you know we always wanted visibility and a lot of guys are talking about control towers and having control towers, if you look at what these guys have done in terms of control tower and automating, you know into end to end visibility and there's a lot that you can read on them and bring it to a level of visibility where it then starts interacting with your business applications. It doesn't matter what problem you are facing technology enables you now to overcome the problem by creating visibility".*

Individual 1: *"We can also look at the need to integrate all the partners in the supply chain, different segments in the supply chain like warehousing and the last mile sales and distribution and then how effectively do supply chain technologies provide real time visibility".*

III. Data and analytics

Data plays a pivotal role in achieving visibility across the value chain by collecting and transmitting data across different stages of fulfilment. The utmost significance lies in ensuring data integrity and enabling real-time data streaming for prompt decision-making. "Streaming data is data that is emitted at high volume in a continuous, incremental manner with the goal of low-latency processing. Organizations have thousands of data sources that typically simultaneously emit messages, records, or data ranging in size from a few bytes to several megabytes (MB). Streaming data includes location, event, and sensor data that companies use for real-time analytics and visibility into many aspects of their business. For example, companies can track changes in public sentiment on their brands and products by continuously analysing clickstream and customer posts from social media streams then responding promptly as needed." (Amazon web services, 2024). Reliability in data input, processing, and output for subsequent stages is crucial to execute tasks according to order requirements. There has been a

notable transition from traditional data collection and processing methods, such as SQL, to more intuitive and automated technologies.

The shift involves embracing technologies like artificial intelligence, particularly machine learning. Through the adoption of these technologies, organizations can evolve from descriptive analysis to prescriptive analysis.

This transformation enables organizations to engage in proactive planning through the maturation of prescriptive data analytics. Operating in a real-time data environment, organizations can unleash data streaming capabilities across the entire value chain.

Individual 2: *“What the guys have done lately is they've enhanced the artificial intelligence and their machine learning engines to learn more and they starting to apply deep learning and stuff like that, but the single biggest problem is getting the data out of your network. But what is done is they've created this environment where you have visibility and where you can react, and there are artificial intelligence chatbots engines that can also take decisions based on your prescriptive analytics. Now you can take any data from anywhere and you can hook it up and bring up to create different topics and generate new sets of data with diverse sources of data. You now have data that is always live and is always fresh and it doesn't go down.”*

Individual 1: *“If you don't have the right data, you can't make the right decisions all, things have advanced to a point that we can perform analytics, because we have got the data now, we have the insights to be able to do that It has to be real time, so if I consume that product now, any person in any point wants to see my inventory levels should be able to see it, you know not to wait perpetually. Issues like the system hasn't updated are no longer prevalent, so it must be real time updates and it boils down to your data quality. The quality of the data is big within the space.”*

4.4 Summary of the results/findings

While the technology capabilities have reached a mature stage and shown positive outcomes in certain areas of application, their implementation within the South African context remains fragmented, focusing narrowly on specific segments of the supply chain value chain.

CHAPTER 5. DISCUSSION OF THE RESULTS OR FINDINGS

5.1 Introduction

The research findings presented here are grounded in the parameters outlined in the literature review, which scrutinizes cutting-edge technologies within the supply chain and their levels of adoption. The primary objective is to reassess the subjects investigated in the literature review through the lens of the respondents, elucidating the results of the interviews and drawing comparisons with the existing body of reviewed literature.

By conducting structured interviews across the supply chain spectrum, the research seeks to offer a comprehensive understanding of how industry-leading technologies are perceived and implemented in practical scenarios. This approach aims to bridge the gap between the literature and real-world applications as experienced by professionals in the field. The juxtaposition of interview outcomes with the existing literature will provide valuable insights into the alignment or disparities between theoretical considerations and practical experiences within the supply chain. This comparative analysis is crucial for gaining a nuanced comprehension of the challenges, opportunities, and trends shaping the contemporary supply chain landscape in South Africa.

