Investigating the impact of shipping vessel dwell times in South African harbours on supply chain efficiency

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Mini-dissertation accepted in partial fulfilment of the requirements for the degree *Master of Business Administration* at the North-West University

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DECLARATION

I hereby declare that the assignment submitted herewith to the North-West University in partial fulfilment of the requirements for the Master of Business Administration (MBA) degree is my own original work. It has been professionally text-edited in accordance with academic communication standards and has not been previously submitted to any other institution for evaluation purposes. I further declare that the study was not written by artificial intelligence (AI), but that Grammarly was used solely to correct language and grammar-related issues.

Pieter Janse van Rensburg

Date: November 2025

DEDICATION

I dedicate this work to my Heavenly Father, whose grace and blessings have guided and sustained me throughout this journey. I am deeply grateful for His favour upon my family and for granting me the strength and opportunity to complete this study.

PREFACE

This mini-dissertation has been prepared in accordance with the structural and formatting requirements prescribed by North-West University (NWU) for the Master of Business Administration (MBA) programme. The study is organised to provide a logical progression from the identification of the research problem through to the conclusions and recommendations, following a qualitative research design.

Chapter 1 introduces the study, outlining the background, problem statement, research objectives, and methodological overview.

Chapter 2 presents the literature review, exploring global and local perspectives on port performance, supply chain efficiency, and vessel dwell times.

Chapter 3 outlines the research methodology, including the approach, data collection, analysis, and ethical considerations.

Chapter 4 presents the empirical findings and thematic analysis, highlighting six key themes that illustrate the operational, financial, and systemic impacts of vessel dwell times.

Chapter 5 concludes the study by integrating the findings with theory, providing recommendations, and presenting an implementation framework for improving South Africa's port and logistics efficiency.

This research was undertaken as part of the requirements for the MBA degree at North-West University, South Africa.

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ABSTRACT

This study investigates the impact of shipping vessel dwell times in South African harbours on supply chain efficiency within the manufacturing sector. Prolonged vessel dwell times have been identified as a major contributor to production delays, increased logistics costs, and reduced international competitiveness. The research therefore seeks to understand the underlying causes, effects, and mitigation strategies associated with these inefficiencies, and to propose practical solutions for improving national port performance.

The literature review explores global and local perspectives on port efficiency, supply chain resilience, and the operational, financial, and policy factors influencing dwell time performance. Key theoretical frameworks related to logistics governance, risk mitigation, and supply chain resilience are examined to establish a conceptual foundation for the study. The review highlights persistent infrastructure challenges, governance shortcomings, and limited digital integration as critical inhibitors of efficiency in South Africa's ports.

A qualitative research design was employed, using semi-structured interviews with industry professionals from the manufacturing and logistics sectors. The data were analysed using thematic analysis to identify recurring patterns and insights. Six interrelated themes emerged, reflecting the operational, financial, and systemic consequences of prolonged dwell times. Participants emphasised that although firms employ short-term mitigation measures—such as safety stock and supplier diversification- these responses are reactive, financially unsustainable, and insufficient to address structural inefficiencies.

The findings reveal that sustainable improvement requires coordinated reform across multiple dimensions, including infrastructure modernisation, digital integration, governance restructuring, and private-sector participation. The study concludes with practical recommendations and an implementation framework aimed at restoring port reliability, reducing costs, and enhancing supply chain resilience.

Key terms: Vessel dwell times, port efficiency, supply chain resilience, logistics governance, manufacturing, South Africa

LIST OF ABBREVIATIONS

ACTs	Automated Container Terminals
AI	Artificial Intelligence
CPS	Cyber-Physical Systems
CTCT	Cape Town Container Terminal
DCT	Durban Container Terminal
DEA	Data Envelopment Analysis
FMCG	Fast-Moving Consumer Goods
GCH	Gross Crane Hour (moves per gross crane hour)
IoT	Internet of Things
IT	Information Technology
JHB	Johannesburg
KPI	Key Performance Indicator
MBA	Master of Business Administration
MCDA	Multi-Criteria Decision Analysis
MPT	Multi-Purpose Terminal
NWU	North-West University
PCS	Port Community System
PI	Physical Internet
PO	Purchase Order
PPP	Public–Private Partnership
ROI	Return on Investment
RTG / RTGs	Rubber-Tyre Gantry (crane) / Rubber-Tyre Gantry cranes
SARS	South African Revenue Service
SC	Supply Chain
SCM	Supply Chain Management
SCRM	Supply Chain Risk Management
SWH	Ship Working Hour / Moves per Ship Working Hour
TAT	Turnaround Time
TEU / TEUs	Twenty-foot Equivalent Unit(s)
TNPA	Transnet National Ports Authority
TPT	Transnet Port Terminals
UN SDGs	United Nations Sustainable Development Goals

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 NATURE AND SCOPE OF THE STUDY

1.1 Introduction

Over the past 20 years, modern society has undergone significant changes. People now live faster-paced lives, and technology has enabled individuals around the world to interact more quickly and efficiently. News spreads rapidly, keeping everyone connected in real-time. Supply chains have become essential to everyday life, with people increasingly dependent on them for goods and services.

A well-established notion in modern society is that time is money, and money is everything. The consumer market is aggressive; the quicker things get done, the better. The attention to supply chain management has never been more pronounced in history, with research by Xu et al. (2020:3508-3526) indicating a significant increase in published literature on this topic over recent years.

As Liao et al. (2017:17-23) assert, every industrial revolution in the last 200 years has been initiated by changes in production methods. Steam engines fuelled the first revolution, the second by electricity, and the third by electronics and information technology (Liao et al., 2017:17-23). Recently, the rise of the Internet of Things (IoT) and cyber-physical systems (CPS) has drawn attention to their potential to enhance interactions among people, products, and data (Khaitan & McCalley, 2014:350-364).

The fourth industrial revolution places significant pressure on supply chains, a cornerstone of the manufacturing industry, as it paves the way for the automation of manufacturing processes. Implementing automation across systems such as warehousing and operations can save considerable time, increase output and profitability, and reinforce the notion that "time is money." However, this modern manufacturing landscape presents a new challenge, as breakdowns or downtimes cannot be afforded.

As Arm et al. (2018:473-478) explain, the efficiency gains from automation mean the impact of lost time is more pronounced than ever. One way many South African companies address this issue is by investing heavily in solutions to mitigate the effects of production losses; it is more cost-effective to maintain operations than to suffer losses from downtime.

In the past five years, the world has witnessed wars and other catastrophic events that have severely impacted global supply chains. Analysing these events provides insight into the impact of a complete supply chain halt. The COVID-19 pandemic, in particular, caused significant disruptions, with container throughput at global ports plummeting. Zhao et al. (2022:91-93) reported that the ports of Los Angeles experienced a year-on-year drop of approximately 30.9%. Bai et al. (2022:224-241) noted a substantial decrease in port calls at Chinese ports that dropped from a weekly average of 1,200 containers in December 2019 to 800 in January 2020.

Despite advancements in manufacturing, transportation methods have remained relatively stagnant. Although air freight accounts for more than 35% of global trade value, as indicated by Sales & Scholte (2023:2-6), the cost-effectiveness of diesel engines for transporting goods still prevails. Delays and travel costs have posed significant challenges for manufacturing in recent years, particularly in South Africa.

South Africa's state-owned enterprise Transnet, responsible for loading and unloading ships at ports, has faced criticism for its subpar maintenance and management. A study by Gidado (2015:160-167) found that ships experienced significant dwell times at South African ports, which Chinedum (2018a:70-82) states resulted in extreme delays in supply chains. In a struggling economy, these delays have significant implications, such as fines for missed deadlines, increased inventory financing costs, and reputational damage.

Mitigation strategies must be continuously revised and analysed to remain relevant in the dynamic field of supply chain management. Therefore, further research is needed to evaluate the effectiveness of current strategies in the South African manufacturing industry and their ability to address extended dwell times.

1.2 Problem Statement

The efficient functioning of supply chains is crucial to a successful manufacturing environment, especially in today’s highly interconnected and globalised economy. Supply chain networks have become increasingly complex and interdependent; thus, delays and disruptions pose serious challenges for businesses. For the South African manufacturing industry, these disruptions are compounded by extended dwell times in the country’s harbours, where shipping vessels often experience delays before unloading or loading cargo. Dwell times, defined as the duration vessels spend waiting at port facilities, are caused by an array of complex issues at South African ports. Dwell time is a significant contributor to bottlenecks in the movement of goods, affecting both the manufacturing sector and the broader economy.

South African harbours, primarily managed by Transnet, grapple with ageing infrastructure, inadequate maintenance, and capacity constraints. These issues have been widely acknowledged in recent literature, with studies indicating that delays in South African ports are among the highest globally, often exceeding international efficiency benchmarks by over 30% in average turnaround times (Gidado 2015:160-167). These extended dwell times disrupt the flow of goods, effectively leading to increased operational costs, inventory holding expenses, and financial penalties for manufacturers who rely on timely shipments to maintain productivity. In cases where delays are prolonged, companies are forced to impose short-time working arrangements, as stipulated by the Labour Relations Act (Chinedum, 2018b:70-82), resulting in financial strain on both businesses and employees.

The impact of these delays is acutely felt within the manufacturing sector, which forms a substantial part of South Africa's economy and is a major driver of employment in the current economic climate, characterised by high unemployment and rising operational costs. These extended dwell times threaten the competitiveness of South African products in global markets and increase the overall cost burden on domestic companies.

Although various supply chain strategies have been explored globally, such as multi-sourcing and pre-positioning inventory as proposed by Kamalahmadi & Parast (2017:210-230), there is limited research focused on the specific challenges posed by dwell times within South African harbours. This lack of research presents a substantial gap, as the effectiveness of these strategies in mitigating delays caused by harbour inefficiencies remains unexamined, mainly in the South African context.

Addressing this research gap is essential, as it offers an opportunity to understand how dwell times uniquely impact the supply chains of South African manufacturers. By investigating the specific effects of these delays, this study aims to contribute valuable insights into how dwell times disrupt supply chain operations and explore practical strategies to mitigate these challenges. This research will synthesise and critically evaluate existing scholarly works to illuminate the underlying causes and effects of dwell times. Ultimately, the goal is to support the development of mitigation strategies that could enhance supply chain efficiency and resilience in South Africa's manufacturing sector. These insights have the potential to inform policy adjustments and operational improvements that will contribute to the competitiveness and sustainability of the South African manufacturing industry.

1.3 Rationale And Significance of the Study

This study aims to contribute valuable knowledge on supply chain management, specifically within the South African manufacturing industry context. Focusing on the impact of dwell times in South African harbours, this research addresses a critical gap in existing literature, as few studies have comprehensively examined how port delays affect supply chain efficiency and resilience within the South African context. The anticipated findings will offer theoretical insights into the dynamics of supply chain disruptions, providing a more nuanced understanding of how delays specific to South African harbours impede the smooth operation of interconnected supply chains.

Practically, this study will provide industry stakeholders, particularly those in manufacturing, with actionable recommendations for mitigating the adverse effects of dwell times. By identifying and analysing strategies that mitigate the impact of these delays, the study will provide manufacturers with tools to enhance supply chain resilience, reduce operational costs, and improve local and global competitiveness. Additionally, policymakers could benefit from these insights, as findings may inform infrastructure and operational improvements within South African harbours, ultimately supporting economic growth and employment stability.

This study is particularly relevant to social groups dependent on manufacturing jobs, as improved supply chain efficiency has the potential to stabilise employment by ensuring uninterrupted production. Additionally, the research could benefit scholars in supply chain management, logistics, and economic policy, providing them with a deeper understanding of how port delays impact the South African economy. This research thus holds significance for a wide array of stakeholders, including supply chain professionals, industry executives, policymakers, and scholars interested in enhancing South Africa’s industrial capabilities in the face of logistical challenges.

1.4 Aim and Objectives of the Study

1.4.1 Aim

This study aims to investigate the impact of shipping vessel dwell times in South African harbours on the efficiency of supply chain operations within the manufacturing sector. In doing so, the study seeks to identify the underlying causes, assess the operational and financial implications, and propose effective mitigation strategies to enhance supply chain resilience and improve overall performance.

1.4.2 Primary Objective

In line with the research aim and problem statement, the primary objective of this study is:

To examine how shipping vessel dwell times influence supply chain efficiency in South African harbours and to identify strategic interventions that can mitigate their adverse effects on manufacturing operations.

1.4.3 Secondary Objectives

To achieve the primary objective, the following secondary objectives have been formulated:

- *Secondary Objective 1: To evaluate the effects of vessel dwell times on key dimensions of supply chain efficiency in South Africa's manufacturing sector, including productivity, costs, and delivery reliability.*
- *Secondary Objective 2: To identify and assess the current mitigation strategies employed by industry stakeholders to manage delays arising from extended vessel dwell times.*
- *Secondary Objective 3: To propose refined or innovative mitigation strategies tailored to the unique infrastructural, operational, and policy challenges of South Africa's port logistics environment.*
- *Secondary Objective 4: To determine the potential benefits of implementing the proposed strategies in enhancing supply chain resilience and supporting policy recommendations aimed at improving port efficiency.*

1.5 Purpose Statement

This study aims to shed light on the significant effects of dwell times of shipping vessels in South African harbours on supply chain operations within the manufacturing industry. By understanding the specific consequences of these delays and identifying effective mitigation strategies, this research aims to provide policymakers, industry stakeholders, and supply chain practitioners with valuable insights. Ultimately, the findings of this study have the potential to inform decision-making processes, enhance supply chain efficiency, and bolster the resilience and competitiveness of the manufacturing sector in South Africa.

1.6 Scope of Study

The research focuses on the dwell times of shipping vessels in South African harbours, particularly in ports such as Durban, Cape Town, and Port Elizabeth, and their impact on supply chain operations within the diverse sectors of the South African manufacturing industry. This investigation examines the unique challenges presented by South African harbour infrastructure, regulatory frameworks, and geographical factors, providing insights tailored to the dynamics of the manufacturing sector in this context.

CHAPTER 2 LITERATURE REVIEW

2.1 Background to the Study

Supply chains are the backbone of the global economy. Over time, they have been defined in various ways, reflecting their evolving role in supporting economic activities. However, for this study, the definition provided by Mentzer et al. (2001:7) is particularly relevant. As mentioned in their work, a supply chain can be understood through three key perspectives:

1. A systems approach, which views the supply chain as a whole and emphasises managing the total flow of goods and inventory from the supplier to the ultimate customer.
2. A strategic orientation, focusing on cooperative efforts to synchronise and align both intrafirm and interfirm operational and strategic capabilities into a unified system.
3. A customer-centric approach, aimed at creating unique and personalised sources of customer value, ultimately resulting in customer satisfaction.

These perspectives provide a comprehensive framework for understanding supply chains and their pivotal role in today's interconnected world. This study will focus on point one, as defined by Mentzer et al. (2001:7), delving into the flow of goods and inventory from the supplier to customers.

2.2 Overview of Global Shipping Dynamics

Maritime transportation can be defined as "a means to transfer goods (or people) via sea routes" (Lau et al., 2024:3-5). This concept is not new. Significant evidence suggests that ancient Egypt was among the first civilisations to use sailing ships for coastal trade, as indicated in a study done by Weshahy. (2021:141). From the ancient Egyptians to the Dutch East India Trading Company, transporting goods by boat has been a fundamental part of human history. It will undoubtedly remain a vital aspect of our future.

However, there has been a major shift in how goods are transported via sea freight today compared to the past. Lau et al. (2024:4) state this shift is primarily attributed to the standardisation of freight by containers, which has led to economies of scale and the ability to transport goods over long distances more efficiently. These economies of scale are evident in data from (STATISTA, 2022), which shows that container deadweight tonnage grew from 11 million metric tonnes in 1980 to approximately 293 million in 2022.

Today, over 80% of the world’s trade by volume is transported by sea (Lau et al., 2024:4), making shipping the most cost-effective method for moving large quantities of goods over long distances. Shipping connects producers and consumers worldwide, facilitating the flow of raw materials, manufactured products, and energy resources. Its central role in the global supply chain highlights the importance of efficient maritime logistics in maintaining economic stability.

Freight transported via sea can broadly be categorised into three main types: containerised, bulk, and specialised cargo (Santos et al., 2022). Containerised freight includes manufactured goods packaged into standardised shipping containers, offering flexibility and efficiency in handling. Bulk freight is divided into dry bulk, such as coal, grain, and minerals, and liquid bulk, including oil and chemicals, which require specialised vessels. Specialised cargo, such as vehicles or oversized equipment, necessitates customised handling and transport solutions. The diversity of freight types influences shipping strategies and port operations, as different goods demand specific storage, handling, and regulatory considerations.

The standardisation of shipping methods was a game-changer for supply chains. The holistic process involves several stages, beginning with cargo booking, then loading onto vessels, transporting across the sea, unloading at the destination port, and finally, delivery to the end customer (Lam et al., 2007). Shipping liners operate dedicated vessels that follow specific routes back and forth. Depending on the discharge and destination ports, a specific vessel is assigned based on cargo requirements, space availability, and the vessel's schedule for port calls on the day of discharge.

Freight forwarders and logistics providers coordinate these activities to ensure seamless operations. Efficient customs clearance, documentation management, and cargo handling at ports are essential for minimising delays. A well-managed shipping process depends on synchronised efforts among stakeholders to maintain schedules and reduce costs, making it a vital component of modern supply chains.

