UNIVERSITY OF KWAZULU-NATAL

Enhancing productivity in a container terminal through a systems approach: A case study of the Port of Durban

By

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DECLARATION

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ABSTRACT

Ports and container terminal processes are vital constituents contributing to the economy of a country. The management of these facilities, including operational productivity advancement strategies, are critical for a port's competitiveness. A systems approach, with a focus on causal loop diagrams which are part of system dynamics, and aspects of soft systems methodology and container terminal productivity, are the underlying theoretical concepts for this investigation. The research sought to enhance productivity in a container terminal through a systems approach, using the Port of Durban as a case study. The study reports on a sensitivity analysis of key performance indicators for port productivity and how the performance can be improved using systems approaches. The methodology followed a mixed methods approach which incorporated qualitative and quantitative data collection. Secondary data analysis and semi-structured interviews were conducted, including Causal Loop Analysis and Soft Systems Methodology workshops. The key findings of the multiple regression analysis indicate that the critical elements for enhanced productivity at Durban Port are gross crane hour, ship working hour and rail turnaround time. A systems approach facilitated development of causal loop diagrams, rich pictures, root definition, conceptual model and analysis of Customers, Actors, Transformation process, Worldview, Owners and Environmental Constraints for improved terminal operations, with a focus on improved ship turnaround time. The causal loop analysis was instrumental in determining cause and effect factors contributing to the inefficiencies of the terminal and facilitated the discovery of key variables contributing to optimised maritime, terminal and hinterland operations. The Soft Systems Methodology approach facilitated a process of constructing a framework for improving terminal operations by identifying system structure, transformation process, main players and customers, including their interactions within the system, using a CATWOE analysis. The conceptual model enabled identification of required activities needed to improve marine, terminal and hinterland activities within the port and terminal-owned system. The study contributed to new knowledge by exploring all three dimensions that impact efficiencies in the South African context, and through the development of the conceptual model for enhanced terminal operations using a systems approach.

Keywords: Container Terminal Productivity, Systems Approach, Key Performance Indicators, Sensitivity Analysis, Soft Systems Methodology and Systems Dynamics

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

CLD	Causal Loop Diagrams
CSH	Critical Systems Heuristics
DCT	Durban Container Terminal
E-RTGs	Electrified- Rubber Tired Gantry-Cranes
GCH	Gross Crane Hour
ITD	Induced Travel Demand
MTSs	Multi-trailer Systems
PA1	Port Authority Respondent 1
PA2	Port Authority Respondent 2
PA3	Port Authority Respondent 3
PA4	Port Authority Respondent 4
PT1	Port Terminal Respondent 1
PT2	Port Terminal Respondent 2
PT3	Port Terminal Respondent 3
R1	Rail Division Respondent 1
R2	Rail Division Respondent 2
R3	Rail Division Respondent 3
RH1	Road Haulier Respondent 1
RMGs	Rail Mounted Gantries
RTGs	Rubber Tyre Gantries
RTT	Rail Turnaround Time
SADC	Southern African Development Community
SD	System Dynamics
SFDs	Stock Flow Diagrams
SL1	Shipping Line Respondent 1
SL2	Shipping Line Respondent 2
SL3	Shipping Line Respondent 3
SL4	Shipping Line Respondent 4
SODA	Strategic Options Development and Analysis
SSM	Soft Systems Methodology
STAT	Ship Turnaround Time
SWH	Ship Working Hour
TCP	Transnet Capital Project
TE	Transnet Engineering
TEUs	Twenty-Foot Equivalent Units
TFR	Transnet Freight Rail
TNPA	Transnet National Ports Authority

TP	Transnet Property
TPL	Transnet Pipelines
TPT	Transnet Port Terminal
TTT	Truck Turnaround Time
TTUs	Tractor Trailer Units
VSM	Viable Systems Model

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Improved port infrastructure in developing countries is a critical driver for economic growth, considering its capabilities to enable enhanced logistics performance contributing to increased seaborne trade (Munim and Schramm, 2018). Given the complexity of the overall supply chain, management of the value chain using a systems approach to ensure smooth operations is important. Disruptions and changes in one dimension have a potentially adverse impact on other dimensions, impacting on the overall operations. The management of container terminal operations and development of enhancement strategies through a systematic approach to improve productivity, is essential for a port's performance and competitiveness. The introductory chapter of this thesis provides a concise overview of the background, offering a context and rationale for the study. The chapter outlines the problem statement and the importance of the study. It highlights the aims, objectives and research questions of the study, and finally, provides a high-level overview of the methodology, including the limitations and delimitations of the study.

1.2 Background to the Problem

Sea ports continue to play an important role within a logistics chain, acting as gateways connecting local and national trade with global markets (Chhetri et al., 2016). The Port of Durban is the main South African container port strategically located to service KwaZulu-Natal, the Gauteng region and neighbouring countries (TNPA, 2016). The Port of Durban is central to the maritime connections with the rest of the world and makes a significant contribution to the economy of the city, accounting for 10% of the total employment and providing both direct and indirect jobs (Rodrigue et al., 2014). Nabee and Walters (2018a) allude to the fact the Port of Durban is the preferred leading port connecting to the busiest corridor in Southern African Development Community (SADC), North-South Corridor. The good credentials of this corridor and its expansion are boosted by the location, existing infrastructure and continuous development of the Port of the Durban, when compared to other SADC seaports and neighbouring corridors.

According to Fraser et al. (2014), the container terminal in the Port of Durban is the biggest and central port with respect to the liner shipping network in the Southern Hemisphere, accounting for 55% market share. The Ports Regulator of South Africa (2016a) further indicates that the Port of Durban handles about 57% of container volumes passing through the South African ports. It serves as the major gateway for the industrial centre for the South African economy and the worldwide economic trade. Caschili and Medda (2015) also indicate that the ports of Cape Town and Durban in South Africa are the main gateways into the country. Xu et al. (2015) add that the Port of Durban plays a critical role as a transhipment hub for trade in transit from Asia to West Africa and South America East Coast and *vice versa*. Scholtz (2017) agrees that Durban functions as the main hub for containerised cargo serving the Middle East, Far East, Indian Ocean Islands and Australia.

Durban's inbound and outbound container operations are continuously being congested (Govender and Mbhele, 2014); however, there are plans to increase container capacity on a short-medium- and long-term basis. Hence, the Port of Durban is positioned to continue to be the port of choice serving Gauteng and surroundings, including the neighbouring countries (TNPA, 2016). The planned development will allow the Port of Durban to maintain its position as the main and busiest port in South Africa, with one of the largest container terminals in the Southern Hemisphere**.** Rodrigue et al. (2014) further add that the Port of Durban will continue to act as a regional gateway and one of the global hub-ports for Africa. However, according to Fraser and Notteboom (2015), South African ports have been struggling meeting its productivity targets such as ship working hour (SWH), ship turnaround time (STAT) and truck turnaround time (TTT). As a result, there is high pressure from industry to improve the container terminal productivity of South African ports.

1.3 Problem Statement

According to Mulla and Bester (2016), the movement of cargo in a port is complex and results in inefficiencies. Therefore, full comprehension of various touchpoints by stakeholders managing the operations is required, with the intention of developing relevant policies to ensure smooth processes. While the Port of Durban is considered to be attractive when benchmarked with other Southern African ports due to superior infrastructure and trade and industry conditions (Caschili and Medda, 2015), its performance is not optimum. The biggest container port in South Africa encounters efficiency problems as it experiences congestion at the port gate and terminal. Durban terminal operations are considered less efficient compared to its contenders and other big ports in the world (Rodrigue et al., 2014). Gumede and Chasomeris (2013) further indicate that port stakeholders have criticised the Port Authority for poor productivity and efficiency, among other issues, which impede port competitiveness when compared to other international ports.

According to the Ports Regulator (2016b), Durban ranks below average on ship turnaround time (STAT) and gross crane per hour (GCH), achieving 2 days' ship dwell time and 24 moves per gross tonnage *versus* the global trend of 1.03 days STAT and 35 moves per GCH. With respect to berth productivity, Durban achieves a lower berth productivity of 53 moves per hour. Some major ports in the world achieve a much higher berth productivity; for example, 108 moves per hour were achieved in the Port of Yokohoma in Japan, while the Port of Tianjin achieved 130 moves per hour in 2013 (Journal of Commerce, 2014). There are various other productivity measures that are tracked at container terminals such as ship working hour (SWH), truck turnaround time, (TTT), terminal berthing delays and Rail Turnaround Time (RTT). According to Ducruet et al. (2014), there is scant academic research with respect to container productivity indicators. The data is generally captured by particular port experts, shipping lines and ports. Hence, there is a need for more academic research to be conducted in this area, which this study intends to do.

Several management models including, but not limited to the following, have been investigated with respect to container terminal productivity: Decision Support System (Ursavas, 2014), Multi Agent Systems (Henesey, 2004 & 2006), Critical Systems Approach (Rappetti, 2012), Supply Chain Management and Performance Management System (Hector and Ruthven, 2012). However, these models and studies have not assessed the concept holistically by looking into maritime, terminal and hinterland operations. A study by Ursavas (2014) made the recommendation of a decision support system to improve performance only on the quayside operations and did not consider the overall operations at the container terminal. Studies by Henesey (2004 and 2006) investigated container terminal productivity improvements using a multi-agent systems approach. The results generated through these studies revealed that the use of multi-agent-based technologies can assist in decision-making and enhance container terminal performance.

An investigation by Rappetti (2012) regarding use of a critical systems approach to understand and investigate productivity improvements in the Port of Durban was conducted, but the study was focused only on marine services which revealed a minimal impact on STAT. The study also recommended that further investigation be done on other factors such as period spent at anchorage and at berth. Hence the intention of this study is to investigate port productivity using a systematic approach which will allow the researcher to review the situation holistically, considering all dimensions that affect productivity including maritime, terminal and hinterland operations.

The study by Hector and Ruthven (2012) developed a performance management system for the South African Ports for the overall logistic chain; however, the model only assists with assessing performance and does not look into the interdependencies of various components that affect productivity. A study by Chasomeris (2011) also indicated that there are various factors that do not fall within the jurisdiction of the Port Authority, that impact container productivity in the port environment, including adverse weather settings and interruptions by shipping liner operators impacting on the overall vessel stay. Rodrigue et al. (2014) indicated that the three dimensions that impact on inefficiencies within the port system are maritime operations, terminal operations and hinterland operations. The management of the overall dimensions in a systematic approach using systems thinking is critical in improving operations.

Bala et al. (2017:15) describe systems thinking as “a method of studying the dynamic behaviour of a complex system considering the systems approach, i.e. considering the entire system rather than in isolation”. They further indicate that a systems approach looking at the overall problematic unit required to be investigated, considers all the variables impacting the dynamic forces of a complex system with the intention to solve a problem. Reynolds and Holwell (2020) assert that a systems approach has the ability to streamline thought process and the management of complex challenges. Through systems thinking, it is able to choose components that reveal the thought process in a translucent manner with the intention of reflecting the situational fundamental issues from different perspectives.

According to Reynolds and Holwell (2010), there are five systems approaches applicable for managing complex situations: System Dynamics (SD), Viable Systems Model (VSM), Strategic Options Development and Analysis (SODA), Soft Systems Methodology (SSM) and Critical Systems Heuristics (CSH). VSM is a self-governing system that requires a thriving environment in varying circumstances to ensure viability. According to Williams and Hummelbrunner (2010), VSM specialises in the organisational structure, data process flow and decision-making and can be utilised as both an analytical and design instrument. A study by Hildbrand and Bodhanya (2015) applied a VSM approach in the sugar cane industry with the intention of demonstrating how a diagnosis can be used by consultants and researchers. The research outcome of this study based on the experience conducted, revealed that the model is an excellent investigative instrument that can enhance other research methods in the analysis of businesses or logistics networks.

Strategic Options Development and Analysis (SODA) is an approach that facilitates rigorous personal engagements to ensure organisational change (Reynolds and Holwell, 2010). A study by Guarnieri et al. (2016) used the SODA approach to investigate strategy through stakeholder engagement with decision-makers. The research outcomes discovered four actionable sets for implementation, which were a result of both technical review and stakeholder views. Research by Santos et al. (2019) examined a complex management challenge in Santana Catarina State, where various stakeholders had different views on the utilisation and preservation of native forests using mapping analysis instruments of the SODA methodology. The research results revealed that the SODA method was instrumental in sketching out the complex challenges experienced, and that economic assessment, together with supervision of forest assets, emerged as the major issues for the leadership of Santa Catarina's native forest.

CSH facilitates a process of determining the most critical and less important value-adding aspects to a situation or environment, so that boundary rulings are managed appropriately (Reynolds and Holwell, 2010). CSH is further described as a learning instrument that can be used within any particular situation for identification of important systems boundaries and investigation of the consequences thereof (Williams and Hummelbrunner, 2010). A study by Gharehgozli et al. (2014) investigated the stacking of import containers within a container block, with the intention to reduce container reshuffling incidence through use of stochastic dynamic programming model and a decision-tree heuristic. The research outcomes reveal that the exercise was effective whereby the trees are able to process ideal decisions with smaller scale challenges, while the heuristic outclassed the well-known heuristics for large scale projects. Furthermore, the experiment also showed that joint stacking is more productive compared to exclusive stacking as it allows container stacking from various vessels.

Xi and Poh (2013) describe SD as a method for comprehending the manner in which the systems behave over time. It shows the various reactions that impact on system and has competencies that are capable of simulating the results of several policies which can be used as a decision-making tool. Bala et al. (2017:15) further define SD as "a tool or field of knowledge for understanding the change and complexity over time of a dynamic system". Ridwan and Noche (2018), state that the SD is an ideal tool for understanding the dynamic conduct of a complex system such as a port. It facilitates comprehension of vibrant systems, specifically social systems. It deals with how the situation is configured and the influence on response delays, including control features affecting the environment, that have diverse interconnections (Williams and Hummelbrunner, 2010). The Sustainability Laboratory (2019) further elaborates that SD is an instrumental tool to model people's mental models and to articulate their view of how the world operates.

Reynolds and Holwell (2010) describe SSM as a method that enables the modelling of organisational procedure that has been widely utilised to investigate organisational change in big corporates with a huge number of employees. SSM is mostly utilised to assess complicated environments, where the problem seems to be interpreted differently and allows exploration of different options for assessing in order to address a problematic situation. It looks at various possible solutions to a problem and how these enable understanding of a system's behaviour and modification implications. SD and VSM are known for their ability to determine interrelatedness and interdependencies between components in an environment, while strong points for SSM are developing and engaging with diverse perceptions (Williams and Hummelbrunner, 2010).

A combination of systems approach methodologies was used by Bošković (2018) to resolve a problematic situation where Soft Systems and Complexity Methodologies were utilised. His paper states that various approaches can be used to ensure innovative solutions to problematic areas as there is no single approach that can optimally investigate a challenging situation, as each method has its pros and cons. The study clarified how the two approaches complemented each other, where SSM as a main method was used to have a full view of the situation, while the complexity management as a support tactic managed to show the complexity and volatility of the problem. The findings of the SSM study by Hanafizadeh and Mehrabioun (2017) showed that a solitary approach was used minimally by researchers and an amalgamation of methodologies was preferred, implying that SSM is better utilised with a combination of other approaches.

Akkermans and van Oorschot (2005) investigated the development of the business scorecard using systems dynamics. The process of developing causal loop diagrams facilitated a process of identification of critical elements, including their causal linkages. The process seemed to be beneficial considering it is able to tap into corners in which it is difficult to acquire theoretical and reliable information through simulation. While other methodologies could be suitable in certain instances, systems dynamics was relevant for business scorecard development and proved to be advantageous to the situation. The study conducted by Ridwan and Noche (2018) also used a combination of an SD and six sigma approach to understand the nature of the port within a complex environment. The SD allowed for the consideration of various underlying forces to determine a model for improving performance in the port space.

As per the researcher's knowledge, a systems approach using a combination of soft system methodology and systems dynamics has not been investigated in the South African Port System and specifically in the Port of Durban.

1.4 Aim and Objectives of Study

1.4.1 Aim

The aim of the study is to investigate how the performance of a container terminal can be improved using systems approaches with respect to aspects of SD and SSM. It involves a case study of the Port of Durban.

1.4.2 Research Objectives

a) To determine which critical performance indicators of productivity from the systems approach could be investigated to ensure optimised maritime, terminal and hinterland operations in a container terminal.
b) To analyse the container terminal operations using conceptual models, root definitions and rich pictures with the intention to ensure terminal productivity improvements.
c) To conduct a sensitivity analysis to determine critical performance indicators influencing productivity of the container terminal using secondary data.
d) To determine the relevant systems approach strategy for improving productivity at the container terminal in the Port of Durban.

1.4.3 Research Questions

a) Which critical performance indicators of productivity from the systems approach that could be investigated to ensure optimised maritime, terminal and hinterland operations in a container terminal?
b) How can container terminal scenarios be analysed using conceptual models, root definitions and rich pictures to improve terminal productivity?
c) What is the correlation and impact of each key performance indicator element on the overall productivity of the container terminal?
d) What is the relevant systems approach strategy for improving productivity of the Container Terminal in the Port of Durban?

1.5 Study Significance and Contribution to New Knowledge

From the researcher's knowledge, there appears to be a research gap in the literature with respect to a systems approach using a combination of SSM and SD on container terminal productivity. This type of study has not been investigated in the South African Port System and certainly not in the Port of Durban. A systems approach will assist in determining interrelatedness and interdependencies of various components of productivity using causal loop analysis to ensure optimised maritime, terminal and hinterland operations in this container terminal. This approach will also assess and depict various scenarios affecting productivity using conceptual models, root definitions and rich pictures, with the intention of ensuring terminal productivity improvements. Most importantly, the study will allow development of the relevant systems approach strategy with respect to SD and SSM for the Container Precinct in the Port of Durban. This study will therefore also fill a gap in developing knowledge and contributing to the theory of SSM and SD in South African Ports, with the objective of improving container terminal productivity.

1.6 Overview of Methodology

This research adopted partially integrated mixed methods, where a combination of quantitative and qualitative approaches was used for the investigation. A combination of a case study and archival and documentary research with respect to research strategy was also considered appropriate. A qualitative method was utilised using a systems approach to establish enhancement strategies for container terminal productivity through semi-structured and focus group interviews. A quantitative method through documentary research was used to collect data using descriptive statistics, where key performance indicators from marine, container and hinterland areas were requested from respective companies to determine the correlation and impact of each input element on the overall productivity of the container terminal.

Secondary data was analysed using Stata Software to determine the critical input elements of productivity for container terminal operations from a maritime, terminal and hinterland perspective, using regression and multiple regression analysis. The qualitative analysis of this study through semi-structured interviews followed a deductive content analysis approach and the six (6) steps approach by Creswell (2014). Data collected through focus group interviews were collected through SSM and Causal Loop Analysis Workshops. In order to ensure the reliability and validity of the study, data was collected legally from reliable sources; for instance, operational reports reflecting key performance indicators were requested from the operations department of the respective organisations.

1.7 Delimitations and Limitations

According to Hancock and Algozzine (2006), limitations are restrictive aspects impacting the outcomes of the investigation, while delimitations refer to the confinement of the study where generalization can be carefully accommodated. Theofanidis and Fountouki (2018:157) state that possible limitations may incorporate "assumptions regarding underlying theories, causal relationships, measurement errors, study setting, population or sample, data collection/analysis, result interpretations and corresponding conclusions". For the purposes of this study, the delimitations and limitations are as follows:

1.7.1 Delimitations

This study has used a single case study, meaning that it focused on one case and has drawn conclusions only about the organization being studied, that is, the Port of Durban (Saunders et al., 2016). The study is therefore not representative of all the container ports in South Africa.

1.7.2 Limitations

It must be noted that while the study has used the systems approaches, it is not using all five systems approaches but aspects of the SD and SSM to determine the relevant systems approach strategy for improving productivity of the container terminal in the Port of Durban. The VSM, SODA, and CSH methodologies have not been investigated in this research. With respect to the two (2) methodologies studied, SD and SSM, only certain steps are followed in this research since the nature of the study specifically explores enhancing container terminal productivity as opposed to developing a productivity model. For example, with respect to the SSM, only the first three (3) steps of the methodology were utilised. With respect to Systems Dynamics, the study uses only casual loop diagrams (CLDs) and does not utilise the stock flow diagrams (SFDs) and simulations. While the literature review makes reference to the SFDs and simulations, the study does not conduct any SFDs and any simulations. With respect to sensitivity analysis, the study focused only on key performance indicators that were monitored by shareholders for the period under review. Considering the research objectives, which focused on container terminal productivity improvements, only the basic features of systems approaches were utilised to arrive at an enhancement strategy. However, it must be noted that from a methodological perspective, the chosen approach is justified as the initial novel study intended to home in on an enhancement strategy as opposed to developing complete systems models for productivity.

1.8 Format of the Study

Chapter One is the introductory section that gives a background of the study, the problem to be investigated, the significance, purpose and objectives of the study. It also reveals the critical research questions of the study and the format of the study.

Chapter Two of this thesis provides the situational analysis of the Port of Durban, outlining the various operations and particular chaotic areas within the container terminal operations from the marine perspective; the different piers and types of equipment utilised; the operating model, the status of productivity, productivity measures and the socio-economic impact of the Port of Durban.

Chapter Three gives an overview of container terminal operations outlining the various activities involved in the handling of containerised cargo. The complexity of container terminal operations is explained considering all aspects that cause the operations to be intricate. The importance of managing container terminal operations as a system is also discussed.

Chapter Four of this thesis offers an overview of the concept of container terminal productivity and systems approach, outlining its importance and the productivity levels achieved worldwide. The critical indicators for measuring productivity, including the factors impacting efficiencies of container terminals are elaborated. The impact of productivity on operations, and measures to enhance productivity at the container terminals are explained. Other factors practised worldwide to improve efficiency of the container terminals are discussed.

Chapter Five describes the methodologies and the techniques adopted in the study. It outlines the blueprint of how the study was conducted from the beginning to the end. It discusses the use of all analytical tools in pursuance of the aims and objectives of the study. The chapter deliberates on the research design, strategy, different research methodologies, sampling methods, data collection, analysis, and ethical considerations that were critical to the study. The manner in which the data was analysed is also described in this chapter.

Chapter Six of the thesis outlines the findings of the secondary data analysis which focused on the sensitivity analysis determining critical performance indicators influencing productivity of the container terminal from the marine, terminal and hinterland perspectives. The finding of the analysis identified areas of focus for enhancing productivity of the container terminal by reducing the ship dwell time in the port. The findings of the sensitivity analysis were linked to the literature review to show the significance of the research outcomes.

Chapter Seven provides detailed findings and discussion of the findings from semi-structured interviews which investigated how the performance of a container terminal can be improved using the systems approach. This chapter details the context and problematic situation of the research study sourced from research participants, which was analysed through Nvivo Software to produce common themes underlying the research study. These were then also compared with the existing literature. This chapter contributed to the identification of critical input elements which became the source of information for development of CLDs and rich pictures presented and discussed in Chapter 8 of this thesis.

Chapter Eight details presentation of the findings and discussion of the focus group interviews which were conducted in the form of SSM and Causal Loop Analysis Workshops, with the intention of improving the performance of a container terminal using the systems approach. The chapter shows how aspects of SD and SSM can be utilised to improve container terminal operations through use of CLDs, rich pictures, root definition, CATWOE Analysis and the conceptual model.

Chapter Nine of the thesis concludes the research study, highlighting the findings of the research from the literature review, secondary data analysis, semi-structured interviews and focus group interviews, with respect to how container terminal productivity in the Port of Durban can be improved using a systems approach. Additionally, the chapter incorporates recommendations on strategic initiatives to maximise container terminal productivity using a systematic approach to ensure optimised maritime, terminal and hinterland operations. This chapter also outlines its originality within the theoretical framework and provides suggestions for future research.

1.9 Conclusion

This chapter has provided an overview and background of the study, including the problem statement that was being explored in the research. It has outlined the gaps that exist in the literature in relation to the systems approach and port productivity studies within a South African context, and the approach the study chooses to use to close the gaps. It has defined the significance of the study and the original contribution of knowledge it is to the body of literature. It has clearly stated the research purpose of the study and outlined its objectives and relevant research questions. Lastly, it shows how the research study is structured. The next chapter deals with the situational analysis of the research subject, the Port of Durban, with a particular focus on container terminal operations.

CHAPTER TWO: SITUATIONAL ANALYSIS

2.1 Introduction

Ports function within operational processes such as marine services, terminal operations and hinterland operations, which must be managed as a system. Chapter Two of this thesis provides the situational analysis of the Port of Durban outlining the various operations and particularly, the chaotic areas within the container terminal operations, with consideration of the marine perspective, different piers, types of equipment utilised, the operating model, status of productivity, productivity measures and the socio-economic impact of the Port of Durban. All these operations are complex as the various aspects have diverse problems which affect productivity of the overall container terminal. A study by Oztanriseven et al. (2014) indicates that Systems Dynamics Models can be used positively to explain the complex nature of the maritime transport network. Their research managed to exhibit the causal interactions between the various elements of the marine transport system through a literature review and proposes further development of the SD model with the intention of acquiring more knowledge about the system elements and their impact on the system's behaviour. Further development of this would assist with resolutions that will bring competitive advantage to all system stakeholders.

Analysis of container terminal operations using systems tools and instruments looks at the port system in its entirety, as opposed to solving only part of the problem. This is essential to ensure terminal productivity improvements. According to Arnold and Wade (2015), systems thinking allows an integrated perspective with an ability to detect intra- and interconnections and dependencies, including the comprehension of varied contexts and the conduct of complex systems. It is also characterised with capabilities to project the impact of alteration to the system consistently.

2.2 Background of the Port of Durban

The Port of Durban falls among the eight sea ports administered by TNPA, an integral operating component of Transnet State-owned Company (SOC) Limited in South Africa (Meyiwa and Chasomeris, 2016:855). Transnet Soc. Limited is a public organisation owned by government with the directive to facilitate economic growth and safeguard security of supply through provision of relevant infrastructure with respect to port, rail and pipeline services. Other responsibilities incorporate safety, security and efficiencies of the ports and management of the overall logistics chain as a network (Transnet, 2018).

According to an Integrated Report by Transnet (2019), the organisation drives its objectives through five operational divisions and support divisions functional in most parts of South Africa, as reflected in Figure 2.1.

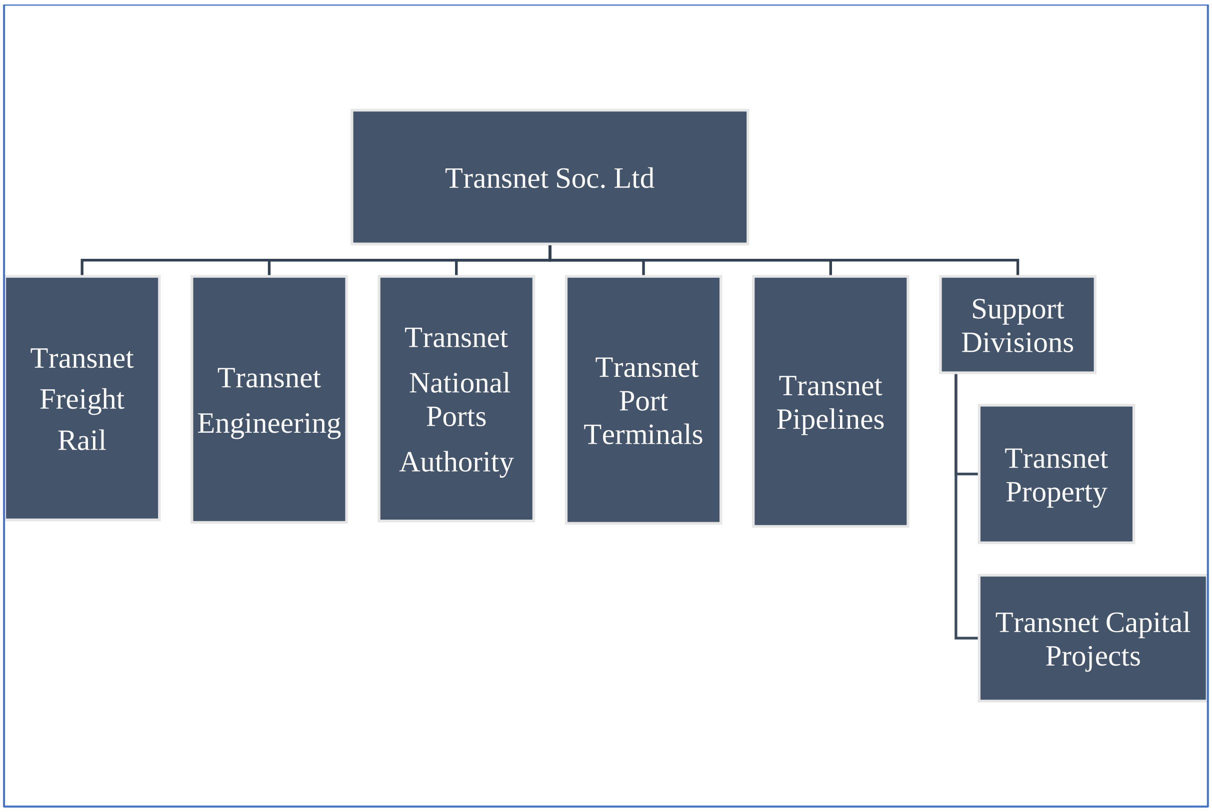

Figure 2.1: Transnet Organisational Structure (developed by researcher)

The freight rail division is one of the biggest units within Transnet, focusing on rail services for transportation of cargo locally, regionally and to international markets. It has a world class export line servicing coal and iron ore; however, containers and various other bulk commodities are also transported by rail using a rail network equivalent to 31 000 track kilometres. This complex network is a critical linkage connecting port terminals and manufacturing hubs to ensure delivery of cargo in partnership with other Transnet Divisions and customers. The division plays a critical role by ensuring connectivity through rail network not only to local markets, but to SADC regions, thereby promoting regional integration (Transnet Freight Rail, 2019).

Transnet Engineering (TE) is the progressing manufacturing unit of Transnet, which has placed itself as Africa's original wagon equipment manufacturer. The division focuses not only on the manufacturing aspect, but plays a critical role in the maintenance of the freight and port equipment. This focus of the division guarantees minimal disruptions, which reduce train delays, including cancellation of train services. The division also ensures that operational efficiencies are improved by ensuring that the rolling stock is available and reliable (Transnet Engineering, 2019). Transnet Pipelines (TPL) is the multi-product pipeline division transporting liquid bulk products through a 3800-kilometre network, with the strategic objective of guaranteeing security of supply in the country (Transnet Pipeline, 2019).

TNPA is mandated by the State to manage, control and administer the South African Ports System, such that ports are safe, efficient and functioned economically as per the National Ports Act (2005). This is a critical position within the logistics supply chain, considering the management of 8 commercial ports, Richards Bay, East London, Ngqura, Port Elizabeth, Mossel Bay, Cape Town, Saldanha and Durban, as shown in Figure 2.2 (TNPA, 2019).