5.2 Demographic profile of respondents

The identification of respondents constituted a crucial undertaking aimed at ensuring that the study garnered precise insights rooted in industry expertise, with a specific focus on all facets of the value chain. These respondents possess expertise in supply chain technology sales, implementation, as well as maintenance and support. Consequently, the input gathered from these individuals is highly articulate and detailed, offering a clear picture of the current state of supply chain technology adoption, utilization, and performance. The demographic composition of the respondents reflects their exposure to the

evolution of supply chain technology, and their firsthand experience encompasses driving technology adoption across various organizations. An integral aspect that emerged during the interview process was the international exposure of the respondents. This exposure enables them to draw comparisons between the South African landscape and other countries that have undergone similar technological adoption trends. This international perspective adds a valuable dimension to the study, facilitating a more comprehensive understanding of how technology is embraced and implemented within the South African context in comparison to global practices influenced by analogous drivers.

5.3 The implementation of e-commerce influences the company's adoption of supply chain technologies.

Proposition 1 aims to assess the correlation between the adoption of e-commerce and the subsequent integration of supply chain technologies within the value chain. The integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders allow organisations to leverage the efficiencies and effectively implement quick to market strategies that allow for market share gains (Lambert et al., 1998, p.1). The focus is on evaluating key principles highlighted in the literature review that led to the formulation of proposition 1. The literature review delved into studies on the adoption of Fourth Industrial Revolution (4IR) technologies and their relation to the implementation of e-commerce. The preceding chapter extensively discussed the viewpoints expressed by interviewees regarding the adoption of 4IR technologies. This discussion initially examined the factors that promote or hinder the adoption of these technologies, followed by an analysis of the overall adoption trends observed in 4IR technologies. Drawing from both the literature review and the interviews, a comprehensive analysis was conducted to examine the exhaustive array of themes and sub-themes. This analytical process aimed to address the overarching question of whether e-commerce influences the adoption of supply chain technologies. Remarkably, congruence was identified between the findings from the literature and the research, particularly on multiple themes and sub-

themes related to Fourth Industrial Revolution (4IR) technology adoption within the supply chain.

Table 2 - Thematic analyses for research question 1

Research Question 1	Sub - Themes	Themes
What are the drivers that influence supply chain technology adoption in the South African context?	Legacy technology Risk appetite Risk management Demographics Risk sensing Skills Cost of implementation Human resources	Technology adoption detractors
	Customer experience Consumer behaviour Catastrophic events Demographics Customer satisfaction Audit trail Competition Strategy change Innovation E-commerce Cost reduction	Technology adoption promoters
	Machine learning Artificial intelligence IOT Machine learning Cloud services Robotic process automation Cloud computing Software as a service	4IR technologies implementation

There was clear concurrence between the findings from the literature review and insights gathered during interviews, particularly regarding the increased adoption of robotics, machine learning, and implementation of Internet of Things (IoT) within the supply chain. However, interviewees emphasized that while there has been some level of implementation of these technologies, there is a critical need for integration across the entire value chain to fully leverage their benefits and achieve visibility.

Interviewees indicated that robotics are primarily utilized for automating mundane and repetitive tasks, such as invoicing and supplier registration within ERP systems for tendering purposes. However, this automation often remains

confined within individual processes without integration into other human-dependent processes across the value chain.

A significant challenge highlighted was the lack of optimization in manual processes, characterized by the absence of formally defined standardized procedures. This limitation hinders the adoption of machine learning, robotics process automation, and other technologies, as the quality of output is heavily dependent on the quality of input. Some interviewees even expressed concerns that the accuracy of certain automated processes does not exceed 80%.

Cost emerged as a prevalent detractor for technology adoption, according to interviewees. However, the adoption of cloud services was cited as a significant advancement in addressing this barrier. Cloud services offer organizations access to tools tailored to their needs at a reduced cost, enabling them to subscribe only to necessary applications and functionalities instead of implementing full-scale ERP systems. The increasing adoption of cloud services is further facilitated by a shift in approach from leading ERP system developers, who now offer modular solutions and relevant applications that allow organizations to access various technology platforms.