2.2.1 The Role of Harbours in The Supply Chain

Ocean freight is a critical piece in the global puzzle of supply chains, and several key stakeholders are involved, each playing a crucial role in ensuring smooth operations. Shipping lines provide the vessels and transportation routes, while freight forwarders handle logistics and documentation. Port authorities oversee the infrastructure and services required for vessel docking and cargo handling. Terminal operators manage loading and unloading, while customs authorities ensure compliance with regulations and taxation. Collaboration between these stakeholders is essential to ensure the efficient movement of goods, reduce bottlenecks, and meet customer demands.

A harbour is a central hub for loading and discharging containers; thus, it plays a crucial role in the functioning of global supply chains, serving as the interface between sea and land transportation. As key nodes in maritime logistics, harbours facilitate the smooth transfer of goods from vessels to trucks, trains, or warehouses, ensuring the continuity of the supply chain. Their strategic location and infrastructure enable harbours to handle large cargo volumes efficiently, supporting international trade and local economies.

Dowgiewicz. (2022:4-5) states that a harbour's primary function is to provide a safe docking area for vessels to load and unload cargo. This process involves specialised equipment such as cranes, container terminals, and bulk cargo handling facilities. Beyond handling physical goods, harbours are also responsible for managing the flow of information and documentation required for customs clearance and regulatory compliance. These processes ensure goods move swiftly through the supply chain without unnecessary delays.

Modern harbours are undergoing a significant transformation as they increasingly adopt advanced technologies and automation to enhance efficiency. Automation in container terminals, pioneered by the Port of Rotterdam almost 30 years ago (Dowgiewicz, 2022:3-5), is now seen as a driver of cost reduction and reliability in maritime logistics. Automated container handling systems, digital tracking platforms, and port community systems streamline operations, improve cargo movement accuracy, and reduce vessel turnaround times. However, despite these advancements, approximately 97% of container terminals worldwide remain non-automated, with many struggling to achieve the anticipated productivity levels and cost benefits due to fragmented supply chain integration (Hsu et al., 2024).

When automation is configured and employed appropriately, container terminals can transform into reliable and flexible logistics hubs. Kusumawati et al. (2023:58) assert that this can result in predictable flows of containers in and out of terminals, allowing harbours to act as pivotal links between maritime and inland transport. These hubs also offer value-added services, such as warehousing, cargo consolidation, and distribution, enabling businesses to centralise logistics activities near import or export points. Such integration helps optimise supply chain operations while supporting regional economic development by creating jobs, attracting investment, and connecting local businesses to global markets.

In this context, technological progress, such as the implementation of automated container terminals (ACTs), offers a pathway to consistency. Ports with advanced automation and integrated supply chain systems can better manage disruptions, maintain predictable cargo flows, and enhance overall supply chain reliability (Dowgiewicz, 2022). Harbours remain indispensable in global trade, serving as the backbone of modern supply chain networks by adapting to the demands of an increasingly interconnected and volatile world.

2.2.2 The Role of South African Harbours

South African harbours serve as critical gateways for trade, connecting regional and international markets. Positioned along key global shipping routes, the country's major ports, namely Durban, Cape Town, Port Elizabeth, and Richards Bay, play a vital role in facilitating the movement of goods between Africa and the rest of the world. Kgwedi & Gabedava (2023:48) highlighted that these harbours not only support South Africa's imports and exports but also act as trans-shipment hubs for neighbouring landlocked countries such as Zimbabwe, Botswana, and Zambia, linking them to global supply chains.

South African ports are crucial to the larger supply chain because of the variety of goods they handle. As the busiest port in Africa, Durban is a key hub for importing and exporting manufactured products due to its expertise in containerised commodities (Mthembu & Naude, 2023:206). Havenga et al. (2023:4) note that South Africa's ports have a distinct function in the cargo they handle. Richards Bay is a leader in bulk cargo, especially coal, while Cape Town is crucial in exporting agricultural products, such as fruit, to foreign markets. All these ports work together to boost regional commerce and allow South Africa to become part of the global economy.

As the state-owned company in charge of freight logistics in South Africa, Transnet is essential to administering and operating the nation's principal harbours. It manages the construction, upkeep, and operation of South Africa's port infrastructure through its subsidiary, the Transnet National Ports Authority (TNPA) (Konstantinus & Woxenius, 2022:2065). Konstantinus & Woxenius (2022:65) state that the mandate of TNPA includes ensuring the harbours serve the nation's internal and regional logistical requirements and act as effective entry points for international trade.

The bulk of South Africa's imports and exports are handled by the eight commercial ports that Transnet oversees, including Richards Bay, Cape Town, Durban, and Port Elizabeth. The TNPA oversees these ports, maintains records of their infrastructure, and ensures compliance with international regulations. Another division, Transnet Port Terminals (TPT), handles bulk, breakbulk, and container freight (Konstantinus & Woxenius, 2022:2026).

While all the ports in South Africa are primarily state-owned and managed by TNPA, private-sector involvement is on the rise. Mazibuko et al. (2024:24) observed an increase in private sector participation, particularly through terminal concessions and public-private partnerships. Private companies operate specific terminals or facilities within the ports under concession agreements. The largest facility where this practice is observed is the Richards Bay Coal Terminal, privately owned by a consortium of coal mining companies and serving as a specialised export terminal.

Additionally, public-private partnerships have been leveraged to enhance port infrastructure and operational efficiency by incorporating private sector expertise and investment (Matekenya & Ncwadi, 2022:15). Beyond the ports, private companies also operate dry ports and warehousing facilities, which complement seaport activities by facilitating inland cargo movement and reducing congestion at port terminals (Mthembu & Naude, 2023:200-205). While these elements demonstrate significant private sector involvement, South Africa does not have fully private ports. TNPA retains control over port infrastructure, regulatory oversight, and strategic development to align port operations with national economic and trade objectives.

In conclusion, South Africa's ports are integral to the global freight forwarding supply chain, where efficient operations are essential for meeting delivery timelines. Any delays or disruptions at these ports can have a cascading effect on subsequent port calls, resulting in increased time and costs for cargo movement and ultimately impacting the entire supply chain.

2.2.3 Measuring The Efficiency of a Port

The efficiency of a harbour is a critical determinant of its performance and contribution to regional and global supply chains. As ports have evolved from simple cargo transfer points into complex logistics hubs, the methods used to measure their efficiency have also become more comprehensive. Evaluating harbour performance involves examining various aspects, including operational output, financial management, service quality, connectivity, and sustainability. Together, these factors provide a holistic view of a port's capabilities and ability to meet modern trade demands.

The efficiency of a harbour is fundamental to its role in global supply chains. Ports are critical nodes where goods are transferred between seaborne and land-based transport systems. Measuring their efficiency requires a multidimensional approach that evaluates operational, financial, and sustainability metrics (Song, 2021:2). Operational metrics, such as throughput, the volume of cargo handled in twenty-foot equivalent units (TEUs) and vessel turnaround times, are key productivity indicators. Efficient ports aim to reduce congestion, optimise cargo handling, and ensure faster vessel operations (Song, 2021:5)

The efficiency of a harbour is a crucial determinant of its performance in global supply chains. Ports are complex logistical nodes where goods transition between sea and land transportation systems. To assess their performance, various metrics are used, including operational metrics, such as cargo throughput, berth occupancy rate, and vessel turnaround time. Chinedum (2018a:71) defines cargo throughput as the total volume of goods handled within a port, which directly correlates with other operational indicators such as berth occupancy and vessel waiting times. Efficient ports aim to minimise vessel turnaround time and berth congestion, which is critical for reducing shipping delays.

A key indicator is cargo dwell time, which measures the duration goods remain at the port before being transported inland. High dwell times are indicative of inefficiencies and often result in port congestion. As highlighted by Chinedum (2018a:74), African ports, on average, exhibit longer dwell times compared to global benchmarks, which hampers trade competitiveness. Durban, for instance, maintains an average of four days for cargo dwell time, positioning it as one of the more efficient ports in the region.

Financial performance is critical to port efficiency and is assessed through metrics such as port charges, handling costs per unit, and return on investment (ROI). These metrics are crucial for assessing a port's capacity to generate revenue while maintaining competitive pricing. Musso et al. (2006:173) state that port investments play a pivotal role in driving profitability and economic impact, with financial strategies often balancing public and private interests. Efficient pricing structures are integral to achieving this balance. Meersman (2014:10) highlights that port charges, including terminal handling costs and cargo-related fees, significantly influence a port's financial viability and competitiveness.

Ports with sound financial management can attract more business by offering competitive rates without compromising profitability. As highlighted by Musso et al. (2006:176), the strategic allocation of public and private investments ensures that ports remain competitive, even in highly contested markets. Additionally, Meersman et al. (2014:12) discuss how pricing schemes impact overall efficiency, influencing user decisions and promoting equitable cost distribution. These considerations are particularly relevant in an era of intense global competition, where ports must consistently invest in infrastructure and technology to remain efficient and profitable.

Connectivity is a critical measure of port efficiency, reflecting a port's ability to integrate seamlessly into global and regional logistics networks. Intermodal connectivity, which includes the integration of rail, road, and port infrastructure, is essential for efficient cargo movement. South Africa's ports, such as Durban, Cape Town, and Richards Bay, face significant challenges in achieving this integration. For instance, congestion and underinvestment in infrastructure at Cape Town port have exacerbated inefficiencies, while equipment breakdowns and intermodal bottlenecks at Durban port have led to delays in cargo movement (K Tulsi, 2024:3)

The broader regional trade landscape highlights the implications of poor connectivity. The construction of the Trans-Kalahari Railway to a Namibian port, bypassing South African ports, exemplifies a shift in regional trade dynamics caused by inefficiencies in South African intermodal systems. Such developments pose economic risks, including reduced competitiveness and the potential loss of South Africa's status as a primary regional trade route (K Tulsi, 2024:4)

To address these challenges, enhancing intermodal connectivity is imperative. Improvements in rail infrastructure, road linkages, and terminal integration are essential to streamline operations and bolster the reliability of South African ports. Strategic partnerships and policy adjustments are also required to strengthen the country's role in regional trade and prevent further shifts in trade routes away from South African ports (Mathebula, 2023:46).

The quality of service a port provides is a vital metric of its efficiency, with customer satisfaction playing a central role. Penceliah & Sreenivasan (2020:96) state that service quality encompasses several factors, including reliability, transit times, and the ability to meet customer expectations. However, Penceliah & Sreenivasan (2020:111) note that challenges persist for smaller companies operating in the port environment. These firms often struggle to compete in a monopolistic setting dominated by more prominent, financially robust players with superior connectivity. Such dynamics underscore the importance of ports in ensuring equitable service delivery and maintaining customer satisfaction.

Agility and responsiveness have also become critical in modern supply chains, as ports must provide real-time solutions to address fluctuating demands. As noted in South Africa, customer satisfaction and service delivery are crucial for ensuring competitiveness in today's challenging port sector (Penceliah & Sreenivasan, 2020:114). Ports that prioritise these aspects can strengthen their position as critical nodes in global logistics networks and better adapt to evolving market demands.

In recent years, sustainability has emerged as a measure of port performance, reflecting the growing emphasis on environmentally friendly practices within the maritime industry. Ports are under increasing pressure to adopt initiatives for emissions reduction, noise control, waste management, and energy efficiency. Lim et al. (2019:59) mentioned these sustainability metrics highlight a port's commitment to environmental responsibility and enhance its attractiveness to stakeholders prioritising green initiatives.

The research done by Lim et al. (2019:59) indicates that sustainable development practices in ports contribute to long-term operational efficiency and service quality. Adopting green port management systems, such as the Eco Ports framework implemented in Europe, has enabled ports to benchmark their environmental performance against established standards, promoting cooperation and knowledge sharing. While sustainability initiatives may require significant upfront investments, they often lead to economic benefits in the long run, including enhanced competitiveness and alignment with global environmental goals (Hossain et al., 2021:8).

Integrating sustainability into port operations requires collaboration among diverse stakeholders, including governments, local communities, and private organisations. According to Alamoush et al. (2021:32-35), policies and frameworks that incentivise eco-friendly technologies, efficient resource management, and sustainable infrastructure development are essential for achieving meaningful progress. By prioritising sustainability, ports can balance environmental, economic, and social goals, ensuring their continued relevance and competitiveness in a rapidly evolving global trade environment.

The multifaceted nature of port operations means that measuring efficiency often involves using multi-criteria decision analysis (MCDA). This approach considers factors such as operational productivity, financial performance, connectivity, and sustainability, allowing ports to balance competing priorities. MCDA provides port authorities with a structured framework for decision-making, enabling them to align their strategies with market needs and stakeholder expectations (Fahim et al., 2022:88).

Physical Internet (PI) has added new dimensions to port efficiency. The PI emphasises hyperconnectivity, digitalisation, and modular logistics, requiring ports to function as active nodes in a dynamic network. In this context, metrics such as network interconnectivity and advanced information systems have become increasingly important. Ports must now leverage real-time data, automation, and digital platforms to remain competitive and responsive in a rapidly evolving logistics landscape (Fahim et al., 2022:88).

Measuring the efficiency of a harbour is a complex process that requires a multidimensional approach. Ports must continually adapt to the demands of global trade by focusing on operational excellence, financial stability, robust connectivity, high-quality service, and sustainability. By integrating these metrics into their evaluation frameworks, ports can enhance their performance and reinforce their position as critical nodes in global supply chains. Advanced tools, such as MCDA, and emerging concepts, like the PI, offer valuable opportunities for ports to remain agile and competitive in an increasingly interconnected world.

2.3 Supply Chain Efficiency

Supply chain efficiency is a cornerstone of modern supply chain management. Borgström (2005) explains that it involves the optimal utilisation of resources, such as materials, labour, and time, to produce and deliver goods at the lowest possible cost while maintaining high quality. Efficiency is an internal performance measure, whereas supply chain effectiveness assesses how well the supply chain meets external customer demands (Pfeffer & Salancik, 2015). Achieving a balance between these constructs is critical, as they are both interdependent and dynamic within the context of the supply chain.

2.3.1 Defining Supply Chain Efficiency

Supply chain efficiency involves reducing waste, improving operational workflows, and ensuring that goods and services are delivered on time and at the lowest cost. Efficiency in a process environment refers to the ability to maximise output while minimising input through effective resource utilisation.

Supply chain processes are an essential part of manufacturing and trade. Supply chain efficiency specifically focuses on optimising logistics, reducing lead times, improving coordination between stakeholders, and ensuring the timely delivery of goods and services at the lowest possible cost. A study done by Davuluri (2023:13) found that efficiency is often assessed through metrics such as inventory turnover ratios, order accuracy, and the perfect order index, which measures the percentage of orders delivered on time, complete, and damage-free. Achieving high efficiency must be balanced against the need for effectiveness.

The distinction between supply chain efficiency and effectiveness lies in their core objectives and areas of focus. Borgström (2005:5) defines efficiency as primarily targeting the optimisation of internal processes, emphasising cost minimisation and resource utilisation. At the same time, effectiveness is outwardly focused, aiming to meet or exceed customer expectations by delivering the right product at the right time and place.

While efficiency often prioritises lean operations, reducing waste, and streamlining workflows, effectiveness ensures that the supply chain is adaptable and responsive to market demands. The most successful organisations recognise the interplay between these two dimensions. According to Snyder & Shen (2019:3-5), by balancing efficiency with effectiveness, they achieve operational excellence without sacrificing their ability to meet customer needs. This balance ensures that the supply chain remains both cost-efficient and resilient in responding to dynamic market conditions.

2.3.2 The Importance of Supply Chain Efficiency

Supply chain efficiency is critical for organisations seeking to maintain competitiveness and improve overall performance. An efficient supply chain delivers multiple benefits, including cost reduction, improved responsiveness, and enhanced competitiveness. Streamlining operations enables organisations to reduce lead times, optimise inventory levels, and minimise waste, resulting in significant cost savings. Efficient supply chains are more agile, enabling organisations to adapt to market changes swiftly and respond effectively to customer demands and external disruptions. In highly competitive markets, where profit margins are often thin, supply chain efficiency becomes a critical differentiator, allowing organisations to outperform competitors (Sari & Al Azhar, 2016:59).

SMEs leverage supply chain efficiency through practices such as inventory management and supply chain integration. There are several theories on managing inventory to achieve efficiency, as stipulated by Kamalahmadi & Parast (2017:210-230). These theories include the Pre-positioning Inventory Model, the Backup Suppliers Model and the Protected Suppliers Model. Other theories exist but are beyond the scope of this study.

The Pre-positioning Inventory Model, as identified by Kamalahmadi & Parast (2017:3), is a model that describes a strategy for warehousing key parts to prevent supply chain disruptions, representing the concept of pre-positioning inventory, also known as operational slack. This theory involves maintaining buffer stocks to ensure production continuity in the event of supplier failures. While this strategy can mitigate disruptions and enhance resilience, it introduces higher costs and challenges to lean management practices, making it particularly suitable for items with low holding costs and non-perishability.

The name of the Backup Suppliers Model is self-explanatory. Tomlin & Wang (2011:79-101) describe this theory as a backup supplier that serves as a secondary supplier activated only when a primary supplier is disrupted, ensuring material flow continuity. Unlike pre-positioning inventory, where the firm holds the stock, the backup supplier holds the inventory. This mitigation tactic differs from multi-sourcing, as backup suppliers are utilised only when primary suppliers are unavailable.

The theory of protected suppliers involves fortifying suppliers to enhance their reliability and resilience against disruptions. This strategy, highlighted by Boudreau et al. (2015:3-25), focuses on optimising supplier selection and resource allocation to minimise costs and ensure continuous supply chain operations during crises. In the manufacturing industry, implementing robust supply chain strategies, as outlined by Tang (2006:33-45), such as Dynamic Assortment Planning, Strategic Stock, and "Make and Buy" has proven effective in minimising losses associated with downtime and achieving a high level of supply chain efficiency in product throughput.