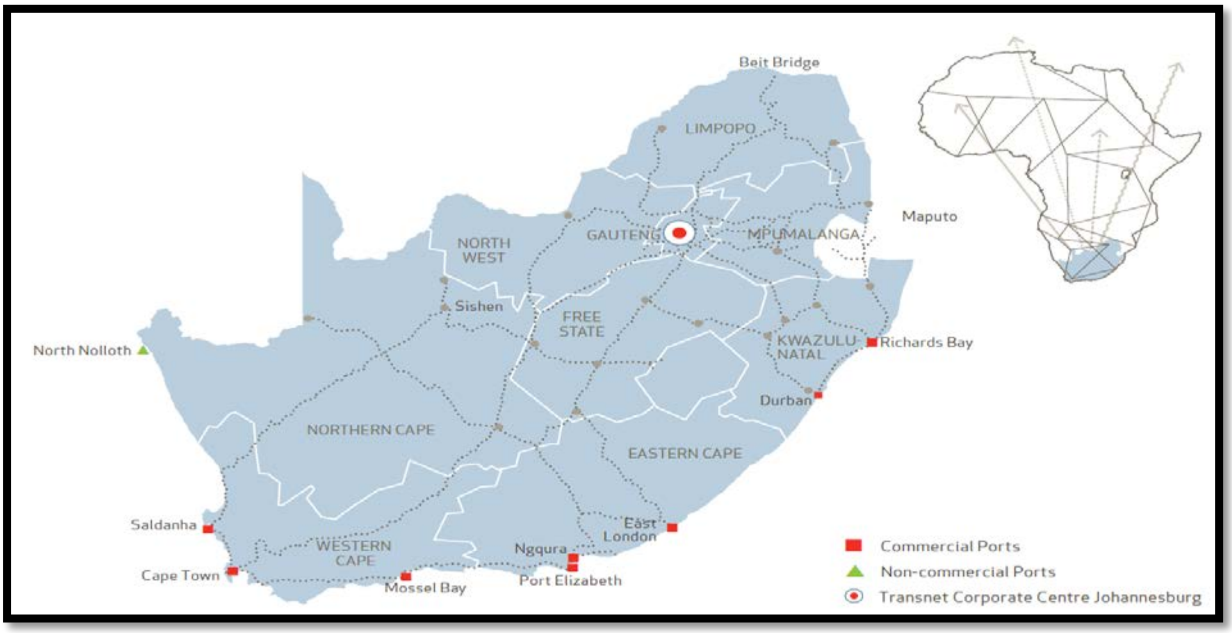

Figure 2.2: South African Port System (TNPA, 2019:2)

According to the Port Development Plan by Transnet (2017), the Port of Durban is the major container sea port in South Africa, acting as a gateway not only to KwaZulu-Natal but the Gauteng hinterland and Southern Africa. The port is considered to be one of the most attractive and appealing in Sub-Saharan Africa, with a total land and water area of 1,769 hectares (land 973hs, water 796ha), and handles an excess of 3450 vessels per annum (TNPA, 2018). The boundary limitations experienced are that the port is bordered by municipality developments and residential areas which restrict its growth extension on the land side (Transnet, 2017). The situation demands innovative ideas to accommodate cargo efficiently, given projected cargo growth over the next few years.

The port comprises 46 berths with a length of 10 933m, which handled about 61 million tonnages of cargo in 2016. The projected 30-year estimate is 147 million tonnages of volumes yearly. The Port of

Durban has about 8 containers berths with capacity of 3 600 000 twenty-foot equivalent units (TEUs) per annum at both Piers 1 and 2 (Transnet, 2017). Rodrigue et al. (2014) state the Port has the capability to safely handle vessel size of 4500 TEUs. The bigger vessels can only be handled either on high tide or when partially laden, which is another restriction in accommodating vessels in the port.

The Port is divided into 5 Precincts: i) Point and Leisure (composed of mainly Automotive, Fresh Produce and Cruise Industries); ii) Maydon Wharf (handling mainly Dry Bulk, Break Bulk and Multi-Purpose Cargoes); iii) Bayhead (comprised of largely Ship Repair, Marine Engineering Industries and Container Depots); iv) Container Precinct (Durban Container Terminal or DCT, comprising Piers 1 and 2 for handling containerised cargo) and lastly, v) Island View (responsible for mostly Liquid Bulk Cargoes such as Chemicals, Oils, and Petroleum Products). The aerial view and current layout of the Port of Durban are depicted in Figures 2.3 and 2.4 (TNPA, 2018a).

Figure 2.3: Aerial View of the Port of Durban (Transnet, 2017:267)

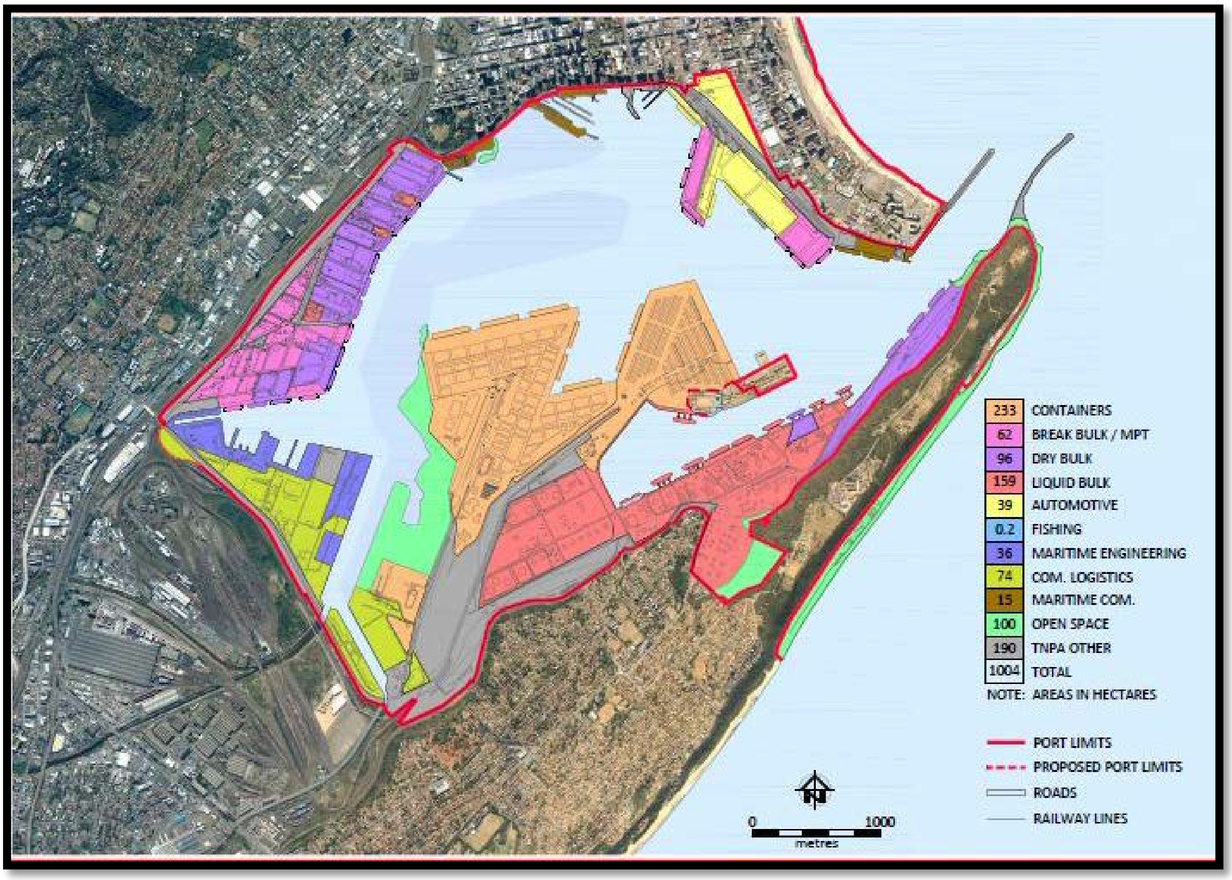

Figure 2.4: Current Layout of the Port of Durban (National Ports Authority, 2019:31)

The Port of Durban has various stakeholders who are involved in daily operations from a marine, terminal and hinterland perspective. The linkages among the 3 subsystems need to be managed well in order to ensure smooth operations. According to Chikere and Nwoka (2015), organisations must be viewed as a system with its interconnected parts in order to ensure efficiency and effectiveness. Systems theory assists with connections among parts instead of limiting a unit into its fragments. This study proposes that contemporary organisations adopt a systems approach considering the component of contingency that emerges in the day-to-day operations. It is thus important for container terminal operations in the Port of Durban to be analysed in a systematic way in order to determine the critical components contributing to the overall effectiveness of the system. The status of the subsystems within container terminal operations with respect to marine, terminal and hinterland operations, is discussed next.

2.3 Marine Operations at the Port of Durban

Marine Services are oriented in delivering safe, efficient and proactive service to customers. The Port of Durban currently has 8 operational tugs that are operated on a 24/7 basis. From a marine perspective, the Port of Durban is also resourced with 2 pilot boats, 5 launches, 2 helicopters, 1 pollution boat, 1 VIP craft and 1 floating crane (TNPA, 2018a).. In 2018, the Port of Durban did not achieve the targeted key performance measures in relation to productivity at container terminal docks, with an actual average anchorage waiting time of 42 hours against a target of 28 hours at Pier 1, and 79 hours against a target of 36 hours. Similarly, the ship dwell time has been below the planned targets, attaining 69 hours at Pier 1 and 72 hours at Pier 2, against a target of 55 and 53 respectively (TNPA, 2018b). Rodrigue et al. (2014) state that the longer vessel waiting times at South African ports result in increased costs with respect to importation and exportation of cargo, thereby derailing the attractiveness of the ports as compared to other ports globally. The poor performance of Durban with respect to both anchorage waiting time and STAT thus require a detailed investigation to determine the root cause behind low productivity, taking into account all dependencies impacting on the outcomes achieved. The poor performance from the maritime perspective is interconnected with measures from other dimensions and contributes to lower productivity of the overall terminal, hence it is critical to review the system holistically.

2.4 Characteristics of the Durban Container Terminal

According to Schroder (2013), the Container Terminal in the Port of Durban is divided into two docks which function independently from each other, having diverse operational procedures. Both terminals are operated on a 24-hour basis; however, due to shift changes, the net real operational time is reduced to 21.83 hours on a daily basis. The port is resourced with the latest container handling equipment such as tandem-lift and ship-to-shore cranes, including straddle carriers and rubber tyre gantries (RTGs; see Rodrigue et al., 2014). Table 2.1 indicates the various characteristics of the Container Terminal.

Table 2.1: Features of the DCT by Dyer (2014:14) and Scholtz (2017:57)

CHARACTERISTICS	**PIER 1**	**PIER 2**
Quantity of Berths	2	6
Berth Extent	600m	2000m
Number of ground slots	4000	16274
Stacking System	Rubber Tyre Gantries	Straddle Carrier
Number of Cranes	6 super-post Panamax STS Cranes	7 Tandem Lift Cranes, 6 Liebherr, 6 Noel, 1 Impsa
Haulers	54	53
Trailers	55	53
Stackers	2 Reach Stackers	4 Reach Stackers
Forklifts	2 Forklifts	7 Forklifts
Handlers	2 EC Handlers	12 EC Handlers
	2 Rail Mounted Gantries, 22 Rubber Tyre Gantries	113 Straddle Carriers
Maximum Effective Height	5	3
Dwell Time	5	5
Transhipment %	15	15
Operational Hours Per Year	8760	8760

According to the latest developments, Pier 2 has only 4 operational berths, as berth 205 on the North Quay has been out of commission for a while as it can no longer accommodate the size of ships calling the port on its own. Berths 202 and 200 were combined into one berth on the East Quay in order to dock the latest bigger ships in the port. The combination of berths at both North Quay and East Quay has resulted in a reduction of the number of berths at the container terminal, limiting the number of container vessels that can be serviced at any particular time. This automatically has an impact on the waiting of vessels in the port, resulting in the ineffectiveness of the port and contributing to the challenges experienced. Pier 2 also has 7 Liebherr cranes instead of 6, as one crane was transferred from the Eastern Cape ports to the Port of Durban. The number of haulers has also been increased from 54 and 53 at Pier 1 and Pier 2, to 55 and 95 respectively.

2.5 Type of Equipment Used in the Port of Durban

The two piers at the container terminal in the Port of Durban have different operating models and utilise different equipment, as reflected in the sections that follow.

2.5.1 Type of Equipment used at Pier 1

Schroder (2013) has recorded that Pier 1 uses quay cranes to discharge containers from the vessel and position them on the horizontal vehicles which move them to the stacking area, where they are positioned using RTGs. The horizontal vehicles used are tractor-trailer units (TTUs). This operational method is referred to as the Chassis Method. The use of the Chassis Method is a result of space constraints at Pier 1, which require containers to be piled using the block stacking procedure. According to Li and Lu (2019), the chassis system is conducive for ports with small amount of volumes and can render a door-to-door service, while the straddle system is ideal for huge import volumes and minimal export boxes. Considering the minimal volumes handled at Pier 1, of approximately ±700,000 TEUs, the chassis systems seem to be an ideal operation as per the theoretical suggestions by Li and Lu (2019). However, the definition with respect to the small amount of volume will need to be quantified to give assurance to the assumption made.

Naicker and Allopi (2015a) indicate that Pier 1 used to operate using Straddle Carriers in the past but these have moved over the years to RTGs, as they are the most suitable equipment, considering that the terminal was developed on reclaimed land. It must be noted, however, that worldwide, these types of equipment are being replaced, given the exorbitant energy requirements for the operation. New forms of equipment contributing to energy savings, which are also eco-friendly, are being considered. Determination of the type of equipment and operational model to be utilised thus requires investigation in order to comply with the latest worldwide trends for effectiveness of the terminal operations.

2.5.2 Type of Equipment used at Pier 2

Quay cranes are being utilised at Pier 2 to offload containers from the ship to the quay side, while the straddle equipment lifts containers from the wharf side to the stacking space. This process of using straddle carriers to move containers from the quay side at Pier 2 is called a linear stacking procedure, as indicated by Schroder (2013). According to a report by TPT (2017), the terminals are subject to various equipment problems resulting in downtime of key performance indicators, which impacts on the productivity of the terminal.

2.6 Capacity of the Durban Container Terminal

According to Scholtz (2017), the Container Terminal in the Port of Durban has a capacity of 3 600 000 TEU moves per annum. However, there are constraints with respect to stacking yard capacity at both piers, resulting in a deficit of 1.6 million TEUs between the berth theoretical capacity and storage yard capacity. The optimum capacity of the terminal can be realised if the yard stacking capacity is enlarged, while the container stacking system also needs to be improved through use of RTGs and a shuttle carrier system.

2.7 Hinterland Connections

The Port of Durban is connected to its hinterland through road and rail. Transnet (2016) indicates that most of the South African cargo is transported on the Natal Corridor to and from Durban and Gauteng regions, as the Port in Durban handles over 70% of the country's containerised cargo. There are access constraints through both road and rail to the port, leading to congestion in the area and this has a bearing on the port productivity. As a result, Transnet is working on enhancing not only rail, but also terminal and yard capacity to meet market demand. This should assist with the provision of cost-effective supply chain solutions to customers.

2.7.1 Road Connections

The port is well linked to local and national roads, with the Gauteng to Durban (N3) being the main corridor connecting Durban and Johannesburg. Local roads incorporate the N2 freeway from the city of Cape Town and down the Eastern Coast of the country. A two-fold roadway at Edwin Swales is the primary freight connection between N2 and Durban Port, also linking with the N3. The challenge that remains is the imbalance of road and rail market share which is at an 80/20 percentage split. This creates congestion given the number of trucks travelling to and from the port (Transnet, 2017). Urban-Econ (2013) further states that most cargo coming either to or from the port, warehouses, inland terminals, and manufacturing centres, is moved by road. As a result, there is traffic congestion in areas surrounding the port, increasing the costs of doing business in the port.

Van Tonder (2015) spells out that some of the bottlenecks encountered in South African ports are inadequate port accessibility and truck staging zones, including external road infrastructure. The lack of an oversight role on traffic laws results in vehicles that are not roadworthy arriving at the port to collect goods. Other blockages relate to delays at the arrival and exit of either administration or inspection or terminal processes, including peripheral congestion impacting on the accessibility of the port. The lack of accountability and consistency for collection of cargo by road transporters is also an area of concern.

According to a report by Transnet (2017), there is a need for an enhanced transport solution which will facilitate efficient movement of cargo to and from the port. The solution should not only lead to reduction of cost but also in terms of conservation of time and energy, thereby improving the environment within the logistics chain, which is instrumental in advancing the economy of the country. There are various measures jointly being implemented by the City and Transnet, ranging from short- to medium- and long-term solutions. However, these problems cannot be resolved in isolation but require a systematic view and involvement by all stakeholders, as each aspect affects another in one way or another. Systems thinking presents variety of ideas, instrument and techniques to manage complex problems and it is an ideal, intelligent instrument for multifaceted situations. It provides context and considers how the interactions among various characters facilitate the performance of the entire team (Armson, 2011).

A study by Feldman and Kirkham (2017) used SSM to determine a holistic view of stakeholder essentials, concerns, challenges and requests regarding the organisational upgrade project. Through the development of rich pictures, the study was able to simplify and communicate complex projects such that stakeholders had improved comprehension of the investigated situation. The rich pictures provided the required insights that assisted with the conceptual model development for improved decision-making for the enterprise system upgrade strategy, through the consideration of participants' views. The involvement of the port stakeholders is thus necessary to facilitate efficient movement of cargo to and from the port.

2.7.2 Rail Connections

The Durban Port is linked to its countryside via the Natcor rail passageway which provides rail services to Gauteng and the Southern African region. The Natal Corridor is the main outlet of containerised cargo to and from Gauteng area, where most rail corridors connect through the port through City Deep Inland Terminal. While the rail substructure in ports belongs to the Port Authority, the railway lines and terminals including yards, are managed by the Freight Rail Division (Transnet, 2017).

Both Piers 1 and 2 are connected through rail through the Kings Rest Yard (port rail terminal), with Pier 1 designed to cater for 250 000 TEUs while Pier 2 has a capacity of 300 000 TEUs. Pier 1 has six lines and three rail-mounted gantry cranes and is able to accommodate a 50-wagon container train. The other three lines have no gantry cranes. Pier 2 provides 3 loading and off-loading lines with three rail mounted gantry cranes. There is additional facility in the Bayhead area with three rail lines catering for 40-50 wagons functional through rail mounted gantry cranes (Transnet, 2016).

According to Transnet (2017), the current rail line between Gauteng and Durban is in a bad condition considering that the speed limits in certain areas is estimated at 50km per hour. This requires a new line to be developed to operate at an optimum speed limit of 120km/h with most devotion to cargo traffic. The potential impact are the delays on cargo which needs to depart through the port, resulting in longer dwell times of ship while waiting for goods to come through. A report by Transnet (2017) further indicates that enhanced operational efficiencies would create an additional capacity of 2 million metric tonnes, from 27 to 39.

According to the Department of Transport (2017:15), while the country prides itself on the longest heavy haul rail network, outdated technologies are comprising the safety of this transportation mode: "The key railway metrics, axle load and speed, are mediocre compared to countries with standard (or broad) gauge railways", impacting the freight rail operational efficiency measures. These inefficiencies result in an unwarranted number of derailments and work stoppages. The ineffectiveness of rail network will thus potentially impact on cargo volumes destined for export market, thereby contributing to the factors affecting port performance. The rail infrastructure for the Durban Gauteng corridor is supported by the inland terminal at City Deep, which is the biggest and only intermodal terminal in South Africa. This development of this terminal dates back from 1977 with a capacity of 280 000 TEUs and expansion plans and equipment upgrades to 400 000 TEUs in the short-term and 700 000 TEUs in the medium-term (Rodrigue, 2013).

2.8 Developments in the Port of Durban

2.8.1 Port Developments

There are various port development projects taking place in the Port of Durban; however, the main ones affecting the container terminal operations are the reconstruction of berths 203 to 205 at the container precinct, the Salisbury Island infill at Pier 1, and Durban Dig-out Port. The port is anticipated to expand slightly from 968 to 1004 hectares with the development of Salisbury Island infill for the extension of container terminal operations, while the Durban Dig-out Port will be developed over 527 hectares (Transnet, 2017). The Salisbury Island infill project includes reclamation and conversion of the island to a bigger stacking yard and addition of two berths, resulting in the lengthening of the quay by 700m. A report by TNPA (2019) indicates that the Salisbury Island infill has two phases which will provide 3 berths and increase the stacking area to 233ha in overall. The project will improve terminal's capacity from 700 000 TEUs to 2.4m TEUs.

According to Scholtz (2017), the berth deepening project at the North Quay incorporates the widening of the berth and lengthening of the north quay. For Container Management (2019), this project will deepen the berths to 16.5m from 12m, thereby increasing Pier 2 capacity from 2.4million TEUs to 2.9 million TEUs, expanding the quay. This will further facilitate the North Quay's capacity to operate 3 x 350m vessels concurrently. The entrance channel was widened from 125m to 225m and deepened from

12.8m to 16m, and 19m at the inner and outer entrance respectively (Civil Engineering, 2010). However, the berths inside the port at the container terminal have not been dredged in alignment to the entrance channel to accommodate megaships. The berth deepening of the 3 container berths and Salisbury Island infill projects are reflected on the Figure 2.5 below.

Figure 2.5: Artist's Impression of Salisbury infill and Berth Deepening at North Quay by Transnet Soc. Ltd (2016:303)

The Durban Dig-out Port will be constructed in three phases, with the first phase anticipated to be concluded by 2037 with 4 berths, while phase 2 will bring an additional 4 berths by 2046. Phase 3 of the Dig-out Port involves the extension of the dig-out area with provision of 7 additional berths, as reflected in Figure 2.6 below (TNPA, 2019).

Figure 2.5: Durban Dig-out Port Long Term Layout Plan by TNPA (2019:38)

The artist’s impression in Figure 2.7 depicts a fully established port with a container terminal providing berths which have capability to dock 18 000 TEU vessels. Other facilities shown are the back of port intermodal nodes and logistics areas, including rail and road infrastructure linked to the 2050 Durban-Gauteng Freight Vision. The Dig-out Port will facilitate renovation of the overall Southern Industrial Basin, which will assist in alleviating road bottlenecks and incompatibility of land uses. The project will also ensure better hinterland connectivity for freight forwarders with the manufacturing centres (Transnet, 2016).

Figure 2.6: Artist’s Impression of Durban Dig-out Port by Transnet Soc. Ltd (2016:307)

Brueton et al. (2013) state that for the Port of Durban to compete as a hub port in Southern Africa, it should cater for mega ships which need deeper and longer berths and channels. The port upgrades, including the deepening of the container berths, bring various benefits such as the achievement of economies of scale for port users, enhanced productivity and job creation, not only at a local level but also at regional and national levels. According to Urban-Econ (2013), while the Transnet Market Demand Strategy ensures provision of infrastructure to meet the demand, these upgrades should be coupled with resolution of labour productivity matters in order to guarantee that turnaround targets are met.

Furthermore, in order to ensure capacity creation and modernisation of operations, the Port of Durban has ordered a new helicopter which serves as a replacement for the existing fleet to service the Port. TNPA has also been involved in the process of acquiring nine tugs which form part of the national ports fleet replacement programme aimed at ensuring improved operational efficiencies. The new tugs will facilitate improved marine services, resulting in quick turnaround of vessel movements (TNPA, 2018).

2.8.2 Port Terminal Developments

According to a report by TPT (2017), the interior entry road within the terminal operational zones was refurbished in order to ensure safe access. The acquisition of replacement straddle carriers was done with the intention of enhancing efficiencies and reliability of the fleet at Pier 2 at DCT. Further to that, DCT introduced a hauler operation on arrival of hauler and trailer equipment which allowed indirect operations access. Considering the berth deepening of the North Quay of the Container Terminal conducted by the Port Authority, the capacity of Pier 2 will be restored to 2, 9 million TEUs (TPT, 2018). Further developments include equipment deliveries of 10 empty container handlers at Pier 2, and 18 haulers at Pier 1 for improved and consistent fleet performance and efficiencies (TPT, 2019).

2.8.3 Rail Developments

There are various rail development plans that Transnet is working on in order to improve service provision to the various customers. According to Morapeli and Makhari (2017), some of the projects that are on the pipeline are: i) the construction of a new railway line between Durban and Gauteng; ii) Cato Ridge Dry Port; iii) adaptation of King Rest Rail Terminal including its expansion of Phase 2 and 3; iv) Reconfiguration of Bayhead Yard to accommodate a 75-wagon train, and v) the development of the Durban Dig-out Port Rail Yard. A report by Transnet (2017) further confirms the development of the Durban-Gauteng Corridor as part of the key deliverables of the National Development Plan. The transportation of cargo from the port to the Gauteng region as the country's economic hub is critical, considering the size of the market share and its growth for the following 30 years.

The Planning Phase for Cato Ridge Dry Port is in the final stages and will assist with reduction of bottlenecks in the port area, as cargo will be shuttled by rail to and from the port to Cato Ridge to cater for both import and export traffic. This should eliminate bottlenecks as well as constraints experienced with stacking in the port, as cargo will be delivered at the port on a just-in-time basis (Morapeli and Makhari, 2017).

2.8.4 Road Developments

Transnet is working together with the Durban Municipality to bring about solutions with respect to road bottlenecks on a short-medium- and long-term basis. This is to ensure that cargo is moved in an efficient manner through the road network. Some of the projects that are being considered on a short-term basis are the Bayhead Road expansion, including provision of a connecting road to Solomon Mahlangu. Other long-lived assignments incorporate reviewing the neighbouring intermodal logistic nodes and development of road infrastructure plans that take into consideration port expansion plans (Transnet, 2016). Transnet (2017) further indicates that plans are underway regarding the extension of both the N2 and N3 highways, including compulsory and dedicated freight lanes on the way to Cato Ridge. A dedicated route connecting the current port with the expected new Dig-out Port is also anticipated.

2.9 Status of Productivity in the Port of Durban

The Sub-Saharan African Container Port System is faced with various challenges, including shallow drafts, lack of equipment, limited capital investment, political instability and uncertainty, regulatory impediments and low levels of port performance (Rodrigue et al., 2014). The Port of Durban faces changes similar to the rest of other Sub-Saharan container ports. It does not have the required draft levels and is only able to dock vessels up to 9000 TEUs without being fully laden with the high tide. Ship sizes have outgrown the berth sizes as a result of limited water depth. This arrangement will limit the port with respect to the size and number of vessels it can dock, thereby reducing the competitiveness of the province (Naicker and Allopi, 2015b). ITF (2018) further states that the development of increasing ships capacity by liners with the intention of achieving economies of scale, demands some port infrastructure adaptations. Long and strengthened quay walls, larger and deeper navigation channel, bigger cranes, and extended yard including buffer capacity are some of the configurations that need to be taken into account.

According to Meyiwa and Chasomeris (2016), the Port of Durban normally experiences bottlenecks due to its geographic positioning in facilitating local trade. Most complaints indicate that the ports in South Africa are ranked with the most ineffective ports in the world. This limits them from contributing significantly to progress, including advancing the country's economy. Urban-Econ (2013) spells out that the major blockage on the maritime supply chain is terminal efficiencies which are below expectations, impacting the cost-effectiveness of doing business to end users and lowering the competitiveness of South African ports.

Gumede and Chasomeris (2015) indicate that port industry stakeholders are criticising the Port Authority on low productivity and inefficiency, among other factors, spelling out the problems related to port operation delays, congestion, longer dwell times, limited number of hourly container moves and underutilisation of port infrastructure. The variety of issues characterising the Port of Durban requires a systematic approach considering the dynamic and complex environment in which the port operates. An investigation by Chikere and Nwoka (2015) examined the implementation of systems theory in the contemporary organisation using a literature review and survey methodology. Based on the conceptual output generated from the study, the proposed recommendations for modern companies is to implement a systems approach to ensure order, reliability of operations, business growth and viability. They further indicate that systems theory allows corporations to operate orderly without glitches as areas of responsibility are clearly outlined as a result of existing connections among subsystems.

According to Kamalakannan (2016), a systems approach was instrumental in enhancing energy efficiency measures within the shipping sector. The approach facilitated the learning of interfaces among energy efficiency stakeholders which allowed for the collection of data from various sectors utilising a structured methodology. This resulted in a significant contribution to the subject under investigation. The systematic approach assisted with the development of a conceptual model which was helpful for decision-making purposes in energy efficiency enhancement. The method also allowed the classification of key performance indicators for organisational energy efficiency initiatives through the development of causal loop diagrams (CLDs). The researcher is building on this research approach by constructing CLDs for the container port system and also classifying critical performance indicator through a sensitivity analysis.

According to a report by TPTs (2017), the terminals have not met their turnaround time on the container moves per SWH and TTT. They only met their goals on the train turnaround time in 2017, as depicted in Table 2.2.

Table 2.2: Key Performance Indicators by TPT (2017)

CONTAINER MOVES PER SHIP WORKING HOUR	**YEAR 2016**	**YEAR 2017**	**YEAR 2017**
KEY PERFORMANCE INDICATORS	**ACTUAL PERFORMANCE**	**TARGETED PERFORMANCE**	**ACTUAL PERFORMANCE**
Number of movements at DCT – Pier 1	53	53	45
Number of movements at DCT – Pier 2	70	70	55
Train turnaround time			
DCT – Pier 1	2,9	≤4	2,9
DCT – Pier 2	2,6	≤4	3.5
Truck turnaround time			
DCT – Pier 1	37	≤35	37
DCT – Pier 2	40	≤35	79

It is critical to determine the underlying reasons behind low productivity at the container terminal in Durban. A systems approach will allow the researcher to view the situation holistically with its challenges rather than only its elements, and determine the source of the problem. Armson (2011) indicates that looking at the situation holistically assists in ascertaining enhancements that do not affect other parts in a harmful way. The Systems Dynamics (SD) and Soft Systems Methodology (SSM) will be utilised where mapping of container terminal operations through rich pictures and CLDs will be done, thereby assisting with the holistic view of operations for decision-making (Xi and Poh, 2013).

According to The Sustainability Laboratory (2019), causal loop diagrams are qualitative illustrations mapping the various factors giving rise to a particular challenge. They are helpful with analysis of the foundation of problems and the feasibility of the proposed solution.

The SSM, through conceptual models, root definitions and rich pictures, will assess the complex environment by exploring different options in order to address the problematic situation (Williams and Hummelbrunner, 2010). An SSM study by Yıldırım and Bayraktaroğlu (2018) was instrumental in the identification of different methods for improvement. The approach allowed for a constant learning process among stakeholders, which facilitated collaboration to attain the required results. It has the capability to unearth the flaws that could not be detected by other systems approaches. It enables business analysis, outlining existing gaps in the business processes and ascertaining sections that require improvement.

2.10 The Economic and Social Impact of the Port of Durban

According to Brueton et al. (2013), the Port of Durban is the major entry port to South Africa. Urban-Econ (2013) further indicate that the port serves as a vibrant trade link not only to its region, that is, KwaZulu-Natal, which is the second largest economy in the country, but also to most of South Africa's surroundings, including the Gauteng region and adjacent countries. The port is connected to its hinterland by both rail and road, with access to the Gauteng and Southern African markets. The economic contribution of the port is further discussed by Rodrigue et al. (2014), who states that value-add is realised through capital investment and cost reduction leading to improved cargo volumes. In essence, the value-add is not only realised through trade facilitation but also through the multiplier effect as a result of increased demand of services offered by the various industries within the city.