Interviewee 2: The likes of Oracle as an ERP system is also very dominant, what we've seen is the shift to ERP systems like NetSuite, which is part of Oracle suite of solutions, which can integrate easily into a whole bunch of other applications. All very interesting concepts of multiple apps, so not necessarily a full-blown ERP, but multiple apps that have different functionality and those then integrate through an integration platform to talk to each other.

The shift in approach by leading solution providers and new entrants in the field has significantly eased the cost burden associated with technology adoption in the supply chain.

Responses to the pivotal inquiry concerning the impact of e-commerce on the adoption of supply chain technologies in South Africa extensively scrutinized. All respondents unequivocally affirmed that e-commerce significantly enhances the adoption of supply chain technologies, primarily propelled by competition and

catastrophic events. The ubiquitous presence of e-commerce was confirmed in all organizations where the interviewees were engaged, consequently driving the implementation of supply chain technologies. Notably, some organizations are processing more e-commerce orders than traditional shopping, mirroring global trends in e-commerce adoption.

5.4 Companies that have adopted e-commerce have better supply chain digital maturity.

Proposition 2 primarily seeks to examine the proposition that companies emphasizing e-commerce exhibit superior supply chain digital maturity. This proposition extends from the first proposition to delve deeper into whether the combination of e-commerce adoption and implementation of supply chain technologies leads to enhanced supply chain technology maturity. Given the limited existing literature on defining specific models or frameworks for supply chain technology maturity, the formulation of views in this research is based on a subjective analysis of participant perspectives supplemented by available literature. Key areas of focus for this proposition include reviewing literature on characteristics of supply chain maturity such as resilience, agility, and lean supply, along with exploring existing maturity models designed to assess technology in general. Data gathered from interviews delves into critical guidelines for the implementation and utilization of technology aimed at enhancing efficient and effective execution of supply chain functions across the entire value chain.

The thematic analyses of the data converged into 4 primary themes formulated based on the activities performed in the supply chain, the related technology, and the processes for optimisation of the supply chain from traditional to digitally centric supply chain. The table below depicts the hypothesis, all the sub themes picked up during the interviews as well as the resultant themes from the analysis.

Table 3 - Thematic analyses for research question 2

Research Question 2	Sub - Themes	Themes
What is the digital maturity of supply chain technologies in South Africa?	Transformation Planning Technology evolution Catastrophic events	Change management (Inception)
	Demand management Inventory management Automation Data management Distribution Automation Visibility ERP systems Forecasting Modular systems and applications Digital twin Manufacturing	Resilience (Maturity)
	Prescriptive analysis Descriptive analysis Business simulation Data management	Analysis / Data streaming (Maturity)
	Automation Centre of excellence End to end visibility	Process mining (Maturity)

I. Change management

Business transformations, catastrophic events, and technological advancements emerged as the primary catalysts for implementing technology within organizations, marking the initial phase in the journey toward supply chain technology maturity. Participants generally concurred that catastrophic events played a pivotal role in driving technology implementation, surpassing other triggers, both internal and external to the organizations. It was challenging for interviewees to pinpoint significant instances of technology evolution not instigated by catastrophic events. Examples cited included the redistribution of manufacturing locations from weather-prone areas to more stable regions.

Most interviewees emphasized the importance of stakeholder buy-in, including external stakeholders in the value chain, during this initial phase. Competing priorities for investment within organizations, particularly focusing on new

revenue-generating innovations, often pose challenges. The prevalent adoption of outsourced supply chain models was highlighted, limiting organizations' ability to obtain a comprehensive end-to-end view of the value chain. Consequently, change management was underscored as critical for establishing a conducive environment for the successful execution of technology strategies.

II. Resilience

The literature emphasizes resilience as a key indicator of mature supply chain technology implementation. The supply chain landscape has witnessed the growing significance of agility, resilience, and reliability as key strategies to overcome the prevalent challenges in today's digitalized world. Nonetheless, the implementation of digital technologies within supply chain operations gives rise to significant concerns such as effective coordination, accurate tracking, and enhanced flexibility (García-Reyes, 2022).