These strategies have enabled firms to achieve competitive pricing and higher customer satisfaction, increasing sales and market share (Sari & Al Azhar, 2016:58-60). Miyare (2014:35) states that a focus on operational efficiency highlights how streamlined supply chain processes can reduce logistics and financing costs, directly boosting profitability and achieving a competitive advantage.

Competitive advantage refers to an organisation’s ability to outperform competitors by delivering unique value through superior products or services. Supply chain efficiency plays a crucial role in this by optimising core processes such as procurement, production, and distribution (Miyare, 2014:34). Key dimensions of efficient SCM practices include strategic supplier partnerships, customer relationship management, information sharing, and postponement (Li et al., 2006:110). Research by Jamaludin (2021:701) demonstrates that efficient supply chain practices enhance product quality, reduce costs, and shorten time to market, all critical factors for achieving competitive advantage.

Organisational performance and the achievement of financial and operational outcomes are closely linked to supply chain efficiency (Li et al., 2006:115). Efficient supply chains enable firms to optimise resource utilisation, minimise operational costs, and ensure customer satisfaction. In SMEs, efficient supply chain practices have a positive correlation with operational performance, as streamlined processes lead to better financial returns and enhanced market positioning (Jamaludin, 2021:704-705).

2.3.3 Differences In Supply Chains

Supply chains vary significantly in their structure, strategies, and objectives, depending on the nature of the goods or services involved. These differences influence how efficiency is achieved and the role that shipping plays within each supply chain model. There is a clear distinction between service-based and asset-intensive supply chains, with shipping contributing to operational efficiency in the latter, which rely on the movement of physical goods.

The main difference between service-based and asset-intensive supply chains is their focus and dependence on shipping. Ellram et al. (2004:17-32) define service-based supply chains, such as those supporting digital platforms, as focusing on real-time responsiveness and resource optimisation. The efficiency of these supply chains is primarily achieved through digital tools, data analytics, and algorithms. According to Johnson & Mena (2008:2-3), these supply chains usually do not involve transporting physical goods, meaning shipping has a limited role. Instead, the emphasis is on managing demand and supply within local networks.

Asset-intensive supply chains are highly dependent on the movement, storage, and management of physical goods. A study done by Abbey & Guide (2017:15-20) highlights that manufacturing, retail, and logistics industries rely heavily on shipping to facilitate the transportation of raw materials. As highlighted by Sigalas (2024:2-4), resource allocation decisions in asset-intensive industries are crucial for enhancing shipping efficiency. These decisions are vital for reducing transit times, optimising costs, and ensuring the timely delivery of goods in optimal condition. In global supply chains, shipping is fundamental in driving overall operational efficiency (Sigalas, 2024:16-17).

Cost optimisation is one of the most significant ways shipping goods contributes to efficiency in asset-intensive supply chains. In the modern economy, products are increasingly indistinguishable from one another and can be compared to similar products on the market that perform the same function. As a result, the price point of a product has become a key consideration, with customers opting for products that can perform the same function at a lower market entry price.

Maritime shipping offers substantial cost advantages, particularly when large volumes of goods are transported. The economies of scale achieved by using larger vessels and containers reduce the per-unit logistics cost, making it a cost-effective solution for global shipping needs. This ability to transport goods in bulk allows companies to minimise logistics expenses while maintaining the flow of goods over long distances.

2.3.4 Metrics To Measure Supply Chain Efficiency

Organisations must adopt a range of metrics that enable them to assess and monitor their supply chain performance. According to Singh (2022:2), these metrics provide invaluable insights into various aspects of the supply chain, from order fulfilment to inventory management. Four key metrics commonly used to measure supply chain efficiency are the Perfect Order Index, On-Time Delivery Rate, Inventory Turnover Ratio, and Order Accuracy Rate (Singh, 2022:2-5).

One of the most comprehensive metrics is the Perfect Order Index. The research done by Jacyna-Gołda et al. (2019:3) highlights that this metric assesses whether an order is delivered on time, without damage, and with the correct documentation. A high Perfect Order Index indicates that an organisation effectively manages its supply chain processes and consistently meets customer expectations. It combines multiple elements of the order fulfilment process, offering a holistic view of how well the supply chain is performing. A low score in this area often highlights issues in areas such as logistics, packaging, or order processing, all of which are crucial for customer satisfaction (Jacyna-Gołda et al., 2019:32-35).

Another vital metric is the On-Time Delivery Rate, which tracks the percentage of orders delivered within the promised timeframe. Liu et al. (2021:5) affirm that this metric is significant for industries where timely delivery is a competitive differentiator. A high On-Time Delivery Rate signifies that the supply chain operates efficiently, with minimal delays or disruptions. Conversely, a low rate may indicate problems with production schedules, transportation, or inventory management. As businesses increasingly focus on customer satisfaction, ensuring that orders arrive on time is fundamental to supply chain success (Liu et al., 2021).

The Inventory Turnover Ratio is another key metric that measures how frequently a company sells and replaces its inventory within a specified period. As highlighted by Syvänen (2023:8-12), a high turnover rate suggests that a business is managing its inventory efficiently, reducing the risk of overstocking or stockouts. It indicates that products are moving quickly through the supply chain, typically a sign of strong demand and effective inventory management. An excessively high ratio could also indicate that a company is understocked, potentially resulting in lost sales opportunities. Balancing inventory levels is therefore critical to maintaining efficient supply chain operations (Syvänen, 2023:6).

The Order Accuracy Rate measures the percentage of orders processed and delivered correctly, without any discrepancies or errors. A study by Narayanan et al. (2019:480) demonstrates that this metric is crucial for assessing the supply chain's performance in handling orders during processing and delivery stages. A high Order Accuracy Rate demonstrates effective communication, proper inventory management, and accurate picking and packing processes. Mistakes in this area can lead to customer dissatisfaction, increased returns, and additional operational costs, making it an essential metric to track for any organisation focused on continuous improvement (Narayanan et al., 2019:480-484).

These metrics play a pivotal role in evaluating supply chain efficiency. By regularly measuring and analysing these metrics, organisations can identify areas for improvement, optimise their operations, and ultimately enhance customer satisfaction. The ability to monitor and refine supply chain performance is a critical component of business success in today’s competitive and fast-paced market environment.

2.3.5 Global Disruptions

In the past five years, the world witnessed the breakout of wars, horrific fires, and even a worldwide lockdown brought upon by the COVID-19 pandemic. By critically analysing the impact of some of these events, a comprehensive picture can be formed of exactly how overwhelming a complete stop can be for a supply chain. The COVID-19 pandemic created a blockage in the supply chain for up to two years in specific companies, and this can be construed as the most dramatic and widespread event. For a long time, it will be analysed for its effects. According to Zhao et al. (2022:91-100), the container throughput at all ports worldwide plummeted. The ports of Los Angeles experienced the most significant year-on-year drop, at approximately 30.9%.

Various harbours recorded a record-breaking backlog in shipping containers during the epidemic, with China experiencing this issue from the start. Bai et al. (2022:4-6) state that the number of port calls at all Chinese ports dropped from a weekly average of 1,200 containers in December 2019 to an average of 800 containers in the first week of January 2020. After the initial shock of the epidemic subsided, supply chains had to restart and re-establish their pace as organisations worked their way back to normal. However, the certainty of the unforeseen persists as the “new normal” sets the wheels in motion for the Ukraine-Russia war. As mentioned by Cui et al. (2023:2-7), the war has significantly impacted every supply chain importing and exporting goods to and from Russia, as worldwide sanctions were implemented against them.

2.4 Shipping Vessel Dwell Times

Shipping vessel dwell time refers to a vessel's period at a port, from arrival to departure (Aminatou et al., 2018). This metric is a critical indicator of port efficiency, as prolonged dwell times can disrupt supply chains, inflate costs, and diminish competitiveness. Several interconnected factors contribute to extended dwell times at South African ports, and each requires attention.

2.4.1 South African Port Performance

The infrastructure of a port serves as the backbone for its operations. Seamless connectivity between mechanical components, such as cranes, and integrated technology is essential to ensure optimal functionality. Operational downtime can severely hinder a port's efficiency if proper maintenance schedules and timely upgrades are not in place. According to Makgopa (2024:3), South African ports face chronic issues due to decades of underinvestment, culminating in ageing equipment and reduced operational capacity, as evidenced by Transnet’s operational performance data.

Despite isolated improvements, Transnet's operational performance for 2023/24 reveals persistent challenges. Container volumes, although showing a 2.9% increase to 4,152,288 TEUs, remain below historical levels, as shown in Figure 1 below.

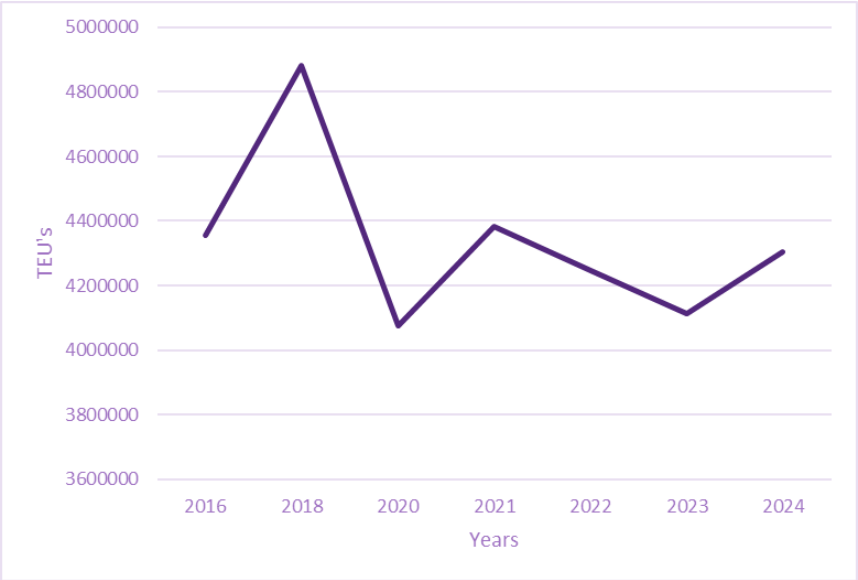

Figure 1:Transnet's containerised cargo volumes handled (Source: TRANSNET, 2024b)

According to the annual report by Transnet (2024a:8), systemic issues such as frequent equipment breakdowns, adverse weather conditions, and significant rail supply disruptions, including widespread cable theft, continue to hinder sustainable progress.

The annual report for 2023/24 showed that the performance of container terminals demonstrated uneven results, with key operational metrics declining across most ports. Moves per ship working hour (SWH) and gross crane hour (GCH) were particularly affected. The Durban Container Terminal (DCT), Pier 1's SWH fell from 39 moves in 2022/23 to 34 in 2023/24, while the Cape Town Container Terminal (CTCT) reported a decline in GCH from 17.5 to 15.5 moves per hour (TRANSNET, 2024a:8). These reductions were primarily attributed to equipment unavailability and weather-induced delays. Additionally, CTCT experienced a 10.4% drop in container volumes, exacerbated by vessel omissions, industrial action, and environmental factors.

In the bulk and break-bulk sectors, volumes stagnated at 71.6 million tonnes per annum (mtpa), with a 1.7% decline in iron ore shipments due to rail supply issues and labour disruptions. Break-bulk volumes fell by 2.5%, with notable declines at terminals such as Maydon Wharf and Richards Bay Multi-Purpose Terminal (MPT). Despite some isolated improvements at the Durban MPT, these gains were insufficient to offset broader declines.

Persistent equipment challenges remain critical, with cranes and rubber-tyre gantry cranes (RTGs) operating well beyond their design life. While Transnet has initiated a recovery plan, including acquiring seven second-hand RTGs for the Cape Town Container Terminal, these measures provide only temporary relief (TRANSNET, 2024a). The broader impact of load-shedding, geopolitical tensions, and inflationary pressures continues to exacerbate delays and operational costs, further limiting the efficiency of South African ports.

2.4.2 Turnaround Time

Turnaround time (TAT) is a crucial performance indicator in logistics and transportation, reflecting the efficiency with which cargo or vehicles are processed and cleared within a facility. In South Africa, where the transportation and logistics sectors play a vital role in supporting regional and global trade, TAT is significant. Delays in TAT can impair supply chain efficiencies, inflate costs, and erode the competitiveness of South African ports and rail systems on the international stage.

Optimising TAT is, therefore, integral to South Africa's goal of remaining a competitive global trading partner. Faster TAT improves customer satisfaction, reduces operational costs, and enhances port utilisation rates. Achieving these benefits requires comprehensive systemic interventions, including significant infrastructure upgrades, improved labour relations, and robust stakeholder engagement. Technological innovations such as automated systems and predictive maintenance tools could significantly enhance operational efficiency.

Studies by Gidado (2015:160-167) highlight the impact of prolonged TAT on South African ports, noting that ships experience considerable dwell times due to inefficient processing. During the investigation (Chinedum, 2018a:70), it was discovered that these prolonged dwell times severely disrupt South African supply chains, exacerbating the challenges faced by the logistics sector.

The economic implications of these delays are especially pronounced in a struggling economy like South Africa's. For manufacturers, these delays often lead to significant operational disruptions, with companies forced to implement reduced working hours in line with the Labour Relations Act 66 of 1995, where workers may stay at home without compensation. The financial consequences of these delays are multifaceted, including fines for missed deadlines, increased costs due to prolonged inventory financing, and reputational damage resulting from missed deadlines.

2.4.3 Port Congestion

Port congestion remains a persistent issue that undermines the efficiency of global seaports. It manifests as delays in various operational stages, including cargo handling, vessel berthing, and transactional processes. Research has highlighted that factors such as limited port capacity, inefficiencies in cargo throughput, and elevated berth occupancy rates significantly contribute to these challenges (Bray et al., 2015). Chinedum (2018a) states that congestion is closely linked to extended dwell times, encompassing delays in cargo storage, operational processes, and other logistics bottlenecks

A study by Ojadi & Walters (2015:14) on Lagos seaports identified key barriers to improving port efficiency. Among these are inadequate transport networks, the absence of streamlined supply chain practices, and mismanagement within government and private entities operating at the ports. Additionally, systemic issues such as corruption and fraudulent activities further aggravate delays, causing ripple effects throughout the supply chain.

2.4.4 Labour And Skills Gaps

Labour and skills shortages are a significant concern for South Africa's port systems, impacting the efficiency and overall performance of maritime operations. According to the TNPA (2023:6-15), there is a pronounced deficit in skilled maritime professionals, including master mariners, pilots, marine engineers, and general-purpose ratings. This skills gap contributes to inefficiencies in ship docking, navigation, and overall port operations, with approximately 20% of pilot positions, 26% of tug master positions, and 24% of marine engineering roles unfilled (Transnet National Ports Authority, 2018).

The ageing workforce exacerbates this issue, as fewer younger professionals enter the maritime industry due to limited training opportunities and the scarcity of South African-flagged ships for practical experience. According to Chetty & Moodley (2022:8-10), the absence of adequate workforce planning and technological systems to manage maritime operations compounds delays and operational inefficiencies. Compared to international benchmarks, South African ports have a higher ratio of pilots to tugboats, leading to increased costs for shipping lines. Addressing these labour and skills gaps is crucial to enhancing port performance and meeting the demands of the maritime sector.

2.4.5 Inefficiencies In Freight Handling

Freight handling inefficiencies represent another key challenge facing South Africa's ports. Chetty & Moodley (2022:7-10) concluded that these inefficiencies stem from outdated infrastructure, insufficient equipment, and poor coordination among stakeholders in the logistics chain. The ageing fleet of tugboats, workboats, and cranes is particularly problematic, with many crafts operating well beyond their intended lifespan. According to TNPA (2021), most tugboats in South African ports are between 16 and 30 years old, with only eight out of 31 being under 10 years old. The underutilization of marine crafts has resulted in delays in cargo handling, increased turnaround times, and reduced overall throughput.

The lack of integrated technology systems for freight management contributes to miscommunication and scheduling issues. Mthembu & Naude (2023:8) found that delays at anchorage, caused by terminal holdups, cargo surveying, and documentation errors, further disrupt the supply chain. South Africa's ports face challenges with berth congestion, resulting in missed berthing windows and higher costs for port users due to prolonged shipping vessel dwell times. The annual report of TRANSNET (2024a) notes that efforts to modernise freight handling processes, invest in new equipment, and enhance coordination among port stakeholders are essential for reducing inefficiencies and improving the competitive position of South African ports in the global shipping industry.

2.4.6 Lack Of Intermodal Connectivity

The absence of efficient intermodal connectivity significantly contributes to extended shipping vessel dwell times in South African ports. K Tulsi (2024:2-3) defines intermodal connectivity as the seamless integration of transport modes, such as sea, rail, and road logistics, to ensure the swift movement of goods. According to TNPA (2023:9), South African ports struggle with poor integration between port operations and hinterland transport networks, leading to delays in cargo evacuation and prolonged vessel berthing times.

Rail transport, a vital component of intermodal logistics, operates below capacity due to infrastructure failures and inefficiencies in scheduling (K Tulsi, 2024:3). In Durban, where rail should evacuate 30% of cargo, the actual figure is closer to 13%, placing undue strain on road transport (Chetty & Moodley, 2022:12). The lack of coordination between trucking companies and port terminals contributes to congestion, causing trucks to wait for long periods to load or offload cargo.

These connectivity issues create a ripple effect, with ports unable to clear incoming vessels efficiently, thereby prolonging dwell times. Addressing these gaps requires a concerted effort to invest in multimodal transport infrastructure, streamline coordination mechanisms, and improve technological integration across logistics networks.