Maharaj (2013) states that the Port of Durban plays a significant role in the economy of the city considering that it business, and related businesses, account for the employment of an estimated 50 000 people in this industry. Many manufacturing companies are located in Durban because of the existence of the port, as their businesses are dependent on port logistics from an import and export perspective. The port related businesses vary from manufacturing, freight and logistics, maritime firms and component assemblers to tourism companies. It must also be noted that the impact of port business extends beyond the city and has broader influence on the provincial, national and SADC region, as a result of its strategic location to service the KwaZulu-Natal area, the Gauteng region and neighbouring countries. It is a noteworthy role: the Port of Durban as a logistical centre is critical for Africa's advancement.

The contribution of the Port of Durban to the economic viability of the city is also alluded to by Rodrigue et al. (2014:57-58), who state that port accounts for about 10% of the eThekwini Municipality employment, with an added value ranging from 8% to 14% which cuts across various industries. They further find that for every vessel call in the port, there is direct expenditure involving “shipping, cargo handling, ship repair, customs clearing” multiplied through secondary spending, by port related businesses such as “manufacturing, inland freight transport, petrochemicals, agriculture” and others.

2.11 Port of Durban Competitors

According to Nabee and Walters (2018a), the SADC is bordered by ports of Durban, Maputo and Dar es Salaam, which strategically service their own hinterlands. However, the ports of Maputo, Walvis Bay and Ngqura are considered to be competitors to the Port of Durban. According to the researcher, this relates to gateway cargo with respect to Maputo and Walvis Bay, while Ngqura is competing on the transhipment cargo. The Port of Ngqura has been positioned as a Transhipment Hub by TNPA, indicating that South African Ports are a complementary port system with each port servicing its niche market, and therefore unable to compete with each other for cargo. In this scenario, the Port of Ngqura as a transhipment hub complements the Durban Port as a gateway port.

Nabee and Walters (2018a) further indicate that while the SADC is also surrounded by Maputo and Dar es Salaam Dar, Durban is main hub port for the region considering the number of direct liner services, infrastructure developments, volume throughput and accessibility to feeder ports it has, as compared to other competing ports. The other ports in the region such as Lobito, Beira and Nacala will grow aligned to infrastructure development at both the port and hinterland areas; however, these ports mainly service the bulk market. Maputo will remain a secondary port to Durban since these ports service similar markets.

A study by Rodrigue et al. (2013) further indicates that Durban serves as one of the major gateways and an international hub port for Africa because of its maritime linkages with the world. It has a variety of connections with most of the ports and its centricity in the port network differentiates it from other South African and regional ports which do not hold the same position with respect to the role it plays. The centrality of the Port of Durban is also discussed in a report by Botes and Buck (2018), who state that Durban appears as the main hub in Southern Africa with no contender because of its liner connectivity, the extent of trade activity and the magnitude of the hinterland it services. A report by Transnet (2017) also notes that the significance of the Durban Port is seen through the size of the hinterland it services and the market share it has, which incorporates the Gauteng region: this positions it to be the main gateway port for the next 30 years.

According to Nabee (2015), as some of the strategic SADC ports expand, driven by their own hinterland growth, the attractiveness of Durban port is expected to diminish. However, the decline in the port's appeal is only applicable to certain categories of cargo as containers are transported through the North-South corridor via Durban, giving assurance of its attractiveness with respect to liner shipping trade. This implies that Durban will remain the port attracting certain cargoes, given its connectivity to the liner shipping trade. Nabee and Walters (2018b) further state that while Durban will retain the status of the main port of entry, the cargo percentage split between competitors will reduce as other ports in the region develop in line with shipping liner markets.

Transnet (2016) indicates that the Port of Durban will always make provision for port infrastructure and cargo operational services. As a result, Durban will remain an attractive port for high value cargo to and from Gauteng and the surrounding hinterland, driven by accessibility of logistics services and ancillary local manufacturing businesses. A further report by Transnet (2017) confirms the continuity of port services, noting the advanced infrastructure and complementary local manufacturing base and the future positioning of the port as the preferred port for containerised cargo for stakeholders in Gauteng and the surrounding hinterland. Nabee and Walters (2018a) add that as long as the Port of Durban continues to create capacity ahead of demand and provides excellent customer service, it will remain a port of choice as compared to regional ports within the SADC region.

2.12 Summary of Chaotic Circumstances in the Port of Durban

The Port of Durban is confronted with variety of challenges from a systems perspective with respect to all three dimensions, maritime, terminal and hinterland operations. From a maritime perspective, the port is struggling with capacity on the waterside with respect to the required draft levels required by ships calling the port. The number of berths as well has reduced, given the bigger size of vessel calling the port, which are now accommodated in a combination of two berths. From a performance perspective, the port is also not meeting its set targets in terms of anchorage waiting time and STAT creating bottlenecks for ships on the waterside. It is thus necessary to determine the underlying factors contributing to the inefficiencies and to find a way to improve the circumstances.

From a terminal perspective, the terminal battles with various challenges, including equipment breakdown, yard capacity constraints, and human resource issues leading to the inefficiencies in the container terminal. The equipment problems result in bottlenecks both on the waterside and yard operations. The limited yard capacity creates problems on the yard operations which impact both the waterside and hinterland operations. The terminal is also not meeting key performance targets such as GCH and SWH, which are critical for improved turnaround of the vessel. Detailed analysis of operations is required to have a full comprehension of various interfaces and the impact on each other for improved operations.

From a hinterland perspective, the terminal is challenged with access constraints through both and rail, leading to inefficient operations. Some of the problems associated with road transport are inadequate road accessibility to the terminal and limited truck staging areas, while the rail to road market share of 20/80 split also exacerbates the problems being experienced. All these challenges create congestion and bottlenecks in areas surrounding the port area. Further challenges of inefficient rail network in the main corridor (Natal Corridor) servicing the port, affect the speed at which cargo is moved to and from the port to inland. It is thus critical for productivity improvements to be investigated using a systematic approach through instruments that enable review of the system holistically. This will help to determine context and causal relationships which will ensure strategic development of initiatives that will bring change across the port system.

2.13 Conclusion

This chapter has outlined the current status with respect to the dynamics that influence cargo operations of the container terminal in the Port of Durban. It has outlined resources available from a marine perspective to container terminal operations to hinterland activities, including the development plans from port, terminal, rail and port perspective. It has revealed the various type of operations practised at two piers of the Durban Container Terminal. The chapter has also outlined the significance of Durban port to KwaZulu-Natal as a province, but also at a national level, including the SADC region. Most importantly, this chapter has spelled out the challenges, limitations and problems experienced at the port from various aspects, starting with the marine, terminal and hinterland, leading to poor efficiency and targets not being met, which in turn affect the productivity of the container terminal. It has, finally, presented a brief theory and literature review to show how a systems approach was applied, which provided value to some organisations.

CHAPTER THREE: CONTAINER TERMINAL OPERATIONS

3.1 Introduction

Chapter Three of this thesis provides an overview of container terminal operations, outlining the various activities involved in the handling of containerised cargo. The complexity of container terminal operations is explained considering all the intricate aspects of the operations. The importance of managing container terminal operations as a system is also discussed.

3.2 Container Terminal Operations

3.2.1 Containerisation

Kotachia et al. (2013) indicate that ports are the major intermodal centres where various means of transportation, such as trains, trucks and vessels converge to interchange goods. The management of this operation is complex and requires a holistic approach to problem solving with the involvement of various stakeholders. Systems thinking affords an opportunity to look at a situation considering all the dimensions of a system (Armson, 2011). There are various studies where systems thinking has been used on port operations (Allan et al., 2008; Kotachi et al. 2013; Lu and Park, 2013 and Huang et al. 2012). It is thus important to utilise a systems approach in enhancing terminal operations because of its applicability and relevance within complex environments.

Gujar and Thai (2013) note that while marine transportation has been in existence since the beginning of civilisation, containerisation has, however, transformed the maritime sector which is considered a necessity as it implies different modes of transport. According to Maharaj (2013), containerisation has been growing fast while other forms of cargo handling have had minimal cargo volume growth. Gadeyene and Verhamme (2011) add that the utilisation of containers in comparison with conventional bulk handling methods is beneficial in the sense that it results in less cargo damage and packaging, and improved productivity.

Rodriguez-Molins et al. (2012) describe container terminal as precincts where containers are moved to and from ships and vehicles or trucks. Chafik et al. (2016) agree that container terminals are workstations where containers are moved to and from ships, trucks and trains. Gadeyene and Verhamme (2011) indicate that containers are big boxes utilised for the movement of cargo from one destination to another. According to Govender and Mbhele (2014), containers are the main tools for moving manufactured products within a logistics supply chain structure. Moving cargo on containers facilitates improved productivity with respect to multimodal and intermodal logistics processes. Maharaj (2013) asserts that containers usually move high value cargo compared to other forms of cargo handling.

3.2.2 Input and Output Variables in Container Operations

A study conducted by Lu and Park (2013) identified annual throughput on each berth as the critical indicator for productivity. Some of the input variables identified for the study are yard size, the number of quay cranes, berth dimension and yard tractors, while throughput was considered to be the main output element. Other factors that are considered essential as input elements are crane working hours, equipment and level of maintenance. Chang et al. (2013) also recognised throughput as the output variable while input factors were identified as human resources, quayside cranes, hauling gear and marshalling yards. Suarez-Aleman et al. (2015) concur that the number of units handled are considered as outputs, while inputs incorporate employees, cranes and terminal facilities available for port operations.

Soares and Neto (2013) indicate that the port activities involved in container handling are dynamic, hence it is critical to consider SD in exploring the input and output elements of a container precinct system. It is helpful in examining complex processes which involve input and output elements, including the development of strategies in the corporate and government sectors. A study by Oztanriseven et al. (2014) also proved that the development of SD model with the intention to explore its influence on the critical factors of the maritime transport system, facilitates improved decision-making which is beneficial to all interested parties. A study by Chikere and Nwoka (2015) investigated the management of systems theory in contemporary organisations considering the independent and dependent model. The study recommends that modern-day businesses should consider systems theory as it promotes added value to organisations with respect to sustainability and growth.

3.2.3 Container Terminal Equipment

Container equipment is considered to be a component of input elements of productivity in container terminal operations. According to Jonker et al. (2019), quay cranes are a critical indicator for productivity at the container terminal. The waterside process involves the operation of a single and twin lift container handling by dock cranes including yard and computerised guided vehicles. The key responsibility of dock cranes is the movement of containers between the vessel and the quay. Kress et al. (2019) further state that cranes are required for the discharging of containers arriving from a ship; these containers will be further transported to the storage area and leave the port by road, rail or vessel. They are also responsible for loading of containers from the quay side to the ship.

Kress et al. (2019) allude to the fact that after a container has been offloaded from the ship, the next activity relates to its transportation from either the quay side to the storage area or from the yard to the quay side, which is done through automated guided vehicles or yard trucks. However, the loading and the unloading needs to be processed by quay and yard cranes, depending on the area of operation at that particular time. Alternatively, the automated vehicles can perform this function as they have loading and discharging capabilities. The function of automated guided vehicles is also alluded to by Jonker et al. (2019), who state that these vehicles ensure the transfer of containers between the dock and yard while yard cranes facilitate the shifting of boxes within the yard.

According to Naicker and Allopi (2015a), the use of RTGs has been the backbone for handling containers worldwide over the past 50 years. However, this equipment has its own advantages and disadvantages. The disadvantages relate to exorbitant maintenance costs as a result of constant mechanical breakdown; high operating costs through excessive usage of fuel and lastly, environmental pollution because of noise and exhaust excretions. The benefits for this type of equipment are efficiency considering the ability to handle a number of containers and achievement of added container space utilisation and the usage of storage blocks. Schroder (2013) further states that the advantages of RTGs are that they can serve a dual purpose for loading trains and trucks on the landside while RMGs are more efficient, reliable and durable with lower operating costs, even though they are costly to purchase.

Naicker and Allopi (2015a) note that while RTGs have been the workhorse of the container business, ports now need equipment that can endure endless demand. There is an increasing demand for improved productivity and efficiencies given the larger parcel sizes that have to be handled. Ports are considering the use of Electrified- Rubber Tired Gantry-Cranes (E-RTGs) which come with a lot of advantages, including 95% of energy savings, trimming of both operation and maintenance costs and pruning of noise pollution and exhausts excretions. Phang et al. (2019) further indicate the importance of e-RTGs do not only result in the reduction of costs through electricity usage, they also bring the added benefit of producing greener ports due to zero emissions emanating from this operation. However, this operation requires a significant financial investment on the onset, which is valuable over time.

Kress et al. (2019) state that straddle carriers and reach stackers present added benefits and are preferred equipment considering the capabilities which enable them load, discharge and stack independently, even though reach stackers can only be operated in small to intermediate size ports. Hangga and Shinopa (2016), however, find that a drawback of Straddle Carrier is the rate of increased maintenance and energy costs as compared to other equivalent equipment, including RTGs and RMGs. Furthermore, while this equipment provides flexibility of movement in the yard and results in decreased idle time, the challenge with the operational model to ensure maximum utilisation for improved efficiencies, remains.

3.2.4 Container Handling Systems

Container Terminals have various operating models. Li and Lu (2019) have outlined the benefits and weaknesses of the container handling operating model in Table 3.1:

Table 3.1: Container Terminal Operator Operating Models by Li and Lu (2019)

OPERATING MODEL	ADVANTAGES	DISADVANTAGES
Chassis System	• It has minimal links which can be openly landed • It has a minor wheel pressure • It is characterised by simplicity • It does not require much workforce • It does not require any complicated equipment	• It occupies a bigger space • There is low site usage rate • It requires many chassis vehicles • It is difficult to realise automation • It requires regular maintenance
Straddle-Car System	• It is a multifunctional system with reduced linkage • It provides flexibility which facilitates improved efficiency • It is a balanced system • The yard utilisation rate is high	• It has a complex structure with a significant failure rate • It has a huge wheel pressure • It has large body which requires operational assistance • It has a difficult stacking process • It requires a huge investment in the beginning
Rail-Mounted Container Gantry Crane System	• The site usage is very high • It has a simple structure with a steadfast coordination of gantry cranes • The maintenance requirements are convenient resulting in reduced costs • It is automated with energy saving benefits • Automation is easily attainable	• It has reduced mobility • Lifting and reversing the container is complex • It requires huge initial investment
Tire type gantry crane system	• The site usage rate is substantial • Costs related to yard pavement are insignificant • It has simple equipment with minimal operational demands • The damage rate for boxes is negligible • It is a small footprint operation with cross-box area • Automation is easily achievable	• Working through the box-area is laborious • It has a higher lodging rate • More linkages are required for the system to operate • It requires a huge initial investment • It has substantial energy consumption.

While each operating model has its own benefits and drawbacks, Li and Lu (2019) further recommend the use of a hybrid system which is widely preferred by various terminals as it is characterised by usage of variety of equipment and is regarded as seamless and reasonable.

3.2.5 Intermodal Transport

Qu et al. (2016) define intermodal transport as the distribution of goods from one area to another through the amalgamation of different modes of transport. Gu and Lam (2013) also state that container intermodal transport is considered as door-to-door transportation within the supply chain that connects the origin of cargo to the destination. Crainic et al. (2019) find that intermodal transportation has been supporting global trade over the years and is significant for the growth of the economy. It further stimulates the effectiveness of emerging transportation operating and commercial models to attain socio-economic and environmental goals. Due to the extensive number of stakeholders involved in the intermodal transportation, including planners, operators and shareholders, the process is considered complex.

According to Gu and Lam (2013), the intermodal transport system has three modes of transportation that connects the port and the inland, that is, barges, trucks and rail. In the South African context, there are only two (2) transport modes available to transport containers from sea ports, that is, rail network and trucks. This means that the country is dependent mainly on rail and road for the transportation of intermodal cargo, which requires both these modes of transport to be efficient in order to ensure that the country remains competitive.

3.2.6 Constraints to Container Terminal Capacity

According to Scholtz (2017), the leading constraints to container terminal capacity are quay side and yard capability. The berth capability is dependent on the quantity of TEU traffic that berths can accommodate per annum, while the stowage capacity is limited by the number of TEUs the storage yard can handle per annum. The stack capacity must be equivalent or above the available berth capacity. The other factor which impacts container terminal capacity is crane capacity, including road and rail terminal capacity.

Park and Suh (2019) indicate that quay capacity could be due to increased mega ships calling ports. They note that the largest ship currently being built is about 23 000 TEUs and anticipate a 30 000 TEU ship built by 2025. This development therefore demands that container terminals be reconfigured with respect to berths, quay cranes, stacking area and the quantity of the loading and discharging equipment. For a 30 000 TEU vessel, a berth length of 500 metres will be a minimum considering vessel length of 498 metres. The minimum outreach of quay crane should be 81 metres, while the water draft should be 20m deep for the mega ships to dock at the port. The stacking area should be expanded and quantity of handling equipment increased to cater for a higher number of containers. It is thus important for the ports and terminals to monitor the global ship development trends and continuously review and consider to reconfigure their infrastructure and fleet development plans.

3.3 Importance of Container Terminals

Container terminals continue to play a critical role in the transportation of goods in the world (Baran and Gorecka, 2015). Suárez-Alemán et al. (2015) add that the maritime sector moves almost 80% of world cargo and ports play a significant role which impacts on the country's attractiveness. Wu and Ting (2016) confirm that there is a significant role played by container terminals with respect to the coordination of trade flows between sea and land side. Song and Cui (2014) assert that container terminals are essential facilities in the international supply chain with respect to the movement of cargo considering growth of worldwide trade, and Lee and Lam (2015) concur that a container terminal is a critical component of the overall supply chain management with respect to the worldwide trade growth.

According to Huang et al. (2012), it is imperative to manage the container terminal performance as it talks to the competitiveness of the port. Wilmsmeier et al. (2013) also indicate that ports, including their level of productivity, are important factors among other determinants, of the country's competitiveness. According to the researcher, the attractiveness then of the port has an impact on the port city, the surrounding communities and the country at large. The management of the overall container terminal activities in a systematic approach is therefore critical in improving operations. Systems thinking facilitates innovative ideas about the situation, thereby ensuring the formulation of prospects for enhancement which will be approved by all stakeholders, as it allows for the exploration of various perspectives (Armson, 2011). Through this investigation, the researcher used systems theory to find new ways to enhance container terminal operations from a systems perspective by engaging stakeholders through semi-structured and interactive groups.

3.4 Complexity of Container Terminals

Investigation of complex systems is one of the approaches originating from complexity theory, which considers a variety of issues that have related assumptions regarding certain reality. The assumptions made are replaced by the alternating techniques of thinking and researching reality. Other theoretical and operational methodologies of complexity theory classification include unconventional patterns to science, compatible procedures and techniques and theoretical backing to research (Kallemeyn et al., 2020). The Sustainability Laboratory (2019) states that the complexity of the system is caused by the extent of interaction between its components, which makes it difficult to project how each variable will have an impact on another variable. The report further outlines that even if there is no variety of components, the system can be complex; however, the situation gets compounded when there are additional variables. The magnitude of interdependency among components within a system demands holistic understanding of the overall unit for the resolution of systematic challenges.

According to the National Research Council (1986), the complexity of a marine terminal is because of the diversity of key elements and constituencies that are involved in port operations, including port infrastructure, equipment, labour, shipping lines, port authority, terminal operator and truckers. Baran and Gorecka (2015) refer to container terminals as complex networks since their operations involve a variety of activities which require enhanced port systems. Considering the number of transport modes involved, the type of equipment utilised and the number of vessels arriving in different terminals, container terminal operations are regarded as complex (Kotachia et al., 2013).

According to Lange et al. (2014), container precincts are also considered complex systems as a result of various interfaces with respect to their operations. Toukan and Chan (2018) elaborate that the complexity of seaports is not only a result of port interactions but is compounded by the involvement of various stakeholders within the transportation value chain. This is also supported in a report by Botes, and Buck (2018), which states that port processes are considered complex as a result of the involvement of various government entities and procedures within port operations, including customs clearance, police, immigration and others.

According to Dwarakisha and Salima (2015), ports provide a variety of services, including infrastructure, pilotage, berthing, terminal handling, tug services and movement of goods and passengers. Lange et al. (2014) state that container precinct activities entail quayside operations where container vessels are berthed in order to load and offload cargo through the use of cranes. Other activities include landside operations which involve movement of cargo to and from trucks and trains through either cranes or straddle carriers. The operations at the container terminal are considered complex given the challenges encountered during operations such as the Container Stacking Problem, which happens as a result of the unorderly stacking of containers caused by inaccurate information impacting productivity negatively (Rodriguez-Molins et al., 2012).

According to Lee and Lam (2015), there are a diversity of reasons why container terminals are considered to be complex systems. The rationale on the complexity of container terminal includes terminal layout, which considers applicable modes of transport, size of vessels, type of equipment utilised, level of automation and available storage space for special containers such as reefers and dangerous goods. The Journal of Commerce (2014) further indicates that the process of ensuring enhanced productivity is complex as it comprises a variety of elements including the amount of cargo loaded and offloaded, vessel stowage and size, skills capabilities and assets engaged during vessel working and terminal handling charges.

Lee and Lam (2015) further indicate that the other factor that brings complexity is operational decisions that have to be made with respect to the number of each type of equipment to be utilised; this must take into account its capacity and how these factors have impact on one another. Another aspect refers to the fixed (number of berths and road infrastructure) and variable limitations (shift system, equipment maintenance programme, departure and arrival schedule of trucks, ships and locomotives at the terminal). Yet another facet is unforeseen circumstances such as extreme weather patterns and equipment breakdown that could affect operations. The complexity of container terminal operations requires systematic solutions in order to resolve some of the problems encountered. According to Williams and Hummelbrunner (2010), SD is a credible tool which has been implemented with significant results, providing trusted techniques that are useful in understanding complexity of systems. Ridwan and Noche (2016) further indicate that SD is an ideal instrument to study the port system behaviour considering the complexity of variables and causal relationships within a port environment.

A study by Xi and Poh (2013) revealed that SD is a valuable decision support instrument for complex problems such as sustainability of water supply in Singapore. The SD approach differs from other methodologies as it utilises feedback loops, including stocks and flows in researching complicated systems. SD explore the results of the non-linear relationships and their impact on the environment (Reynolds and Holwell, 2010). Soares and Neto (2016) state that SD facilitates the development of simulation models to complex systems and is essential in linking the internal and external factors of a container terminal structure.

An investigation by Chikere and Nwoka (2015), however, has also shown that while systems theory has been practised in this organization, certain issues, challenges and prospects have cropped up in the course of its application. The challenges experienced incorporated bureaucratic systems within operational environment leading to poor productivity impacting on business performance. Other issues included centralisation of decision-making which could affect the organisation positively or negatively, depending on the circumstances at hand. While these are common challenges in most organisations, the researcher did not focus on these aspects as the main subjects for the research; however, all emerging issues are dealt with based on the research outcomes from respondents.

A study by Toukan and Chan (2018) utilised SD to develop a conceptual model that depicts causal relationships within the Jordan container transportation chain with the intention to evaluate the influence of alternative solutions to the challenges experienced. The results revealed that the third alternative solution, being a combination of investments on hinterland and use of technology for minimising documentation processing period, was more significant when compared to the first and second alternative solutions. However, while the third initiative was effective, the other effect was increased fleet deployment which resulted in terminal congestion, requiring a holistic view by decision-makers when considering implementation of the solution.

The simulation in Figure 3.1 depicts the complexity of container terminal operations with various transportation modes:

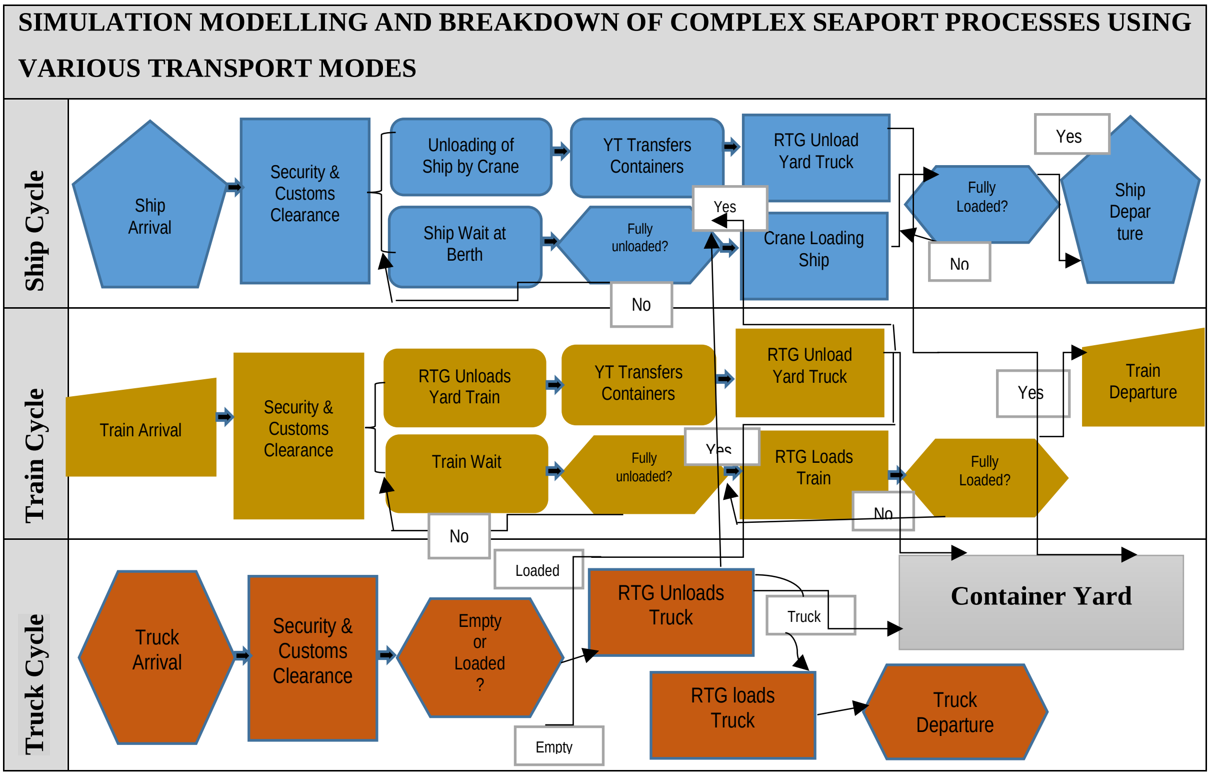

Figure 3.1: Simulation Modelling and Breakdown of Complex Seaport Processes using various Transport Modes by Kotachi, Rabadi and Obeid (2013:232)

Furthermore, Dalkin et al. (2018) propose that SSM is one methodology with the capabilities of making a complex situation unambiguous, with improved transparency, precision, reliability and legitimacy of theory, such that stakeholders have full understanding of the challenges related to a situation. It facilitates extensive understanding of the concept ahead of producing programme theories. It allows stakeholders to discover various aspects of context which assist with theory formulation when outlining interfaces within components. From the discussion above, it is obvious that the complexity of terminal operations requires a systems approach to ensure a holistic enhancement of the system. Without looking at the system in its entirety, some critical elements may be overlooked which may have a negative impact on the system as a whole.

3.5 Management of Container Terminal as System

According to Armson (2011), a system is an assortment of different features and has subsystems that are linked to each other to achieve a particular purpose. Rodrigue et al. (2014) indicate that there are three dimensions that are critical for managing container terminals as a system, that is, maritime, terminal and hinterland operations. These operations are illustrated in Figure 3.2 and have a direct impact on efficiencies in the port system. If these dimensions are not managed as a system, they are likely to impact the efficiencies negatively. Within port operations, the three dimensions are interconnected and cannot be applied remotely from each other, hence they require systems thinking for daily processes. The SSM becomes an ideal tool for analysing the container terminal system using rich pictures, root definitions and conceptual models.

According to Zlatanović and Mulej (2015), the practical tools for SSM are conceptual models, root definitions and rich pictures. Conceptual models are described as actions to be assumed in order to form a system which can be benchmarked with the actual reality in order to improve the problem area, while rich pictures are used to identify relevant insights, norms, principles and stakeholders for consideration in order to develop root definitions. Root definitions look at key issues and principles resulting in innovation for the success of the company.

Williams and Hummelbrunner (2010) further indicate that SSM allows for a combination of various ways of looking at the circumstance and to determine what each perspective provides and the implications thereof, with the intention to resolve the problem. Its process involves the identification of the problem, development of description using rich picture analysis, categorization of critical perspectives using CATWOE analysis followed by a statement analysis using PQR system, development of the model and finally, comparison of various perspectives in order to come up with ideal strategies for the situation.

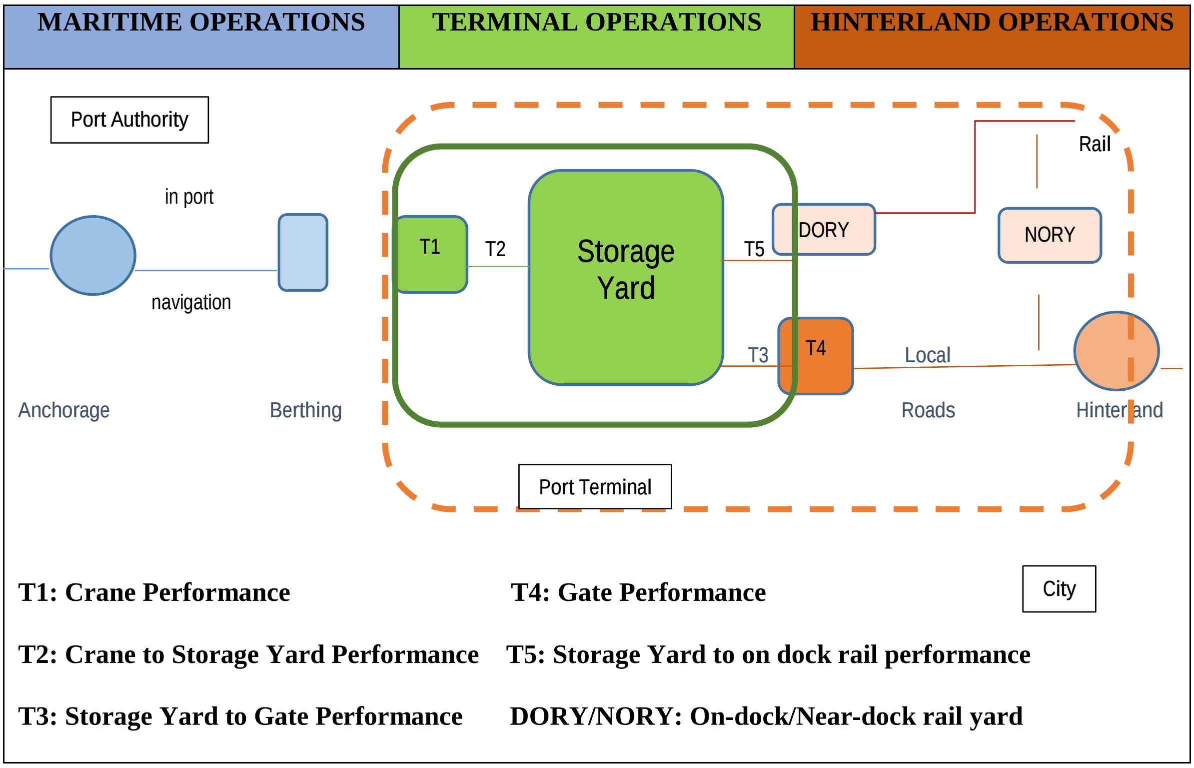

Figure 3.2: Process flow of containers in a seaport container port/terminal by Rodrigue et al. (2014:40)

3.5.1 Maritime Operations

According to Rodrigue et al. (2014), maritime operations incorporate anchorage waiting time by vessels and terminal productivity problems. For the researcher, the maritime operations in the South African Port System context start with vessel arrival at anchorage up until it is berthed along the quay side where it is handed over to the terminal to unload and load the ship. It will be handed back to the maritime section again once it is ready to depart the port.