Resilience is achieved through thorough examination and comprehension of the entire value chain, including identification of both internal and external handover points. Integration is identified as the crucial element enabling optimal configuration of value chain technologies to achieve maturity. Integration involves connecting different fragments of the value chain, facilitating system interoperability and effective data management. This allows for interpretation of current resource utilization and forecasting future demand using historical patterns.

However, ERP systems provide this functionality to a limited extent, with various complications hindering the level of integration needed for end-to-end visibility. Participants highlighted the universal approach to ERP systems development, lacking understanding of dynamic operating environments. The costs associated with reconfiguring systems to fit specific environments are prohibitive, forcing organizations to adapt their operations to system capabilities. The evolution towards modular and application-centric platforms addresses these issues, but there is reluctance to invest in new technologies due to a perception that technology benefits do not justify the investment.

Digital twin technology emerges as a new solution in the redundancy and reliability arena, offering capabilities to create a digital copy of the technology environment to restore operations in case of failure. “Typically described as consisting of a physical entity, a virtual counterpart, and the data connections in between, the Digital Twin is increasingly being explored as a means of improving the performance of physical entities through leveraging computational techniques, themselves enabled through the virtual counterpart” (Jones, et al., 2020).

However, its benefits are largely theoretical, with no real-life implementation experiences mentioned by interviewees. Beyond recovery capabilities, digital twin offers the ability to run simulations predicting future behaviours and disruptions in the value chain. It collects real-time data from physical assets and performs analytics using historical and current data, along with forecasting future scenarios through machine learning technologies, underscoring the importance of data management in organizations and the value chain.

Data plays a critical role in facilitating supply chain resilience, showing historical patterns, current state, and predicting the future state. Real-time collection and sharing of data from order placement to replenishment enable agile and lean supply chains. The concept of data streaming represents the highest level of data management maturity, ensuring real-time data sharing and visibility across the value chain.

III. Maturity models

The consistent theme evident throughout the preceding chapters, based on the literature review, is the limited development of supply chain technology maturity models. During interactions with interviewees, significant emphasis was placed on identifying themes and characteristics deemed defining of a mature environment. The adoption of Fourth Industrial Revolution (4IR) technologies emerged as a constant theme across responses. Interviewees extensively discussed the importance of adopting the right technologies at the right time, with prominent technologies including robotics, machine learning, and cloud computing, as discussed previously.

Considerable effort is required to prepare for the implementation of these technologies, with examples such as data management and process mapping being prevalent. “Process mining is a method of applying specialized algorithms to event log data to identify trends, patterns, and details of how a process unfolds. Process mining applies data science to discover, validate and improve workflows (What Is Streaming Data? - Streaming Data Explained - AWS, n.d.)”. Processes must be defined and standardized before automation can occur. Process mining becomes critical to ensure automated processes flow smoothly throughout the value chain and produce accurate outputs. Effective data management ensures that information entering systems and processes is correct and timely.

The primary focus is on ensuring that the implementation of these technologies improves efficiencies and operational maturity within the value chain. Demonstrable benefits are seen through capabilities such as automation, simulation, and prescriptive and descriptive analytics. The consensus is that it is at this stage, where these functions are executable, that the environment is deemed mature. The highest level of maturity is achieved when there is end-to-end visibility between segments of the supply chain and its participants, both internal and external to the organization.

This is facilitated by the implementation of back-end supporting functions such as the Centre of Excellence, which focuses on optimizing the current environment towards an envisioned future state, with a positive feedback loop between the operations and optimization teams. This is where the intelligence of the system is implemented within properly defined governance structures. It is crucial that the expected future state is defined in both the short term and long term.

5.5 Conclusion

There exists a notable alignment between the findings from the literature review and the insights gathered through interviews. However, the interview participants introduced additional parameters, such as data streaming and process mining, which were not extensively addressed in existing literature. These parameters offer valuable perspectives that contribute to a more comprehensive

understanding of the essential criteria for evaluating the maturity of supply chain technologies.