2.4.7 Cumulative Impact of Contributing Factors

The factors outlined above are deeply interlinked. Together, they create a cascading effect that exacerbates shipping vessel dwell times. Prolonged dwell times disrupt supply chains, inflate costs, erode competitiveness, and undermine economic growth. Effective resolution of these issues requires a coordinated and comprehensive strategy that addresses both immediate bottlenecks and long-term systemic inefficiencies.

2.5 Analysis of Existing Studies

2.5.1 Governance Structures and Operational Efficiencies in Port Systems

Governance structures play a pivotal role in determining port efficiency and supply chain performance. Mthembu and Chasomeris (2023:4-6) evaluated the governance of marine services in South African ports, highlighting inefficiencies stemming from centralised management by state-owned entities, such as Transnet. They argue that integrating private sector participation could alleviate bottlenecks and improve marine service delivery, directly affecting overall port efficiency (Mthembu & Chasomeris, 2023:4-6). While this study provides valuable insights, it does not explore how these inefficiencies affect broader supply chain dynamics, leaving a critical gap for further research.

2.5.2 Technological Innovations and Predictive Tools for Port Management

Recent advancements in machine learning and predictive analytics have proven effective in optimising port operations. Implementations by Yoon et al. (2023:26-28) of multiple regression models for predicting vessel operations achieved improved accuracy compared to traditional methods. Despite the success of these models in the Busan New Port, their applicability to ports in developing regions, such as South Africa, remains unexplored. Tailored technological solutions could address delays caused by infrastructural and operational challenges unique to South African harbours.

2.5.3 Identified Gaps in the Literature

While existing studies offer valuable frameworks for port efficiency, several gaps persist:

- *Limited focus on the direct impact of vessel delays on supply chain efficiency in South Africa, including increased costs, reduced reliability, and disrupted schedules.*
- *Insufficient exploration of targeted mitigation strategies for vessel delays in developing regions. Potential solutions, including collaborative scheduling, real-time data sharing, and predictive analytics, remain underexplored in South Africa.*
- *There is a lack of holistic analyses linking governance reforms, operational innovations, and their cascading effects on the supply chain ecosystem.*

Given these gaps, this study aims to investigate the broader systemic inefficiencies in South African harbours and their direct impact on supply chain efficiency. Specifically, it will explore practical mitigation strategies that integrate governance reforms, technological innovations, and collaborative approaches. By addressing these areas, the research seeks to propose actionable strategies for reducing delays and enhancing the resilience of supply chains in South Africa.

2.6 Theory And Core Concepts

2.6.1 Core Concepts

Automation: According to Hitomi (1994:121-128), the term automation was coined in 1936 by D.S. Harder, an engineer at Ford Motor Company. It uses technology and machinery to perform tasks with minimal human intervention. It aims to increase efficiency, accuracy, and productivity while reducing labour costs and errors.

Fourth Industrial Revolution: the term was coined by Schwab (2016:30-45). He described it as the ongoing transformation of traditional manufacturing and industrial practices through the use of digital technology, automation, and interconnectivity. Integrating cyber-physical systems, the Internet of Things (IoT), cloud computing, and artificial intelligence (AI) into manufacturing processes.

Supply Chain (SC): Janvier-James (2012:194-207) defines a supply chain as a system aimed at adding value to a product by facilitating its transportation from one location to another, potentially involving processing along the way.

Supply Chain Management (SCM): Mentzer et al (2001:2-6) define Supply Management as the flow of goods and services, involving the movement and storage of raw materials, work-in-progress inventory, and finished goods from the point of origin to the point of consumption. It encompasses planning, sourcing, manufacturing, and delivery, intending to maximise efficiency and minimise costs.

Supply Chain Risk Management (SCRM): Chang et al. (2015:642-656) define this as the identification, evolution and management of risks occurring in supply chains, aiming to reduce vulnerability. These mitigation strategies are implemented to minimise or prevent the negative impacts of risks or disruptions in supply chain operations. These strategies may include contingency planning, risk assessment, supplier diversification, and process optimisation.

2.6.2 Framework

The study will commence with a close examination of delays resulting from dwell times of shipping vessels in South African harbours, focusing on understanding the effects these delays have on the supply chain. The investigation will explore strategies to mitigate the impact of these delays by consulting experts in the field, thereby obtaining insights rather than directly implementing the strategies or gathering empirical data.

Interviews with industry experts will be conducted to gather qualitative insights into the complexities of supply chain operations and identify key factors contributing to downtime and disruptions. This descriptive approach is designed to yield a detailed, contextualised understanding of supply chain dynamics. The study will also employ a theoretical framework centred on supply chain resilience, providing a basis for interpreting the expert insights. This framework will facilitate an analysis of how technological advancements, economic forces, and organisational practices interact within supply chains.

By integrating expert insights with theoretical perspectives, the study provides practical recommendations for mitigating disruptions and enhancing the efficiency and resilience of supply chains in the manufacturing sector, particularly in import-dependent regions such as South Africa.

2.7 Chapter Summary

This chapter provided an in-depth review of the existing body of literature relating to shipping vessel dwell times and their influence on supply chain efficiency, with reference to the South African context. It began by exploring the global background of shipping and maritime logistics while establishing the historical and economic significance of sea freight in facilitating international trade. The literature highlighted that maritime transport remains the backbone of the global economy, with more than 80 per cent of trade by volume being carried by sea. The standardisation of containerisation and the development of global shipping networks have significantly enhanced the efficiency of international logistics while enabling economies of scale and cost competitiveness.

The review then examined the critical role of harbours in global supply chains by emphasising their function as logistical nodes connecting maritime and inland transport systems. Efficient harbour operations are essential to ensuring the smooth transfer of goods between sea, road, and rail networks. The section on technological advancements illustrated how automation and digitalisation, such as automated container terminals and predictive maintenance tools, can enhance port efficiency and reduce vessel turnaround times. However, despite these global advancements, the literature revealed that many ports, especially in developing regions, remain largely non-automated and continue to experience significant inefficiencies.

The focus then shifted to the role and performance of South African harbours within this broader global framework. Studies identified that South Africa's major ports, Durban, Cape Town, Port Elizabeth, and Richards Bay, are essential trade gateways for both domestic and regional economies. Nevertheless, chronic challenges, including ageing infrastructure, equipment shortages, limited private-sector participation, and labour-related inefficiencies, have contributed to extended vessel dwell times and reduced throughput. The literature also pointed out that poor intermodal connectivity, particularly between rail and port operations, exacerbates congestion and delays, further undermining South Africa's trade competitiveness.

Further discussion centred on how port efficiency is measured, covering key indicators such as cargo throughput, berth occupancy, vessel turnaround time, and dwell time. Financial, operational, and sustainability metrics were examined to demonstrate the multifaceted nature of port performance evaluation. The review also incorporated the concept of the Physical Internet and multi-criteria decision analysis as emerging frameworks for enhancing port efficiency and decision-making in complex logistical environments.

The chapter proceeded to investigate supply chain efficiency as a theoretical construct. Scholars such as Borgström (2005) and Snyder & Shen (2019) highlighted that efficiency focuses on optimising internal processes, resource utilisation, and cost reduction, while maintaining responsiveness to customer demands. The discussion outlined several efficiency models, such as the pre-positioning inventory model, backup supplier strategy, and protected supplier approach, aiming to strengthen supply chain resilience against disruptions. These models were contextualised within the manufacturing industry, where production continuity and cost control are paramount.

Finally, the literature on global disruptions underscored how events such as the COVID-19 pandemic, geopolitical instability, and systemic bottlenecks can expose vulnerabilities within global and regional supply chains. In South Africa, these disruptions amplified pre-existing structural challenges within port systems, further extending vessel dwell times and impeding supply chain reliability.

In summary, the chapter established a clear theoretical and contextual foundation for understanding the impact of shipping vessel dwell times on supply chain efficiency. It identified that while global best practices and technological innovations offer significant potential for improvement, South African ports face distinct operational and governance-related constraints that hinder their ability to achieve similar efficiency levels.

2.8 Chapter Conclusion

The literature reviewed in this chapter highlighted the complex relationship between port performance and supply chain efficiency, emphasising that extended vessel dwell times are both a symptom and a cause of broader systemic inefficiencies. While international studies illustrate effective strategies for improving port operations, there remains limited empirical insight into how these challenges manifest within the South African context.

This gap underscores the need for a focused investigation into how local manufacturers experience and respond to dwell-time delays. The insights from this chapter, therefore, provide the conceptual foundation for the research that follows, guiding the exploration of real-world impacts and the identification of practical mitigation strategies.

CHAPTER 3 RESEARCH METHODOLOGY

The objective of this chapter is to outline and analyse the methodology used in investigating the research topic. A multifaceted approach was followed, incorporating data collection and analysis. Atlas.ti was employed as the primary analytical tool to extract insights from the data. Chapter 4 will present the results and findings, while Chapter 5 will offer recommendations based on those findings.

3.1 Literature Review

The first component of this research methodology serves as a review of the existing literature on the topic, providing a theoretical foundation for the study. The primary goal of the literature review is to familiarise the reader with the dynamics of global and South African maritime logistics, the concept of supply chain efficiency, and the specific operational challenges linked to dwell times at ports. The research also explored mitigation strategies, port governance, infrastructure limitations, and the broader implications of delayed cargo movement on the manufacturing sector.

A foundational understanding of the topic was achieved through sources which include:

- *Peer-reviewed academic journals.*
- *Industry publications and technical reports.*
- *Dissertations and scholarly papers.*
- *Textbooks on supply chain and port management.*
- *Government publications and Gazettes.*

By collectively reviewing these sources through an analytical lens, the study was designed to ensure a robust foundation for the empirical components that follow.

3.2 Empirical Study

This study follows an empirical research approach, designed to explore how shipping vessel dwell time at South African harbours influences supply chain efficiency. While empirical research is associated with quantifiable, measurable data, its defining feature is the reliance on observable, real-world evidence to develop well-informed conclusions about the phenomenon under investigation.

Guided by the framework as indicated in Figure 2: The Research Onion, the research design incorporates the following key elements:

1. Research Paradigm
2. Approach to Theory Development
3. Methodological Choice
4. Research Strategy
5. Time Horizon
6. Data Collection and Analysis

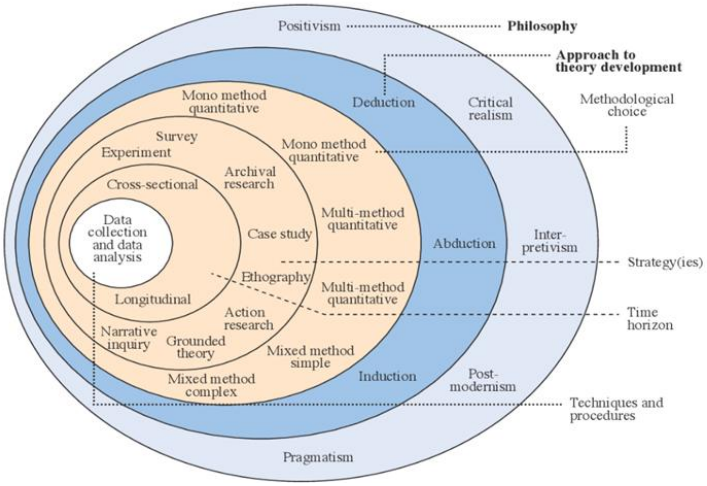

Figure 2: The Research Onion (Source: Bell et al., 2022:127)

This layered design ensures coherence between the philosophical stance, methodological choices, and analytical approach. This approach is achieved by maintaining a direct link to the study's paradigm and research objectives.

3.3 Paradigm

Embedded within my paradigm are the meta-theoretical assumptions of constructivist ontology and critical epistemology. This perspective acknowledges the socially constructed nature of reality (ontology), particularly in the realm of state-owned enterprises (SOEs) and their performance. It recognises that societal interactions, institutional frameworks, and power dynamics shape perceptions of SOE effectiveness. Epistemologically, it asserts that knowledge is not absolute but contingent on context and interpretation. It underscores the importance of critical reflection and interrogation of dominant narratives about SOEs, advocating for an understanding beyond surface-level observations to uncover underlying structural issues and power imbalances.

3.4 Research Approach and Design

3.4.1 Approach to Inquiry

The approach for this study is grounded in thematic analysis. According to Bryman et al. (2015:365), this is a method widely used in qualitative research for identifying, analysing, and interpreting patterns within data. This approach is particularly suitable for exploring the complex, context-specific issues associated with dwell times in South African harbours and their impact on supply chain operations in the manufacturing sector. By focusing on themes that emerge from participant insights, thematic analysis enables the study to uncover detailed and relevant patterns without relying on predetermined categories. This flexibility ensures that the analysis remains closely aligned with the participants' lived experiences and perspectives.

3.4.2 Research Approach

The framework for this study is a qualitative descriptive design, as articulated by Sandelowski (2000:335-337), which provides a structure ideal for capturing phenomena in their natural state. This design aims to describe experiences and insights as they are shared, providing a contextualised and in-depth understanding of how dwell times impact the supply chain within the South African manufacturing industry. By focusing on themes directly derived from participants' responses, this approach enhances the authenticity and richness of the findings, providing a comprehensive view of the supply chain challenges faced in this context.

3.4.3 Research Design

Semi-structured interviews will serve as the primary data collection tool, a method well-suited for thematic analysis in qualitative research. As discussed by Bryman et al. (2015:290) and Saunders et al. (2009:311-320), Semi-structured interviews provide a flexible framework that enables the researcher to explore key topics in depth while adapting to each participant's unique perspective. This method enables participants to share their experiences openly, allowing the interviewer to probe deeper into emerging areas. Open-ended questions create a conversational flow that encourages participants to reveal insights on how dwell times impact their supply chain operations, facilitating the collection of nuanced and detailed data.

3.4.4 Motivation for Choice

The choice of a qualitative descriptive design, paired with thematic analysis, aligns with the study's objective to understand the specific effects of dwell times on supply chains within South Africa's manufacturing industry. Through semi-structured interviews, this approach facilitates the capture of meaningful data, which can be systematically examined to uncover key themes related to supply chain disruptions and operational challenges. As Azungah (2018) highlights, these methodological choices provide a robust framework for generating insights that are directly applicable to industry stakeholders, enhancing their understanding and supporting the development of strategies to improve efficiency within the supply chain sector.

3.5 Population, Sample and Sampling Method

The sampling approach will involve goal-directed non-probability sampling to ensure that participants possess relevant knowledge and can provide diverse perspectives. Recruitment will target key stakeholders through appropriate communication channels, varying according to the setting and participant type. The interview guide will consist of open-ended questions aligned with theoretical or conceptual frameworks to ensure they effectively explore the constructs of interest (Saunders et al., 2009:312-316). Minimal demographic information will be collected to characterise participants without causing discomfort. Interviews will be conducted in person, by telephone, or via video, with audio recording to ensure precise data capture. Transcription will be performed accurately, with measures in place to maintain confidentiality. Data will be securely stored and transmitted using institution-contracted software, ensuring compliance with relevant privacy regulations. This approach will enable a thorough exploration of the research topic, yielding insights that can inform and enhance services.

The population for this study comprises companies operating within the manufacturing industry in South Africa, particularly those involved in various sectors such as automotive, textile, electronics, and food processing. This choice is motivated by the significance of the manufacturing sector in the South African economy and its susceptibility to disruptions caused by dwell times of shipping vessels in South African harbours. The inclusion criteria for selecting companies involve active participation in supply chain operations and a willingness to share insights into how dwell times impact their operations. Exclusion criteria include companies outside the manufacturing industry and those unwilling to participate in the study.

3.5.1.1 Inclusion Criteria

- *Companies operating within the manufacturing industry in South Africa.*
- *Active involvement in supply chain operations.*
- *Willingness to provide insights into the impact of dwell times on their operations.*

3.5.1.2 Exclusion Criteria

- *Companies outside the manufacturing industry.*
- *Companies not actively involved in supply chain operations.*
- *Companies unwilling to participate in the study.*

The sample size for this study will be determined through purposive sampling, aiming to select participants who can provide rich, detailed insights into the consequences of dwell times on supply chain operations within the South African manufacturing industry. As qualitative research focuses on depth rather than breadth, the small sample size will facilitate in-depth exploration of participants' perspectives and experiences. The motivation for a small sample size is to ensure that data collection and analysis remain manageable while still capturing the diverse range of perspectives within the manufacturing sector. Additionally, qualitative research prioritises data quality over quantity, and a small sample size enables a thorough analysis and interpretation of the findings.

The sampling method for this study will be purposive sampling, which was selected for its ability to target participants who possess the specific knowledge and experiences relevant to the research objectives. Purposive sampling enables the researcher to select participants who are directly involved in supply chain operations within the manufacturing industry in South Africa, ensuring that the study captures insights from individuals with relevant expertise and experience. This method aligns with the qualitative descriptive approach of the study, allowing for a focused exploration of the consequences of dwell times on supply chain operations within the selected population.

3.6 Recruitment strategy

The recruitment strategy for this study will utilise the researcher's extensive connections within the supply chain sector, cultivated through professional involvement. These connections provide a valuable network of individuals spanning various sectors that rely on imports and exports. Leveraging these connections, relevant team players within manufacturing companies will be directly engaged to gauge their interest in participating in the study. Potential participants will receive detailed information about the research objectives through personalised invitations, emphasising its significance and relevance to their industry. Furthermore, the invitations will ensure confidentiality and address ethical considerations, fostering trust and confidence in the research process.