Nze and Onyemechi (2018) found that one of the causes of congestions in African ports on the marine side relates to ship berth congestion and ship entry/exit route congestion. The ship berth congestion is attributed to the vessels traffic at anchorage waiting for berths, while the Ship entry/exit route congestion is caused by marine disturbances preventing provision of service to vessels, which could result in queuing and prolonged stay in the port. Systematic processes are generally required to determine decision-making with regard to problems in complex systems such as ports.

A study by Saeed and Larsen (2016) was conducted at the Port of Manila in order to assist with decision-making on investment of additional container berths in order to alleviate vessel congestion. The study assessed the required number of additional berths in order to improve efficiencies and reduce the cost of doing of business for shipping lines and cargo owners. The research used queuing theory which is a process that assists with decision-making on developing optimised workflow systems. The study found that the number of existing berths at the Manila Port were adequate and that other reasons to alleviate port congestion needed to be investigated.

3.5.2 Terminal Operations

Schroder (2013) indicates that a container terminal incorporates four subsystems: ship to shore, transfer, storage and delivery receipt subsystems, as reflected in Figure 7. The ship to shore subsystem incorporates ship loading and unloading through quay cranes. According to the National Research Council (1986), some major components of terminal operations are a berth, crane, container yard, gate system and labour. The cranes are designed to load and unload simultaneous containers to and from the ship to the dock efficiently to ensure productivity. Labour plays a critical role within terminal operations as it impacts on terminal productivity based on the negotiated working arrangements, which consider aspects such as quantity and type of workforce required for a particular shift, and operational hours, including overtime and craft specialisation requirements. The gate system manages the movement of containers to and from the terminal which can be made efficient through the use of multiple lanes and information technology systems for facilitating quick inspection at the port gate. The berth becomes critical with respect to the draft, type of handling equipment and berthing space available to facilitate improved operations.

According to Schroder (2013), the transfer subsystem serves as a connection between ship to shore and the stacking area. The storage subsystem is responsible for keeping containers in the yard before they get transferred to their last destination, while the delivery receipt subsystem functions as a linkage between the terminal and different freight transportation modes such as trains, trucks and barges to their final end point, as reflected in Figure 3.3.

Figure 3.3: Container Terminal Subsystems by Schroder (2013)

Terminal operations refer to port terminal efficiency performance measures such as crane productivity, container storage yard operations, yard to truck or truck to yard operations, gate performance operations and rail loading equipment (Rodrigue et al., 2014). According to Govender et al. (2017), a quay crane is essential for loading and unloading containers from the ship with capability to transport either only one container or four TEUs at once. With respect to crane productivity, there are various types of equipment used to handle containers from the quay side to the storage area.

Processes with regard to shifting of containers from the quay cranes to the storage and backwards are done through multi-trailer systems (MTSs), TTUs or Straddle carriers. Terminal tractor trailer systems are also critical elements of terminal operations from a waterside perspective as they unite the ship with the terminal and storage subsystem. The purpose for the tractor trailer systems is to ensure even and efficient movement of boxes starting at the quay side on the way to the stacking yard and backwards. However, they are considered as passive since they cannot lift containers on their own but are reliant on cranes (Govender et al., 2017).

3.5.2.1 Storage Yard Operations

According to the National Research Council (1986), container terminal demands a large portion of flat land for storage of containers in order to ensure efficient landside terminal operations. Govender et al. (2017) state that a storage yard is used to store containers that have been imported in transit to their final destination and those that are waiting to be transferred to a vessel for shipment to export markets. Various types of equipment are used for movement of cargo to and from a stacking space in the storage yard such as RTGs, which are generally used together with TTUs and MTSs, and straddle carriers, which do not require RTG because they are able to lift and place containers on their own.

Schroder (2013) further asserts that there are various types of stacking equipment utilised in storing and removing containers at the storage yard, the most frequently used being straddle carriers, reach stackers, forklifts and yard cranes. Reach stackers and forklifts are generally used in small ports where there are low volumes or utilised to handle empty or special containers in bigger ports. Yard cranes allow more volumes to be stacked at the same time through use of either RTGs or rail mounted gantries (RMGs).

According to Schroder (2013), containers can be stored using either a chassis or stacking method. Containers are easily accessible with a chassis method which makes this method advantageous; however, it requires a lot of space. The stacking method, which is a well-used method globally, allows various containers to be stored as they are piled on top of each other. However, containers are not easily accessible as the process requires the top containers to be moved to another space before getting the essential container. According to Govender et al. (2017), containers can be piled up with five or six above each other. Wu and Ting (2016) agree that containers require to be stacked up to sixth tier in order to maximise the existing loading space based on the handling capacity of the terminal.

3.5.2.2 Factors Affecting Terminal Operations

According to Nze and Onyemechi (2018), terminal operations in Africa are affected by various elements of port congestion, including ship working congestion, vehicle gate congestion, and cargo stack congestion, which may rise due to various conditions. The ship work congestion is as a result of disturbances during the loading and unloading of vessels, causing stoppages that prolong the vessel stay in the port. The vehicle gate congestion is caused by lack of coordinated systems or procedures on the land side for delivery or discharge of cargo into and out of the port resulting in port gate congestion. The cargo stack congestion is as a result of the prolonged dwell time of cargo at the storage yard, beyond the stacking capacity.

According to Schroder (2013), any interruption between the ship to shore and the stacking area can result in lower productivity of the overall container terminal, leading to bottlenecks and lower levels of customer satisfaction. The operation of transferring cargo from shore to yard requires adequate and correct resources and proper decision-making for operations to be maximised. Tetteh et al. (2016) indicate that container operations require terminal space, equipment and human resources to be used effectively and efficiently for smooth operations. Huang et al. (2012) also state that a container terminal should capacitate itself with multi-faceted equipment or deepen the port to ensure berthing of mega ships, which will guarantee competitive advantage.

The challenges impacting terminal operations require modelling in order to determine causal problems for development of corporate strategy to improve performance. According to Lane (2008), the rationale behind the modelling of SD is to describe circumstances using causal theory as a source of developing strategies that will drive change and enhance performance. The two methods usually used in SD are CLDs, which reflects a wide range view of the feedback structure of a model, and SFDs, which show an in-depth representation of a model. Reynolds and Holwell (2010) indicate that CLDs emanate from SD and are used to reflect the interconnection of various factors in a situation or environment. For the purposes of this study, the CLDs will be used to determine factors affecting terminal operations from a maritime, terminal and hinterland in order to formulate strategies that will improve the performance of the container terminal.

Several studies have used SD for decision-making on improvement of services within organisations. A study by Briano et al. (2009) investigated the application of a combination of a SD Approach with a Balanced Score Card with the intention of determining important measures essential for decision-making and delivery on the business objectives. It was found that SD was effective in facilitating decision-making of complex problems such as the container terminals, as it allows modelling of various port operations, thereby assisting with decision-making of various operational circumstances. The incorporation of the model with an ERP system also allows production and management of real time information essential for relevant decision-making for a specific port context.

A system dynamic model was also used by Santos et al. (2015) to investigate the management policies within a container terminal challenged by environmental and municipal problems. The research made a comparison of policies related to reduction of port tariffs and port expansion in order to improve demand and revenue for the container precinct. The results indicate that the attractiveness of the port can be improved by deploying additional capacity developments in the port. The model results also indicate that capacity improvements also facilitate improvement in service of quality and overall volumes moved through the port.

3.5.3 Hinterland Operations

Rodrigue et al. (2014) indicate that hinterland operations deal with back of port operations which have a direct link to the local road network which could affect port performance, given the level of traffic or bottlenecks encountered. A paper by Acciaro and McKinnon (2013) states that terminal capacity development must be supplemented by sufficient hinterland infrastructure and effective transportation modes to ensure value creation within the supply chain. This requirement is crucial considering the increased demands of the latest trends of bigger container vessels. Halim (2017) further alludes to the fact that the expanding ship sizes have posed operational challenges and bottlenecks from a hinterland perspective and the increased amount of cargo being moved.

Another paper by Acciaro and McKinnon (2013) states that there are three major parts of the hinterland dimension contributing to value creation of the container terminal operations: port gate systems, transportation mode and dry ports. They further indicate that significant improvements can be realised through cooperation of container terminals, transportation modes and dry ports through better management of road and rail transport. Maximisation of infrastructure requires a concerted effort by all stakeholders, including authorities from the port, terminal, rail operator, road hauliers, dry ports and freight forwarders, to ensure reduction of bottlenecks and productivity enhancements. Merk and Nottenboom (2015) further expand that hinterland networks are key measures of port competitiveness. It is essential to coordinate the various players with different objectives within the public and private sector in order to ensure there are sufficient hinterland networks.

Merk and Nottenboom (2015) state that identification of other alternative hinterland cargo transfer modes such as coastal shipping, and inland waterways is required in order to minimise traffic on the road. The use of alternative modes of transport can minimise idle trucks supported by implementation of booking systems, computer generated yard systems and prolonged hours at the entrance of the port terminal. The researcher’s view is that each port needs to identify the ideal cargo transfer modes that are practical in their context, as each country has unique geographic advantages that suit their operations. Furthermore, simulations and sensitivity studies are required in order to fully comprehend and resolve certain problems. A study by Navarro et al. (2015) conducted a sensitivity analysis to assess the behaviour of container flow in order to resolve port congestion. The study commended the use of a truck booking system to decrease congestion.

De Villiers (2015) argues that the overall supply chain should be capacitated to make provision for the increased number of container volumes moving through trains and trucks from the terminal. The focus is on increasing capacity must not only be on the quay side but also on the inland terminals where the value-added logistic functions can be executed. This will allow the gate port entrance to be moved to the hinterland instead of shuttling cargo through rail, trucks and barges from the quay. A similar scenario is also applicable to export of containers thereby cargo is dropped at inland terminals for shuttling to the quay side only when the vessel arrives.

According to de Villiers (2015), the development of inland terminals is essential for relief of congestion in the port and for value-added logistics. This allows the productive use of the port space for primary activities and not secondary or support functions. Monios et al. (2016) concur that inland terminals allow a set of tasks such as port-associated production and distribution of cargo to be conducted, which adds value to the cargo moved through the port. They also facilitate import cargo to be combined and organised according to their hinterland destinations, while export cargo has the opportunity to be stuffed before it is shipped.

Inland container terminals therefore should yield reduced costs as a result of the amalgamation of various functions and value-adding logistics activities. They are essential facilities for the transfer of both import and export cargo in ensuring optimisation of the freight logistics network (de Villiers, 2015). Monios et al. (2016) indicate that inland terminals also allow manufacturing companies that are reliant on import cargo for their production to be placed in the vicinity of the port. The researcher believes that this allows cost-cutting in terms transportation costs, thereby decreasing the operational costs. Analysis of the overall supply chain from a maritime perspective to terminal operations and hinterland processes facilitate the identification of gaps, thereby assisting with proposed solutions within the logistics chain. Williams and Hummelbrunner (2010) indicate that full comprehension of underlying factors between variables enables recognition of areas of leverage that could result in a solution and a grasp of why an alteration in one area can result in changes in the interactions of the overall circumstance at hand.

3.6 Conclusion

This chapter has outlined the importance of containerisation to the international trade. It has explained how the container terminal operations from various subsystem are connected, starting from a maritime perspective to terminal operations and lastly, to hinterland operations. It has also emphasised the importance of capacitating all subsystems with necessary resources as the effectiveness of each area has a direct impact on the overall operations, which automatically has influence on the competitiveness of the port. The chapter has also discussed how the systems approach using SD and SSM is an essential tool to inform decision-making by the major corporates in a dynamic environment.

CHAPTER FOUR: CONTAINER TERMINAL PRODUCTIVITY

4.1 Introduction

Chapter Four of this thesis provides an overview of the concept of container terminal productivity, outlining its importance and productivity levels achieved worldwide. The critical indicators for measuring productivity, including factors impacting efficiencies of container terminals, are elaborated. The impact of productivity on operations and measures to enhance productivity at the container terminals are explained. Finally, other factors practised worldwide to improve efficiency of the container terminals are discussed.

4.2 Port Productivity

Song and Cui (2014:414) define productivity as "the ratio of outputs to inputs". De Langen and Helminen (2015) add that the purpose of productivity is to ensure that output is maximised within the available input, or input minimized while achieving the expected output. The Journal of Commerce (2014) further describes productivity as the average container moves including imports, exports and transhipments achieved per hour for every vessel call, considering the hours spent by a vessel at berth. Yang et al. (2013) confirm that port productivity looks at the quantity of container moves done while the vessel is on berth in the port. Balla et al. (2016) define competitiveness as the ability to offer well organised production procedures which guarantee modernisation, client satisfaction and business advancement. This implies that any activity is measurable and each entity can choose what it wants to use as a measure of productivity.

Beskovnik (2008) defines an effective port system as one that ensures quick turnaround of containers to and from ships and the movement of containers from the port system through either a truck or train system. Some of the essential elements that are considered vital by container carriers in improving productivity are anchorage waiting time for an unused berth, vessel stay time on berth and quay productivity. Crane productivity is considered important in operational productivity as it impacts on the overall productivity, the vessel turnaround and the container dwell time. It is therefore important to note that there are various indicators that determine the effectiveness of the port.

Port performance is measured by the level of productivity, customer satisfaction and volume performance (Felicio et al., 2015). Kgare et al. (2011) measure port competitiveness by the minimal number of days cargo remain in the port. They argue that cargo dwell time must be reduced to acquire more space for handling of containerized cargo, thereby increasing capacity at a minimal expenditure. However, vessel stay is reliant on the berth utilisation processes, including dwell time distribution and occupancy ratios. Wu and Ting (2016) further add that the handling capacity of containers has a direct impact on the dwell time of vessels. Therefore, the quicker the handling capacity, the higher the number of vessels serviced, resulting in improved productivity.

According to Suarez-Aleman et al. (2015), port efficiency and port productivity are sometimes used in parallel even though the latter is a much bigger concept. Port efficiency explores the connection between the inputs and outcomes while port productivity looks at how an organization deploys its resources to get the results. Whilst port efficiencies focus on the capability of the port to utilise minimum resources to get the optimal output, the outcome impacts directly on productivity. Hence this study uses these concepts interchangeably.

4.3 Importance of Container Terminal Productivity

According to Lange et al. (2014), productivity of container terminals has become even more critical because of container vessel size development, which has grown from around 8 000 to more than 18 000 twenty-foot equivalent units (TEUs) within a period of 10 years. Wang et al. (2013) support the sentiment of increased size for container ships operating in the major maritime routes in last 10 years. Lee and Lam (2015) also confirm that the increased size of container vessels has doubled from 8 000 to more than 18 000 from 2004 to 2013. They further emphasize the need to maximise handling of containers to reduce the berthing time of vessels and port charges. Improved productivity will therefore facilitate quick turnaround of vessels and reduce the cost of doing business.

The Journal of Commerce (2014) indicates that the growing trend of mega ships has put pressure on all angles of container terminal operations, pointing on productivity as an area of focus by all stakeholders. This journal further observes that because of the increasing trend of container vessels, it is essential to look at ways to enhance productivity. A study by Lu and Park (2013) points out that terminal operators and authorities encounter challenges with respect to enhancing productivity adequately, given the anticipated large amounts of consignments with respect to container volumes.

The United Nations Conference on Trade and Development (UNCTAD) (2017) indicated that because of the latest advances impacting the shipping liner market, it is critical to ensure that productivity advances, enhanced efficiencies and operational performance are achieved at container terminals. This paradigm shift encourages the ports to improve their performance on various indicators such as STAT, gate waiting time, and cargo dwell time, including intermodal and hinterland connections. The Journal of Commerce (2014) further adds that it is difficult to realize financial performance indicators without enhancing efficiencies. According to Pieterse et al. (2016), out of the various port features, including private sector involvement, terminal infrastructure and connectivity, port efficiency is considered critical in determining transportation costs. Moreno and Camarero (2013) further state that container terminals must be competitive and responsive to customer demands with respect to level of service received. This suggests that port stakeholders consider the level or quality of service as a priority with respect to port performance.

4.4 Importance of Capital Investment

Caschili and Medda (2015) indicate that for ports to be competitive, they must have effective infrastructure and equipment with high productivity levels, and offer reliable, cost-effective service. Schroeder (2013) acknowledges that having the right equipment may require more capital investment from the beginning; however, the combination of the correct equipment and efficient utilisation thereof could yield various benefits.

4.5 Productivity Levels achieved by World Container Ports

The Journal of Commerce (2014) investigated world productivity levels based on information received from ocean liners using container moves per hour per ship. The results are reflected in Table 4.1.

Table 4.1: Global Port Ranking on Berth Productivity by Journal of Commerce (2014:17)

BEST PORTS: GLOBALLY			
PORT	**COUNTRY**	**2013 BERTH PRODUCTIVITY**	**2012 BERTH PRODUCTIVITY**
Tianjin	China	130	89
Qingdao	China	126	98
Ningbo	China	120	89
Jebel Ali	United Arab Emirates	119	79
Khor al Fakkan	United Arab Emirates	119	79
Yokohama	Japan	108	82
Yantian	China	106	79
Xiamen	China	106	80
Busan	South Korea	105	84
Nansha	China	104	73
Shanghai	China	104	71
Dalian	China	104	85
Mawan	China	95	72
Taipei	Taiwan	93	NA
Salalah	Oman	91	70
Kaohsiung	Taiwan	91	76
Balboa	Panama	91	46
Nhava Sheva (Jawaharlal Nehru)	India	91	78
Chiwan	China	88	NA
Long Beach	U.S.	88	80

According to Pieterse et al. (2016), the top international container ports achieve more than threefold of the normal turnaround of 1.7 days for every 1000 TEUs handled in Durban. Poor performance of 20 crane movements per hour versus 35 and a 60 minutes TTT contribute to the poor performance at the Container Terminal. Armson (2011) argues organisations should not deploy solitary solutions to complex situations with interrelated issues. Shepherd (2014) finds that a holistic methodology is required when resolving transport challenges being faced by the industry. He further alludes that exploring various modelling methods using SD can result in meaningful outcomes and help in ascertaining the ideal models with contribution from stakeholders. According to Manuele (2019), systems thinking is a problem-solving method which allows a thorough investigation before drawing assumptions about the situation and execution. In this instance, the researcher has adopted a systems approach to investigate how the Port of Durban can improve on the poor performance of the container terminal in order to remain competitive.

A study by Bianchi and Williams (2015) used an SD approach to avert, identify and counter behavioural misrepresentation linked to performance management at a municipal level police department in New York. The SD approach was instrumental in determining cause and effect factors accompanying social distortions connected to the City's performance. It enabled the system designers to shape and execute reliable performance measures that can be utilised by the government sector to drive a viable, progressive organisational learning unit, including its expansion. Furthermore, a study by Ridwan and Noche (2016) used the SD and Six Sigma Model to investigate port system behaviour to ascertain enhancement possibilities for minimising the vessel anchorage waiting period among other factors. The results revealed that capacity development on utilisation of cranes will lessen the ship waiting time, which is a critical port performance indicator. It can therefore be argued that the systems approach will be able to facilitate a process to detect causal effects of poor productivity and enhancement variables for operational performance of the Container Terminal.

4.6 Measuring Container Terminal Productivity

According to the National Research Council (1986), any process needs to be measured in order to be managed. Furthermore, Woo et al. (2011) state that the management of performance is a critical component as it measures how the organisation is accomplishing its business goals and objectives and looks at ways to improve performance. This requires performance measurements aligned to the industry norms to be developed. Similarly, while ports are also pursuing to meet customer demands, performance measures such as quality of service, pricing, connectivity and value-added services are some of the measures critical in port operations.

It must, however, be noted that shipping lines are more concerned with quality of service, implying that this measure is important for their operations and must be included in the performance metrics. This requirement therefore compels both terminal operators and port authorities to strive to find ways to improve operational performance.

4.6.1 Critical Indicators for Measuring Productivity

There are various indicators that are being used to measure productivity such as STAT, Berth Occupancy, Crane Productivity, TTT, average waiting time at anchorage, SWH, and Pilotage and Tug Availability. Port performance can be determined by a variety of indicators that have been used over the past decades, including measures that review utilisation and productivity of storage yards, gantries, docks, entrances or exit openings and gangs for containers moved for each crane or number of vessels berthed per annum (UNCTAD, 2017). The utilisation performance indicators such as TEUs/ per crane hour, moves per crane hour, berth utilisation vessels/year per berth, vessel service times (hrs), TEUs/year per berth, TEUs/storage acre, containers/hour/lane, truck time in terminal, and number of moves/man-hour, were identified as critical for container productivity (Gonzalez et al., 2017).

According to Ducruet et al. (2014), STAT measures the time the vessel stays in the port working cargo showing the port terminal's ability to move cargo efficiently. A report by UNCTAD (2017) also confirms that STAT in essence gives an overview of the port performance as it calculates the average period spent by vessels in the port before sailing to the next port. De Langen and Helminen (2015) further indicate that there are various factors behind STAT, such as pilotage and tug services, anchorage time, loading and off-loading activities, bunkering and ship chandelling services. The quick turnaround time of vessels has a positive impact on both shipping lines and cargo owners as it allows early arrival of cargo for the owners while ships are able do additional voyages. The average waiting time is described as the period the vessel waits at anchor until there is a berthing slot which is a variation between the arrival of a ship in a port and the actual berthing time (Tang et al., 2016). Ridwan and Noche (2016) further state that cargo throughput gets affected by the vessels waiting at anchorage, considering that the number of unloaded containers at any given point in time impacts on volume performance.

According to Van der Spoel et al. (2016), TTT is the overall period spent by trucks loading and unloading containers at the terminal. Juhel (2017) further adds that TTT ascertains the length of time the truck spends from arrival to departure in the terminal while loading or unloading a box. 24 minutes is the norm as per global benchmarks. This measurement looks at the time the truck waits to collect or handover the container and the allowance time to exit the terminal, given the truck waiting time outside the gate (De Langen and Helminen, 2015). The National Research Council (1986) also indicates the turnaround time gets impacted by mix load, ship schedule, administration of paper work, extent of automation, customs protocols, safety requirements and out of port container depots.

A paper by Zhang et al. (2013) proposed a model that elevates an appointment system with an intention to reduce the TTT. The findings of the study revealed that the extent of time apportioned for the booking time is the critical element influencing the TTT. The research suggests that the TTT must be set at reasonable levels in order to drive timekeeping of trucks. At the same time, De Langen and Helminen (2015) state that cargo owners and road haulers are concerned with the delivery time of a container emphasising the importance of attaining the TTT. As noted by these authors, it is clear that the efficiency of trucks in the port can impacts cargo movements on both the import and export legs. With specific reference to the export leg, it can influence the vessel turnaround time as the vessel can be delayed while awaiting export boxes arriving through trucks; on the import leg, it impacts on departure of cargo from port to its final destination.

Juhel (2017) explains that Container Dwell Time establishes the time spent lifting up the import container from the ship to the time it leaves the storage yard and *vice versa* for exports. He further indicates that there must be restrictions on cargo dwell time as two days are sufficient for export cargo, while seven days seem to be adequate for import cargo. Ducruet et al. (2014) indicate that port authorities and terminal management are able to change the cargo dwell period for the purposes of acquiring additional space and improving storage yard capability. Considering that the Port of Durban has space constraints, this suggests that the port should review the cargo dwell time in order to optimise the stacking capability and efficiencies within the terminal.

De Langen and Helminen (2015) state that berth occupancy measures the proportion of the utilisation of a berth by a ship comparing it to the overall accessible time. If ships are scheduled appropriately, the berth occupancy can be high without really causing bottlenecks in the port system. A study by Gonzalez et al. (2017) evaluated key factors impacting on productivity using total quality management tools at the Ports of Charleston, Rotterdam and Shanghai. This study found that berth utilisation was critical in enhancing productivity at Charleston, while Shanghai needed to make improvements on container movements per hour per lane and number of moves per gang. Rotterdam had good performance on overall factors, but needed to enhance activities around the crane movements and on TTT.

De Langen and Helminen (2015) state that crane productivity examines the number of container movements per crane on an hourly basis. This measurement has an impact on the turnaround time of the ship. However, this measurement is dependent on various elements including type of cranes available and the level of experience for crane drivers. This suggests that gross crane per hour is another critical indicator impacting on the productivity of the container terminal, more so on the vessel turnaround time. According to the National Research Council (1986), some of the factors that contribute towards low crane productivity are poor yard operations, late deliveries of cargo to the yard and equipment breakdowns. Brava et al. (2015) describe SWH as a rate that assesses the number of moves for each hour worked on a ship.

According to Juhel (2017), Quay Productivity reviews the amount of container movements on a yearly basis considering the quay meter which measures the capacity deployment of the waterside of the terminal. Terminal productivity assesses the quantity of box movements against the square meter of storage yard per annum. This measurement determines the deployment capability of landside of the container terminal taking into consideration container dwell time and the variety of equipment utilised. The National Research Council (1986) further indicates that berth productivity is prejudiced by various elements including ship schedule, number of container moves, berth dimension and quantity of cranes on each berth. The varying vessel schedule with respect to incoming and departing ships results in reduced berth productivity. The increased number of container moves and the higher dimension of berth help attain a higher berth productivity.

According to Oktafia et al. (2017), pilotage and tug services are critical for the berthing of vessels in the port. The overall problems impacting on their provision are the availability of pilots, including readiness of tugs for a particular service. The unreliability of the service is generally caused by the fleet maintenance requirements, weather challenges, and availability of marine pilots, including arrival of ships at the same time in the port. Other measures pointed out by the National Research Council (1986) are labour productivity and yard storage productivity. Yard storage productivity measures the solidity of the yard system and is subject to height storage restrictions and type of operation between chassis, straddle carrier (SC) and stacking crane operation. Other conditions that impact on yard storage productivity are compulsory safety distances and space in-between ground slots. Labour productivity is influenced by variety of factors including the extent of pre-planning, supervisory efficiency, expertise of workforce, essential gang deployment, mode of operation, safety demands, ship size and features and operational standards.

A study by Henesey (2004) investigated the key indicators of productivity and their interconnectedness with the intention to improve problems encountered at container precincts. The results indicated that the utilisation of agent-based technologies is a practical and sustainable approach for container precincts as it facilitates decision-making with respect to alternative ways of capacity expansion other than increasing resources and physical development. This study proved that there is a need for innovative ideas with respect to use of technology in order to manage complicated structures like container precincts. From this research, it is clear that deployment of technology for enhancement of container terminal operations is a necessity.

A study by Alamoush (2016) conducted a sensitivity analysis on the contribution of hinterland transport on the functioning of ports in Jordanian ports using NAFITH traffic system. In this case, TTT was used as an independent element while berth productivity, ship size, berth occupancy and ship turnaround time were considered to be dependent elements. The study concluded that positive changes in the hinterland transport have a positive contribution on port performance and that the NAFITH system assisted with traffic management within the port city, resulting in streamlined traffic flow and minimal congestion.

A study by Premathilaka (2018) conducted a regression model to determine the relationship and aspects contributing to the productivity of container vessels. This study focused in detail on areas that were controlled by the terminal operator. The results revealed the number of container moves, crane intensity, quantity of cranes, and gross crane and berth productivity are critical factors affecting vessel turnaround time. The study, however, acknowledged that there are other factors such as vessel waiting time, vessel confinement time, vessel berthing including sailing delay, that were important variables impacting turnaround time.

A study conducted by Lu and Park (2013) identified annual throughput on each berth as the critical indicator for productivity. Some of the input variables identified for the study are yard size, the amount of quay cranes, berth dimension and yard tractors, while output was considered as the main output element. Other factors that are considered essential as input elements are crane working hours, equipment and level of maintenance. Chang et al. (2013) also recognised throughput as the output variable, while input factors were identified as human resources, quayside cranes, hauling gear and marshalling yards. Suarez-Aleman et al. (2015) concur that the number of units handled are considered as outputs, and that inputs incorporate employees, cranes and terminal facilities available for port operations.

For the purposes of this study, the STAT was identified as the output variable and the input elements were derived from the key critical indicators from all dimensions that impact on productivity of the terminal, that is, maritime, container operations and hinterland operations. The input elements from the maritime sector were regarded as the anchorage waiting time, while for container terminal operations, GCH and SWH were the main independent variables. The elements for hinterland operations were TTT and RTT. Considering the complex nature of this study, it was necessary to conduct a sensitivity analysis to determine the critical performance indicators influencing productivity of the container terminal in order to identify quick wins that require urgent attention with respect to enhancing productivity.

A study by UNCTAD (2017) states that while port turnaround time cannot accurately determine the port efficiency as it does not extricate waiting or idle time, it can be used as a measure for the port performance and also assesses the overall ships dwell time. The study further indicates the average vessel dwell time globally is 1.37 days, with Singapore identified as the best performing port in the world with a turnaround time of 0.5 days. The study also notes that other key performance indicators that support STAT including berth productivity, are cargo dwell period and GCH. De Langen and Helminen (2015) state that shipping operators are more concerned with the ship dwell time as compared to crane productivity as the underlying factor is productivity and cost savings. According to Cheon et al. (2017), one of the critical measures for a port's appeal is its capability to process cargo within a reliable and expected time frame. This analysis justifies the rationale for the STAT to be the main output element of productivity with respect to key port performance indicators.

4.7 Factors impacting on Productivity of Container Terminals

According to Pieterse et al. (2016), in order to determine port efficiency, the marine, terminal and hinterland activities must be reviewed. Rodrigue et al. (2014) also indicate that port productivity is dependent on operations from the maritime, terminal and hinterland sectors, as each dimension impacts on another. The ITF (2018) observes that some of the bottlenecks experienced at ports such as longer ship and container dwell time, extended truck and rail turnaround times including futile terminal moves which cut across all dimensions, are due to the ineffectiveness of existing channels to guarantee free flow of information for alignment and coordination thereof. This report therefore suggests that the integrated interface of supply chains within maritime supply serves as a trigger for driving efficiencies.

A systematic approach in determining factors impacting container terminal productivity with respect to maritime, terminal and hinterland was followed. According to Williams and Hummelbrunner (2010), systems dynamics identifies the critical variables in an environment and investigates their connection and how they impact each other. Other factors impacting container terminal operations falling outside of marine, terminal and hinterland were also identified. This is supported by Ducruet et al. (2014), whose study revealed that while port authorities can play a critical role in enhancing port efficiency, they are subjected to national conditions which impact productivity.

4.7.1 Marine Factors

According to the Journal of Commerce (2014), there are various factors impacting the productivity of terminals, including size of ships calling the port, apportionment of equipment, human resources deployment and the positioning of the port as either a gateway or transhipment port. Maritime operations are impacted among other factors by: 1) unavailability of berthing slots; 2) terminal inefficiencies; 3) pilotage, and 4) tugs services (Rodrigue et al., 2014). Felicio et al. (2015) also indicate that the main characteristics impacting on port performance are port and terminal features, including infrastructure and port services which must be reviewed systematically to guarantee improvement in service reliability. This means that any of the mentioned factors has a direct impact on productivity depending on the state of each factor.