CHAPTER 6. CONCLUSIONS & RECOMMENDATIONS

6.1 Introduction

The focus of the research study was to assess the drivers of technology adoption specifically in the supply chain value chain. Both the detractors and drivers of adoption were evaluated based on literature and research interviews with the participants. Furthermore, the research aimed to understand the digital maturity of the supply chain technologies in South Africa learning from literature review and subjective view of the participants.

6.2 What are the drivers that influence supply chain technology adoption in the South African context?

The research question aimed at understanding the drivers for supply chain technology adoption in the South African context. Literature prescribes that the drivers for technology adoption are to address uncertainty and sudden shifts in market and fast changing consumer needs, therefore, supply chains need to be resilient, agile, and adaptable. From the customer's perspective, easy internet access is a crucial element that enables them to visit e-commerce sites and make purchases. E-commerce facilitates connection with consumers and enabling customers to shop online with 24/7 availability, allowing customers to shop at any time (Nimna, 2017). The literature also points out that adopting technology results into competitive prowess justifying the investment in technology initiatives (Ackerman et al., 2003) identified several important trends in supply chain management (SCM) that are supported by enterprise resource planning (ERP) systems. These trends include:

1. **Mass Customization:** ERP systems enable the customization of products through a variety of predefined options.

2. **Process and Data Standardization:** ERP systems assist in standardizing processes and data across the organization, ensuring uniformity and efficiency.
3. **Global Business Integration:** ERP systems support the integration of operations for companies with a global presence, promoting coordinated management across various international locations.

4IR technologies are the bedrock to realisation of the adaptable and resilient supply chain owing to the benefits of providing an end-to-end visibility through the supply chain, achieved by establishing linkages between machinery, supply systems, production facilities, end products, and customers, facilitating the seamless collection and exchange of real-time information and data. Upon the evaluation of the literature a proposition was formulated to assess the relationship between e-commerce implementation and technology adoption in the supply chain. The research revealed consistent patterns between the literature and the insights gathered from participants who have experience implementing supply chain technologies in the country. These parallels primarily revolve around the catalysts that drive technology adoption, both within and outside businesses. Internally, the main drivers for technology adoption include changes in strategy, innovation, and cost reduction. To formulate a digital transformation strategy, companies should prioritize their business strategy while considering the key aspects of digital transformation, leveraging technology, transforming value creation, making structural adjustments, and addressing financial considerations (Mashalah et al).

Among the prominent external motivators are the widespread expansion of e-commerce, unforeseen catastrophic events, and shifts in customer behaviour. The advancement of e-commerce and the embrace of digital transformation strategies are restructuring the patterns of technology adoption within supply chain operations.

The identified primary drivers for technology adoption in South Africa are customer behaviour, strategy change, and catastrophic events.

6.3 What is the digital maturity of supply chain technologies in South Africa?

This question forms the essence of the research, to assess the digital maturity of supply chain technology in South Africa. There were no defined frameworks that could be used to measure the maturity of the technology. The literature defines maturity as a progressive journey to realisation of the objectives defined by the organisation undergoing the transformation. The most common objectives are resilience, agility, and adaptability.

The participants in the data collection highlighted that the key characteristics of a mature supply chain are supply chains that are integrated and provide end to end visibility. The participants believe that the current state of technology implementation is siloed and provides minimal benefits to the overall value chain.

The implementation of the supply chain technologies is lacking integration, stifled by the inflexibilities of the ERP systems hindering the end-to-end visibility.

As a result, there is a growing requirement for integration, with organisations opting for smaller systems strategically positioned throughout the supply chain (Taylor et al., 2019).