In addition to direct outreach, snowball sampling techniques will be employed as advised by Naderifar et al. (2017:2-4) to expand the participant pool further. Initial participants who express interest and agree to participate will be encouraged to recommend others within their professional network with relevant insights. According to Noy (2008:5), this approach will leverage participants' social networks to identify additional key informants, ensuring a diverse range of perspectives is captured. By tapping into the connections and recommendations of participants themselves, the aim is to access individuals deeply entrenched in supply chain operations, enriching the depth and breadth of data collected. A final question is included in the interview guide to enable snowball sampling.

Overall, this recruitment strategy is designed to facilitate targeted engagement with individuals directly involved in supply chain operations within the manufacturing industry. By leveraging existing connections, extending personalised invitations, and employing snowball sampling techniques, comprehensive coverage of perspectives and experiences related to the impact of dwell times on supply chain operations is sought. This approach is crucial for capturing the nuanced insights necessary to explore the research topic thoroughly.

3.7 Data Collection Tool

For this study, semi-structured interviews will be the primary data collection tool. As noted by Bryman et al. (2014:268-290), semi-structured interviews are well-suited to qualitative research, providing a flexible yet structured format that allows for in-depth exploration of themes within the study's context. This approach enables the researcher to adapt the interview questions according to the conversation flow, fostering a more natural and open-ended dialogue with participants (Saunders, 2009:311-320).

The semi-structured format is advantageous for exploring complex issues, such as supply chain disruptions and challenges within the manufacturing sector, as it allows participants to elaborate on their experiences. Furthermore, it enables the interviewer to follow up on specific responses, facilitating a nuanced understanding of the impact of dwell times on supply chain operations. Open-ended questions create a conducive environment for participants to share insights in their own words, which is particularly valuable for qualitative analysis (Bryman et al., 2014:260-290).

To ensure consistency across interviews, an interview guide outlined core questions that enable comparability of responses whilst preserving the flexibility to explore unique insights from each participant. This approach ensures that all key areas of enquiry are covered, enhancing the reliability and richness of the data collected. Additionally, the data captured is accurate and valid, as it focuses on participants' words and utilises audio recordings and field notes.

3.7.1.1 Draft Interview Tool

The eight questions that will be used as the basis for the data enquiry tool are as follows:

Table 1:Interview Guide

Briefly explain the purpose of the study, discuss the interview process and obtain consent.	Thank you for your time. I want to repeat that you may withdraw at any point without consequence. Your identity and opinions will be totally confidential, and you can feel free not to answer any question if you don't want to. The interview should take approximately 45 minutes and will be conducted in English. If you want to answer in another language that both you and I understand, feel free, but in this case, the interview will be transcribed in English. Do I have your permission to record the interview so that I can write it down accurately? By continuing with this interview, you give

	me permission to use your responses in my research. Are you okay with that?
Background Information:	Q1: Can you describe your role in the company and your involvement in supply chain operations? Additionally, could you share any previous experience you have in supply chain management?
Impact of Dwell Times:	Q2: How have dwell times at South African ports affected your supply chain operations?
Challenges	Q3: What are the main challenges you face in managing dwell times?
Mitigation Strategies:	Q4: What strategies has your company implemented to mitigate the impact of dwell times?
	Q5: How effective have these strategies been?
Solutions	Q6: What solutions or improvements would you recommend?
Conclusion	Q7: Do you have any additional insights or comments on the topic?
This guide ensures comprehensive coverage of the research objectives while allowing participants the freedom to share their experiences and insights in detail.	Q8: Can you recommend any other person who could add insights to an interview? If I want to contact them, would you be willing to make the connection for me?

3.8 Data Analysis Methods

Thematic analysis will be the primary method for analysing interview data, following the guidelines (Bryman et al., 2014). This approach allows for systematically identifying and analysing recurring patterns or themes within qualitative data. It is particularly suited to exploring subjective experiences, such as perceptions of supply chain delays and their operational impact.

The thematic analysis will follow the six steps proposed by (Braun & Clarke, 2006:96):

1. Familiarisation with Data: Initial readings of interview transcripts will enable the researcher to become deeply acquainted with the content, noting any preliminary ideas or patterns.
2. Generating Initial Codes: Text segments relevant to the study objectives will be coded to capture key concepts or ideas. This step aids in organising data systematically, setting the foundation for theme identification.
3. Searching for Themes: Coded data will be grouped into potential themes aligned with the study's objectives.
4. Reviewing Themes: Themes will be refined, combined, or discarded as necessary to ensure clarity and distinction.
5. Defining and Naming Themes: Clear definitions and names for each theme will be developed to reflect their significance accurately.
6. Writing the Analysis: The final step involves a cohesive analysis that presents themes supported by data excerpts, connecting them to the study's research questions.

This method is valuable for this study as it provides flexibility to derive themes organically from the data, avoiding researcher bias. Field notes taken during interviews will supplement the thematic analysis, offering context on non-verbal cues and other observations that might not be evident in transcripts. These notes enrich the thematic analysis by adding layers of insight to the participants' responses.

In summary, using thematic analysis with open coding provides a systematic yet adaptable framework for uncovering key themes within the data, enabling a deeper understanding of the impact of dwell times on supply chains in the South African manufacturing industry. This approach ensures a comprehensive and trustworthy interpretation of the findings by grounding the analysis in participants' own words and incorporating field notes.

3.9 Informed Consent

The informed consent process for this study will involve multiple steps to ensure that participants are fully aware of the research objectives, procedures, and their rights as participants. Initially, the researcher will approach the CEOs of relevant companies to request access to key role players within their organisations who have insights into supply chain operations and potential delays resulting from dwell times. The CEOs provided detailed information about the study, including its purpose, scope, and expected outcomes.

They were also assured of confidentiality and informed that participation is voluntary. Upon receiving consent from the CEOs, the researcher contacted the identified role players within the companies to provide further details about the study and obtained their informed consent for participation. Participants were provided with a consent form outlining the research objectives, procedures, risks, benefits, and their rights as participants. They were encouraged to ask questions and seek clarification before voluntarily signing the consent form. Additionally, participants were informed of their right to withdraw from the study at any time without penalty. The informed consent process was documented and stored securely to demonstrate compliance with ethical guidelines throughout the research process.

3.10 Ethical Considerations During Data Collection

Several measures have been implemented throughout the study to protect participants' privacy throughout the research process. Firstly, informed consent was obtained from all participants, clearly outlining the study's purpose, procedures, and their rights, including the right to withdraw at any time without penalty. Participants were assigned unique identification codes to anonymise their data, ensuring that personal identities are not linked to the responses in public documentation or reports. To prevent unauthorised access, interviews were conducted in a private setting via Microsoft Teams or in person. Additionally, any demographic information collected will be minimal and non-intrusive, focusing solely on characteristics relevant to the study while avoiding unnecessary exposure to personal details.

To ensure the confidentiality of participants' data, strict data management protocols were followed. Audio recordings of interviews were securely stored on encrypted devices, and only the research team had access to these files. Transcriptions omitted any personally identifiable information and were stored in password-protected files. Data were shared with the research team on a need-to-know basis only, and all team members were trained in confidentiality and data protection practices.

All the necessary steps were taken to ensure compliance with the POPIA Act. Upon completion of the research, all identifiable data were securely destroyed, and findings were presented in aggregate form, ensuring that individual responses could not be traced back to any participant. These measures collectively safeguarded the confidentiality and integrity of the data collected.

3.11 Trustworthiness

The trustworthiness of the data in the study is critical, as mentioned by Bryman et al. (2015:45). Trustworthiness depends on four aspects: Credibility, Transferability, Dependability, and Confirmability.

1. Credibility: Credibility was achieved by selecting participants with extensive, factual, and practical knowledge of supply chain operations, gained from daily experience in forwarding goods in and out of South Africa via containerised shipments. As mentioned by Bryman et al. (2015:45), credibility can be drawn from the relationship between respondents' answers, as one of the questions asked respondents to provide all their prior experiences in supply chain management.
2. Transferability: Transferability, as referred to by Bryman et al. (2015:44), is when the results of the study can be transferred from one setting to another. The data collection process includes multiple companies within the manufacturing sector, thus ensuring that the findings are not limited to the experiences of a single organisation. To achieve a state where results can be transferred from one setting to another, the reader must be able to identify the similarities that occur when data saturation is achieved.
3. Dependability: According to Bryman et al. (2015:45), the dependability of results can be achieved when the research study demonstrates trustworthiness in its approach, making it suitable for audit. By recognising the evolving nature of supply chain management and ensuring that data is gathered within a set timeframe to prevent external factors from affecting the study, the dependability of the study was upheld. Additionally, the research process followed well-documented steps with knowledgeable participants, where results can be audited.
4. Confirmability: Confirmability, as defined by Bryman et al. (2015:45), is a measurement to ensure that the personal biases of the researcher do not influence the research and the results of the findings of the study. Confirmability was achieved through triangulation, which serves to validate the accuracy and objectivity of the findings by cross-referencing data from interview transcripts, field notes, and thematic analysis, thereby minimising any biases introduced by the researcher.

A limitation of the study is the sample size as empirical analysis was based on eight semi-structured interviews. While being appropriate for the purpose of qualitative analysis it allows for insights into the complex problem, it is however, limited to the extent of findings that can be generalised beyond the contexts represented by the participants. Thus, the results should be interpreted as providing analytical insights rather than statistical conclusions.

CHAPTER 4 RESULTS AND FINDINGS

4.1 Introduction

Chapter three served as a guide to the research methodology followed for the study. This chapter presents the empirical results of the study, derived from eight semi-structured interviews with supply chain professionals in South Africa. This chapter aims to examine the impact of shipping vessel dwell times on supply chain efficiency while identifying key challenges associated with managing these dwell times. The focus was also placed on evaluating the effectiveness of current mitigation strategies and highlighting recommendations for improvement.

The analysis followed a structured three-tier process:

1. First-level analysis – Descriptive overview and initial impressions.
2. Second-level analysis – Identification of recurring patterns, supported by a word cloud from Atlas.ti.
3. Third-level analysis – Thematic analysis, involving coding of the interview data, grouping into categories, and the development of overarching themes.

Findings are reported in line with the research objectives. To ensure transparency, each theme is supported by a thematic analysis table presenting the theme, categories, codes, and illustrative quotes.

4.2 Data Overview

Eight interviews were conducted with participants from diverse industries, including automotive, logistics, manufacturing, and FMCG (Fast-moving consumer goods). The participants' years of experience ranged between 10 and 25 years, and all held roles with direct involvement in logistics, customs clearance, and supply chain decision-making.

To maintain confidentiality, participants are anonymised as Participant A–H. This diversity ensured a wide range of perspectives on the effects of dwell times in South African ports, below a demographic summary of study participants:

Table 2: Participants' Demographics

Participant	Role	Industry Sector	Years of Experience
A	Head of Supply Chain	Automotive & Rail	15
B	Commercial & Operations Manager	Freight Forwarding & Logistics	20
C	Operations Director	Manufacturing	18
D	Senior Logistics Executive	FMCG	12
E–H	Mixed roles	Transport, Warehousing, Clearing	10–25

4.3 First-Level Analysis: First Impressions

The first-level analysis provides an overview of the striking comments or topics that arose during the interview process. This level serves as an initial assessment of the impact of dwell times at South African harbours. These impressions capture the initial responses before deeper coding and thematic analysis were applied. Examining these first responses is helpful as they highlight the issues perceived as most urgent or problematic by stakeholders, thereby providing a baseline understanding of how dwell times are experienced within supply chain operations.

Table 3: First Level Impressions

Participant	Role / Sector	First Impression	Tone
A	Head of Supply Chain (Automotive & Rail)	The participant indicated that dwell times had not yet had a significant effect on their organisation, primarily due to reliance on alternative supply channels and air freight. While acknowledging that delays could pose	Neutral / Low impact

		future risks, the participant described the current impact as minimal.	
B	Commercial & Operations Manager (Freight Forwarding)	This participant expressed concern over the negative consequences of dwell times, particularly in terms of penalties imposed on clients and damage to organisational reputation. They highlighted how delays undermine both operational performance and customer trust.	Strongly Negative
C	Operations Director (Manufacturing)	The participant reported that extended dwell times had forced the company to incur additional costs such as storage fees and demurrage. They also emphasised the resulting strain on cash flow, as payments had to be made upfront while goods were delayed in transit.	Negative
D	Senior Logistics Executive (FMCG)	This participant emphasised that the unpredictability of rail and port operations poses significant challenges for planning and scheduling. The inconsistency in lead times was described as a significant disruption to efficient supply chain management.	Negative
E	Logistics Manager (Manufacturing)	The participant stated that delays had eroded overseas client confidence because reliable delivery timelines could no longer be guaranteed. They viewed reputational damage as a particularly serious outcome of persistent dwell times.	Negative
F	Warehouse & Transport Coordinator	According to this participant, operational inefficiencies at ports were exacerbated by frequent equipment breakdowns and the unreliability of IT systems such as NAVIS.	Negative

		They described these systemic failures as a significant source of frustration in day-to-day logistics operations.	
G	Supply Chain Planner	The participant reported that the company had increasingly turned to air freight to bypass port delays. While acknowledging that this ensured critical deliveries were met, they highlighted the financial burden of such a costly strategy.	Negative
H	Freight Clearing Specialist	This participant voiced strong concerns about customs processes, describing clearance as inconsistent and sometimes dependent on personal networks. They suggested that corruption and lack of transparency were contributing to unfair delays in clearing goods.	Strongly Negative

In conclusion, based on the first impressions of participants, a predominantly negative view was perceived when focusing on the effect of dwell and its consequences. Although one participant experienced minimal disruption, the majority associated delays with financial strain paired with reputational damage, operational inefficiencies, and governance concerns. These findings suggest that dwell times are perceived not only as logistical obstacles but also as systemic risks with wide-ranging implications for supply chain efficiency. This baseline understanding provides a foundation for the deeper analysis of recurring patterns and thematic coding.

4.4 Second-Level Analysis: Word Cloud and Patterns

4.4.1 High-Level Analysis

The second-level analysis moves beyond the initial responses of the participants by identifying recurring word phrases across all interview transcripts. This analysis was done by analysing word frequencies in Atlas.ti.

By analysing word frequencies, it is possible to visualise which concepts were most salient to stakeholders. A word cloud was generated from the transcribed interviews, highlighting the terms that appeared most frequently in relation to dwell times at South African harbours.

Figure 3: Word Cloud - All Participants

The word cloud in Figure 3: Word Cloud - All Participants illustrates the most frequently occurring words across all eight interviews. Prominent terms include *"port", "time", "container", "stock", "cost", "clients", "freight", "Transnet*", and *"SARS".* These terms indicate that participants primarily associated dwell times with port operations, scheduling delays, financial implications, and systemic inefficiencies.

References to rail, Durban, Cape, shipping, and vessel reflect the geographical and infrastructural context within which delays occur. Words such as 'cash' and 'clients' suggest that participants were highly concerned with the financial and reputational impact of dwell times on their organisations.

The prevalence of time and delay-related expressions further underscores the centrality of waiting periods and uncertainty in participants' experiences. Overall, the word cloud highlights three dominant areas of concern: time delays, cost implications, and systemic inefficiencies.

4.4.2 Industry Level Analysis

The second level of analysis involved a deep dive into business demographics, grouping participants to identify specific demographics that experience dwell times differently across these sectors. The logic behind the strategic groupings is illustrated in Table 4 below.

Table 4: Participants Grouped by Business Demographics

Group	Description	Participants
Automotive and Trailer Parts Manufacturing/Supply	These participants work in companies focused on manufacturing or supplying parts for commercial vehicles, trailers, rail, and trucks. Their businesses involve heavy imports of components, long lead times (9-12 months), and export activities.	A,C,E,F
Steel and Materials Import/Distribution	Focused on importing raw materials like steel plates or coils for manufacturing/distribution, often serving automotive or industrial sectors. These involve customs-heavy processes, material certifications, and dealing with SARS inspections/samples.	G,H
Freight and Logistics Services	Service-oriented providers handling forwarding, clearing, warehousing, and transport. This group deals directly with port operations, client contracts, KPIs, and third-party dependencies.	B
Commodities and Machinery Import (FMCG/Agriculture-Related)	Involves private equity-managed imports of commodities (fuel, fertiliser) and machinery (farming/yellow metal equipment). Focus on diverse portfolios, including wheels and agricultural implements	D

4.4.2.1 Automotive and Trailer Parts Manufacturing/Supply

The word cloud for the Automotive and Trailer Parts Manufacturing/Supply industry can be seen in Figure 4 below:

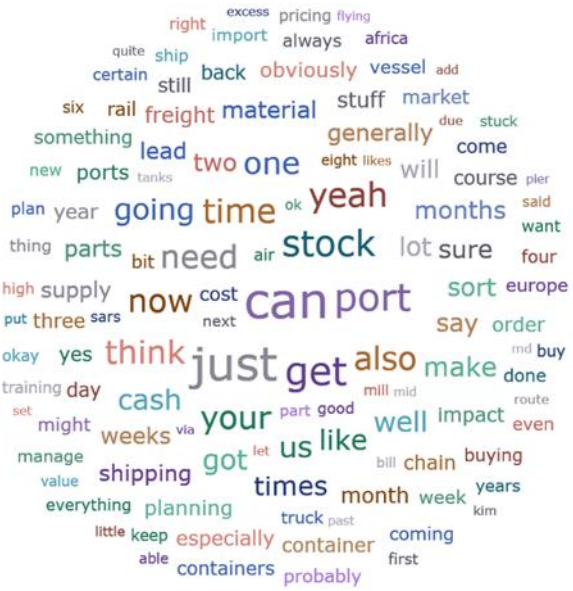

Figure 4: Word Cloud for Automotive and Trailer Parts Manufacturing/Supply

The most prominent words that emerged from the word frequency analysis include "*can", "just", "get", "port", "stock", "time", "yeah", "need", "now", "think", "also", "your", "one", "going", "us", "cash", "material", "lead", "parts", "weeks", "months", "shipping", and "supply".*

These words can all relate to the following:

- Supply chain complexity: Words like lead, weeks, months, planning, ordering, forecasting and inventory reveal the group's long planning horizons (9–12 months) and vulnerability to disruption when delays occur.