A study by Felicio et al. (2015) revealed that the geographical location, maritime and land accessibility, shipping connectivity, flexibility of port authorities, terminal layout including integration of logistics services, are considered critical features impacting container terminal productivity. Other factors that are considered important by shippers are port costs, shipping charges, throughput volumes, market accessibility, turnaround time, trade routes and service reliability. Shipping lines consider certain factors essential to include a port on its route, such as the location of the port, reduced port costs and reliability of service. Other factors include customer satisfaction, productivity levels, and throughput volumes. Gohomene et al. (2016) add that port infrastructure is critical with respect to the appeal of the port in West Africa, while the cost of doing business and service excellence are seen as the most important factors when choosing ports in other developed regions such as Asia, Europe and North America. The factors identified are more relevant in relation to the attractiveness of the port, even though they may impact on productivity in some way or the other.

A study by Nze and Onyemechi (2018) found that the causes of congestion on some African ports are exorbitant requests of port services by industry, outdated infrastructure and lack of technological advancements which negatively impact the efficiency and productivity of sea ports. The results of their study indicate that congestion at ports in the African continent stem from scheduling, capability, efficacy, and regulation or consolidation of these factors. A study by Gidado (2015) further confirms the causes of bottlenecks in sea ports like Lagos, Durban and Mombasa, relating to bad scheduling, capacity constraints, regulation and lack of efficiency or an amalgamation of these factors. Other factors resulting in port congestion relate to unfavourable weather, unexpected increase in demand, mishaps in operations, land congestion, waterside congestion, industrial strike, impact of public holidays and storage yard congestion. Congestion is one of the consequences of inefficient port operations resulting in bottlenecks within the port system.

Gidado (2015) indicates that port congestion is linked with long queues, delays, longer stay of vessels and cargo in the port which have unintended outcomes on the overall supply chain with respect to additional costs, disruption of services and loss of business. He further mentions the various types of congestion that are dominant in Africa such as ship berth congestion, ship work congestion, vehicle gate congestion, vehicle work congestion, cargo stack congestion and ship entry/exit congestion. Ship berth congestion happens when there is a number of ships awaiting berth availability, while ship work congestion is due to delays experienced during loading and unloading of containers which impacts on ship's dwell time in the port. This suggests that congestion originates from various dimensions of both transport and operational modes, that is, shipping perspective, stacking angle and trucking view. The investigation by Comtois and Slack (2019) further states that other than bottlenecks in operations, the shipping lines also have their share contribution in longer dwell time as a result of non-adherence to vessel arrival schedules.

4.7.2 Terminal Factors

A study by Felicio et al. (2015) revealed that the performance of a container terminal is directly linked with the port and terminal characteristics even though they do not necessarily have a similar impact. Nyema (2014) indicates the various factors influencing container productivity including yard capacity, dwell time of trucks, crane performance, security procedures, infrastructure and custom processes. According to Gidado (2015), terminal operations are dependent on: 1) crane productivity; 2) storage yard operations; 3) truck transloading operations; 4) gate performance and 5) rail equipment. Crane productivity is the most critical factor impacting terminal operations as it determines ship dwell time based on the available cranes to work the ship and moves to be done per hour per crane. It is very clear that in order to improve productivity of the terminal, the strategy should be centred around the deployment of cranes.

Soares and Neto (2016) state that container terminals are commonly challenged by a huge number of containers in the stacking space and their dwell time in the terminal affects productivity of the terminal. The dwell time of the containers could be a result of various factors such as terminal design, legal aspects including commercial arrangements with the terminal. A study by Gidado (2015) points out that a long cargo dwell time in the port before it is distributed to the hinterland is the major contribution of bottlenecks, as it becomes an impediment to incorporation of sub-Saharan economies in global trade networks. Longer dwell times directly impact port efficiency negatively, thereby causing port congestion which can hamper economic growth. This implies that cargo dwell time in the port must be structured such it does not impact productivity of the terminal.

A study by Lu and Park (2013) investigated the sensitivity analysis with respect to determining the most important elements of productivity in a container terminal using Data Envelop Analysis and Regression Analysis. The study, based on the data collected on the 28 container terminals in East Asia, found that some of the critical factors are Terminal Cranes and Yard Tractors, while some of the greatest delicate performance indicators affecting container performance are the overall quantity of berths and resources deployed during operations. Wilmsmeier et al. (2013) also add that labour is a critical input feature on terminal productivity unless operations are fully automated. It is without doubt essential for ports and terminals to always review the quantity of equipment and resources deployed during terminal operations in order improve efficiencies.

Rodrigue et al. (2014) indicate that efficiencies in the Port of Durban are affected by various factors including bottlenecks at the port gate, inefficient operations at the terminal, limited rail and container stacking capacity. This results in a longer waiting times of vessels at anchorage which impacts the cost of doing business in South Africa, thereby derailing the competitiveness of the country. According to Pieterse et al. (2016), performance at DCT is also aggravated by inadequate container stacking space, low productivity and bottlenecks at the gate leading to longer vessel waiting times. According to the researcher, the situation described shows a positive causal relationship with respect to terminal operations impacting on marine operations, where the terminal inefficiencies are contributing negatively on anchorage time of vessels requiring a systems approach through the use of CLDs to visualise the interconnections. Williams and Hummelbrunner (2010) state that CLDs are valuable tools in displaying and analysing close connections of any environment while distinguishing the fundamental reasons behind the *status quo*.

The study by Comtois and Slack (2019) states that bottlenecks in operations among other factors such as poor crane performance, congestion, and employee issues affect the ship dwell time. Rodrigue et al. (2014) allude to the fact that labour factors with respect to performance incentives contribute to disruptions when it comes to productivity of container terminal operations. According to Gidado (2015), the main type of congestions that take place at the terminal are vehicle gate congestion and cargo stack congestion. The vehicle gate congestion refers to obstructions caused by lack of proper land access to the port through trucks, while vehicle work congestion is a result of operational disruptions due to inadequate required resources. Cargo stack congestion is due to longer dwell time of cargo in the stacking space beyond allowed time but ship entry/exit route congestion is a result of general obstruction of ships on the water side due to various factors leading to overstay of ships in the port boundary. Availability of space and equipment is essential for smooth operation for movement of containers from yard to truck and truck to yard as it impacts on truck dwell time (Rodrigue et al., 2014).

A study by Pieterse et al. (2016) indicates that the terminal targets with respect to turnaround time of trucks cannot be achieved at the Container Terminal. The actual performance is frequently more than 60 minutes compared to a target of 35 minutes. A study by Navarro et al. (2015) conducted a sensitivity analysis to assess the behaviour of container flow in order to resolve port congestion. The study recommended the use of a truck booking system to decrease congestion. This may suggest that the deployment of the truck appointment systems in the Port of Durban must be fully implemented and adhered to, as currently it is not compulsory, resulting in bottlenecks in the areas within and around the port.

4.7.3 Hinterland Factors

According to Caldeirinha et al. (2013), the hinterland accessibility is impacted by various factors such as efficiency of transportation mode, costs and interconnectedness of transport networks. Rodrigue et al. (2014) add that hinterland operations are dependent on: 1) inland operations; 2) road network capacity, and 3) traffic bottlenecks within the proximity of the port, for which the Port Authority and the municipality is responsible. Maharaj (2013) alludes that factors contributing to inefficient supply chains other than ship berthing delays and level of productivity at the container terminal in Durban, are inefficient customs processes, road bottlenecks, limited supply of rail including power and water supply disruptions. It must be stated that this study only investigates the hinterland aspects that are in control by the port, such as TTT and rail turnaround time and does not include customs, private sector and municipality processes.

A study by Govender and Mbhele (2014) indicated that the hinterland operations in the Port of Durban are affected by reliance on the road transport network among other issues which accounts for almost 87% of containerised cargo resulting in congestion in the port area. This is supported by Rodrigue et al. (2014), who indicate that only 15% of containerized cargo is moved by rail in the Port of Durban. Pieterse et al. (2016) also confirm that only a limited number of containers, that is, 15% are moved by rail in this port, resulting in increased road transport which leads to severe congestion. Other factors contributing to poor performance at Durban are lack of adequate space for container stacking and port gate congestion. They further state that other factors that contribute to inefficiencies fall outside of the Transnet jurisdiction as they entail hinterland operations by the private sector.

The dominance of road transport in Durban results in bottlenecks in areas surrounding the port, including warehouses (Rodrigue et al., 2014). Pieterse et al. (2016) further add that the move by port users from rail to road is burdensome on the highway. The problems associated with road transportation are accidents, customs clearance procedures, traffic bottlenecks, weighbridge processes and overweight containers (Govender and Mbhele, 2014). Phan-Thi and Kim (2013) also indicate that the other challenges brought by road transportation are traffic congestion, including carbon dioxide emissions at container terminals due to truck idle time at the port entrance, which pose an environmental threat in the area. The research suggests that the Port of Durban must focus on maximisation of rail in order improve the bottlenecks and eliminate congestion in the port.

A study by Pieterse et al. (2016) indicates that unreliability of rail transport due to delays and cancellations was the major reason for users to change to road transport. The impact of these delays is the late arrival of goods to customers as well as the inability to provide track and trace systems of cargo at any particular time, which is generally provided by road haulers. According to de Villiers (2015), road transport is ideal for small parcel sizes within a short distance, while rail is suitable for long haul with big parcel sizes at a high speed. It follows that TFR needs to resolve the inefficiencies it experiences resulting in rail customers migrating to road transport and bottlenecks in the overall logistics chain.

Rodrigue et al. (2014) indicate that trucking is considered to be efficient in the South African context, providing quick turnaround service with cost effective packing systems. While road transport is costly and has adverse effects on carbon emissions, it is considered to be the shortest mode of transport with respect to time. However, this transportation mode should be discouraged and only utilised when there is urgency with the delivery times of a consignment. Maharaj (2013) further projects that although there is focus on shifting cargo from road to rail, the road-based traffic is still expected to increase by 100% by year 2030. The use of traffic by both the freight industry and passengers as a result of residential parts nearby the port will cause bottlenecks. It is therefore essential for rail to invest in the required infrastructure, equipment and assets to drive cargo movement so that only the short haul cargo is directed to road.

According to Govender and Mbhele (2014), the density of traffic on country wide roads and freeways has a direct impact on planned distribution times due to congestion on intermodal logistics near the Port of Durban. The findings by Ducruet et al. (2014) reveal that national dynamics have an impact on port operations. Whilst port authorities can do their outmost to enhance productivity at the ports, unfortunately, the performance could still be jeopardised by national factors.

A report by Botes and Buck (2018) indicates that traffic bottlenecks are a result of a lack of proper traffic management initiatives and not necessarily inadequate infrastructure. The report suggests that coordinated traffic plans could alleviate port congestion by assigning particular road lanes to freight vehicles during peak periods. A study by Muller and Bester (2016) further alluded to the fact that while the port strategy is to drive cargo to move on rail, there will be some reliance on road transportation considering the expected port volume projections, which will also increase the numbers of trucks on the municipal roads on particular routes. According to the researcher, it is very critical for the Port Authorities, Department of Transport including the Municipalities, to work together in ensuring competitiveness of the ports in their regions by driving coordinated initiatives to address road traffic challenges.

4.8 The Impact of Productivity on Operations

The findings of the study by Yang et al. (2013) indicate that poor productivity results in unreliability of schedule of liner vessels, yielding high operational costs. Furthermore, the impact of productivity on one port also impacts on the schedule reliability of another; hence it is important for terminal operators to be aware of the developments in other ports. This implies that if port productivity is improved, it will automatically enhance schedule reliability including reducing the cost of doing business. The study by Suarez-Aleman et al. (2015) further indicates that the overall impact of enhanced productivity yields savings on port associated logistics overheads, thereby improving global trade and competitiveness.

The Journal of Commerce (2014) states that terminals should continuously increase their productivity levels considering the shipping line's requirements to slow steam their ships for the cost reduction of fuel. Yang et al. (2013) further indicate that improved productivity results in reduced fuel costs. A study by Dappe et al. (2017) also asserts that any efficient port is able to minimise the marine transportation costs by an average of 14 per cent, while growing their export cargo by more than 2 percent. This means that all ports must be encouraged to improve their port productivity as its enhancement results in reduction of the transportations costs and eventually a decrease in the cost of doing business.

A study by Song and Cui (2014) states that the substantial operational improvements including management thereof, among other factors, have resulted in increased throughput in Chinese ports. According to UNCTAD (2017), improving productivity and the period cargo stays in the port are essential for cost-reduction and enterprise attractiveness. Port efficiency plays a critical role in trade competitiveness and the capacity of the ports to contend in a difficult and changing market structure. There are therefore several added outcomes of improving productivity which have an impact on various stakeholders, such as shipping lines, port authorities and terminals, cargo owners, cities and the country as a whole. The reduced cost facilitates the ease of doing business and promotes growth of the economy.

4.9 Measures to enhance Productivity of Container Terminals

4.9.1 Marine Operations Measures to enhance Productivity

Dappe et al. (2017) state that there are means to enhance the competitiveness of ports other than the development of a huge new infrastructure. This can be achieved by improving the existing facilities through enabling them to move higher volumes of cargo. Ducruet et al. (2014) specify that the upgrade of port facilities including enlargement of the entrance/exit channel including deployment of vessel queuing and schedule optimisation systems, will enhance operations.

Nyema (2014) further adds that the provision of deeper drafts for berthing of ships, deployment of bigger cranes, a huge storage yard and road and rail infrastructure are a necessity for ports to accommodate bigger ships. This requires large investment. A study by Zhen et al. (2017) emphasised on the importance of planning as critical in determining the schedule of mega ships as they are dependent on tide patterns for passing through the port channel for berthing and sailing purposes. The scheduling of tidal vessels can be projected earlier based on the anticipated tide patterns, including vessel drafts. This approach will ensure that efficiencies are enhanced in a cost-effective manner, thereby improving port competitiveness.

According to Oktafia et al. (2017), collaboration is required among the administration office, tugs and pilots in order to ensure that the berthing and unberthing procedure is effective. This process requires both the pilotage and tug service providers to be available at the same time for it to be actualised. Without cooperation, there will be no good service delivery, resulting in customer complaints. They further indicate that the effectiveness of this service is measured by ensuring timeous service delivery in order to ensure customer satisfaction. It is therefore a necessity for a coordinated, thorough plan be available in advance to ensure timeous service delivery by the Port Authority for improved customer satisfaction.

Other factors that contribute to improved productivity are the terminal gate booking system, good hinterland connections, existence of competition among various terminals in the port and attraction of international terminal operators in the port system for same market share. However, some of these solutions are practical in new ports, where space constraints and congestion are not prevalent in the city (Ducruet et al., 2014). A simulation study by Huang et al. (2012) to determine the contribution brought by developing private terminal operations to enhance berth utilisation and capacity, revealed that terminal capacity can be enlarged by approximately a quarter (20-30%) while decreasing associated costs by an average of 15% (10-20%). According to the researcher, the Port Authority must encourage participation of private international operators in the container sector in order to improve productivity.

A study by Nze and Onyemechi (2018) recommends that ports in Africa must heighten the regulatory framework and advance capacity and efficiencies in order to minimize the port bottlenecks, going forward. With respect to regulation in Durban, there must be administration of law and introduction of innovative procedures regarding precise forecasts of expected truck traffic. Provision of truck staging areas both inside, preferably Ambrose Park, and outside the port, which is the crossing of N2 and M7, is critical. Traffic management should ensure the installation of extra CCTV cameras and linkage of N3 Toll Route, South African National Roads Agency and eThekwini Transport Authority’s traffic management areas to the TNPA Operations Centre, which also requires upgrading (Van Tonder, 2015).

Gidado (2015) further endorses various action items to eliminate congestion such as commissioning appropriate programming systems for coordination of ships in the port limits, expansion, dredged berths, and advanced berth specialisation for maximising berth occupancy. The automation of various processes, creation of cloud database for all users, and improved communication among all stakeholders which requires a computerised communication system, are also some of the proposed considerations to road challenges in ports (Van Tonder, 2015).

According to Juhel (2017), one measure for enhancing productivity is for the Port Authority to play an oversight role on operators continuously by analysing monthly or operational performance reports which are agreed on by shipping lines during the planned port community meetings. This process will also allow penalty measures which can be reviewed annually when the operators cannot meet performance objectives by more than 20% for three sequential operational years. Considering the underperformance of the port operator, the Port Authority may consider termination of the Agreement pursuant to Terminal Operator Default; however, there must be provision for default based on performance contained in the terminal operator agreement.

The Port Authority may also consider quarterly review sessions over and above the monthly reports, where penalty measures are reviewed per annum where performance targets are not met. The performance review may consider the overall performance of the terminal including compliance of the implementation of the International Ship and Port Facility Security Code, entry protocols, safety measures, customer reviews and maintenance plans of equipment and infrastructure (Juhel, 2017). He further indicates that continuous assessment of terminal performance should be done month-to-month, while key performance indicators for contractual arrangements should be reviewed per annum. Where the annual key performance indicators cannot be achieved, monetary penalties should be considered; however, the incentives and penalties should only be applicable on performance measures which are directly under the jurisdiction of the operator for fairness and effectiveness. From the insights shared here, it follows that the Port Authority must proactively elevate the implementation of the regulatory framework and the oversight role to eliminate inefficiencies within the port system.

4.9.2 Terminal Operations Processes to improve Productivity

Ursavas (2014) states that maximising container terminal operations is dependent on various factors, including berth allocation (which is a method to allocate berthing time and location of a vessel), crane quay allocation and crane scheduling, which are processes guiding the sequence of movement of cranes to a ship. Management of these processes is critical in a container terminal as they impact on productivity measures including waiting times, service times of ships and operating costs. Hence a systems approach is required to determine which productivity measures can be improved in a container precinct in order to ensure that the port is attractive to the international market.

According to a study by Lange et al. (2014), simulation is an essential tool that has contributed significantly in production and logistics, which can be utilised in a complex structure such as container terminals. The benefit enabled by simulation is the ability to identify current productivity constraints and potential solutions which can be compared to other possible approaches without causing any risk or harm to operations of existing terminals, while on new terminals it can assist with projections of anticipated performance and likely problems even before effecting the system. Kotachi et al. (2013) further highlight that simulation assists with forecasting the performance system and indicators considering the complexity of container terminal operations and various resources and interactions required.

A study by Mamatok et al. (2019) used SD to come up with a CO_2 emission mitigation systems model to resolve environmental challenges within a port space. The outcomes of the study facilitated decision-making by port directors to determine the suitable mitigation plan for each port. The systems dynamics enabled worthwhile conclusions on mechanisms for strategic planning of coastal seaports using simulation. This model could be used worldwide as it could be standardised for any other coastal seaport to meet the specific requirements. This means that simulation is an effective strategy essential in complex environments such as container terminals to predict various factors impacting terminal productivity and solutions thereof.

Ursavas (2014) also indicates that the use of the decision support system (DSS) is essential for maximising container terminal operations on the quayside. This system is required considering the number of stakeholders that are participating in the decision-making procedures, as it is critical to consider all differing demands and requests from customers. This study provided a DSS that regulates the concurrent allocation of berths and cranes and revealed that the execution of the model produces operational enhancements fluctuating from 10% to 25% on time and costs.

According to Ducruet and Merk (2013), terminal operations can be improved by ensuring that there is a booking system, skilled labour with the capability to drive maximum crane productivity levels and use of latest state of the art equipment which allows double handling and lifting of several cranes at the same time. However, these operations are reliant on stacking yard equipment, stowage capability including terminal scheduling and surface. The Journal of Commerce (2014) further suggests that terminal operators must deploy adequate container handling equipment for each vessel call to avoid congestion. Schroder (2013) states that for a container terminal to maximise operations, there must be accurate numbers and types of equipment available for operations. The more the horizontal transport, the more the bottlenecks at the loading area, and the less the transport, the more sluggish will operations be.

A study by Suarez-Aleman et al. (2015) indicates that a longer berth and the sum of mobile and STS gantry cranes contributes greatly to productivity; however, it must be noted that STS cranes offer more competitive advantage as compared to mobile cranes. Schroder (2013) states that the port can benefit by ensuring that there is appropriate equipment which is utilised effectively in cargo handling. Gidado (2015) further stipulates that other initiatives to reduce congestion are the deployment of adequate terminal handling equipment and promotion of reduced cargo dwell time. The results of the study by Suarez-Aleman et al. (2015) further indicate that the total berth length provides a greater contribution toward port productivity *versus* the overall total terminal area. It is therefore apparent that the length of the quay side including the quantity and type of equipment utilised, play a critical role in driving efficiencies of the container terminal.

A study by Nze and Onyemechi (2018) recommends many other initiatives to minimise bottlenecks in African ports, including berth specialisation to maximise berth occupancy, investment on terminal equipment to improve berth productivity and STAT, expansion of storage capacity at yards and reduction of cargo dwell time by encouraging cargo owners to move their cargo timeously from the terminal. The Journal of Commerce (2014) indicates that most container ports with deeper drafts are capitalising on enhanced yard equipment, bigger cranes, increased container yards, additional truck gates and high-tech operating systems.

A study by Govender and Mbhele (2014) revealed that use of technology has a positive impact on the transfer of containerised cargo as it assists with synchronisation of outgoing and incoming scheduling systems on both terminal and hinterland operations. Nyema (2014) discovered that the non-availability of Information Technology System is a threat to container terminal performance as it results in delays in Customs clearance processes. A study by Huang et al. (2012) also recommends a technology upgrade in order to increase the port efficiencies considering that it will improve the handling rate at container terminals. This will in turn facilitate the appeal of the port with respect to handling additional cargo and subsequently result in reduced costs with container handling per unit.

The Journal of Commerce (2014) further adds that it is difficult to meet shipping lines needs in the absence of technology. A study by Moreno and Camarero (2013) indicates that maximum automation of a terminal does not always have positive impact on operations and financial performance as there are other factors that are critical for maximising terminal productivity. However, the findings of their study indicate that full automation of terminals handling import and export cargo above 1.2 million TEUs and transhipment volumes of more than 1.6m TEUS per annum, results in a profitable terminal, hence full automation will be preferred. Semi-automation as well is adequate subject to other factors being favourable for improved productivity. The study by Govender and Mbhele (2014) also found that advancement in technology assists with mitigation measures and shows harmonisation of import and export intermodal and inter-terminal activities. According to Heilig and Voß (2017), information systems are crucial to ensure that ports are not only competitive but also to ensure transparency, efficiency, dependability and security, including collaborative communication and decision-making. Provision of these value-added services is essential to retain competitiveness and to guarantee compliance to regulatory obligations.

Van Tonder (2015) states that some of the enhancements to be considered at DCT are the creation of records; induction for truck drivers; computerisation of processes including the staging area; deployment of control for the staging area, including the PA system all over the terminal; scanning of export boxes through weigh in motion, and execution of penalties. Other medium-to long-term projects are the mandatory booking system, integrated computerised inspection facility, capacity upgrade of Bayhead Road to the M4 and extension and upgrade of South Coast Road. It is therefore essential for actions to be executed to back the utilisation of new technology by the port stakeholders (UNCTAD, 2017).

Caldeirinha et al. (2013) indicate that terminal productivity can be enhanced by a well-designed layout of the terminal which subsequently impacts the performance and service quality of the terminal positively. Felicio et al. (2015) further add that for ports to improve productivity, they should have improved focus on customers to ensure agility and flexibility to meet new market demands and develop innovative ways of arranging a terminal layout that creates capacity and supports productivity. According to Rodriguez-Molins et al. (2012), to maximise productivity, stacking must be done such that import containers must be allocated in a free space while export containers should be stacked in close proximity to the unloading zone before vessel departure.

For Scholtz (2017), the stacking system at Pier 2 needs to be reconfigured which will ensure capacity improvement of close to 1 million TEUs per annum. Part of contribute to the improvement of the stacking capacity is the transformation of the stacking operation from usage of SC to RTGs. According to Schroder (2013), while each operational system has its pros and cons, the SC operation outperforms others economically as it does not require many people and equipment even though it is a complex operation which demands experienced operators and extended time with respect to the reshuffling of containers. The SC is considered to be a dynamic vehicle due to its ability to confiscate multiple boxes from the stack and position them on trucks and trains, including the capability to stack boxes up to three levels high.

Innovation with respect to techniques should be utilised in order to realise substantial enhancements with respect to lead times, storage use and volume throughput (Rodriguez-Molins et al., 2012). Schroeder (2013) also indicates that there is quick turnaround time for stacking and recovery of containers when using RTG and ASC, while the benefits of using TTU and RTG process are simpler operations without any complexity and do not require a major investment of capex and skills. However, the TTU and RTG systems need more time and equipment to move a similar number or quantity of containers as the SC.

According to Pieterse et al. (2016), the areas of focus to improve efficiencies at DCT are terminal operations, road turnaround time, move from road to rail, direct operation to terminals, less stay for free storage and development of inland terminals. Schroder (2013) argues that there are ways to reduce bottlenecks at the terminal through various ways of assigning vehicles to cranes. The first method is a single cycle which allows allocation of a vehicle to a single crane at a particular moment. The alternative process is a dual cycle which can be of service to several cranes allowing transportation of both imports and exports. Wilmsmeier et al. (2013) confirm that the positive impact is realised on container movements and productivity when the capacity of cranes is increased.

A study by Govender et al. (2017) on the impact of a multi- trailer system on terminal operations revealed that quay crane productivity at DCT Pier 1 can be improved by deploying multi-trailer systems with capacity to handle four 6-metre containers which will facilitate reduced terminal functional costs between the vessel and stacking space per shift. The use of multi-trailer systems is considered by various terminal operators as a critical tool to move additional containers at the same time, thereby improving efficiencies. The benefits that come with the use of equipment that can handle more containers with one move are reduced costs for labour and equipment while improving the terminal performance. Zangwa (2018) further adds that ports must consider a concurrent crane operation for loading and offloading cargo to and from the vessel and yard.

Govender et al. (2017) also found that while the use of MTS has proved to increase productivity, greater benefits are realised on the unloading processes as compared to loading. Operational costs for offloading cargo can be improved by 27% when nine MTS are deployed, as compared to using fifteen TTUs. However, the reduction of labour costs can be a controversial subject and is likely to be opposed by labour representatives, hence there is a need for engagement with all relevant stakeholders on how the MTS can be deployed for mutual advantage of the terminal and employees.

Zangwa (2018) states that for the port terminals to improve STAT, they need to increase SWH moves by the maximum deployment and placement of cranes for each vessel. This will ensure productivity improvements reflected with the reduction of dwell time for every vessel. He further adds that the equipment must be functional both technically and mechanically to ensure improved SWH and GCH. Zangwa (2018:55) recommends use of an "intelligent crane management system" as one of the critical factors to assist with efficiencies when it comes to equipment breakdowns and to assist with continuous maintenance on a short-term basis. The system acts as an investigative instrument that gives early signal of equipment problems. The system therefore permits prognostic maintenance for detected areas and this information is used to project future maintenance plans.

A study by Soares and Neto (2016) found an SD model to be a useful tool in determining the development of container terminal capacity and its productivity, using simulation. The model was not only able to show the underlying factors behind the system's behaviour but also assisted with projections of required terminal capacity and equipment over time to meet market demands. The simulation also prepared the terminal executives to review their handling methods including operational strategies for enhanced productivity and cost-effectiveness.

Azab and Eltawil (2016) also conducted a simulation to determine the impact of inflow patterns of truck on the TTT and arrival enhancement strategies thereof. The simulation results revealed that the TTT can be improved by the deployment of a truck appointment system which will assist with the elimination of congestion at port gates without reducing truck arrivals. It is critical for terminal operators to reduce TTT as it has operational consequences on terminal efficiencies.

An SD model was also used to determine induced travel demand (ITD) in order to understand the organisational complexity within road construction. A systems approach using CLDs and SFDs was utilised to explain the structural complexity of ITD using feedback loops and to simulate travel demand. The results revealed that new roads encourage increased kilometres by current vehicles in the interim period, while in the long run it showed increased traffic (Angarita-Zapata et al., 2016). CLDs are ideal tools for visualising the critical interrelated environments and the reasons behind those situations. They are able to investigate complex interconnections in a situation through use of feedback loops which facilitates identification of areas of influence leading to a solution or understanding of underlying factors. On the other hand, SFDs make use of simulations to acquire knowledge on behavioural patterns through computer-based approaches (Williams and Hummelbrunner, 2010). It must be noted that for the purposes of this study, CLDs will be developed which are instrumental in modelling thoughts of various stakeholders regarding a problem with the intention to develop a shared understanding, ownership and solutions. This methodology provides possibilities for increased stakeholder involvement which is crucial for decision-making (The Sustainability Laboratory, 2019).

The Port of Le Havre which was faced with a complex challenge of storage space for handling bigger vessels and competition from other northern ports had pressure to derive a solution which was going to bring them competitive advantage. A development of a modern logistics system comprising of a midway multi-modal terminal was necessary to serve as a hub for bringing together cargo within its proximity. A multi-paradigm simulation model for the required logistic system was used to determine the prospects of the system. The simulation model assisted the Port Authority with a prognostic of performance indicators for operations purposes. The simulation revealed that modern system outpaces the existing one as it is economically, eco-friendly and safer, supporting the Port Authority plans to develop sustainable logistics systems. Further to that, the simulation model was going to be used as a decision tool within the operations (Leriche et al., 2015).

A study by Guo et al. (2015) investigated the impact of critical influence aspects on throughput capacity of container terminals. The study found that a simulation model is an appropriate approach in resolving complex systems that cannot be untangled through mathematical form. This model found that the capacity is directly linked to uninterrupted use of berths by the similar service level agreement. SD modelling was used to investigate the essential type of investment for ship deployment as a result of limited capacity and increased number of volumes. The study was intended to ascertain the size and type of ships necessary for growing volumes and improved customer care using a Systems Dynamic simulation method. The research revealed that deployment of bigger ships will facilitate increased number of volumes as a result of a spark in sailings. The study assisted decision-makers within the shipping fraternal regarding the suitable capital investment plans that will ensure ideal performance of their businesses (Park et al., 2014).

A study by Schroder (2013) conducted a simulation which determined the amount of equipment required to ensure smooth operations at the container precinct in Durban, and the results indicated that Pier 1 requires about four TTUs and RTG per dock crane. This operation will guarantee that there is a quick turnaround of vessels which will translate into improved customer satisfaction and further generate higher monetary returns. This study also developed a model which was used to investigate the amount and type of equipment which would facilitate efficient operations at the Container Terminal. The results revealed that the Pier 1 at DCT requires about four TTUs and four RTGs in order to improve efficiencies, while Pier 2 requires four SCs for each quay crane considering the parameters involved in the project. Zangwa (2018) further suggests a concurrent crane operation for loading and offloading cargo to and from the vessel and yard for the port terminals to improve STAT.

4.9.3 Hinterland Operations Methods to advance Productivity

According to Ducruet et al. (2014), the factors essential for enhancing productivity at the terminal are huge highways, national waterways including availability of bulk rail. Felicio et al. (2015) agree that for ports to improve productivity, there should be capital investments on the hinterland which will allow additional access thereby facilitating improved terminal operations. Caldeirinha et al. (2013) also state that terminal productivity can be enhanced by investments on projects that facilitate access to the hinterland. According to Gidado (2015), the upgrade of hinterland networks such as road connections including rail and traffic management in the port boundary will assist in eradicating congestion in ports.