Within the specified scope of this study and through analysis of the South African context, the findings reveal the current state of supply chain technologies in the region is:

Level 2: Awakening

At this stage, the organization acknowledges the importance of adopting technologies and staying abreast of supply chain trends. Various technologies are integrated into process enhancements aimed at embracing supply chain advancements. However, these technologies and the accompanying systems remain isolated or only partially integrated with the supply chain. Employees receive periodic training on the adoption of new technologies and the requisite technological skills.

The maturity view formulated based on the research is as follows:

Table 4 - Maturity status of supply chain technologies in South Africa

Driver	Current State	Mature state
Resilience	• Siloed implementation • Data inconsistency	• Process mining • Centre of excellence. • Digital twin • Data streaming
Agility	• ERP systems	• Modular systems and applications
Reliability	• Descriptive analysis • Human interference	• Prescriptive analysis • Automation

6.4 Recommendations

The recommendations to the executives are as follows:

1. Perform internal benchmarking with functional areas in the business where technology was successfully implemented and achieved defined objectives.
2. Perform external benchmarking with businesses that have successfully implemented technology across the supply chain value chain.
3. Prioritise upskilling human resources on the cutting-edge technologies.

6.5 Suggestions for further research

The lack of defined maturity models results in a very subjective view of the appraisal of supply chain technology maturity, further research can be conducted in the following area:

1. Develop frameworks that can be adopted to appraise the technology maturity in supply chain.

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Has your company achieved digital maturity?

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DEFINING SUPPLY CHAIN MANAGEMENT

John T. Mentzer, William DeWitt, James S. Keebler, Soonhong Min, Nancy W. Nix, Carlo D. Smith, Zach G. Zacharia

First published: 10 May 2011 <https://doi.org/10.1002/j.2158-1592.2001.tb00001.x>

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APPENDIX A - PARTICIPATION INFORMATION

Participation Information Sheet for Academic Research



Dear Sir / Madam

My name is Monde Nkwenkwe. I am a Masters student in Master of Management: Digital Business at the University of the Witwatersrand, Johannesburg. My supervisor is Dr Pius Oba. I am conducting a research study about digital maturity of supply chains in South Africa. The study title is: **The digital maturity of supply chain technologies in South Africa.**

I am inviting you to take part in an interview. If you decide to take part, your participation in this research study will last about 1 hour. The interview will take place via an online platform or a face-to-face meeting at a time agreed by both of us.

With your permission, I would like to audio record the interview activity. This data will be stored in iCloud drive for 1 year and deleted after 1 year. Only the researcher will have access to the data.

The interview will be confidential and anonymous. When I share the results of the research study, I will not include your name or anything else that could identify you. With your permission, other researchers may use the data collected from this research study, but your name and any personal information will not be used or passed on.

If you decide to take part in the research study, it should be because you want to volunteer. You do not have to take part. You can stop being in the study at any time. You do not have to answer any questions if you do not want to. You will not get any direct benefits if you choose to join the research study. You will not lose any services, benefits, or rights you would normally have if you decide not to join. Taking part in the research study will not cost you anything. You will not be paid for being in this research study. Your travel/data costs to attend the interview will be reimbursed to a maximum of R150.

The risks for this research study are no more than what happens in everyday life.

This research study will be written up as a research report. The report will be available on the university library website. If you would like to receive a summary of this report, I will be happy to send it to you.

If you have any questions during or afterwards about this research study, feel free to contact me or my supervisor on the details listed below. If you have any concerns or complaints about the ethical procedures of this research study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Yours sincerely,
Monde Nkwenkwe

Researcher:

Monde Nkwenkwe, email: 2069323@students.wits.ac.za, phone number: 081 572 9338

Supervisor:

Dr Pius Oba, email: pius.oba@wits.ac.za, phone number: [+27 11 717 3976](tel:+27117173976)

APPENDIX B – CONSENT FORM

Consent Form for Participation into An Academic Research

Research Topic: The digital maturity of supply chain technologies in South Africa:

Name of researcher: Monde Nkwenkwe

I, ... agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.	YES	NO
--	-----	----

I understand that I can volunteer to take part in the study	YES	NO
---	-----	----