- Financial pressure: Strong references to cash, cost, pricing, and money indicate that tied-up capital and financial strain are significant concerns when shipments are delayed.

- Operational dependencies: The frequent use of ports, shipping, freight, containers, vessels, Transnet, congestion, rail, road, and logistics underscores the group's reliance on smooth port and inland operations.

- Customer and market effects: Terms such as customers, market, sales, and demand highlight the downstream risks, including production stoppages, client dissatisfaction, and lost sales, if parts fail to arrive on time.

- Mitigation mindset: Terms like planning, forecasting, buffer, strategies, and mitigation indicate that firms in this sector actively work to build resilience through stockholding, forecasting, and safety buffers.

For automotive and trailer parts manufacturers/suppliers, dwell times present a strategic risk to production continuity and financial stability. Their long lead times and reliance on imports make them highly vulnerable to delays, forcing them to adopt buffering, forecasting, and mitigation strategies to safeguard production and meet customer commitments.

4.4.2.2 Steel and Materials Import/Distribution

The word cloud for the Steel and Materials Import/Distribution industry can be seen in Figure 5 below:

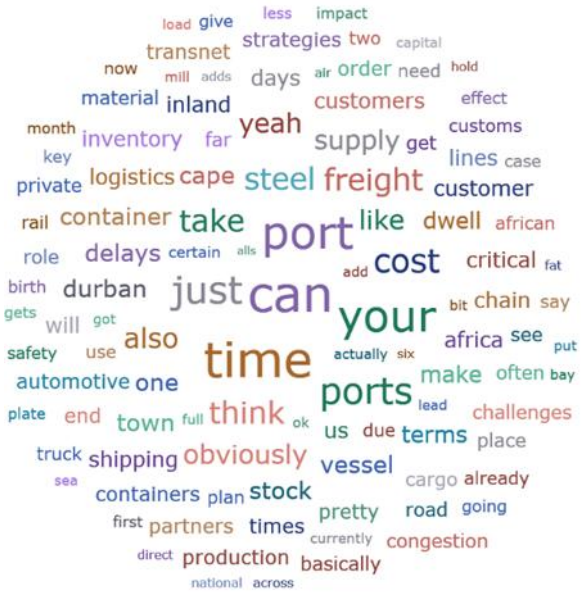

Figure 5: Word Cloud for Steel and Materials Import/Distribution

Key terms include *"SARS", "think", "can", "just", "time", "correct", "clear", "customs", "codes", "pre", "anticipate", "duty", "mitigate", "vessels", "containers",* and "*documentation".*

These words can all relate to the following:

- Regulatory intensity: A heavy emphasis on SARS, customs, codes, duty, and documentation indicates that this group experiences delays primarily due to regulatory processes and compliance requirements.

- Anticipation and planning: Words like anticipate, mitigate, pre, clear, and correct suggest that firms in this sector must plan extensively to avoid penalties, shipment delays, or compliance failures.

- Financial exposure: References to capital, cost, and duty indicate that customs clearance delays directly tie up working capital and add financial strain.

- Time-related risks: The recurrence of time-related issues, such as delay, congestion, and backlog, underscores how customs-driven inefficiencies disrupt supply chains and downstream manufacturing.

For steel and material importers, dwell times are predominantly driven by compliance-related delays, with customs inspections and SARS processes creating financial and operational bottlenecks. Their focus lies in documentation accuracy, mitigating delays, and managing tied-up capital.

4.4.2.3 Freight and Logistics Services

The word cloud for the Steel and Materials Import/Distribution industry can be seen in Figure 6 below:

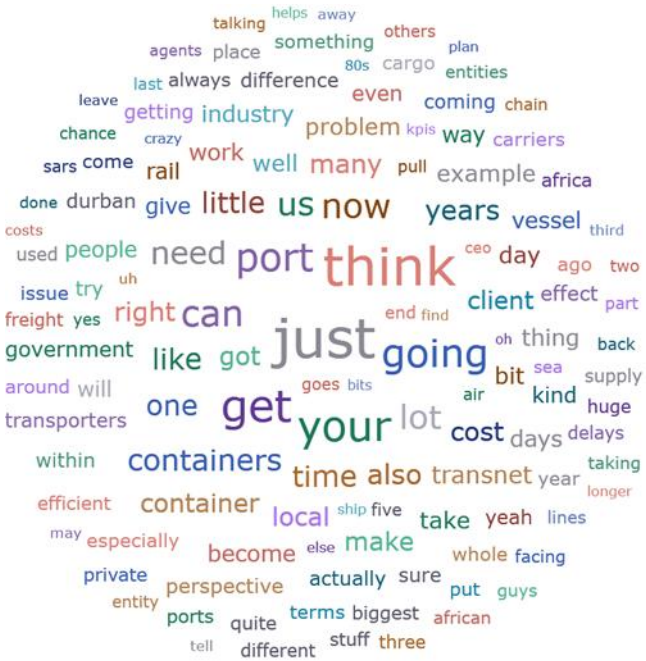

Figure 6: Word Cloud for Freight and Logistics Services

The most prominent words here *include "port", "time", "your", "can", "just", "cost", "vessel", "delays", "Transnet", "supply", "strategies", "customers",* and *"stock".*

- Operational focus: Strong emphasis on port and time, showing that this group is highly sensitive to dwell times as they directly manage cargo movement.
- Customer-centric terms: Frequent references to "you," "customers," "customer," and "partners" suggest that their concern lies in client satisfaction, contractual obligations, and service reliability.
- Systemic issues: Terms such as delays, congestion, Transnet, logistics, and customs underscore frustration with bottlenecks and third-party dependencies impacting service delivery.
- Financial impact: The appearance of cost, stock, critical, and production highlights how inefficiencies ripple into inventory management, supply chain stability, and client costs.

For logistics providers, dwell times are seen primarily as a service reliability challenge, directly linked to client trust, contractual KPIs, and operational efficiency—their perspective centres on delays, costs, and strained client relationships due to systemic inefficiencies.

4.4.2.4 Commodities and Machinery Import (FMCG/Agriculture-Related)

The word cloud for the Commodities and Machinery Import (FMCG/Agriculture-Related) industry can be seen in Figure 7 below:

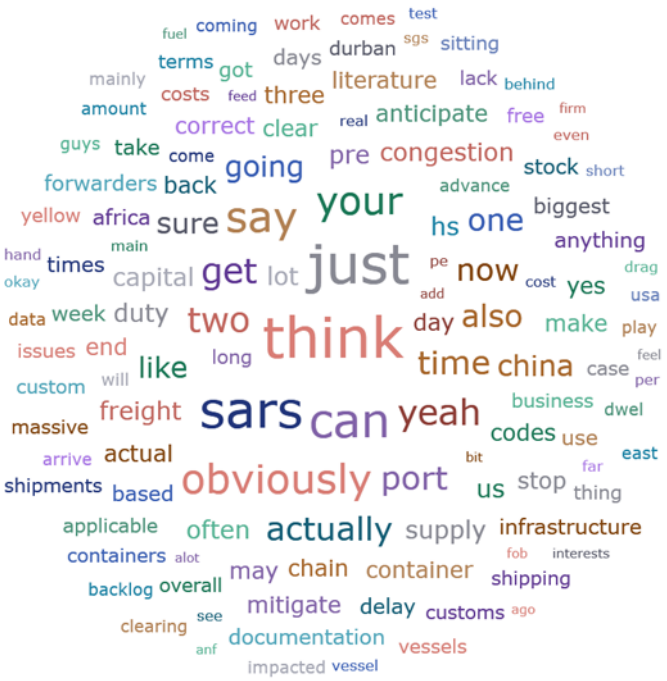

Figure 7: Commodities and Machinery Import (FMCG/Agriculture-Related)

Prominent terms include *“think”, ”"time”, “port”, “'get”, “your”, “freight”, ”Africa”, “stock”, “vessel”, "supply”, “production”, “'road”, “rail”, “inland”, “strategies”, "order”, "cost “, "customers”* and *“logistics”.*

- Diverse supply base: Terms such as commodities, production, inland, road, rail, Cape, and Durban suggest the group operates across multiple geographies and transport modes.
- Supply chain resilience: Frequent mentions of strategies, order, inventory, stock, and production point to the constant balancing act of securing commodities and machinery while minimising delays.
- Systemic concerns: Words like 'port,' 'Transnet,' 'congestion,' and 'delays' highlight infrastructure and operational inefficiencies as central obstacles.
- Client and market focus: The use of customers, supply, Africa, and cost shows that delays impact not only operations but also customer availability and regional competitiveness.

For commodity and machinery importers, dwell times represent a broader vulnerability in the supply chain. Their experience spans infrastructure limitations, transportation dependencies, and the need for strategic planning to ensure a reliable flow of commodities and machinery.

The industry-level word clouds demonstrate that while all participants share common concerns around time delays, costs, and systemic inefficiencies, the way these issues are experienced differs according to business context. Together, these patterns show that dwell times are not a uniform challenge, but rather a multifaceted issue that manifests differently across sectors. This result reinforces the need for a deeper exploration of the underlying themes that cut across industries, moving beyond word frequency to uncover the systemic, financial, and strategic dimensions of port dwell times.

Leading up to Section 4.5, which presents the third-tier thematic analysis, as it synthesises these patterns into broader themes to provide a more holistic understanding of how dwell times affect the supply chain efficiency of businesses operating in South Africa.

4.5 Third level - Thematic Analysis

The third-level analysis involved a systematic review of the cleaned interview transcripts, where key topics and mentions were initially highlighted before the codes were generated in Atlas.ti.

After initial familiarisation and word frequency inspection as per Section 4.4, a rough theme sheet was constructed as per the themes that arose during the interview process. These roughly constructed themes, as they presented themselves, can be seen in Figure 8: Initial Themes.

Coding was conducted in Atlas.ti by identifying common themes and patterns that emerged during the interview process. These codes were grouped into categories and then into overarching themes. Networks were constructed in Atlas.ti to visualise relationships between themes and sub-themes.

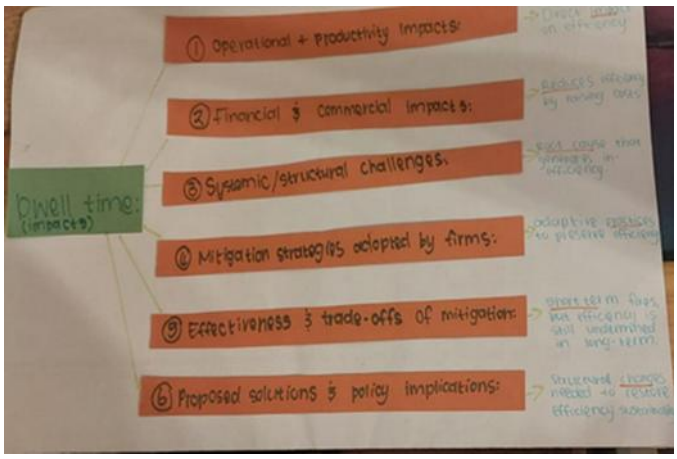

Figure 8: Initial Themes

From the coding and grouping process, six primary themes emerged, which were identified as central to understanding the impact of vessel dwell times on supply chain efficiency in South African harbours.

1. Operational & Productivity Impacts
2. Financial & Commercial Impacts
3. Systemic / Structural Challenges
4. Mitigation Strategies Adopted by Firms
5. Effectiveness and Trade-offs of Mitigation
6. Proposed Solutions and Policy Implications

4.5.1 Theme 1: Operational & Productivity Impacts

During the interview process, participants reported that vessel dwell times continuously disrupt production schedules, forcing their resources to idle and creating complicated planning processes. These operational inefficiencies undermine supply chain efficiency by introducing unpredictability into their lead times and forcing costly workarounds.

From the initial impressions, participants highlighted immediate operational concerns. For example, Participant D described unpredictability in port operations as a “Major disruption” to efficient supply chain management. At the same time, Participant F emphasised how equipment breakdowns and unreliable systems, such as the NAVIS port booking system, directly obstructed day-to-day operations.

The word cloud from the second-level analysis reinforces these impressions by showing the dominance of terms such as port, time, container, stock, Transnet, and vessel. Across all industries, operational terms were strongly tied to dwell times with variations by sector:

- Automotive and trailer parts manufacturers stressed the importance of lead times, planning, inventory, and parts availability, illustrating how delays can jeopardise production continuity.
- Freight and logistics service providers highlighted port, time, vessel, and other delays, as well as strategies, showing that operational inefficiency directly undermines service delivery and contractual reliability.
- Commodity importers emphasised production, supply, order and inland transport, indicating that dwell times ripple through their operational pipelines.

Thus, the thematic coded table for Operational & Productivity Impacts can be seen in Table 5 below.

Table 5: Thematic Coding Operational & Productivity Impacts

Theme	Category	Code	Quotes
Operational & Productivity Impacts	Production Disruption	Delays to production / lead-time variability	*"Extended dwell times have forced us to hold higher buffer stocks inland to mitigate unpredictability… it disrupts our just-in-time strategies."* (Participant C)
	Resource Idling & Turnaround	Vehicle/equipment turn delays	*"Armed escorts arrive ready to transport … then they've got to wait five hours — it's a cost element and a safety risk."* (Participant B)
	Planning Complexity	Unpredictable berthing/scheduling	"*Sometimes the vessel comes in on time, but then gantries break down — what happens that day makes all the difference."* (Participant F)

4.5.1.1 Interpretation

Theme one demonstrates that dwell times erode operational efficiency by disrupting the smooth flow of goods at ports, as they introduce scheduling uncertainty and cause resources to idle. The convergence of first-level impressions, paired with word cloud patterns and coded evidence, confirms that participants experience these impacts as systematic operational inefficiencies, which in turn forces firms to adopt costly buffers or workaround strategies.

4.5.2 Theme 2: Financial & Commercial Impacts

Participants linked vessel dwell times directly to financial strain, in both immediate costs incurred from demurrage, storage, and emergency transport, as well as indirect consequences, including tied-up cash flow, reputational damage, and business trust lost. These impacts reduce supply chain efficiency by increasing operating costs while undermining client trust.

From the initial impressions, several participants emphasised financial pressure as a dominant concern. Participant C, who operates in the manufacturing industry, described how extended dwell times forced upfront payments and incurred demurrage, creating “Major cash flow repercussions.” Participant E noted that the reputational damage was tied to financial loss, as overseas clients lost confidence in the reliability of delivering final goods. Participant B also highlighted how penalties and reputational costs affected both clients and service providers.

The word cloud analysis revealed frequent use of terms such as “cost”, “cash”, “clients”, “stock”, and “pricing”, indicating that dwell times strain financial performance across industries.

- Automotive and trailer parts firms emphasised cash, cost, material, stock, and pricing, highlighting how capital is locked up when goods are delayed.
- Steel and material importers emphasised the importance of duty, customs, mitigation, anticipation, and documentation, highlighting the financial exposure associated with compliance delays.
- Freight forwarders repeatedly used terms like cost, supply, customers, and strategies, showing that inefficiencies at ports directly translate into penalties and client dissatisfaction.
- FMCG and commodity importers highlighted cost, production, order, and customer issues, underscoring the connection between delays, lost revenue, and downstream supply shortages.

Thus, the thematic coded table for Financial & Commercial Impacts can be seen in Table 6 below:

Table 6: Thematic Coding Financial & Commercial Impacts

Theme	Category	Code	Quotes
Financial & Commercial Impacts	Direct Costs	Demurrage & storage charges	"*If your containers stay an extra day, they charge you 9,000 or 11,000 Rand — that takes you out of the market*." (Participant B)
	Emergency Logistics	Airfreight & premium transport	"*We once moved a 51-tonne shipment by air — it cost three arms and three legs, but we did it to save reputation."* (Participant B)
	Cash Flow & Financing	Working capital strain/trade finance	"*You expect a consignment in 45 days and you get it in 70 — that has major cash-flow repercussions; some clients must use trade finance."* (Participant C)
	Commercial Outcomes	Lost sales & reputational damage	*"Clients are facing loss of sales and reputational damage due to late deliveries — competitors step in."* (Participant E)

4.5.2.1 Interpretation

Theme 2 demonstrates that dwell times erode supply chain efficiency not only by creating operational friction but also by imposing severe financial burdens. Costs incurred from demurrage, emergency air freight and trade finance drain resources while operational harm and lost clients reduce competitiveness. Together with first-level impressions, word cloud patterns, and coded evidence confirm that financial and commercial impacts are among the most critical consequences of vessel dwell times, as everything comes down to the bottom line at the end of the day.

4.5.3 Theme 3: Systemic / Structural Challenges

When looking beyond the immediate operational and financial effects, participants repeatedly identified systematic and structural issues within South Africa's ports as key drivers of dwell times.

These issues include inadequate infrastructure, unreliable IT systems, and complex customs processes, all of which are compounded by weak coordination between stakeholders. The inefficiencies were seen as contributing to the root causes that amplify dwell times and erode supply chain efficiency.