Ducruet et al. (2014) also indicate that the other factors that are critical for efficiencies are good hinterland connections providing a united transport system and use of truck booking systems. Phan-Thi and Kim (2013) agree that terminal operators must deploy a truck booking system in order to reduce congestion. This system is a software that will facilitate truck appointments taking into consideration the capability of both the trucking businesses and container terminals. According to De Langen and Helminen (2015), most terminals have established truck booking systems to ensure even distribution of truck arrival times per day which facilitates better planning of operations. A study by Ramírez-Nafarrate et al. (2017) applied a simulation model together with a heuristic procedure to assess the contribution of configuration of the truck appointment systems and its impact on terminal operations with respect to container reshuffling and turnaround period of trucks. The results of the study specify that container reshuffling will be minimized while improvement in TTT will be realised with the implementation of the truck booking system.

Azab et al. (2017) investigated the use of traffic appointment system to assist, with the intention to determine possible benefits for decision-makers. The assessment revealed that the system brought value with the reduction of both truck waiting times at port gates and TTT by 21% and 23% respectively. The system also contributed with elevation of congestion especially at peak times and subsequently smoothened the amount of work at the terminal, including balancing truck arrival processes. The deployment of this dynamic collaborative appointment systems was valuable for both the terminal and truckers and the overall shipping fraternal. It is thus critical for container terminal operations to ensure deployment of truck appointment system for productivity improvements.

ITF (2018) further proposes uses of truck staging areas which are far from the terminal gate which will serve as a holding area for truckers while waiting for their appointed slot for picking up or dropping off containers. This arrangement will assist with reduction of traffic within the critical port space and municipal roads. Van Tonder (2015) indicated that some of answers with respect to road problems facing South African ports require improvement by the provision of additional road linkages, revamping current roads and effective management of traffic. Some of the immediate initiatives to be considered with respect to road accessibility are extra traffic lanes, both in Langeberg and Bayhead Roads; expansion of the juncture of South Coast and Bayhead roads; introduction of ramps at South Coast Road junction, including a roundabout, and truck staging areas at the crossing of Maydon and Johnstone Roads. He further indicated that the quantity of entrances to Bayhead must be reduced and altered into a one-way lane, where each access must be fully controlled and have its own truck staging area.

Maharaj (2013) further indicates that the deployment of rail *versus* road will assist in elevating bottlenecks in the supply chain as the rail cost and inefficiencies have exacerbated the use of road transport. A study by Sáez et al. (2019) investigated innovative solutions to increase the utilisation and attractiveness of rail transport. One of the proposed solutions was the provision of direct discharge of cargo boxes from the ship to train, thereby reducing the handling movement through operating a "Just-In-Time" rail shuttle facility. The new service offering provided advantages for both shippers and rail operators, where rail operators had flexibility with respect to frequency of slots and regularity of service offering, while the shippers could increase train utilisation and thereby cost per container. In essence, the success factor of this initiative was the cost reduction which made it more attractive compared to road transportation. It is thus important for the terminal and rail division to devise innovative solutions to shift cargo from road to rail with the intention of improving productivity.

Road transport must only be considered on short haul transport for servicing the nearby hinterland and for cargo that cannot be handled on rail. There must be a focus on developing the city freight plan considering dedicated routes, and back of port areas must be prioritised (Maharaj, 2013). Govender and Mbhele (2014) investigated the influence of intermodal systems on port activities and found that the dynamics for the road transport are controlled by the road infrastructure and turnaround times, hence there is a need to assign a dedicated line of traffic for packed container trucks subject to the essential clearance of duties being aligned to the Transnet main system to speed up the lengthy delivery times to clients.

According to Maharaj (2013), most international ports make use of inland hubs (dry ports) to clear, de-stuff cargo, re-configure it and channel it to different networks. The development of a dry port will reduce the container stay at the port as it will allow containers to be transferred to the dry port and *vice versa* through a shuttle service (Scholtz, 2017). It is, however, critical for dry ports to be built to complement the cargo from inland that is far away from ports (Gu and Lam, 2013). Gujar and Thai (2013) further state that dry ports contribute significantly in the transportation of cargo acting as a consolidation and distribution centre between the port and the inland.

According to Gu and Lam (2013), dry ports bring added value for a rail transportation mode which is distant from sea side, hence road transport for lengthy distance must be restricted. Other forms of transportation such as barges or rail ensure added advantages with respect to monetary impact and conservation of the environment. However, it must be noted that in order to ensure environmental preservation transportation methods, the country must build ancillary substructure such as railway lines, canals, dry ports etc. The worldwide port cities use different approaches for their growth path. This includes prior investment of port infrastructure considering anticipated demand, provision of efficient rail network, support of inland hubs for delivery and reconfiguration of goods and lastly, efficient roads that do not interfere with passenger transportation (Maharaj, 2013).

A paper by Chen et al. (2016) assessed the seaport-hinterland connectivity of the container terminal in Malaysia considering transportation modes and inland freight terminals. The study proposed that hinterland connectivity be improved by deploying strategies that will advance rail capacity and service and debottlenecking road networks, including expansions of inland terminals. Rodrigue et al. (2015) also state that the planning of port and transportation mode infrastructure requires a rigorous process considering that responsibility for this is managed under different jurisdiction, as is the case for the Durban-Gauteng corridor. It is thus very clear that hinterland connectivity plays a critical road in the productivity of the container terminal, and that while advancements are executed on the port side, the hinterland must also get capacitated. Plans need to be coordinated and aligned to ensure smooth transfer of cargo to and from the port.

4.9.4 Other Considerations for Productivity Improvement

4.9.4.1 Participation by all stakeholders

According to Hector et al. (2012), for inefficiencies to be minimised, they require collaboration by all stakeholders within a supply chain, as no one organisation can resolve them on their own. A study by Govender and Mbhele (2014) revealed that delivery time plans in the Port of Durban can be improved by strategic routing if clearing and forwarding agents line up the coordination of incoming and outgoing operation plans. The study also indicates that if alignment between import and export port activities are well planned, on time distribution times will be achieved. Chasomeris (2011) indicates that the Port Authority is not the only organisation that must account for the ship turnaround time, as some of the underlying factors are not within their jurisdiction, including weather and shipping lines delays. However, Huang et al. (2012) state that it is the responsibility of the Port Authority is to ensure that container terminal capacity is used effectively.

Pieterse et al. (2016) further indicate that the Port Authority is not the only stakeholder to resolve the congestion problems: the solution requires improved planning by all stakeholders involved in the container operations, including cargo nodes and corridors to and from sea ports. According to the Journal of Commerce (2014), productivity is a joint responsibility as shipping lines have an obligation to provide the terminal with timeous and correct information on vessel arrival and container stowage 24 hours prior to arrival. The expectation from shipping lines based on the normal terminal's productivity is for ships to be worked quickly so that slow steaming is maximised, while vessel assets are utilised efficiently.

4.9.4.2 Shipping Lines owned Terminals

A study by Chang et al. (2013) revealed that most shipping lines have dedicated container terminals in major ports which facilitate steady service provision that allow them to compete in the market. For these shipping lines to remain competitive, they ensure capital investment in these dedicated terminals. Ducruet et al. (2014) also confirm that dedicated terminals allow terminals to achieve improved berth occupancy as compared to all-purpose terminals resulting in enhanced ship turnaround times. They further elaborate that dedicated terminals have the capability to attain advanced berth occupancy ranks as compared to common user terminals, leading to enhanced port turnaround time.

While shipping lines have varying business procedure modes, there is a trend to incorporate a door-to-door provision for their inland clients. As a result, some shipping lines sub-contract some or all their hinterland transport operations, whereas others prefer to integrate them into their business operations. The shipping line's priority is to reduce the cost; however, the decision is dependent on the market needs with respect to meeting delivery time requests by clients (Gu and Lam, 2013).

4.9.4.3 Privatisation of Container Terminals

A study by Huang et al. (2012) recommended terminal privatisation in order to heighten port efficiencies and performance through berth and facility optimisation. Terminal privatisation will facilitate autonomous management of terminal operations which will ensure quick decision-making and the provision of efficient services. This will in turn result in increased cargo output and condensed container handling costs per unit. According to UNCTAD (2017), there are enormous advantages of involving private sector in terminal operations, such as capital investment, skills transfer and new technology. Private sector partnerships have in the past assisted with investment, access to specialised expertise, innovation and technology in terms of the development, operation and maintenance thereof of terminals.

UNCTAD (2017) suggests that investments by the private sector should not be made only in ports but also in the intermodal connections. The capital investment can incorporate joint ventures between the public and private sectors, as executed over the past decades. A study by Suarez-Aleman et al. (2015) revealed that the involvement of the private sector, eradication of fraud in the government segment, enhancements in liner network and availability of multiple linkages, contribute to the improvement of efficiencies in the emerging countries.

4.9.4.4 Modern Processes

According to UNCTAD (2017), other critical factors contributing to improved port performance are operational advancements, purchase of equipment, expansion of infrastructure, effective stakeholder engagement, agile practices, enhanced businesses processes, focused activities and improved administrative methods. The Journal of Commerce (2014) further indicates that productivity in Asian ports is driven by a 24-hour operation, the level of automation, increased number of shifts and huge transhipment volumes in the area.

4.9.4.5 Training and Development

Nwaeke and Onyebuchi (2017) argue that the success of a business is reliant on people's skills, knowledge and expertise, hence training and development is recognised as a critical tool to advance productivity and performance thereby increasing organisational competitiveness. They further state that organisations need to pursue employee development rigorously for organisational success. Employee development should be part of organisational strategic objectives, since it contributes in the productivity and the survival of businesses in a changing environment. It can help corporates to acquire critical competitiveness that enhances innovation and provides strategic direction that opens opportunities for competitiveness also to the international markets.

4.10 Conclusion

This chapter has defined the container terminal productivity theory, indicating its importance, including the benchmarks achieved in the major ports in the world. It has outlined the critical indicators for measuring productivity and the factors impacting efficiencies of container terminals, from a maritime perspective to terminal operations and lastly, to hinterland operations. It has also discussed the impact of productivity on operations, and measures to enhance productivity at the container terminals. Other factors practised worldwide to improve efficiency of the container terminals have been elaborated. This chapter, in doing so, has thus presented a literature review on resolving container terminal productivity issues using a systems approach.

CHAPTER FIVE: RESEARCH METHODOLOGY

5.1 Introduction

Chapter 5 of this thesis describes the research methods used in conducting this study. The section provides a blueprint of how the study was conducted, from beginning to end. The researcher discusses the research design, strategy, different available research methodologies, sampling methods, data collection, analysis, and ethical considerations.

5.2 Research Purpose

According to Saunders et al. (2016), the research is a logical method with specific objectives of acquiring information with the intention to enhance understanding of a particular subject. In this study, the purpose of the research was to arrive at valid conclusions through scientific enquiry on how the performance of the container terminal in the Port of Durban can be improved using a Systems Approach with respect to SD and SSM. The research investigated the relevant input productivity elements from a systems approach by analysing container terminal operations using conceptual models, root definitions, rich pictures and CLDs, with the intention to improve productivity of the container terminal. The study further conducted a sensitivity analysis to determine to determine critical performance indicators influencing productivity of the container terminal using secondary data.

5.3 Research Design

De Vaus (2001) describes research design as a systematic process of investigation to enable the research purpose to be achieved unambiguously. He further emphasises the need to acquire research evidence that is convincing to the theory as opposed to research results that align to theory. Saunders et al. (2016) define a research design as a plan to respond to the research enquiry giving details on data collection sources and methods, including analysis and ethical considerations. According to Saunders et al. (2016), the research design provides about three options through which data can be collected, quantitative, qualitative or combination of the two processes.

De Vaus (2001) cautions about equating research design to data collection methodology being quantitative or qualitative and insists on the need to identify the type of research results required before selecting the research method. This implies that the expected research results should determine the methodology to be followed. Creswell (2009) further describes research design as a plan to undertake research which incorporates the philosophical approach, research strategy and research methods applicable to the research study.

According to Creswell (2009:6), the philosophical worldview approaches are "postpositivism, constructivism, advocacy/participatory and pragmatism". The postpositivism is a scientific research approach which is quantitative in nature with the purpose of determining causal relationships in an environment. This approach generally begins with a theoretical framework before data collection. Constructivism is aligned with qualitative research, which seeks to understand context and complexity of environments via interaction with others using open-ended questions. The advocacy and participatory worldview is qualitative and collaborative in nature, such that it allows engagement with research participants from the beginning of the research to the analysis stage, producing unified research findings that will bring change and reformation in the environment. Pragmatism is aligned to mixed methods research as it allows exploration of both quantitative and qualitative approaches to achieve the research purpose.

Some of the strengths identified within the pragmatic philosophy are its mixed approach form of data collection which allows acquisition of research information in both a qualitative and quantitative manner. It is not limited to a single approach but provides an opportunity for researchers to use a variety of research techniques and instruments that are suitable to source data aligned to their purpose. It also permits diversity of worldviews, assumptions including data analysis techniques (Creswell, 2014).

The study utilised a pragmatic worldview and appropriate research approaches to gain full comprehension of the circumstances. As a result, a mixed methods research incorporating a combination of qualitative and quantitative research methods was used to collect data. Creswell (2014) indicates that the mixed methods relates to the combination of the quantitative and qualitative research methods. According to Flick (2009), combining research methods provides validity of the research results of both methodologies. Furthermore, a combination of research approaches facilitates acquisition of broader knowledge as opposed to conducting research with a single technique. Cook and Cook (2016) further state that there is no perfect research design, as each design has its advantages and disadvantages. Creswell (2009) also state that mixed methods neutralises limitations and biases that are characterised in a single methodology.

According to Gorard (2015), the mixed methods paradigm seems to be demanding and complex but yet innovative, as it incorporates both quantitative and qualitative approaches in one research study. This study analysed the various researchers' approach to mixed methods and found that most new researchers generally opt to use this methodology to investigate significant exploratory problems. Creswell (2014) adds that a mixed method affords a detailed investigation of a research problem as opposed to conducting research using a single approach. The type of mixed methods that was used in this research is a partially integrated approach as only one objective required use of quantitative data; the rest of the objectives were studied using a qualitative approach.

The mixed methods approach provides variety of advantages with respect to the collection and analysis of data. Different methodologies allow acquisition of different data sets which assist with different objectives of the study. It allows a complementary role to be played by variety of research techniques, whereby instruments from one form could be suitable for a particular population and not for the other. It is advantageous when one research design is not adequate to respond to a particular research problem. A mixed approach also ensures that comprehensive research findings are attained stemming from variety of data collection methods (Creswell, 2014). Ilovan and Doroftei (2017) also state that utilisation of both qualitative together with quantitative research methods allows extensive findings which may not be revealed with a single methodology. The mixed method process facilitates robustness in research and is beneficial for investigations that depend on both data and people's views.

According to Saunders et al. (2016), quantitative research allows data to be investigated between variables using numbers through arithmetic and graphical form. Creswell (2009) further states that quantitative approaches include complex experiments and structural equations that reflect causal paths and determination of the joint strength of various variables. A quantitative approach was followed in order to determine critical performance indicators influencing productivity of the container terminal between independent and dependent variables through secondary data analysis. According to Creswell (2009), independent variables are elements that influence outcomes, while dependent variables are reliant on other variables to occur.

The quantitative approach is advantageous when there are limitations with time and resources considering that the research instruments associated with this approach such as experiments and surveys, are easy to administer. The data collection methods involved have the capability to generate meaningful data within the shortest period of time and limited investment on people and resources. It can be achieved with limited interaction of research participants (Hancock and Algozzine, 2006).

Saunders et al. (2016) state that qualitative study examines research participants' views and the associations between them using various data collection and analysis processes in order to advance and ensure contribution to intellectual and academic agenda. A qualitative method was applied because the objectives of the study demanded an in-depth insight into the phenomenon of a systems approach with respect to SD and SSM and port productivity. Cook and Cook (2016) further indicate that qualitative research allows provision of detailed description of the subject being investigated and while it is generally descriptive, it can investigate the interactions among variables. Marzooqi (2015) further alludes to the fact that qualitative research is essential in the development of the common relationship for specific theories.

Qualitative studies allow an investigation of performance, proceedings, organisational operations, social settings, interactions and relationships and are "suitable when the objectives of the study demand in-depth insight into a phenomenon" (Ghauri et al., 1995:98). Ritchie and Lewis (2003) declare that a qualitative study is relevant to investigate occurrences that happen over time and deal with difficult issues. Creswell (2014) further states that qualitative research allows exploration of research participants' attitude about a particular problem, which is a process that incorporate emergence of themes during data analysis.

A qualitative approach is beneficial when there is limited information about the subject under study as it allows exploration of a variety of factors impacting the environment. Considering the data collection options available for this methodology such as archival document analysis, observations, face-to-face and focus group interviews, comprehensive information regarding the subject is attainable, and a critical advantage. However, the disadvantage of this technique is the amount of time and resources required to conduct data collection which may delay the research process especially if there are restrictions with research participants. The research method also requires the researcher to devote a substantial amount of time collecting and analysing data which is demanding (Hancock and Algozzine, 2006).

Systems theories with respect SSM and SD were studied with the intention of mapping how the container terminal productivity can be enhanced in the Port of Durban using these techniques. A situational analysis of the Port of Durban outlining the various operations within the container terminal operations was conducted to give context of all factors involved in container operations. Literature was therefore reviewed on the container terminal operations showing the complex nature of this process taking into account its input and output elements, and the terminal productivity outlining critical performance indicators such as impact factors and enhancement elements. Key themes that were used to elicit responses were developed out of the literature review.

Findings derived from the face-to-face interviews were compared to the generalised findings found in the literature. The group interviews, that is, SSM and causal loop analysis workshops were used to develop rich pictures and CLDs; thereafter, conclusions were drawn about the study and recommendations made.

A study by Kubanza and Simatele (2017) conducted a qualitative research using systems approach to come up with processes to enhance solid waste management in the Democratic Republic of Congo. Systems thinking and systems approach were utilised to determine the causal relations within the solid waste management systems in Kinshasa. The study revealed that a systems approach was essential in understanding the complex dynamics within the solid waste management system which uncovered various underlying factors (dilapidated roads, lack of hygiene, electricity disruptions, non-existent environmental legal frameworks etc.), leading to system failures. The research also assisted in unpacking a framework to enhance SWM which formed a sustainable foundation system that should govern urban areas. The systems approach also allowed facilitation of implementation of advanced technologies and processes in handling waste management in an ecologically and viable manner.

5.4 Research Strategies

According to Saunders et al. (2016), the research strategy gives a view of how research questions will be responded to by participants. The various research strategies available to researchers generally include experiment, survey, case studies, grounded theory, ethnography, action research, narrative inquiry, archival and documentary research. For the purposes of this study, the researcher has used a combination of a case study and archival and documentary research. Both case study, including archival and documentary research strategies, incorporate quantifiable or qualitative study or a combination of the two mentioned approaches.

5.4.1 Archival and Documentary Research

Archival research is research conducted through other readily available documents which were compiled for a different purpose. Documentary research can be the most resourceful approach of conducting research as secondary documents provide rich data which can be analysed for research purposes; however, the documentary sources used to collect data must be relevant to the research study and be accessible (Saunders et al. (2016). Lancaster (2005) states that secondary data is useful in supplying supplementary information and new ideas into primary data when conducting research, though it can also be used to identify the research problem and define research objectives.

Documented data provides substantial value for research studies' however, it is subjected to criticism as data might not be applicable for the research objectives and could be manipulated. In certain circumstances, data might not be accessible while in certain instances it may be costly to acquire it (Saunders and Lewis, 2012). According to Hancock and Algozzine (2006), the value provided by archival and documentary research is the wealth of information acquired to enhance data collected through other forms such as interviews and observation. This type of information combined with other forms of data collection, is beneficial in case study research methods with provision of variety of information from different sources which facilitate responses to research questions for the subject under investigation.

5.4.2 Case Study

De Vaus (2001) states that a case study allows the investigation of a unit as a whole. Saunders and Lewis (2012) indicate that case studies allow the investigator to acquire a thorough knowledge of the research context, including activities within a particular context. Saunders et al. (2016) further state that a case study allows usage of mixed methods, which facilitate a comprehensive investigation resulting in rich, all-encompassing data. They further mention that case studies may deploy a combination of documentary research and other research strategies, including interviews and focus groups. A case-study research method was chosen for this study because it enables an in-depth examination of a particular concept or situation. This study has used a single case study, meaning that this study was focused on one case and has drawn conclusions only about the organisation being studied, namely, the Port of Durban.

Hancock and Algozzine (2006) further indicate that case studies allow researchers to have a detailed understanding of the environment due to its descriptive nature and the variety of information entailed in the investigation. Given the exploratory nature of case studies, they facilitate identification of themes as opposed to proving relationships and hypotheses. Considering the multiple forms of data collection involved in a case study, there is an opportunity for researchers for exploration of supplementary questions with the intention of acquiring further information and subsequently investigating the subject in detail. The disadvantage of this approach is its demand of time considering research instruments which are qualitative in nature incorporating research interviews, documentary analysis and observation, as compared to other forms of research.

Some of the strengths of case studies identified by Queirós et al. (2017) are comprehensive information about situations and the capability to modernise and transform existing theoretical norms. Furthermore, case studies are beneficial as they can serve as substitute or a complementary instrument to focus group studies. It must, however, be noted that this methodology makes it challenging to determine causal effect linkages to make conclusions. Other challenges include limited ability to generalise research findings, inability to cater for all subjects in a cases study and lastly, difficulty to adhere to ethical considerations with respect to confidentiality.

5.5 Population

According to Saunders et al. (2016:274), "the population is the full set of cases or elements from which a sample is taken". For the purposes of this research, the population is all operational staff members working with terminal operations from a marine, container and hinterland perspectives for all the organisations involved in port container terminal operations. The target population for this study was all senior managers involved in the operations of the container of the terminal from identified stakeholder organisations in the Port of Durban.

The target population was therefore all the senior operations managers from TNPA, TPT, TFR, SAASOA and Harbour Carriers Association, as they are considered to have knowledge on factors impacting productivity of the container precinct. The total target population was comprised of approximately 25 participants overall, with 4 senior operations managers from TNPA, 4 senior operations managers from TPT, 3 senior operations managers from TFR, 12 senior operations managers from SAASOA, and 2 senior operations managers from Harbour Carriers Association.

Junior officers, which include general workers, middle managers, dockside workers, were not part of the population to be interviewed because of the complex nature of the research and the holistic approach and concepts involved in the study, since some of them are illiterate and do not have a universal understanding of the operations. Junior officers, including general and dockside workers, needed to be literate to understand the concepts that were used in the study.

5.6 The sample

According to Saunders and Lewis (2012), a sample is a subsection of the overall population. The advantages of sampling are time saving, in-depth and simpler management of data collection considering the limited number of people to be interviewed. The type of sampling options are probability and non-probability, where the prior option refers to the likelihood of each case being considered for research is obvious and equal for the identified population. With respect to the latter, inferences from a sample regarding the population will need to be determined in order to satisfy the requirements of the research objectives (Saunders et al., 2016). Non-probability sampling was used in this study as the research objectives required an in-depth study into the phenomena where the sample was selected to meet the research objectives.

5.6.1 Non-Probability Sampling Techniques

The non-probability sampling techniques available are quota sampling, purposive sampling, volunteer sampling and haphazard sampling. Quota sampling is ideal for standardised interviews applicable in a quantitative research, while purposive sampling requires the researcher's ruling in determining participants that are suited for the research objectives and able to respond to applicable questions. Volunteer sampling has two techniques: snowball and self-selection sampling, where the first method refers to a situation where cases are volunteered as opposed to being selected, while the latter permits participants to choose to partake in the research (Saunders et al., 2016).

According to Flick (2018), another non-probability sampling technique available is convenience sampling which allows selection of research participants that are easy to access. However, he further mentions that this strategy must only be deployed if other techniques are not working. Saunders et al. (2016) further indicate this technique is haphazard as there are no principles informing selection of research participants. This type of sampling uses research participants that are easy to find for sampling purposes.

The type of non-probability sampling for collecting qualitative data for both semi-structured and focus group interviews that were used in this study, is the purposive sampling method. Rowley (2014) indicates that purposive sampling allows the researcher to intentionally select a sample that is expected to generate critical data applicable to the research conducted. Saunders et al. (2016) further add that non probability sampling is applicable in group interviews where participants are ideal candidates to learn from for a particular research study.

According to Creswell (2014), the purpose of qualitative research is to choose research participants purposefully that have a full knowledge of the subject being investigated. Etikan et al. (2016) further state that purposive sampling can only be applied if the research study is qualitative in nature; however, they further state that the limitation of this approach is that it does not involve random selection of participants. This limitation for the purposes of this study is countered by the fact that different data collected methods are utilised.

5.6.2 Sample Size

According to Saunders (2012) in Saunders et al. (2016), the minimum sample size for conducting in-depth interviews is between 5 and 25 interviews when conducting non-probability sampling. The researcher continued to collect data or conducted further interviews through semi-structured interviews until data was saturated, meaning that interviews continued to be done until the new information collected did not provide significant value. The total sample size was comprised of 15 participants overall, with 4 senior operations managers from TNPA, 3 senior operations managers from TPT, 3 senior operations managers from TFR, 4 senior operations managers from SAASOA, and 1 senior operations manager from the trucking fraternal. The semi-structured interviews took place from the 27th November 2018 till the 18th of February 2020. Research by Boddy (2016) revealed that sample sizes using a single case in medical and management studies can generate massive educational and meaningful information. He further concludes that theoretical saturation is a valuable guide when conducting qualitative studies, where data overload can be reached with a sample of 12 cases in a similar population.

5.6.3 Data Collection Procedures

According to Bell et al. (2019), data collecting is a critical phase of any research study which can follow a structured or unstructured approach. Structured questionnaires and interviews allow the researcher to investigate particular questions, while the unstructured research methods such as participant observation and semi-structured interviews, are open, facilitating the emergence of perceptions and philosophies of the interviews. Moser and Korstjens (2018) state that participant observation, face-to-face and focus group interviews are commonly used for qualitative research.

For the purposes of this study, data was collected through secondary data using sixty (60) observations, face-to-face (semi-structured) with fifteen (15) participants and focus group/interactive group interviews, which were done through SSM with a total of eight (8) participants, and causal loop analysis workshops with the six (6) stakeholders. The 8 participants from the SSM workshop included the following: two (2) from TNPA, three (3) from TPT, two (2) from TFR and 1 from haulier operation. The causal loop analysis workshop had the following participants: three (3) from TNPA, one (1) from TPT, one (1) from TFR and one (1) from the road transport industry. Four (4) members participated in both workshops with candidates coming from TPT, TFR, TNPA and transport industry. About 2 respondents from shipping lines were visited separately, as they could not make to the workshop due to their work schedules, to give input on CLDs and rich pictures. The contributions from the additional visits were incorporated into the diagrams.

5.6.3.1 Secondary Data

Johnston (2014) describes analysis of secondary data as an assessment of information which was collected for other purpose for other research objectives. This form of analysis is regarded as a viable instrument for systematic investigation and beneficial for the researcher with resources and time restrictions. According to Saunders et al. (2016), secondary data can either be qualitative or quantitative and entails three subsections: documents, surveys and data emanating from various sources.

Documentary data generally originates from other research projects that gather primary data and contain both numeric and non-numeric data that can be examined both quantitatively and qualitatively. Secondary data through surveys is data assembled through survey questionnaires for a different objective. Data coming from different sources can be compiled from both documentary or survey data or a combination of the two. The advantages of using secondary data is that it is not costly and time consuming, as compared to collecting primary data. While secondary data has its own advantages, it might not be relevant for a particular research study, expensive to acquire and data quality not guaranteed. Bell et al. (2019) confirm that secondary analysis allows research investigation without a lengthy route of primary data gathering.

For the purposes of this study, secondary data was used to collect quantitative data using descriptive statistics where container terminal performance reports were requested from respective companies to determine the correlation and impact of each input element on the overall productivity of the container terminal. Key Performance Indicator reports were requested from TNPA and TPT and used as secondary data where descriptive statistics were used to determine the correlation and impact of each key performance indicator on the overall efficiency of the terminal.

The information acquired relates to tug availability, ship turnaround time, berth productivity, gross crane per hour, SWH, rail turnaround time, TTT and container/cargo dwell time. Saunders et al (2016) indicate that organisational information showing daily operations can be used as a secondary data for research purposes.

5.6.3.2 Research Interviews

Saunders et al. (2016) defines the research interview as an intentional communication amongst two or more participants, where the interviewer probe relevant straightforward questions to which the interviewees are keen to pay attention to and provide responses accordingly. The research interviews can be structured, semi-structured or unstructured, and can have in-depth interviews. Structured interviews allow similar set of questions to be used. The structured interviews are generally used in a quantitative research approach. Saunders et al. (2003) states that interviews are instrumental in collecting accurate and trustworthy information appropriate to research questions and objectives.

The qualitative research approach often uses open ended research questions to solicit data. According to Moser and Korstjens (2018), the intent of the qualitative research interview is to define key themes emanating from the overall view of research participants which is generally unstructured and flexible. The semi-structured interviews provide themes; however, questions may differ from participant to participant. Unstructured interviews generally do not have any form of structure as they are used to explore a particular subject in detail; however, the researcher still requires an awareness of the subject being investigated. Focus group interviews are generally conducted with more than two participants where participants range from 4 to 12, depending on the subject being investigated (Saunders et al., 2016).

Both semi-structured and focus group interviews were conducted with operations managers from TNPA, TPT, TFR, South African Association of Ship Operators and Agents (SAASOA) and Harbour Carriers Association who interact daily with marine, terminal and hinterland operations. According to the National Research Council (1986), the interest of stakeholders within container terminal operations are diverse, with shipping lines being concerned with the ship dwell time in the port as the increased stay in the port results in the ship being less competitive in comparison to other ships who are using a different terminal. The interest of the Port Authority is maximisation of port resources with respect to land usage and berths. Terminal operators are primarily concerned with the productivity of their employees, while truckers are worried about the efficiency of the port gate system as it impacts their turnaround time which is manifested in freight rates, and influences the port competitiveness. Hangga and Shinopa (2016) further state that terminal operators are concerned with improving productivity and ensuring adherence to emerging operational standards.

5.6.3.2.1 Face-to-Face Interviews

Face-to-face interviews with a semi-structured interview schedule on key themes were used to collect qualitative data. According to Rowley (2014), open questions allow gathering of detailed information which in turn encourages respondents to express their opinions. Ilovan and Doroftei (2017) concur that semi-structured interviews facilitate open responses which are beneficial for gathering information within a short period of time. This process is advantageous considering that it incorporates collecting information by interacting with people and can be utilised with other research methods.

Marzooqi (2015) outlines the advantage of semi-structured interviews: they are flexible and allow for a variety of questions to be discussed, which elicit detailed information with the respect to the context under investigation. This type of data gathering facilitates exploration of issues and delving in detail into the situation, while interacting with research participants, enabling development of the preliminary framework for the research study. Queirós (2017) further states that semi-structured interviews provide an opportunity to explore research questions in detail through the use of a set of pre-defined interview schedule.