I agree that the interview/focus group/other activity may be audio recorded	YES	NO
---	-----	----

I agree that direct quotations from my interview/focus group/other activity may be used by the researcher in their research report/ manuscript/book chapter	YES	NO
---	-----	----

I agree that my participation will remain anonymous (my name or other identifying data will not be used by the researcher in their research report/manuscript/book chapter)	YES	NO
---	-----	----

I agree that other researchers may use the information I provide in my interview/focus group/other activity (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on

YES NO

..... (signature)

..... (name of participant)

..... (date)

..... (signature)

..... (name of researcher/person seeking consent)

..... (date)

APPENDIX C – INTERVIEW QUESTIONNAIRE

INTERVIEW QUESTIONS FOR REPORT RESEARCH

TOPIC: The digital maturity of supply chain technology in South Africa

1. How would you define the current maturity level of supply chain technologies on a scale from emerging to mature.
2. What would you attribute as the main drivers or detractors for adoption of technology in supply chain?
3. Would you say E-commerce is the biggest driver of the adoption of supply technologies?
4. Where are most of the transactions processed between traditional sales and e-commerce?
5. To what extent are supply chain technologies integrated with other enterprise systems?
6. How well do these technologies facilitate interoperability across different stages of the supply chain?
7. How effectively do supply chain technologies provide real-time visibility into the entire supply chain?
8. To what degree are automation and robotics technologies implemented in supply chain processes?
9. What are the key challenges and opportunities associated with the adoption of automation in the supply chain?
10. How user-friendly are the interfaces of supply chain technologies, and what is the level of user adoption?
11. How resilient are supply chain technologies in adapting to unexpected disruptions or changes in the business environment?
12. Evaluate the sophistication of analytics capabilities embedded in supply chain technologies, including predictive analytics, prescriptive analytics, and other data-driven decision-making tools?

APPENDIX D – THEMATIC ANALYSIS FOR OBJECTIVE 1

Name	Files	References	Created on	Created by	Modified on	Modified by
What is the digital maturity of supply chain technologies in South Africa?	4	41	09/Feb/2024/14:35	A11	09/Feb/2024/17:13	A11
Technology adoption detractors	2	18	09/Feb/2024/14:37	A11	09/Feb/2024/17:13	A11
Cost of implementation	2	4	09/Feb/2024/14:30	A11	09/Feb/2024/14:47	A11
Demographics	1	1	09/Feb/2024/14:30	A11	09/Feb/2024/14:48	A11
Human resources	2	3	09/Feb/2024/14:30	A11	09/Feb/2024/14:45	A11
Legacy technology	1	4	09/Feb/2024/14:28	A11	09/Feb/2024/14:52	A11
Risk appetite	2	2	09/Feb/2024/14:29	A11	09/Feb/2024/14:47	A11
Risk management	1	1	09/Feb/2024/14:29	A11	09/Feb/2024/14:48	A11
Risk sensing	1	2	09/Feb/2024/14:30	A11	09/Feb/2024/14:49	A11
Skills	1	2	09/Feb/2024/14:30	A11	09/Feb/2024/14:52	A11
Technology adoption promoters	4	22	09/Feb/2024/14:38	A11	09/Feb/2024/17:13	A11
Audit trail	1	2	09/Feb/2024/14:40	A11	09/Feb/2024/15:29	A11
Catastrophic events	3	3	09/Feb/2024/14:40	A11	09/Feb/2024/14:49	A11
Competition	1	3	09/Feb/2024/14:40	A11	09/Feb/2024/15:29	A11
Cost reduction	1	2	09/Feb/2024/14:41	A11	09/Feb/2024/14:44	A11
Customer behaviour	4	3	09/Feb/2024/14:39	A11	09/Feb/2024/14:45	A11
Customer experience	2	3	09/Feb/2024/14:39	A11	09/Feb/2024/14:48	A11
Customer satisfaction	1	1	09/Feb/2024/14:40	A11	09/Feb/2024/14:45	A11
Demographics	1	1	09/Feb/2024/14:40	A11	09/Feb/2024/14:42	A11
E-commerce	1	1	09/Feb/2024/14:41	A11	09/Feb/2024/14:49	A11
Innovation	1	1	09/Feb/2024/14:41	A11	09/Feb/2024/14:47	A11
Strategy change	1	2	09/Feb/2024/14:41	A11	09/Feb/2024/14:48	A11