From first-level impressions, several participants pointed to system-level failures rather than isolated incidents, where participant F stressed that "frequent equipment breakdowns and the unreliability of IT systems such as NAVIS exacerbated operational inefficiencies at ports." Participant H voiced concerns about customs clearance inconsistencies, suggesting that the lack of transparency in the clearing process and hold-ups at customs are concerning. These comments demonstrate that stakeholders view dwell times as symptoms of deeper, systemic problems.

The word cloud analysis reinforces these perceptions by highlighting terms such as "SARS", "customs", "Transnet", "congestion", "delays", and "documentation". Industry-level differences emerged:

- Steel and material importers repeatedly emphasised SARS, customs, codes, duty, and documentation, showing how compliance processes dominate their experience of delays.
- Freight forwarders and logistics providers highlighted delays, congestion, and issues with Transnet and logistics, underscoring frustration with systemic bottlenecks beyond their direct control.
- Commodity and machinery importers referred to road, rail, inland, Durban and Cape, pointing to broader infrastructure dependencies that contribute to inefficiencies.

Table 7: Thematic Coding Systemic / Structural Challenges

Theme	Category	Code	Quotes
Systemic / Structural Challenges	Infrastructure	Rail bottlenecks; equipment downtime	"*The Durban–Johannesburg rail line must be fixed — moving goods by train is cheaper, but the infrastructure is failing*." (Participant A)
	IT & Systems	NAVIS unreliability/booking failures	"*NAVIS is down a lot — in other ports it works; here the system is unreliable."* (Participant F)

	Customs & Governance	SARS documentation checks / perceived corruption	"*SARS now asks 300 questions and stops cargo — the vetting program helps, but processes are fragile; we also hear NAVIS gives preferences."* (Participant H)
	Stakeholder Coordination	Misalignment between carriers, ports & inland transport	*"There is a lack of real-time visibility and communication between shipping lines, port authorities, and inland transport; scheduling conflicts arise."* (Participant D)

4.5.3.1 Interpretation

Theme 3 highlights how systematic inefficiencies are a central barrier to efficient supply chain operations in South Africa. By linking the first impressions, word cloud and coded analysis, it is clear that the systematic structural challenges represent foundation obstacles. If left unaddressed, they will continue to undermine supply chain efficiency, regardless of firm-level mitigation strategies.

4.5.4 Theme 4: Mitigation Strategies Adopted by Firms

Participants, faced with persistent vessel dwell times, explained how their organisations implemented various mitigation strategies to protect supply chain efficiency. These mitigation strategies include holding safety stock, adjusting procurement cycles and using alternative logistics routes. While these strategies ensured some level of continuity, they were often costly and only partially effective.

At the first level, participants reported that companies were compelled to implement workarounds to mitigate disruptions resulting from dwell times. Participant A indicated "*reliance on air freight to avoid significant downtime"*, while Participant G described how "*their firm increasingly turned to costly air freight to ensure critical deliveries*". Participant E stressed "*the importance of pre-clearing documents to reduce customs-related delays*." These early impressions already highlighted that mitigations had become a necessary but imperfect strategy.

The word cloud analysis supports these findings through frequent references to strategies, mitigation, stock, planning, forecasting, buffer, and alternative. Industry-level differences were visible:

- Automotive and trailer parts manufacturers emphasised *planning, forecasting, buffer strategies*, signalling how they proactively build resilience into long lead-time supply chains.
- Steel and material importers stressed the importance of *anticipating, mitigating, and pre-clearing*, underscoring a focus on documentation accuracy and customs risk reduction.
- Freight forwarders mentioned *strategies, customers, and supply, reflecting* a service orientation toward protecting client commitments through alternative logistics solutions.
- Commodity importers highlighted *order, strategies, and stock,* suggesting a balancing act between securing commodities and minimising risk exposure.

Table 8: Thematic Coding Mitigation Strategies Adopted by Firms

Theme	Category	Code	Quotes
Mitigation Strategies Adopted by Firms	Inventory & Planning	Safety stock; batch PO release; forecasting alignment	"*We use safety stock and release purchase orders in 30-day windows to reduce risk of overstock at supplier*." (Participant A)
	Alternative Logistics	Airfreight; alternative ports	"*We moved an urgent consignment by air; it saved the contract, but it destroyed margins."* (Participant G)
	Process Controls	Pre-submission of documentation to SARS; pre-clearance	*"We submit documents three weeks before arrival to SARS to try to avoid flagging and delays."* (Participant E)
	Strategic Relationships	Use of medium-sized international forwarders	*"Medium-sized international forwarders are more responsive — they're one phone call away from an MD to action issues."* (Participant A)

4.5.4.1 Interpretation

Theme 4 illustrates how firms attempt to safeguard efficiency through proactive mitigation measures. The convergence of first impressions, word frequencies, and thematic coding reveals that mitigation is a multi-pronged approach. From operational (buffer stock, forecasting), logistical (airfreight, alternative ports), and procedural (pre-clearing, customs compliance). However, while these strategies can limit disruption, they are costly and only partially effective, leaving firms vulnerable to systemic inefficiencies beyond their control.

4.5.5 Theme 5: Effectiveness and Trade-offs of Mitigation

While firms adopted a variety of mitigation strategies to reduce the effects of dwell times, participants emphasised that these solutions do come with trade-offs. Short-term relief was achieved, but significant financial costs that occur place significant pressure on working capital. This theme highlights the delicate balance companies face between maintaining service continuity and achieving financial stability.

From the first impressions, it was evident that mitigation was seen as a necessary but burdensome strategy. Participant G noted that "*the use of air freight allowed critical deliveries to be met but at a cost that destroyed margins".* Participant A stressed that *"forecasting-based mitigations were only proving to be effective if internal sales discipline was strong*", which was not always the case. Participant C confirmed that "*while safety stock protected operations, it tied up valuable cash flow."*

The second-level word cloud analysis supports these views, with frequent references to cost, cash, stock, strategies, and clients. The prominence of cash and cost illustrates that financial trade-offs were at the forefront of participants' concerns:

- Automotive and manufacturing firms focused on *stock, cash, and cost*, reflecting the challenge of balancing buffer inventories against liquidity constraints.
- Freight forwarders and logistics participants highlighted *clients, strategies, and cost*, showing how mitigation strategies preserved relationships but eroded profitability.
- Steel/material importers stressed the need to *anticipate, mitigate and pay duty*, pointing to compliance-based workarounds that carried financial implications.

Table 9: Thematic Coding Effectiveness and Trade-offs of Mitigation

Theme	Category	Code	Quotes
Effectiveness and Trade-offs of Mitigation	Short-term Relief	Airfreight / ad-hoc fixes	*"Airfreight works, but it kills you financially."* (Participant G)
	Internal Discipline Limits	Forecasting & sales discipline	"*Forecasting is only as good as the sales discipline behind it — often poor, so we still react."* (Participant A)
	Financial Trade-offs	Inventory vs cash availability	"*We don't like safety stock because it locks up cash, but sometimes it's unavoidable*." (Participant C)

4.5.5.1 Interpretation

Theme 5 demonstrates that although mitigation strategies enable companies to cope with dwell times, their effectiveness is constrained by financial and organisational trade-offs. Firms must weigh service continuity against the erosion of profitability and liquidity. The convergence of first impressions with word cloud insights paired with coded evidence confirms that these strategies cannot provide sustainable efficiency gains; instead, they function as costly stopgaps in the absence of systemic reform.

4.5.6 Theme 6: Proposed Solutions and Policy Implications

While participants highlighted multiple operational and financial challenges caused by vessel dwell times, they also emphasised the importance of long-term reforms in restoring supply chain efficiency. Proposed solutions focused on upgrading infrastructure, reforming customs processes and addressing governance issues. These systematic changes were viewed as essential to address the root causes of inefficiencies and achieve sustainable competitiveness.

At the initial stage, participants emphasised the need for structural changes beyond firm-level strategies. Participant A argued that "*fixing the Durban–Johannesburg rail line would significantly improve efficienc*y and reduce costs". Participant H called for "*customs reforms"* and noting the "*inconsistencies in clearing procedures"*. Participant E highlighted the value of a SARS' vetted importer programme to "*reduce unnecessary inspections and improve clearance speed"*.

The word cloud analysis also reflected systemic reform as a recurring theme, with terms such as *"rail," "Transnet," "Durban," "Cape," "SARS," "customs," and "Africa"* surfacing across various sectors.

- Automotive and manufacturing participants frequently mentioned rail, road, and Transnet, emphasising the urgent need for infrastructure improvement.
- Steel and material importers focused on customs, duty, codes, and documentation, highlighting the bureaucratic delays tied to SARS.
- Logistics providers pointed to port delays and congestion, calling for governance reform and improved operational management.
- Commodity importers referenced Africa, supply, and production, emphasising how systemic inefficiencies limit regional competitiveness.

Table 10: Thematic Coding Proposed Solutions and Policy Implications

Theme	Category	Code	Quotes
Proposed Solutions and Policy Implications	Infrastructure Investment	Rail line repairs (Durban–JHB); port equipment upgrade	*"Fixing the Durban–Johannesburg line would immediately reduce costs and congestion."* (Participant A)
	Customs Reform	Preferred importer / risk-based checks	*"Getting onto SARS' vetted programme will help reduce checks and speed clearance."* (Participant E)
	Governance & Market Design	Privatisation / competition; international expertise	*"Efficiency and cost will improve under competition, but local knowledge is lacking — international expertise is needed."* (Participant H)

4.5.6.1 Interpretation

Theme 6 shows that participants recognise the limits of firm-level mitigation and stress the need for systematic and policy-level interventions. Infrastructure investment, customs reforms and improved governance were identified as the most urgent priorities. The convergence with both

first- and second-level analysis confirmed that long-term improvement in supply chain efficiency requires structural reforms rather than minor fixes. These insights underscore the role of both industry stakeholders and policymakers in addressing dwell times, making them central to the recommendations in Chapter 5.

4.6 Chapter Conclusion

The thematic analysis of eight interviews revealed six interrelated themes that capture how vessel dwell times in South African harbours undermine supply Chain efficiency. At the operational level, dwell times disrupt production schedules and create planning complications due to unreliable lead times. Financially, they impose direct costs through demurrage and storage fees for excess stock, while also straining cash flow and damaging client trust.

The Atlas.ti network with codes and themes can be seen below in Figure 9:

Figure 9Atlas.ti Network

Together, these findings demonstrate that while firms can buffer against the immediate effects of vessel dwell times, the persistence of inefficiencies at South African harbours requires coordinated policy-level interventions. This conclusion provides a foundation for Chapter 5, where the key findings are synthesised and actionable recommendations for industry stakeholders and policymakers are presented.

4.7 Chapter Summary

This chapter presented the empirical findings derived from eight semi-structured interviews with industry professionals directly involved in South African supply chain operations. The thematic analysis, supported by first-level impressions and word cloud analysis, revealed six interrelated themes that collectively explain how vessel dwell times undermine supply chain efficiency.

The key findings are summarised below:

- Theme 1 – Operational & Productivity Impacts:
    - Vessel dwell times disrupt production schedules, cause resource idling, and complicate planning processes. Firms are compelled to maintain buffer stock and implement workaround measures, which compromise just-in-time efficiency and increase operational rigidity.
- Theme 2 – Financial & Commercial Impacts:
    - Extended dwell times generate high demurrage and storage costs, constrain cash flow, and damage client trust. The financial strain reduces competitiveness, with many firms resorting to costly emergency logistics to meet contractual obligations.
- Theme 3 – Systemic / Structural Challenges:
    - Inefficiencies are rooted in structural deficiencies, including poor infrastructure, unreliable IT systems, customs bottlenecks, and weak coordination among stakeholders. These systemic constraints perpetuate dwell times and prevent sustainable efficiency improvements.

- Theme 4 – Mitigation Strategies Adopted by Firms:
    - Companies employ a mix of operational (safety stock, forecasting), logistical (airfreight, alternative ports), and procedural (pre-clearance, documentation control) mitigations. While these measures reduce short-term disruptions, they are costly and only partially effective.
- Theme 5 – Effectiveness and Trade-offs of Mitigation:
    - Mitigation strategies yield temporary relief but erode profitability and liquidity. Firms must balance operational continuity with financial sustainability, highlighting that firm-level actions cannot compensate for systemic inefficiencies.
- Theme 6 – Proposed Solutions and Policy Implications:
    - Long-term improvement requires coordinated policy interventions—specifically infrastructure investment, customs reform, and governance restructuring. Participants emphasised the need for competition, private-sector participation, and transparent regulatory processes to restore efficiency.

The findings show that vessel dwell times have multidimensional impacts on operations, finances, and the system. While firms have developed mitigation mechanisms, sustainable efficiency gains depend on structural reform at the national and policy level. These six themes collectively build the narrative for Chapter 5, where the study's conclusions and actionable recommendations are presented.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This final chapter integrates the theoretical foundations established in Chapters 1 to 3 with the empirical evidence presented in Chapter 4 to develop consolidated conclusions, actionable recommendations, and an implementation roadmap. The study aimed to investigate the impact of shipping vessel dwell times in South African harbours on supply chain efficiency within the manufacturing sector, and to identify viable mitigation strategies. Using a qualitative, thematic research design supported by eight semi-structured interviews and triangulated with the literature, six key themes were identified: (1) operational and productivity impacts, (2) financial and commercial impacts, (3) systemic and structural challenges, (4) mitigation strategies adopted by firms, (5) effectiveness and trade-offs of mitigation, and (6) proposed solutions and policy implications.

The purpose of this chapter is threefold.

First, it combines the key insights from both the literature and the empirical investigation into concise conclusions that collectively address the primary research question.

Second, it critically analyses these conclusions in relation to existing scholarly and industry perspectives, highlighting where the study confirms, extends, or challenges existing knowledge, particularly within the South African port context.

Third, it translates the findings into practical, evidence-based recommendations for industry stakeholders and policymakers, followed by a strategic implementation plan and suggested avenues for further research.

The following sections adopt a concise, evidence-based approach, where each subsection aligns explicitly with the stated research objectives to ensure coherence, transparency, and logical continuity. The chapter concludes with a reflection on the study's key contributions, limitations, and the broader implications for enhancing port performance and supply chain resilience within South Africa's manufacturing sector.

5.2 Conclusions

5.2.1 Conclusions from the Literature Study

The literature review established that global maritime logistics underpin over 80 per cent of world trade by volume, positioning port performance as a critical determinant of supply chain efficiency. Ports act as pivotal nodes connecting maritime and inland logistics systems. Inefficiencies in port operations directly influence cost structures, competitiveness, and reliability across supply chains. Within this global framework, vessel dwell time emerged as one of the most salient indicators of operational efficiency, reflecting the extent to which infrastructural, procedural, and governance-related challenges constrain cargo movement.

International studies revealed that world-class ports achieve efficiency through automation, digital integration, intermodal connectivity, and transparent governance frameworks. Automated container terminals, predictive scheduling tools, and private-sector involvement consistently correlate with shorter turnaround times and higher throughput. These findings emphasise that efficient port management depends on physical infrastructure, institutional agility, technological innovation, and collaborative stakeholder networks.

In contrast, the literature emphasised that South African harbours, particularly Durban, Cape Town, and Port Elizabeth, face persistent constraints including ageing infrastructure, inadequate maintenance, limited private-sector participation, and fragmented intermodal systems. Research by Gidado (2015:160-167) and Chinedum (2018a:70-82) positioned South Africa's average vessel turnaround times among the highest globally, exceeding international benchmarks by more than 30 per cent. These inefficiencies heighten manufacturing costs, lengthen delivery cycles, and erode national competitiveness.

The theoretical frameworks examined, such as supply chain efficiency, resilience, and risk management, highlighted that disruptions, including extended dwell times, necessitate both operational and strategic responses. Models including pre-positioning inventory, backup supplier strategies, and protected supplier approaches (Kamalahmadi & Parast, 2017:210-216) provide useful mitigation mechanisms but remain limited when systemic inefficiencies persist at a macro-infrastructure level. The literature thus revealed a critical gap: while mitigation theories are well developed, their contextual application to state-managed ports in developing economies remains underexplored.

In summary, the literature review concluded that vessel dwell times are not merely operational inefficiencies but systemic indicators of broader governance, capacity, and coordination shortcomings. The review identified that enhancing port performance in South Africa requires integrated reforms, spanning infrastructure modernisation, digitalisation, intermodal alignment, and institutional accountability to restore supply chain reliability and competitiveness. These insights provided the conceptual framework that guided the empirical phase of this study.

5.2.2 Conclusions from the Empirical Study

The empirical investigation confirmed that shipping vessel dwell times in South African harbours exert a pervasive and multi-dimensional influence on supply chain efficiency. Analysis of participant perspectives revealed six interrelated themes that collectively demonstrate how operational inefficiencies at the port level propagate throughout the manufacturing value chain, resulting in reduced productivity, financial strain, and systemic vulnerability.

At the operational level, firms experience significant production disruptions, scheduling difficulties, and an increased reliance on buffer stock. These adjustments undermine lean manufacturing principles and inflate overhead costs.

At the financial level, extended dwell times translate into elevated demurrage, warehousing, and transport expenses, constraining liquidity and diminishing price competitiveness—particularly in export-dependent industries.

From a systemic standpoint, participants attributed these inefficiencies to long-standing structural deficiencies such as ageing port infrastructure, poor intermodal connectivity, and fragmented governance within state-owned entities.

To mitigate these challenges, firms have adopted short-term coping mechanisms, including increased safety stock, alternative routing, and supplier diversification. However, these approaches were widely recognised as reactive and financially unsustainable, preserving short-term continuity at the cost of long-term efficiency. The findings therefore reinforce that firm-level action alone cannot compensate for national-level infrastructural and governance constraints.