There were 15 face-to-face interviews conducted which lasted approximately 30 minutes to an hour with 4 members of SAASOA, 4 members of the TNPA, 3 members of TFR, 3 members of TPT and 1 member from the Trucking Fraternity, were conducted. Prior to the construction of the research instruments, the researcher reviewed the literature and examined a variety of research instruments to determine whether there were existing instruments that could be used to gather the necessary information for this study. However, the review of the existing instruments did not uncover appropriate instruments that could have been used to gather the information necessary for this study. The researcher therefore found it necessary to design her own instruments to suit the present study. In developing the tool, the existing instruments were reviewed and a list of themes was developed in conformity with the research objectives and literature review.

The interviews were conducted to determine causal relationships among various variables and to gain understanding into the causal and soft issues impacting productivity of the container terminal. The interviewer was there to ask important questions and to record the responses in order to understand the what, how and why. Respondents were probed so that detailed information about the subject is obtained. Saunders et al. (2016) state that use of interviews allows the researcher to collect valid and reliable information which is appropriate to the questions and objectives of the study. All semi-structured

interviews were recorded both through taking written notes and on a digital recorder. Data was transcribed from the tapes to retrieve all data and ensure alignment with data recorded on the notes.
All irrelevant talk and information which was not relevant to container terminal operations, productivity and systems approach, was discarded. For data collection using semi-structured questions, the researcher utilised research questions that were closely linked to the research objectives, and questions in Chapter One of this research report, as reflected in Table 5.1.

Table 5.1: Linkage of research objectives, questions and interview questions

RESEARCH OBJECTIVE	RESEARCH QUESTION	INTERVIEW QUESTIONS
To determine which input productivity elements from the systems dynamics approach could be investigated to ensure optimised maritime, terminal and hinterland operations in a container terminal.	Which are critical performance indicators of productivity from the systems approach that could be investigated to ensure optimised maritime, terminal and hinterland operations in a container terminal?	• Which are the marine productivity input elements essential for your operations for quick turnaround of vessels in the Port of Durban? • With respect to terminal operations, what do you consider as key factors contributing to efficient operations? • With respect to hinterland operations, what are the underlying elements required for smooth operations at the Container Terminal for your operations?
To analyse the container terminal productivity concept using conceptual models, root definitions and rich pictures with the intention to ensure terminal productivity improvements.	How can container terminal scenarios be analysed using conceptual models, root definitions and rich pictures to improve terminal productivity?	• What is your opinion on how the maritime productivity input elements should be connected to ensure improved ship turnaround of vessels? • How should resources (equipment and human resources) be deployed to fast track handling of containers at the container terminal? • How should the container terminal arrange containers within the terminal in order to allow free flow of cargo and improve efficiencies in a terminal? • What should be in place from a rail perspective to ensure that the vessel receives containers on time for export market? • How should trucks be arranged for import and export cargo to avoid congestion at the port gate and surrounding areas within the port? • How should the operations be improved from vessel arrival, to vessel berthing, to loading and unloading from ship to shore, to transfer of cargo from the shore to wagons and trucks, and warehouses?
To determine the relevant systems approach model for improving productivity at the container terminal in the Port of Durban.	What is the relevant systems approach strategy for improving productivity of the Container Terminal in the Port of Durban?	• From your perspective, please advise what are some of the key strategies that should be implemented in order to improve productivity of the container terminal in the Port of Durban? • What resources will be required to achieve the recommended approach? • What impact will this new approach achieve in terms of productivity?

Considering that the research respondents did not have a full comprehension of Systems Theory, the researcher took it upon herself to discuss the concept during the research interview in order to elicit the required information to respond to research questions. The researcher explained to the respondents that the use of the systems approach was to ensure that a holistic methodology is used to seek ways to enhance container terminal productivity, by reviewing the overall system including its elements in order to have a full understanding of the system and its linkages and dependencies. This meant that the respondent needed to unpack all underlying issues affecting container terminal productivity, not only from his/her area of operation, but all factors emanating from different dimensions contributing to enhanced operations.

5.6.3.2.2 Focus Group Interviews

According to Queirós et al. (2017), focus group interviews are common interactive qualitative research instruments which are beneficial in examining complex behaviours. The strength of these instruments is the speed with the flow of information during interviews as compared to conducting one-on-one interviews. These instruments facilitate variety of information and provide a platform to seek clarity during the interview process. They are also advantageous in the sense that this method can result in reduction of costs and time required to conduct interviews as opposed to face-to-face interviews. The disadvantage though, is difficulty in managing and controlling the group being interviewed and similarly, it can be challenging to persuade everyone to participate during the course of the interview. This limits participation and can have a potential negative impact on representation of the population.

Focus group interviews in the form of SSM and causal loop analysis workshops were used to further collect qualitative data. These focus group interviews were conducted in an interactive and participative manner with all research participants to produce CLDs, root definition, rich pictures, CATWOE analysis and conceptual model. According to Checkland and Poulter (2020), SSM is capable of addressing variety of difficult and messy circumstances. It is a practical approach that allows participants to learn about their environment and suggest actions to improve it through various tools of purposeful action which allows a single view by all. Partakers are given an opportunity to think about their environment in order to understand the complexity that surrounds it. Moreover, the approach allows diverse perspectives to be considered so that rigorous processes should be undertaken to improve the situation.

The SSM is a beneficial approach considering that it is flexible and able to handle fluctuating, complex environments. It can be adaptable to any real situation in which people are looking for solutions to improve. It facilitates groups of people to find ways to identify plans to improve their situations through a clear process of unpacking their thought process leading to actionable initiatives. This process allows participants to accumulate learning over a certain period of time which enables them to manage other complexities they may encounter in future. This approach enables deeper thinking by participants resulting in intelligible discussions which will result in improved environment (Checkland and Poulter, 2020).

SD assist with the thought process and simulations of various situations within the organisation through visualisation of how different components link and impact each other over a certain period of time. It enables construction of CLDs which are critical visual tools for systems thinkers to reflect causal and effect connections with feedback loops which are drawn, considering all key components including words, expressions, links and loops (Morecroft, 2020).

The Sustainability Laboratory (2019) further indicates that the purpose of CLD is to streamline the complexity in any environment thereby improving understanding of the situation. It provides opportunity for individuals and teams to scrutinise the problem together and discuss their thought processes and understanding. The report further states that the limitations of CLDs are the fact that they cannot provide a rationale for every problem in the system, as the diagram might be too complex to understand.

SSM and Causal Loop Analysis Workshops were conducted with different stakeholders who hold diverse and competing and complementary goals. These involved senior operations managers from TNPA, TPT, TFR, SAASOA and Harbour Carriers Association. The operations managers were considered for this research based on the competency with the subject as they are involved with the operations on a daily basis. Seniority was a critical component in the sense that participants had to have a holistic view of the operations from the organisations they represented as opposed to ground staff, who only understand the area in which they operate. The focus/interactive group interviews were conducted with the purpose of identifying the critical input elements for enhancing container terminal productivity from a systems perspective. There were two focus group interviews conducted with a minimum number of 6 participants from the overall respective companies.

One (1) focus group interview participated in the SSM Workshop, while the other participated in the Causal Loop Analysis Workshop with representatives from respective companies. An SSM workshop was held on the 29th of November 2019 with eight participants. The workshop started with an induction presentation where participants were oriented to the theory behind rich pictures and examples of diagrams constructed in other settings. Research contributors were provided with flip charts and markers to come up with rich pictures. Participants volunteered to provide some of pictures showing business processes from their individual organisations. These pictures were used to develop rich pictures for the maritime, terminal, hinterland and a holistic diagram showing the operations from a systems perspective.

The engagement in the rich picture generated various problem themes and also enabled the selection of relevant system problems to focus on, that is, improved ship turnaround time. The CATWOE analysis was also discussed in detail during the workshop, with all stakeholders relevant in each category. Each category was discussed on its own. Various stakeholders had different customers that were relevant for their operation; however, based on the chosen system model that needed prioritisation as per discussion with stakeholders, the team had to agree on the customer and stakeholders to prioritise for this model. The discussion that took place during the development of the rich picture and CATWOE analysis assisted with the development of the root definition and conceptual model. It must be noted that not all invited stakeholders were in the workshop due to their operational schedules, which encouraged the researcher to arrange a one-on-one session with the participants to review the diagrams and provide input based on their expertise.

The causal loop analysis workshop was held on the 10^{th} of December 2019 at the port offices and the workshops lasted for almost three hours. Research participants were provided with flip charts and markers to come up with CLDs. A similar process as in the SSM workshop, it started with an induction presentation where participants were oriented with the theory behind CLDs. Practical diagrams constructed in other settings were shown to all attendees. The workshop attendees were allowed to develop CLDs from all three dimensions of port productivity, including the overall causal loop diagram showing all operations. Several diagrams were drawn up until the team came to satisfactory diagrams based on the expertise of the respondents who were in the workshop. There were 6 participants present in the meeting as other invited respondents could not attend due to operational reasons. Once all the diagrams were drawn, the researcher arranged face-to-face engagements with absent stakeholders to solicit their input on the drawings.

The use of a combination of the two methodologies allowed a systematic approach from the respective affected stakeholders to communicate their various and diverse perspectives about the challenges and areas of enhancement within the container terminal operations. The unstructured questions which were aligned to the semi-structured interviews with respect to content, were used in order to allow an environment where participants are able to express their opinions freely to facilitate rich and useful information from various stakeholders for the development of rich pictures, root definitions, CATWOEs, conceptual models and CLDs.

A study by Proaches and Bodhanya (2015) endorsed the importance of SSM tools with respect to facilitating discussions whilst engaging participants. The SSM tools, including the rich picture, allow the researcher to unfold the various participant individual interpretations by analysing their objectives, standards and viewpoints, thereby enhancing the validity of the findings. Bell and Morse (2010) describe rich pictures as instruments that facilitate teams to work together in exploring a problematic situation. They assist groups to acquire a common understanding of areas of leverage and contention on the problematic issue. They create a relaxed, non-judgemental environment where teams can discuss a subject freely. Bell et al. (2016) further state that use of rich picture within a team opens up opportunities for removing educational, cultural and language barriers in resolving any situation. It is an influential activity that empowers problem solving and provides added advantage in a long term by avoiding any unfruitful activity, thereby saving time and resources. It allows an opportunity for stakeholders to engage and agree on a resolution on multifaceted and contentious challenges. It has capabilities to epitomise the perspectives of a team and the thoughts of the community.

A study by Nguyen et al. (2015) used a causal loop model to advance the supply chain of coffee in Vietnam to ensure competitive advantage. A causal loop analysis incorporating feedback loops was instrumental in discovering critical variables within the supply chain, which assisted with the establishment of the framework model to boost the attractiveness of the of the coffee products in the global market. The development of CLDs brought insights in comprehending the dynamic linkages within the Vietnamese system which assisted with coming up with strategies to improve the competitiveness of the products with respect to key levers, that is, price, quality, competitive advantage and customer satisfaction.

According to Kouchek and Stojanoska (2017), CATWOE is considered a modelling analysis instrument which allows systems thinking to be applied within real world environments. It has six key elements: client, actor, transformation, worldview, owner and environmental considerations.

The key elements are described in Table 5.2:

Table 5.2: Key Elements of CATWOE by Kouchek and Stojanoska (2017)

KEY ELEMENTS OF CATWOE	
Client	Clients are described as stakeholders who are affected by the system, whether positively or negatively.
Player	Players are participants who are accountable for making changes within a system to ensure that transformation is achieved.
Transformation	Transformation defines the changes that happen within a system, whereby input elements undergo an alteration process to produce an output.
Worldview	The worldview is what necessitates changes in the systems as it reflects stakeholder perception about the world.
Owner	Owners are defined as stakeholders or shareholders responsible for decision-making on how changes should unfold.
Environmental Considerations	Environmental considerations include limitations that may disturb a system.

Nurani et al. (2018), define a root definition as a process of finding out the root cause of the problem incorporating its context and based on the applicable viewpoints. It assists with the development of the conceptual model. The SSM through development of root definition and conceptual model can provide a resolution to regulate the fishing industry. Implementation of these models will assist with the management of this industry with respect to resources and technology in ensuring sustainable fisheries.

Requests for candidates to participate in SSM and CLD Workshops were invited formally by sending a meeting request to all identified participants from respective companies, which was followed by an electronic invite specifying the time and venue of the workshop. Both workshops were facilitated by the researcher who has a background of SSM and CLD theories and took a lead role in engaging participants to partake in the discussions and drawing of rich pictures and CLDs. The intention of the workshops was to determine critical input productivity elements from a systems perspective by analysing container terminal operations using conceptual models, root definitions, rich pictures and CLDs, with the intention of improving productivity of the container terminal.

5. 7 Data analysis

5.7.1 Secondary Data Analysis

Secondary data was analysed using Stata Software to determine the critical input elements of productivity for container terminal operations from a maritime, terminal and hinterland perspective. Regression analysis was utilised to examine the relationship between each input productivity element and the output variable using coefficient of determination, which allows to test the extent of the connection between the dependent and independent variables. Multiple regression analysis utilising coefficient of multiple determination was used to determine the magnitude of the link between a dependent variable and variety of independent variables (Saunders et al., 2016).

Regression analysis is defined as the statistical instrument that reflects connectivity between a variable that is being investigated and another or variety of elements (Schroeder et al., 2017). Sarstedt and Mooi (2014) further indicate that the regression analysis provides added advantages as compared to other techniques such as:

i. Reflection of connectivity significance between independent and dependent variables;
ii. Indication of the extent of influence of various independent variables on dependent factors, and
iii. Provision of projections of future performance of the applicable variables.

According to McDonald (2014), multiple regression is useful when there are more than two independent variables explaining a dependent variable. This methodology is also useful in projecting anticipated performance of a dependent variable or the extent of influence of independent variable on the dependent variable. Furthermore, it also assists with comprehension of practical linkages between dependent and independent elements impacting on changes on the dependent variable. The author further defines the independent variable as the causal factor in a relationship. Schroeder et al. (2017) explain a dependent variable as a factor that is influenced by explanatory variables.

The research outcomes for quantitative data through statistical techniques can ratify theories in relation to various aspects of organisational productivity. This type of analysis also assists in determining aspects impacting on organisational productivity and what can be done to deter the consequences of those factors (Marzooqi, 2015).

5.7.2 Analysis of qualitative data through semi-structured interviews

Moser and Korstjens (2018) refer to four analytical research methods applicable within a qualitative approach, that is, content analysis, ethnography, grounded theory and phenomenology. Content analysis can either inductive or deductive.

The qualitative analysis of this study will follow a deductive content analysis approach, which is a process where theory is used as a basis for formulation of research objectives and questionnaires. Using a deductive approach allows the researcher to initiate the study with analytical framework and connects the research with current body of knowledge (Saunders et al., 2016). Recorded data collected through both semi-structured interviews and focus group interviews were transcribed from digital recordings in preparation for data analysis.

Qualitative data was analysed using the 6-step approach by Creswell (2014), was applied as follows:

1. Administration and preparation of data analysis, whereby recorded data collected through semi-structured interviews, was transcribed from digital recordings including capturing notes taken during research interviews. This data was sorted and arranged into various categories.
2. The second step involved reviewing data to get an indication of common thoughts, perceptions and tone coming from research participants.
3. The third step involved coding, segmenting and labelling data into various categories. The data analysis involved a process of constant comparison, whereby each response was compared with other participants' responses, enabling the researcher to develop a set of broad categories. The process comprised taking one datum in each interview and comparing it with all of the others that might be similar or different, in order to search for relations among various pieces of data. In order to reduce the number of categories this process could produce, they were reviewed for overlap. This resulted in some categories being eliminated while others were merged. Categories emerged from this process, which were representative of all respondents' experiences.
4. The next step involved creation of description of context and themes for the research study using the coding process. The identified themes reflected the main findings of the study, as they revealed various perspectives from research participants which were used to develop a story line.
5. The fifth stage incorporated using the story line to communicate the research findings showing various perspectives from interviewees. This step involved a detailed discussion of themes and subthemes and their interconnection thereof.

6. The sixth and final step comprised the interpretation of research findings which incorporate the researcher's interpretation and the meaning emerging from comparison of findings and literature review and theoretical framework.

5.7.3 Analysis of Qualitative Data using Focus Group Interviews

Data collected through notes during the focus group interviews which were conducted as SSM and CLDs workshops was compared with the rich picture and CLDs drawn during the workshop to further enhance the pictures drawn.

5.7.3.1 Soft Systems Methodology

Due to the nature of research, which sought to review enhancing container terminal productivity rather than developing a systems model, the researcher was naturally guided to use only the first three SSM process steps borrowed from Williams and Hummelbrunner (2010), as per the research objectives. The findings of the semi-structured interviews were utilised to ascertain the context and problematic situation of the research study which is the first step. The second step involved defining the challenging circumstances through the development of rich picture showing processes, stakeholders, their complaints, and inter-relationships. The third step incorporated identification of critical perspectives using root definitions, including development of CATWOE and Conceptual Model.

A study by Proches and Bodhanya (2017) utilised SSM within the Sugar Industry to resolve a complex situation where the qualitative approach was followed through the use of interviews and SSM workshops. Rich pictures were used to investigate various stakeholders' perspectives and overlapping problems within the Sugar Industry. This type of research allowed each participant to outline their perspectives from their institutions as opposed to gathering a perspective from one group, facilitating a wider input into the discussion. The process also allowed collective contribution to improvement initiatives and learning emanating from diverse conversations which looked at resolving the problem systematically. The methodology enabled emergence of multiple views in relation to the bottlenecks and resolutions thereof. This study showed that Soft System Methodology is a valuable tool that enables various participants to identify underlying problems in a situation and presented opportunities for deliberation where stakeholders can come with a proposal that is favorable to all.

A study by Fadhil (2018) also used SSM approach to investigate the improvement of the quality management system of Gayo Coffee Agro Industry. The study managed to identify the various quality problems that needed resolution within the coffee processing logistic chain. SSM was used to uncover solutions for unstructured problems by involving various stakeholders to develop a strategy which incorporated a simulation and a flow chart that was used to re-establish and enhance the quality management system of the industry.

5.7.3.2 Causal Loop Diagrams

CLDs were used in this research to determine the key variables and linkages, including the impact on each variable. They were used to draw interactions among various variables using feedback loops, whether positive or negative. According to Williams and Hummelbrunner (2010), CLDs are ideal for demonstrating intense interrelated circumstances while identifying the structures behind certain trends of proceedings. They are considered to be valuable in resolving complex situations considering their utilisation in analysis of relationships of environments through feedback loops. A study by Kim and Lee (2018) investigated tourist involvement restoration-ecotourism through systems thinking utilizing causal loop analysis. The research established that variables were impacted by causal relationships which is a systematic, efficient, useful and unified approach.

A study by Tao et al. (2018) used the SD approach to explore the impact of Omni-Channel Strategy on organizational performance in order to enhance key financial indicators, product performance and shareholder return of company X in China. CLDs were utilised to define the configuration of a system through use of feedback loops which were initially used to determine the causal hypotheses. A system dynamic model was developed which demonstrated that users are of significance for omni-channel strategy. The study recommended that company X to make use of external platforms, including Alibaba and Tencent, and to consider amalgamation of online channels with physical shops in setting up new brand membership system, with the promotion of communicating customer feedbacks. Other recommendations included reviewing of the strategy, conversion of traditional retailing with respect to service quality and leading a competitive differentiation to meet market demands which will contribute to enhanced performance of traditional retailers.

In the light of the research collected through semi-structured interviews and causal loop analysis workshop, CLDs were used to visualise the dynamic complexity that the terminal operations consist of including the various factors affecting container productivity. A causal loop diagram was drawn in the workshop using flip charts, where research participants were given an opportunity to reflect on various factors impacting productivity and how they interconnected.

Microsoft Visio was used to develop the causal loop diagram from SD perspective based on the conclusions of the workshop and the research findings from the semi-structured interviews. Each research participant had to raise his/her views regarding the causal effects of productivity at the container terminal. The causal loop diagram which was drawn during the workshop was compared with the results of the semi-structured interviews to determine further linkages.

The research map of the study has been summarised as per Figure 5.1:

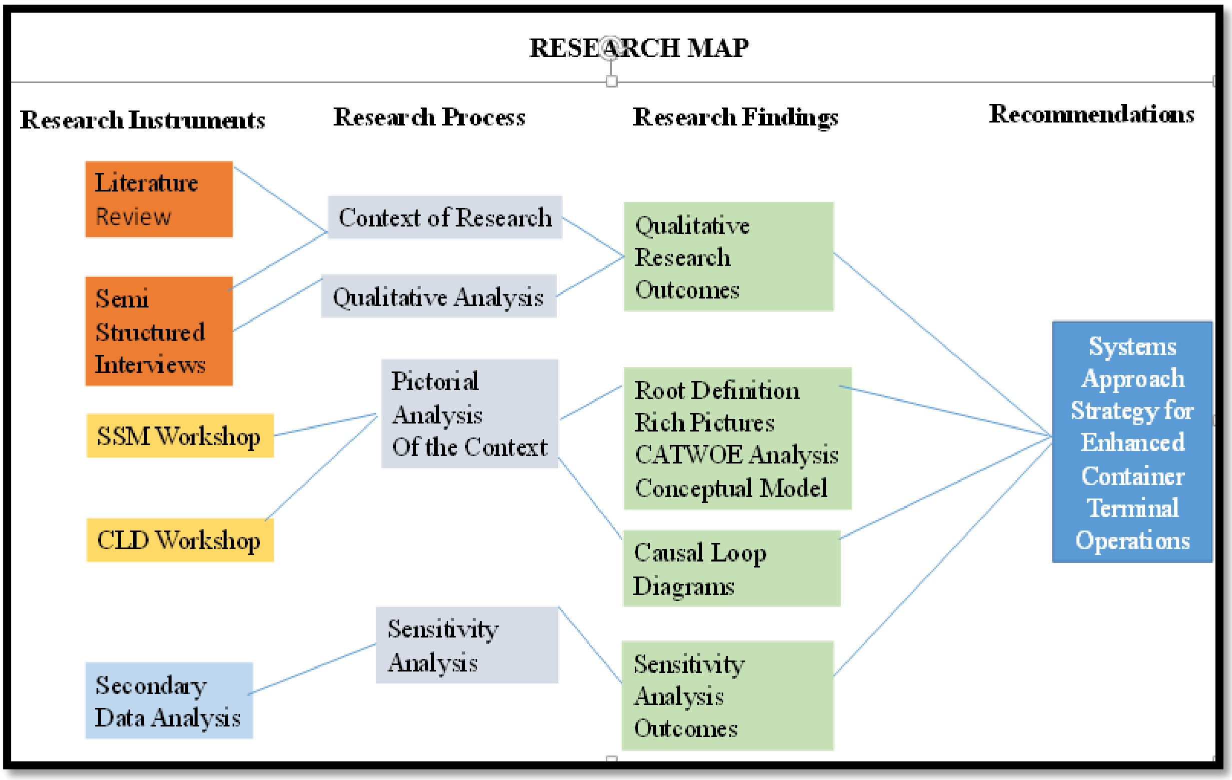

Figure 5.1: Research Map

5.8 Reliability and Validity of study

5.8.1 Validity

Validity refers to the extent to which data collection methods accurately measure what they intended to measure (Saunders et al., 2003). According to Jain, Dubey and Jain (2016), validity checks whether the research precisely assess what it is required to measure. The research instrument should be adequate and incorporate all aspects of the research study. Furthermore, the research instrument should be clear and not complex, to ensure that is understood by all research participants.

For the purposes of this study, a pilot study was conducted with business analysts who work and have worked at the container terminal with senior operations managers to determine if the research instrument is assessing accurately what it needs to measure. 5 pilot interviews were conducted by the researcher before finalising the research instrument that was used to collect qualitative data through semi-structured interviews. A study by Ismail et al. (2018) found that a well-executed pilot study provides methodological rigour thereby ensuring that the validity of a study, including its methodology. The study further indicates that pilot studies facilitate identification of potential errors and reduction thereof.

A pilot study was necessary to determine whether or not there were any ambiguities in the research questionnaire, whether or not the research would bring forth the type of data anticipated by the researcher; and lastly, whether or not the type of data obtained could be meaningfully analysed in relation to the stated research questions. Jain et al. (2016) further indicate that conducting a pilot study provides an opportunity to amend a research instrument in a case where a gap is noted in a research instrument. This reduces the need for the researcher to revert to the respondents for additional information or to clarify certain matters, as well avoiding the possibility of having to discard certain portions due to the fact that it does not successfully measure what it was intended. The research instrument was revised considering lessons learnt while conducting the pilot study. The results of the pilot study showed that the research instruments were valid for the present study and that most of the items were understood as intended by the researcher; however, there were questions that were added to the respective themes identified in the semi-structured research schedule.

5.8.1.1 Bias

According to Creswell (2014), in order to ensure accuracy of the findings, it is important for the researcher to reveal the bias that she brings to the research study in order to confirm its validity. It must be noted that the researcher has worked in the port environment for the Port Authority for more than twelve years. This gives her a competitive advantage with respect to understanding port operations and gaining access to information. The interpretation of the findings of the research is also informed by prior or existing knowledge of the *status quo* with respect to challenges experienced within container terminal operations in the port. However, while the researcher has worked in the port environment, she has never worked at the container terminal, hence the study compelled her to read, learn and understand the operations in order to have prior knowledge of the subject being investigated.

The researcher had to ensure prior research about the subject being studied through a literature review and prepared interview themes ahead of conducting the research and provided the relevant research instruments prior the interview. She also arranged a location for the interview that was convenient for the interviewees to respond to the research questions without disturbance. In most instances, she conducted interviews at the offices of the interviewee in order to ensure that that the participants were comfortable to respond to any question raised. The researcher also ensured that most senior stakeholders involved in container terminal operations in the Port of Durban were included in the sample to avoid any form of bias.

Furthermore, this research study made use of: i). peer examination by another PhD graduate working in the port environment and ii). A detailed report on strategies with respect to data collation and analysis in order to ratify validity of this study. This approach is supported by Creswell (2014), indicating that other graduate assistants can act as assessors of the research study and ensure that a detailed report is provided on data collection and analysis approaches on research methods to guarantee validity. This study draws conclusions only about the organisation being studied, that is, the Port of Durban; therefore, the study is therefore valid as far as the organisation is concerned. The findings of the study cannot be generalised to other organisations. Krusenvik (2016) indicates that while the advantage of case studies is its richness in research findings with respect to developing new theories and adding rigour to past research, its findings cannot be generalised.

5.8.2 Reliability

Reliability is the degree to which data collection methods yield consistency in finding similarity to what other researchers could come up with (Saunders et al., 2003). Jain et al. (2016) further state that reliability checks whether the research instrument produces consistency with the research findings, implying that the study should generate similar results when conducted by another researcher. Bolarinwa (2017) also states that reliability allows a research instrument to produce consistent results over and over again through either test-retest reliability, or alternate-form reliability and internal consistency reliability. Triangulation, which is a process where two or more research methods are used to collect data (Lancaster, 2005), was used in this study in order to verify the quality of the information being collected, and in particular its reliability.

Brooks and Normore (2015) confirm that use of triangulation gives credibility to the research study as it allows all forms of data gathering to be reflected on the findings. Bolarinwa (2017) further states that alternate form reliability allows two or extra research instruments to be utilised either in parallel or following each other to a similar group or different groups. In this case, semi-structured and focus group interviews were used to collect data. The focus group interviews were compared with the substance of the interviews conducted to ensure that reliable data had been elicited.

The researcher made sure that data was collected legally and from reliable sources. For instance, the researcher targeted senior operations managers from the respective companies involved in container terminal operations. The senior operations managers were believed to have vast knowledge and on-hand experience with port operations, and were likely not to be biased in the study. Nevertheless, the reliability of the research instruments was assessed by the supervisor of this study. The research instruments were also reviewed by the researcher's colleague who works in the port and has background knowledge of containers operations and productivity and also extensive experience in research, having completed his doctorate in port studies.

Valuable insights and advice were suggested by the supervisor and the researcher's colleague, and these ideas resulted in the revision of the research instruments. With respect to secondary data, data was collected legally from reliable sources; for instance, from employees who are responsible for collation of performance reports working in operations were targeted to source information as they have vast knowledge and on-hand experience with port operations, in order to ensure reliability of data. Where some data was not clear or had discrepancies, clarity was sought from the people responsible for the collation of data.

The researcher ensured the following in order to safeguard the reliability and validity of the study: a) the appropriateness of appearance at the interview; b) provision of the consent form highlighting the purpose of the research, right to confidentiality, anonymity and themes to be covered; c) phrasing questions appropriate with the right tone; d) formulation of variety of questions; e) appropriate behaviour including posture and tone of voice; f) good listening skills; g) review of points discussed to confirm understanding; h) capability to handle difficult interviewees, and i) recording of data through notes and audio and production of contextual data and related memoranda after interviews.

5.9 Ethical considerations

The purpose of ethics in research is to protect the dignity, rights, safety and well-being of respondents. According to Flick (2009), ethical considerations assist with regulation of relations between the researchers and research participants by ensuring that the interests and needs of the stakeholders involved in the research study are respected and taken into account. In order to ensure that the code of ethics was adhered to, the following ethical considerations were implemented when conducting the study:

i. The research proposal which outlined the research topic, objectives, literature review and methodology was presented to and approved by the Doctoral Panel at the Graduate School of Business and Leadership at the University of KwaZulu-Natal.

ii. The application for ethical clearance incorporating the project title, study location, research questions and objectives, methodology, interview schedule, and informed consent letter and gatekeeper's permission letters from all involved organisations, were tabled to the Humanities and Social Sciences Research Committee. Full approval as per Appendix 5 (Ethical Clearance Protocol) was granted. The interview schedule was examined by the committee to ensure that there is no harm or infringement of any rights of the research participants.

iii. Gatekeeper letters were obtained from all five organisations participating in the study, including TNPA, TPT, TFR, SAASOA and Harbour Carriers Association (South African Association of Freight Forwarders (SAAFF), as per Appendix 3. All five organisations were written letters by the researcher requesting permission to conduct research on their sites._The letter of request highlighted the purpose and objectives of the study. It also detailed the type of research data that will be required, including access to and review of organisational performance and face-to-face interviews. The letter explained the importance of conducting this type of research and how the results will contribute to the organisation. This request was reviewed and approved by the highest leadership in the organisations involved in the operations of the areas under study.

iv. The researcher made arrangements with each interviewee well in advance by scheduling an appointment to ensure that the participant is available to partake in the research. The participants knew that they would be interviewed at a particular time in the course of data collection for the study.

v. At the beginning of each research interview, the researcher explained the purpose of the study and how the study might benefit the company. The participants were made aware of and understood what was required of them as participants in this study. The respondents were given an opportunity to read, understand and sign an informed consent form. The researcher's affiliations and contact details were shared with the participants. The contact details of the project supervisor were given to the participants.

vi. An informed consent form as per Appendix 1, signifying acceptance to participate in the study through a signature by each research participant, was administered to all involved stakeholders. The consent form highlighted the purpose of the study and issues pertaining to confidentiality and anonymity. All participants were informed that their contributions were going to be treated with the utmost confidentiality, and that their identity would not be divulged. The form also stated that participation was voluntary and participants could withdraw from the study at any time. Lastly, the form indicated there was no financial gain by participating in the project.

vii. All the interviews were recorded through handwritten notes and audio-recording. However, permission was requested from all participants for the interview to be recorded which was later going to be transcribed to acquire further details that could have been missed through handwritten notes for analysis purposes. The approval from the participant was noted as part of the signed informed consent form.

viii. At the end of each research interview, the participants were thanked for their participation in the study and informed that once the results were obtained, the final report would be shared with them.

ix. Lastly, the researcher has provided a declaration at the beginning of the research that this research report is the result of her own original research and that this work has not been submitted for examination or degree at another university. All borrowed ideas were acknowledged as being sourced from other researchers.