APPENDIX E - THEMATIC ANALYSIS FOR OBJECTIVE 2

Name	Files	References	Created on	Created by	Modified on	Modified by
What are the drivers that influence supply chain technology adoption in the South African context?	4	147	09/Feb/2024/14:53	A11	10/Feb/2024/13:13	A11
4IR technologies implementation	3	25	09/Feb/2024/14:58	A11	09/Feb/2024/17:12	A11
Artificial intelligence	2	4	09/Feb/2024/14:56	A11	09/Feb/2024/15:17	A11
Cloud services	1	3	09/Feb/2024/14:56	A11	09/Feb/2024/15:02	A11
IOT	1	4	09/Feb/2024/14:56	A11	09/Feb/2024/15:04	A11
Machine learning	2	6	09/Feb/2024/14:56	A11	09/Feb/2024/15:18	A11
Robotics process automation	2	6	09/Feb/2024/14:56	A11	09/Feb/2024/15:19	A11
Software as a service	1	2	09/Feb/2024/14:56	A11	09/Feb/2024/15:02	A11
Analysis	1	4	09/Feb/2024/16:14	A11	09/Feb/2024/17:12	A11
Descriptive analysis	1	1	09/Feb/2024/16:20	A11	09/Feb/2024/16:20	A11
Prescriptive analysis	2	3	09/Feb/2024/16:18	A11	09/Feb/2024/16:20	A11
Change management	4	31	09/Feb/2024/14:55	A11	09/Feb/2024/17:12	A11
Catastrophic events	1	3	09/Feb/2024/14:55	A11	09/Feb/2024/15:20	A11
Centre of excellence	1	2	09/Feb/2024/14:54	A11	09/Feb/2024/15:20	A11
Planning	4	21	09/Feb/2024/14:54	A11	09/Feb/2024/15:45	NV
Technology evolution	1	2	09/Feb/2024/14:54	A11	09/Feb/2024/15:22	A11
Transformation	2	3	09/Feb/2024/14:54	A11	09/Feb/2024/15:27	A11
Process mining	2	16	09/Feb/2024/16:23	A11	09/Feb/2024/17:12	A11
automation	1	9	09/Feb/2024/16:25	A11	09/Feb/2024/16:34	A11
Data streaming	2	7	09/Feb/2024/16:25	A11	09/Feb/2024/16:29	A11
Resilience	4	71	09/Feb/2024/15:32	A11	09/Feb/2024/17:12	A11
Automation	2	8	09/Feb/2024/15:33	A11	09/Feb/2024/15:37	A11
Data management	2	6	09/Feb/2024/15:33	A11	09/Feb/2024/16:32	A11
Demand management	2	8	09/Feb/2024/15:32	A11	09/Feb/2024/16:32	A11
Digital twin	1	2	09/Feb/2024/15:34	A11	09/Feb/2024/15:41	A11
Distribution	2	4	09/Feb/2024/15:33	A11	09/Feb/2024/15:52	A11
ERP systems	2	8	09/Feb/2024/15:34	A11	09/Feb/2024/15:55	A11
Forecasting	2	5	09/Feb/2024/15:34	A11	09/Feb/2024/15:57	A11
Inventory management	2	5	09/Feb/2024/15:33	A11	09/Feb/2024/16:11	A11
Manufacturing	1	4	09/Feb/2024/15:34	A11	09/Feb/2024/16:02	A11
Modular systems and applications	2	8	09/Feb/2024/15:34	A11	09/Feb/2024/16:05	A11
Visibility	3	13	09/Feb/2024/15:34	A11	09/Feb/2024/16:10	A11