Participants emphasised that sustainable improvement requires coordinated reform across four dimensions: infrastructure modernisation, digital integration of logistics systems, enhanced private-sector participation, and stronger policy accountability. These actions are essential to address the root causes of extended vessel dwell times and to restore operational predictability across South Africa’s logistics network.

In conclusion, the empirical findings demonstrate that vessel dwell times are not isolated logistical challenges but symptomatic of systemic misalignment between operational capacity, governance structures, and policy execution. Addressing these inefficiencies requires a national strategy that aligns port operations with industrial competitiveness, ensuring a more reliable, cost-effective, and resilient supply chain environment.

5.2.3 Other Issues

Although the six central themes captured the primary dimensions of the research problem, several marginal but important issues also emerged from participant feedback.

Firstly, communication and transparency between Transnet, port operators, and supply chain stakeholders were consistently identified as inadequate. Participants noted that limited visibility into vessel scheduling, documentation status, and terminal delays made operational planning highly uncertain. This lack of real-time information amplifies inefficiencies throughout the supply chain, creating a reactive rather than proactive logistics environment.

Secondly, data accuracy and availability surfaced as a significant constraint. Participants expressed concern that publicly available port performance data often lacks consistency and transparency, complicating decision-making and benchmarking. This data gap prevents both firms and policymakers from accurately diagnosing performance trends or evaluating the success of interventions.

Finally, several respondents highlighted workforce morale and skills capacity as emerging concerns. Repeated delays, operational bottlenecks, and unpredictable workloads have led to frustration among employees in manufacturing and logistics operations, affecting motivation and productivity. The findings therefore suggest that the implications of vessel dwell times extend beyond systems and processes as they influence the human and organisational dimensions of supply chain performance as well.

These secondary findings reinforce the complexity of South Africa’s port efficiency challenge, illustrating that sustainable improvement must address both the technical and behavioural components of supply chain management.

5.2.4 Critical Analysis of Empirical Conclusions Against the Literature

The integration of the empirical findings with the literature reveals strong alignment in several areas but also highlights critical deviations that underscore the uniqueness of the South African context.

From a global perspective, the literature consistently emphasises that efficient port operations depend on automation, private-sector participation, and effective intermodal connectivity (Dowgiewicz, 2022; Lau et al., 2024). The empirical evidence from this study fully supports these conclusions. Participants repeatedly identified inadequate infrastructure, limited digitalisation, and poor intermodal integration as key drivers of dwell times. The findings, therefore, validate international frameworks linking technological advancement and port productivity.

However, the study diverges from the literature in the magnitude and systemic persistence of inefficiencies observed in South Africa. Whereas global studies tend to frame dwell times as operational deviations within otherwise efficient systems, this research demonstrates that in South Africa, they represent structural and institutional deficiencies embedded within governance and policy frameworks. This finding reinforces the argument by Mthembu and Chasomeris (2023) that centralised state control, without adequate accountability or market competition, perpetuates inefficiency in marine services and port performance.

The literature on supply chain risk management (Kamalahmadi & Parast, 2017; Boudreau et al., 2015) proposes firm-level mitigation strategies such as backup suppliers and pre-positioned inventory as effective responses to external disruptions. The empirical findings here extend that understanding by illustrating the financial unsustainability of such approaches in environments where disruptions are persistent rather than exceptional. Thus, the study advances existing theory by demonstrating that resilience frameworks developed for temporary shocks (e.g., natural disasters or pandemics) are inadequate for addressing continuous structural inefficiencies like prolonged dwell times.

Furthermore, this research contributes to the theoretical discourse on supply chain resilience by emphasising that resilience cannot rely solely on organisational agility but must be supported by an enabling institutional environment. The empirical evidence underscores that without functional infrastructure, governance reform, and reliable policy execution, individual firm efforts to enhance resilience will remain constrained. This finding adds a policy-oriented dimension to resilience theory, positioning government effectiveness and data transparency as integral components of a resilient supply chain ecosystem.

In summary, the critical analysis confirms that the study aligns with established literature on the principles of port efficiency and supply chain risk management, but extends it by situating the problem within a developing economy governance context. It highlights that achieving supply chain efficiency in South Africa requires not only operational optimisation but also systemic reform linking managerial practice, technological innovation, and institutional accountability within an integrated framework.

5.3 Recommendations

5.3.1 Practical Recommendations

The study's findings indicate that extended shipping vessel dwell times in South African harbours stem primarily from structural inefficiencies in infrastructure, governance, and coordination. Therefore, sustainable improvement requires a multi-dimensional strategy that integrates operational reform, technological innovation, and institutional collaboration. The following recommendations are directed at port authorities, policymakers, and industry stakeholders to address the root causes of inefficiency and enhance supply chain resilience:

1. Infrastructure Modernisation and Equipment Renewal
    a. Transnet and the Transnet National Ports Authority (TNPA) should prioritise accelerated investment in port infrastructure renewal. This investment includes replacing obsolete cranes, rubber-tyred gantries, and marine craft; upgrading cargo-handling systems; and implementing preventative maintenance schedules. Transparent performance metrics must support infrastructure renewal to ensure accountability and continuity.
2. Digital Integration and Data Transparency
    a. The absence of real-time data visibility contributes significantly to scheduling inefficiencies. Implementing a centralised port community system (PCS) that integrates shipping lines, customs, freight forwarders, and manufacturers would enable predictive scheduling, cargo tracking, and data-driven decision-making. This system should align with global best practices in digital port management to enhance transparency and reduce administrative delays.
3. Intermodal Connectivity and Logistics Synchronisation
    a. Improved coordination between sea, rail, and road transport is essential. Strategic investment in rail capacity, combined with the rehabilitation of key inland terminals, would alleviate road congestion and enhance cargo throughput. A national

intermodal logistics plan—jointly managed by Transnet, the Department of Transport, and private operators—should be implemented to synchronise transport modes and streamline cargo evacuation from ports.

4. Governance Reform and Private Sector Participation

    a. Findings reveal that limited competition and centralised management within Transnet constrain efficiency. Introducing public–private partnerships (PPPs) and concession-based terminal management could introduce competitive benchmarks, performance incentives, and private-sector expertise. Governance reforms should be underpinned by measurable service-level agreements (SLAs) and transparent reporting mechanisms.

5. Skills Development and Workforce Capacity

    a. Addressing the maritime skills shortage is critical to sustaining operational improvements. TNPA and industry training bodies should expand apprenticeship programmes in marine engineering, crane operations, and port logistics management. Partnerships with higher education institutions could support ongoing professional development and align skills pipelines with emerging port technologies.

6. Policy Alignment and National Logistics Strategy

    a. The government should establish a unified National Logistics Coordination Council (NLCC) to align transport, trade, and industrial policy. This entity should coordinate long-term planning, monitor performance across logistics passages, and ensure accountability for service delivery within the port system.

Collectively, these recommendations aim to reposition South African ports as efficient, competitive gateways within global supply chains. Their implementation would not only reduce dwell times but also improve the country’s manufacturing competitiveness, export reliability, and economic resilience.

5.3.2 Recommendations for Further Study

While this study provided valuable qualitative insights into the impact of vessel dwell times on supply chain efficiency, several areas for further investigation emerged to expand the theoretical and practical understanding of this phenomenon.

1. Quantitative Analysis of Dwell Time Costs
    a. Future research should quantify the financial implications of dwell times across different industry sectors to establish a cost model linking dwell time duration to supply chain losses. Such data would strengthen the economic justification for infrastructure investment and reform.
2. Comparative International Studies
    a. Conducting cross-country comparative research between South Africa and more efficient port systems (e.g., Singapore, Rotterdam, or Port of Tanjung Pelepas) could identify transferable best practices and contextualise the scale of South Africa's challenges within a global framework.
3. Impact of Digitalisation and Automation Initiatives
    a. As South Africa gradually adopts port digitalisation and automation initiatives, longitudinal studies should evaluate their effectiveness in reducing dwell times and improving throughput efficiency. Such a study would help policymakers assess technology adoption barriers and ROI.
4. Intermodal Network Efficiency
    a. Further investigation into the operational alignment between ports, rail, and road logistics is necessary to understand how inland bottlenecks amplify dwell times. Research could focus on the feasibility of expanding dry port networks or introducing rail concession models.
5. Governance and Institutional Performance
    a. Future studies could examine governance reform within state-owned logistics enterprises, assessing how organisational restructuring, accountability mechanisms, and PPPs influence port efficiency outcomes.

6. Human Capital and Organisational Culture

    a. Given the emerging concerns about workforce morale and skills shortages, future qualitative studies should explore the relationship between organisational culture, labour relations, and operational efficiency within port and logistics environments.

In summary, further research should expand upon this study's qualitative foundation by combining quantitative cost modelling, policy analysis, and cross-sectoral evaluation. Such research would deepen understanding of the structural dynamics affecting South Africa's ports and support evidence-based policymaking aimed at restoring global competitiveness. Future studies should consider using larger and more diverse samples to enhance the generalisability of findings. By including a broader range of stakeholders across industries and ports they can potentially apply a quantitative or mixed-method approach as this could strengthen empirical validity and provide a more comprehensive understanding of the impact of vessel dwell times on supply chain efficiency.

5.4 Meeting of Research Objectives

This section evaluates how the study successfully addressed its primary and secondary research objectives as outlined in Chapter 1. The objectives guided both the theoretical exploration and empirical investigation, ensuring that the findings were directly aligned with the study's purpose: to understand and mitigate the impact of vessel dwell times on supply chain efficiency within South Africa's manufacturing industry.

Through a combination of literature review and thematic analysis, each objective was systematically met, providing both conceptual and practical contributions to the field of supply chain management.

5.4.1 Primary Objective

Primary Objective:

To examine how shipping vessel dwell times influence supply chain efficiency in South African harbours and to identify strategic interventions that can mitigate their adverse effects on manufacturing operations.

This objective was comprehensively achieved through the combined insights of the literature review and empirical investigation. The study provided a detailed understanding of how vessel dwell times disrupt supply chain flows, elevate logistics and inventory costs, and diminish the overall competitiveness of South Africa's manufacturing sector.

By identifying both the operational manifestations and the systemic root causes of extended dwell times, the research linked global port efficiency theory to the realities of a developing economy's logistics systems. Furthermore, it proposed practical, evidence-based strategies, such as infrastructure modernisation, digital integration, and governance reform, that holistically address these inefficiencies.

In fulfilling this objective, the study contributes to both academic knowledge and industry practice by reframing vessel dwell times not merely as operational inefficiencies but as indicators of broader institutional performance, policy alignment, and national competitiveness within the logistics and manufacturing sectors.

5.4.2 Secondary Objectives

To support the achievement of the primary objective, the following secondary objectives were addressed through the literature study and empirical analysis.

Secondary Objective 1:

To evaluate the effects of vessel dwell times on key dimensions of supply chain efficiency in South Africa's manufacturing sector, including productivity, costs, and delivery reliability.

This objective was fully achieved through the thematic analysis of qualitative data. Findings under Theme 1 (Operational and Productivity Impacts) and Theme 2 (Financial and Commercial Impacts) demonstrated that prolonged dwell times disrupt production schedules, increase inventory holding costs, and cause delivery delays that undermine competitiveness. The results confirmed that vessel dwell times exert a cascading effect across the entire supply chain, reducing overall efficiency and profitability.

Secondary Objective 2:

To identify and assess the current mitigation strategies employed by industry stakeholders to manage delays arising from extended vessel dwell times.

This objective was met through the findings discussed under Theme 4 (Mitigation Strategies) and Theme 5 (Effectiveness and Trade-offs). The study found that firms employ short-term measures such as increasing buffer stock, supplier diversification, and alternative routing. While these approaches offer temporary relief, they are financially unsustainable and fail to address the systemic inefficiencies underpinning the problem. This finding confirms that current industry

responses are tactical rather than strategic, reinforcing the need for coordinated structural reform across the logistics network.

Secondary Objective 3:

To propose refined or innovative mitigation strategies tailored to the unique infrastructural, operational, and policy challenges of South Africa's port logistics environment.

This objective was addressed through the integration of empirical findings with the practical recommendations presented in Section 5.3. Participants identified the need for long-term systemic interventions, including infrastructure modernisation, digital integration, and enhanced private-sector participation. These strategies were consolidated into actionable recommendations for policy and industry implementation, specifically tailored to the South African context.

Secondary Objective 4:

To determine the potential benefits of implementing the proposed strategies in enhancing supply chain resilience and supporting policy recommendations aimed at improving port efficiency.

This objective was achieved by linking the empirical findings to established resilience and performance frameworks. The study demonstrated that implementing integrated digital platforms, investing in infrastructure renewal, and strengthening governance structures would collectively enhance supply chain resilience, reduce operational costs, and improve national competitiveness. These interventions directly support policy-level efforts to improve port efficiency and overall economic performance.

5.5 Implementation Plan for the Future

Translating the study's recommendations into measurable impact requires a structured and coordinated implementation plan. The plan presented below provides a strategic roadmap designed to operationalise the research findings and ensure that proposed reforms yield tangible improvements in port efficiency and supply chain performance.

Given that the underlying causes of extended vessel dwell times are systemic, spanning infrastructure limitations, data fragmentation, and institutional inefficiencies, successful implementation depends on collaboration across multiple levels of governance. This collaboration should include alignment between national policy, state-owned enterprise operations, and private-sector execution capacity.

The plan adopts a phased approach to reform. In the short term, immediate actions should focus on restoring basic functionality, improving data visibility, and stabilising operations. The medium term should prioritise digital integration, intermodal coordination, and skills development to embed efficiency gains. In the long term, sustained competitiveness will depend on policy continuity, investment in automation, and an enabling governance environment that promotes accountability and innovation.

Clear responsibility and performance monitoring are central to this roadmap. Each recommendation is linked to responsible stakeholders, a realistic timeframe, and measurable outcomes to ensure transparency and continuous improvement.

Table 11: Implementation Roadmap

Focus Area	Key Actions	Responsible Stakeholders	Indicative Timeframe	Expected Outcome
Infrastructure Renewal	Replace obsolete equipment, implement structured maintenance plans, and modernise terminals.	Transnet, TNPA, Dept. of Public Enterprises	Short to Medium Term (1–3 years)	Improved operational reliability and reduced downtime.
Digital Integration	Implement a Port Community System (PCS) for real-time tracking and data transparency.	Transnet ICT Division, Customs, Freight Forwarders	Medium Term (2–4 years)	Increased scheduling accuracy and transparency across supply chains.
Intermodal Connectivity	Expand rail capacity and improve port–rail coordination; pilot inland dry ports.	Dept of Transport, Transnet Freight Rail, PPPs	Medium to Long Term (3–6 years)	Faster cargo evacuation and reduced congestion at ports.

Governance and Policy Reform	Establish National Logistics Coordination Council (NLCC) and enforce performance-based SLAs.	Dept of Transport, Presidency, Private Sector Councils	Short Term (1–2 years)	Clear accountability and streamlined decision-making.
Skills Development	Expand maritime training programmes and partnerships with industry and universities.	TNPA, SETAs, Higher Education Institutions	Ongoing	Improved operational capability and reduced labour shortages.

To ensure sustainability, the implementation process should be monitored through annual performance audits benchmarked against international port standards. Bi-annual stakeholder forums can be used to review progress, address emerging bottlenecks, and adapt strategies in response to technological or policy shifts.

If executed effectively, this roadmap can reposition South Africa's ports as efficient, technology-enabled trade gateways. In doing so, it will contribute to a more resilient manufacturing supply chain, enhanced export competitiveness, and the broader objective of restoring South Africa's role as a reliable logistics hub within the global economy.

5.6 Final Conclusion

This study investigated the impact of shipping vessel dwell times in South African harbours on supply chain efficiency within the manufacturing sector, proposing practical mitigation strategies. Through an extensive literature review and a qualitative empirical investigation involving industry professionals, the research has demonstrated that vessel dwell times are not merely operational inefficiencies but systemic indicators of broader structural, governance, and coordination failures within the national logistics ecosystem.

The findings revealed that extended dwell times disrupt production continuity, inflate logistics costs, and constrain liquidity across manufacturing operations. More critically, they expose long-standing deficiencies in infrastructure maintenance, digital integration, and institutional accountability. While firms have developed coping mechanisms—such as buffer stock, supplier diversification, and route substitution- these strategies remain reactive, costly, and ultimately unsustainable without systemic reform.

From an academic perspective, the study contributes to existing literature on port efficiency and supply chain resilience by situating the problem within the governance and policy dynamics of a developing economy. It extends conventional resilience frameworks by demonstrating that organisational agility alone cannot compensate for institutional inefficiencies; true resilience depends equally on the quality of public infrastructure, policy coherence, and data transparency.

From a practical standpoint, the research offers a roadmap for reform grounded in empirical insight. Recommendations for infrastructure renewal, digital integration, intermodal connectivity, governance restructuring, and skills development collectively form a strategic blueprint for restoring operational efficiency and competitiveness. Implementing these measures through coordinated public–private collaboration will not only reduce dwell times but also reposition South Africa as a credible and reliable logistics hub within global trade networks.

Ultimately, the study concludes that resolving vessel dwell time inefficiencies requires systemic transformation rather than incremental adjustment. Sustainable progress depends on aligning port operations with national economic objectives, fostering accountability in state-owned enterprises, and enabling a culture of performance-driven governance. If implemented with commitment and collaboration, these reforms have the potential to restore confidence in South Africa’s logistics sector, strengthen manufacturing resilience, and contribute meaningfully to the country’s long-term industrial and economic growth.

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