5.10 Conclusion

This chapter has provided a detailed description of how the partially integrated mixed methods was followed where a quantitative approach was used to determine the significance of container terminal productivity input on the overall efficiency of the terminal. It has also outlined how a qualitative method was utilised using a systems approach to establish enhancement strategies for container terminal productivity with a particular focus on CLDs and aspects of SSM. The researcher has also described the research strategy being a case study and documentary research including methods used, that is, semi-structured and focus/interactive group interviews to collect data. Further to that, sampling techniques, data analysis approach and the instruments used to ensure validity and reliability of the study were discussed. Finally, a brief discussion on ethical consideration was included, as this was taken into account throughout the study. In the next chapter the research findings of secondary data, semi-structured and focus group interviews are provided.

CHAPTER SIX:

FINDINGS AND DISCUSSION OF SECONDARY DATA–
PORT KEY PERFORMANCE INDICATORS

6.1 Introduction

The main aim of this section was to conduct a sensitivity analysis to determine the critical performance indicators influencing productivity of the container terminal from a marine, terminal and hinterland perspective using secondary data. The objective of the study was to identify areas of focus for enhancing productivity of the container terminal by reducing the ship dwell time in the port. Chapter Six thus provides the findings of the sensitivity analysis of secondary data for the port key performance indicators. Whilst the sensitivity analysis conducted is not part of the systems methodology, it provided input to the overall research as the enquiry was conducted with a systematic view taking into consideration the key dimensions impacting on port productivity, that is, maritime, terminal and hinterland aspects.

6.2 Findings from Secondary Data Analysis

Secondary data was analysed using Stata Software to conduct a sensitivity analysis to determine correlation between independent and dependent key performance indicators for container terminal operations from a maritime, terminal and hinterland perspective. Regression analysis was utilised to examine the relationship between each input key performance indicator and the output productivity variable, using a coefficient of determination, which allows one to test the extent of the connection between the dependent and independent variables. Multiple regression analysis utilising coefficient of multiple determination was applied to determine the magnitude of the link between a dependent variable and variety of independent variables (Saunders et al., 2016). The overall variables monitored by shareholders are Ship Turnaround Time (STAT), Anchorage Waiting Time (AWT), Gross Crane Hour (GCH), Ship Working Hour (SHW), Truck Turnaround Time (TTT) and Rail Turnaround Time (RTT). The STAT was the main output or dependent key performance indicator, while the rest of the key performance indicators were regarded as input or independent variables. A regression and multiple regression analysis were conducted with all variables monitored by the shareholders from a maritime, terminal and hinterland perspective. The findings are presented based on regression and multiple regression analysis.

6.2.1 Findings of Regression Analysis of Ship Turnaround Time with each independent Key Performance Indicator

The results of a regression analysis between the STAT and each input key performance indicator produced the following results in Tables 6.1, 6.2, 6.3, 6.4 and 6.5:

6.2.1.1 Regression Analysis between STAT and Anchorage Waiting Time

Table 6.1 reflects the results of the regression of the STAT against the anchorage waiting time.

Table 6.1: Regression Analysis of Ship Turnaround Time and Anchorage Hours

Source	SS	df	MS		
				Number of obs =	60
				F(1, 58) =	29.61
Model	2852.17811	1	2852.17811	Prob > F =	0.0000
Residual	5587.47189	58	96.3357222	R-squared =	0.3379
				Adj R-squared =	0.3265
Total	8439.65	59	143.044915	Root MSE =	9.8151

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
anchhrs	.2908472	.0534528	5.44	0.000	.1838498	.3978445
_cons	45.01269	2.645696	17.01	0.000	39.71676	50.30863

The operational framework model and the primary OLS regression resulted in the following equation being attained:

Stat=45.01269+0.2908472anchhrs+u

The results of the regression analysis between the STAT and anchorage hours indicated that the average waiting time has a minimal contribution towards the ship dwell time in the port with the R squared value model of 0.3379 or 33.79% which is below 50%. Since the value is not high, this means that the estimated model is not that powerful in explaining effects of the regressors on the regressand. The coefficient of anchorage hours is 0.2908472, signifying that as the anchorage hours increase by 1 hour, the ship turnaround time increases by 0.2908472 (hours). This means that an increase in anchorage hours does not reduce the ship turnaround time.

The results of the regression analysis between ship turnaround time and anchorage waiting time therefore reflects that there is no significant relationship between the ship turnaround time and anchorage waiting time, with a positive coefficient of 0.2908472. The researcher notes that while the anchorage hours is an important variable to measure, it cannot be considered as a variable that contributes to the ship turnaround time as the ship turnaround time is counted once the vessel passes the breakwater of the port.

This argument is aligned with the description by Tang et al. (2016), who define ship waiting time as the variation between the arrival of a ship in a port and the actual berthing time while waiting at anchor for the available berth. However, Rodrigue et al. (2014) state that the longer vessel waiting times at South African ports result in increased costs with respect to importation and exportation of cargo, thereby diminishing the attractiveness of the ports globally. This implies that while anchorage hours are not a significant element towards measuring container dwell time in the port, it is still an important indicator to measure considering the consequences on stakeholders and the port competitiveness.

6.2.1.2 Regression Analysis between STAT and GCH

The regression of the STAT against the GCH had the following results, as reflected in Table 6.2.

Table 6.2: Regression Analysis between Ship Turnaround Time and Gross Crane per Hour

Source	SS	df	MS
Model	3610.80133	1	3610.80133
Residual	4828.84867	58	83.2560116
Total	8439.65	59	143.044915

Number of obs	=	60
F(1, 58)	=	43.37
Prob > F	=	0.0000
R-squared	=	0.4278
Adj R-squared	=	0.4180
Root MSE	=	9.1245

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
gch	-4.274301	.6490394	-6.59	0.000	-5.573494	-2.975107
_cons	155.8022	14.95059	10.42	0.000	125.8753	185.729

The operational framework model and the primary OLS regression generated the following equation:

$$Stat=155.8022-4.274301gch+u$$

The R – squared of the regression model is 0.4278 or 42.78%, indicating that the GCH contributes about 43% towards the STAT. This implies that there are other critical elements to measure accounting for 57%. The coefficient of GCH is -4.274301, signifying that as the gross crane increases by 1 (hour), the ship turnaround time decreases by -4.274301 (hours). This proves the theoretical expectation for the variable to be correct, meaning that an increase in gross crane reduces the ship turnaround time. The p-value of the regression model is also found to be significant at a value of 0.000. This satisfies the condition where the p-value must be less than or equal to the level of significance of 0.05 to be seen as a relevant variable for the model.

The coefficient results of GCH of -4.274301 are aligned with theoretical expectations. Wu and Ting (2016) state that the handling capacity of containers has a direct impact on the dwell time of vessels. De Langen and Helminen (2015) further allude that crane productivity examines the number of container movements per crane on an hourly basis resulting in a positive impact on the turnaround time of the ship.

6.2.1.3 Regression Analysis between Ship Turnaround Time and Ship Working Hour

The regression of the STAT against the SWH generated outcomes reflects results in Table 6.3.

Table 6.3: Regression Analysis between Ship Turnaround Time and Ship Working Hour

Source	SS	df	MS		
				Number of obs =	60
				F(1, 58) =	33.80
Model	3107.22531	1	3107.22531	Prob > F =	0.0000
Residual	5332.42469	58	91.9383568	R-squared =	0.3682
				Adj R-squared =	0.3573
Total	8439.65	59	143.044915	Root MSE =	9.5884

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
swh	-1.367773	.2352752	-5.81	0.000	-1.838728	-.8968188
_cons	131.8654	12.82591	10.28	0.000	106.1915	157.5392

The operational framework model and the primary OLS regression produced the following equation:

Stat=131.8654-1.367773shw+u

The R-squared of the regression model is 0.3682 or 36.82%, suggesting that the SWH contributes about 36.82% towards STAT. This means that there are other measures that are critical for STAT accounting for 63%. The coefficient of SWH is -1.367773, signifying that as the as the ship working increases by 1 (hour), the ship turnaround time decreases by -1.367773 (hours). This proves the theoretical expectation for the variable to be correct, meaning that an increase in SWH reduces the ship turnaround time. The p-value of the regression model is also found to be significant at a value of 0.000. This satisfies the condition where the p-value must be less than or equal to the level of significance of 0.05 to be seen as a relevant variable for the model.

The regression outcomes of STAT and SWH are aligned with theoretical expectations. These findings are aligned with the study of Ducruet and Merk (2014), who stated that container terminal productivity may be improved among other things by advancing ship-to-shore operations which require advanced vessel control systems, modern equipment for and skilled personnel. Furthermore, they also indicate that ship-to-shore operations are impacted by other factors such as terminal ground, and planning including yard size and machinery. This implies that there are other factors besides terminal elements that influence STAT, and that these are critical to hinterland factors.

6.2.1.4 Regression Analysis between Ship Turnaround Time and Truck Turnaround Time

The regression analysis of the STAT and TTT generated the results as reflected in Table 6.4.

Table 6.4: Regression Analysis between Ship Turnaround Time and Truck Turnaround Time

Source	SS	df	MS			
				Number of obs	=	60
				F(1, 58)	=	26.40
Model	2640.18933	1	2640.18933	Prob > F	=	0.0000
Residual	5799.46067	58	99.9907012	R-squared	=	0.3128
				Adj R-squared	=	0.3010
Total	8439.65	59	143.044915	Root MSE	=	9.9995

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
truckttt	.358152	.0696995	5.14	0.000	.2186333	.4976707
_cons	35.91017	4.423329	8.12	0.000	27.05592	44.76443

The equation below was generated when using the operational framework model and the primary OLS regression:

Stat=35.91017+0.358152trucktt+u

The R-squared value of the model is 0.3128 or 31.28% denoting a 31% contribution towards STAT which is not high, implying that that the estimated model is not that powerful in explaining effects of the regressors on the regressand. Furthermore, the coefficient of truck turnaround time is 0.358152, signifying that as the truck turnaround time hours increase by 1 hour, the ship turnaround time increases by 0.358152 (hours). The variable is seen to be significant by looking at its p-value, which is equal to 0.000. This satisfies the condition where the p-value must be less than or equal to the level of significance of 0.05 to be seen as a relevant variable for the model.

The statistically insignificant coefficient results of 0.358152 do not seem to align with theoretical expectations, meaning that an improvement in truck turnaround time should reduce the STAT considering that a vessel could wait for cargo from trucks which would result in increase in STAT. This interpretation is supported by the findings of Govender and Mbhele (2014), who indicate that the hinterland operations in the Port of Durban are affected by reliance on road transport network among other issues which accounts for almost 87% of containerised cargo resulting in congestion in the port area. This implies that the bottlenecks on road can impact shipping operations. The coefficient results of this variable require further investigation.

6.2.1.5 Regression Analysis between Ship Turnaround Time and Rail Turnaround Time

The regression of STAT against the RTT produced the outcomes in Table 6.5.

Table 6.5: Regression Analysis between Ship Turnaround Time and Rail Turnaround Time

Source	SS	df	MS			
				Number of obs	=	60
				F(1, 58)	=	12.77
Model	1523.27484	1	1523.27484	Prob > F	=	0.0007
Residual	6916.37516	58	119.247848	R-squared	=	0.1805
				Adj R-squared	=	0.1664
Total	8439.65	59	143.044915	Root MSE	=	10.92

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
railtt	-6.615887	1.851076	-3.57	0.001	-10.32122	-2.910556
_cons	75.65624	5.231541	14.46	0.000	65.18417	86.12831

The following equation using the operational framework model and the primary OLS regression was generated:

Stat=75.65624-6.615887railtt+u

The R-squared of the regression model of 0.1805 or 18.05% is extremely low for a good relationship between variables in question; however, these results might be a true reflection in the context of South Africa considering the uneven road and rail modal split. A report by Transnet (2016) also indicates that the imbalance of road and rail market share, which has an 80/20 percentage split, remains a challenge in the port creating bottlenecks. The coefficient of RTT of -6.615887 reflects that as the RTT increases by 1 (hour), the STAT decreases by -6.615887 (hours). The above results align with the theoretical expectation for the variable reflecting that an improvement in RTT reduces the STAT. The p-value of the regression model is also found to be significant at a value of 0.001. This satisfies the condition where the p-value must be less than or equal to the level of significance of 0.05 to be seen as a relevant variable for the model.

The results of the regression analysis between the STAT and each independent key performance indicators indicated that every variable had some contribution towards the ship dwell time; however, none of the variables had R squared above 50%, indicating that no single variable or dimension had a significant impact on the overall STAT. Pieterse et al. (2016) further corroborate that port efficiency is linked with the marine, terminal and hinterland activities. It is therefore important that further investigations with respect to multiple regression analysis be conducted to determine sensitivity analysis among variety of variables.

6.2.2 Findings of Multiple Regression Analysis from each Dimension of Port Productivity

6.2.2.1 Findings from Marine Perspective

Multiple regression analysis for the maritime dimension could not be conducted as the variables under this dimension, that is, STAT and anchorage hours were the only subject of investigation. From the variables measured by the shareholders, there was no other variable under the maritime sector that was being monitored. The results, therefore produced in 6.6 below are similar to the outcomes generated for regression analysis in Table 6.1 earlier on.

Table 6.6: Regression Analysis from a Maritime Perspective

Source	SS	df	MS		
Model	2852.17811	1	2852.17811	Number of obs =	60
Residual	5587.47189	58	96.3357222	F(1, 58) =	29.61
Total	8439.65	59	143.044915	Prob > F =	0.0000
				R-squared =	0.3379
				Adj R-squared =	0.3265
				Root MSE =	9.8151

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
anchhrs	.2908472	.0534528	5.44	0.000	.1838498	.3978445
_cons	45.01269	2.645696	17.01	0.000	39.71676	50.30863

6.2.2.2 Findings from Terminal Perspective

The only measures being monitored by shareholders from a terminal perspective are GCH and SWH. The regression of STAT against the GCH and SWH had the following results, reflected in Table 6.7.

Table 6**: Multiple Regression Analysis from a Terminal Perspective**

Source	SS	df	MS		
Model	4078.8601	2	2039.43005	Number of obs =	60
Residual	4360.7899	57	76.505086	F(2, 57) =	26.66
Total	8439.65	59	143.044915	Prob > F =	0.0000
				R-squared =	0.4833
				Adj R-squared =	0.4652
				Root MSE =	8.7467

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gch	-2.937235	.8241994	-3.56	0.001	-4.587666	-1.286804
swh	-.7032372	.284313	-2.47	0.016	-1.272564	-.1339101
_cons	163.2564	14.64506	11.15	0.000	133.9301	192.5826

The operational framework model and the primary OLS regression led to the following equation:

$$Stat=163.2564-2.937235gch-0.7032372swh+u$$

The regression model from a terminal perspective considering the gross crane and SWH reveal the adjusted R-squared value of 0.4652 or 46.52%. The results of the adjusted R-squared are not that different from R-squared, meaning that the goodness fit of the regression model did not improve despite having more than one explanatory variables. Basically, this means that about 46.52% changes in STAT are explained by GCH and SWH, while the remaining 54.48% explained by other variables which are not part of this regression model.

The coefficient of gross crane is -2.937235, signifying that as the gross crane increases by 1 (hour), the STAT decreases by 2.937235 (hour). For SWH, the coefficient is -0.7032372, signifying that as SWH increase by 1 (hour), then the STAT decreases by approximately 0.7032372 (hours). The p-values of both the GCH and SWH are 0.001 and 0.0016 respectively, showing that they are both significant. Despite the regression model showing a low adjusted R-squared, both gross crane and SWH are significant variables to explain changes in STAT. This analysis is aligned to the theoretical expectation for both variables.

The research outcome is aligned to an investigation by Premathilaka (2018), who conducted a regression model to determine the relationship and aspects contributing to the productivity of container vessels. This study focused in detail on areas that were controlled by the terminal operator. The results revealed the number of containers moves, crane intensity, quantity of cranes, gross crane including berth productivity are critical factors affecting vessel turnaround time. The study, however, acknowledged other factors such as vessel waiting time, vessel confinement time, vessel berthing including sailing delay were important variables impacting turnaround time.

6.2.2.3 Findings from Hinterland Perspective

The only measures that are being monitored by shareholders from a hinterland perspective are TTT and RTT. The regression of STAT against the TTT and RTT had the following results as shown in Table 6.8:

Table 6.8: Multiple Regression Analysis from a Hinterland Perspective

Source	SS	df	MS
Model	3790.42264	2	1895.21132
Residual	4649.22736	57	81.5653922
Total	8439.65	59	143.044915

Number of obs	=	60
F(2, 57)	=	23.24
Prob > F	=	0.0000
R-squared	=	0.4491
Adj R-squared	=	0.4298
Root MSE	=	9.0314

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
railtt	-5.77976	1.539111	-3.76	0.000	-8.861776	-2.697745
trucktt	.3336628	.0632879	5.27	0.000	.2069309	.4603946
_cons	53.12725	6.081179	8.74	0.000	40.9499	65.3046

The operational framework model and the primary OLS regression generated the following equation:

Stat=53.12725-5.77976railtt+0.3336628trucktt+u

The regression model from a hinterland perspective considering the RTT and TTT reflect the adjusted R-squared value of 0.4298 or 42.98%. The results of the adjusted R-squared are not that different from R-squared, meaning that the goodness fit of the regression model did not improve despite having more than one explanatory variables. The research outcome implies that about 42.98% changes in STAT are explained by RTT and TTT, while the remaining 57% is explained by other variables which are not part of this regression model.

The coefficient of RTT is -5.77976, signifying that as the RTT increases by 1 (hour), the STAT decreases by -5.77976 (hour). For TTT, the coefficient is +0.3336628, signifying that as truck turnaround increases by 1 (hour), then the STAT increases by approximately 0.3336628 (hours). The p–values of both the rail and truck turnaround times are both 0.000, implying that both variables are significant at 1% p-value. The analysis of the RTT is aligned to the theoretical expectation confirmed by the research results of Alamoush (2016), who conducted a sensitivity analysis on the contribution of hinterland transport on the functioning of ports in Jordanian ports using NAFITH traffic system. The study concluded that positive changes in the hinterland transport have a positive contribution on port performance and that the NAFITH system assisted with traffic management within the port city resulting in streamlined traffic flow and minimal congestion.

The coefficient assessment of TTT is not aligned to the theoretical probability, considering the recommendation of Gonzalez et al. (2017), who stated that time spent by trucks at container terminals must be reviewed for productivity improvement as it impacts the movement of port activities. The coefficient results of TTT require further investigation to determine why the research outcomes acquired are not congruent to theoretical expectations.

The results of multiple regression analyses from each dimension of port productivity illustrate that of the three dimensions, the terminal perspective contributed the most to port productivity with R squared and adjusted R squared of almost 50% (48.33 and 46.52% respectively). The terminal perspective was followed by the hinterland perspective with an R squared and adjusted R squared of 44.91% and 42.98% correspondingly, while the maritime perspective contributed the least, with R squared and adjusted R squared of 33.79% and 32.65% respectively. It must also be noted that all dimensions achieved R squared and adjusted R squared that is below 50% which concur with the view by Rodrigue et al. (2014), who indicated that port productivity is dependent on joint operations from the maritime, terminal and hinterland sectors as each dimension impacts the other. It was therefore important to further determine how the overall key performance indicators from all dimensions impact on productivity.

6.2.3 Findings of Multiple Regression Analysis from Maritime, Terminal and Hinterland perspectives

The overall variables being monitored by shareholders are STAT, AWT, GCH, SHW, TTT and RTT. The multiple regression of STAT from all dimensions against the explanatory variables revealed the results reflected in Table 6.9.

Table 6.9: Multiple Regression Analysis from Maritime, Terminal and Hinterland Perspectives

Source	SS	df	MS		
				Number of obs =	60
				F(5, 54) =	45.84
Model	6830.40735	5	1366.08147	Prob > F =	0.0000
Residual	1609.24265	54	29.8007898	R-squared =	0.8093
				Adj R-squared =	0.7917
Total	8439.65	59	143.044915	Root MSE =	5.459

stat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
anchhrs	.2037635	.03427	5.95	0.000	.1350563	.2724706
gch	-2.50502	.5535441	-4.53	0.000	-3.614809	-1.395231
swh	-.2317731	.2163395	-1.07	0.289	-.6655076	.2019615
trucktt	.1362358	.0457141	2.98	0.004	.0445845	.2278872
railtt	-5.14768	.986034	-5.22	0.000	-7.124559	-3.170801
_cons	124.6368	13.60454	9.16	0.000	97.36139	151.9123

Using the operational framework model and the primary OLS regression, the following equation is generated:

$$Stat=124.6368+0.2037635anchhrs-2.50502gch-0.2317731swh+0.1362358trucktt-5.14768+u$$

The multiple regression analysis results of the assessed key performance indicators as per Table 6.9 demonstrates that all dimensions combined from marine, terminal and hinterland perspectives contribute around 80% to productivity with the R squared and adjusted R squared of 80.93 and 79.17% respectively. The findings reveal that about 79.17% changes in STAT are explained by anchorage hours, GCH, SWH, RTT and TTT, while the remaining 21% is explained by other variables which are not part of this regression model. These results prove that the regression is powerful considering the R-squared value which is above 50. The Adjusted R-squared value of 0.7917 or 79.17% is not that different from R-squared. This means, the goodness fit of the regression model improved with the addition of explanatory variables from all dimensions. The high value signifies that the estimated model is powerful in explaining effects of the regressors on the regressand. This level of R-squared also indicates that the data links well to the sample regression. This displays the significant impact of all variables from all dimensions and its impact on the overall productivity of the port or terminal.

However, there are other measures that can be considered for such model to complete the 79.17% to 100%. A study by UNCTAD (2017) suggests that another critical performance indicator associated with the STAT and berth productivity is cargo dwell time. De Langen and Helminen (2015) mention other factors contributing to STAT are pilotage and tug services, bunkering and ship chandelling services. Oktafia et al. (2017) further indicate that pilotage and tug services, including the port administration office, are critical for the berthing of vessels in the port.

The coefficient results of GCH, SWH and RTT reveal that an improvement in these variables results in improved STAT. The coefficient of GCH is -2.50502, signifying that as the GCH increases by 1 hour, the STAT decreases by -2.50502 hours. Gidado (2015) states that crane productivity is the most critical factor impacting terminal operations as it determines ship dwell time based on the available cranes to work the ship and moves to be done per hour per crane. The findings by Govender et al. (2017) revealed that the use of multi-trailer systems with the capability to handle multiple containers at a time, will assist with maximising crane productivity at the Port of Durban. Zangwa (2018) further recommended a concurrent operation for loading and unloading of containers for improving efficiencies. Wilmsmeier et al. (2013) confirm that the positive impact is realised on container movements and productivity when the capacity of cranes is increased. It is therefore critical and essential for the Port of Durban to consider using multi-trailer systems that can handle more containers and ensure simultaneous handling of containers. The use of multi-trailer systems will assist in maximising crane productivity thereby enhancing container terminal productivity.

The coefficient of SWH is -0.2317731, signifying that as the SWH increases by 1 hour, the STAT decreases by -0.2317731 hours. The results are aligned to both theoretical expectations and the study by Zangwa (2018), that for the port terminals to improve vessel turnaround time, they need to increase SWH movements by fully utilising cranes to their maximum potential to each vessel. He further adds that the equipment must be functional both technically and mechanically to ensure improved SWH and gross crane hour. According to Transnet (2018), the SWH at DCT Pier 2 in 2018 was affected by unpredictable equipment due to the weather conditions which limited the terminal operational capacity.

The coefficient of RTT is -5.14768, signifying that as the RTT improves by 1 hour, the STAT decreases by -5.14768 hour. These results are aligned with the theoretical expectations. According to Pieterse et al. (2015), the RTT are impacted by the challenges happening at intermodal terminals, recurrent train interruptions and cancellations. They further indicate that for the intermodal terminals to be efficient, it is essential to have modern rail to road intermodal terminals with sufficient infrastructure and efficient rail service.

The coefficient of anchorage hours is 0.2037635, signifying that as the anchorage waiting time improves by 1 hour, the STAT increases by 0.2037635 hour. The p-value of 0.000 depicts the significance of the variable. While anchorage hours are an important variable to measure, it can be not be included in the STAT as the ship dwell time is counted once the vessel passes anchorage of the port. The coefficient of TTT is 0.1362358, implying that as the TTT improves by 1 hour, the STAT increases by .01362358. The findings of the regression model for the truck turnaround time are somehow not linked with theoretical expectation as a vessel could wait for cargo from trucks to load, which could result in increased STAT. The regression model results also show that all variables other than the SWH are significant at 1% p-value. The coefficient of TTT and p-value of SWH therefore requires further investigation.

6.3 Conclusion

This chapter has provided findings of a sensitivity analysis determining critical performance indicators influencing productivity of the container terminal from the marine, terminal and hinterland perspectives. A sensitivity analysis was conducted on key performance indicators of the container terminal where the STAT was identified as the output variable, while the input elements were regarded as anchorage time, GCH, SWH, TTT and RTT. The study identified areas of focus for enhancing productivity of the container terminal as the SWH, GCH and the RTT, which will drive the improved dwell time of ships time in the port. The next chapter deals with the findings and discussion of the semi-structured interviews which identified critical performance indicators of productivity of a container terminal from a Systems Approach perspective.

CHAPTER SEVEN:

FINDINGS AND DISCUSSION OF SEMI-STRUCTURED INTERVIEWS

7.1 Introduction

The main aim of the study was to investigate how the performance of a container terminal can be improved using a systems approach. Chapter Seven of this thesis provides findings of the qualitative analysis of the semi-structured interviews conducted to determine the context and problematic situation of the research study. According to the Sustainability Laboratory (2019), the complexity of the system is caused by the extent of interaction between its components which makes it difficult to understand how each variable will impact other variables. This report further indicates that even if there is no variety of components, the system can be complex; however, additional variables make the systems more compound. The magnitude of interchangeability within a system therefore demands comprehension of the overall unit ahead of implementing initiatives when resolving systematic issues. It was on this basis that an extensive understanding of soft issues impacting terminal operations was investigated from a systematic approach through semi-structured interviews, with the intention of gaining in-depth information from diverse stakeholders involved in the operations.

A systems thinking approach was used in this study where expert opinion was sought through semi-structured interviews to determine the problem and ascertain the critical factors impacting the system behaviour (Bala et al., 2017). The qualitative analysis of the semi-structured interviews followed a deductive content analysis approach using the 6-step approach by Creswell (2014) as described in the Research Methodology Chapter (Chapter Five) of this thesis. The sets of data that emerged from this process, which were a representative of all respondents' experiences were categorised into common themes. These findings were complemented by direct quotations from the various research informants, keeping in line with the systems approach methodology.

7.2 Findings from Semi-structured Interviews

The semi-structured interviews were analysed using Nvivo computer software program which assisted with generating the following themes, as depicted in Figure 7.1, which displays the key findings of the study emanating from information gathered from the various stakeholders interviewed. The various stakeholders who participated in the research process were categorised with codes as follows: TNPA respondents (Respondent 1=PA1, Respondent 2 = PA2, Respondent 3 = PA3 and Respondent 4 = PA4), TPT respondents (Respondent 1 = PT1, Respondent 2 = PT2 and Respondent 3 = PT3), TFR respondents (Respondent 1 = R1, Respondent 2 = R2 and Respondent 3 = R3), Shipping Lines

(Respondent 1 = SL1, Respondent 2= SL2, Respondent 3 = SL3 and Respondent 4= SL4) and Road Haulier as RH1.

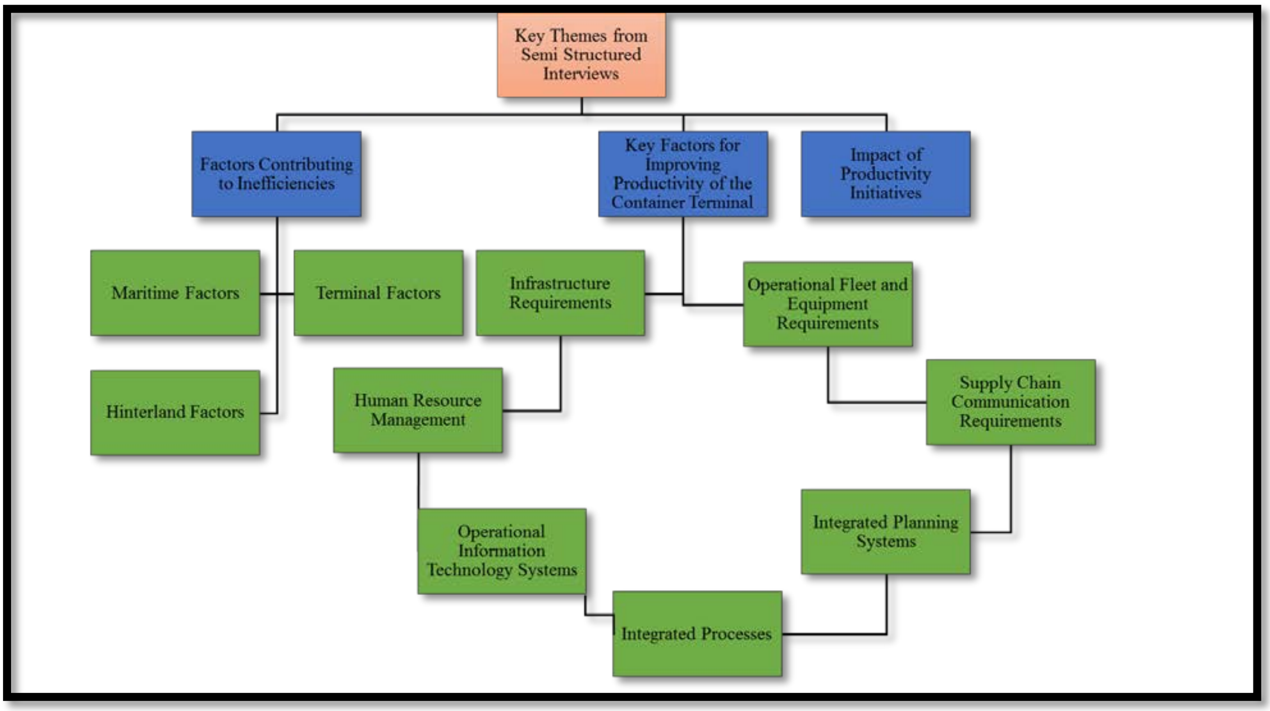

Figure 7.1: Key Themes emerging from Semi-structured Interviews

7.2.1 Factors Contributing to the Inefficiencies of the Container Terminal and Implications

The factors contributing to the inefficiencies in a container terminal were reviewed from all three dimensions that impact productivity, that is, marine, terminal and hinterland perspectives, ensuring that a holistic approach is considered. The factors contributing to the bottlenecks at the container terminal were unpacked as follows and depicted in Figure 7.2.

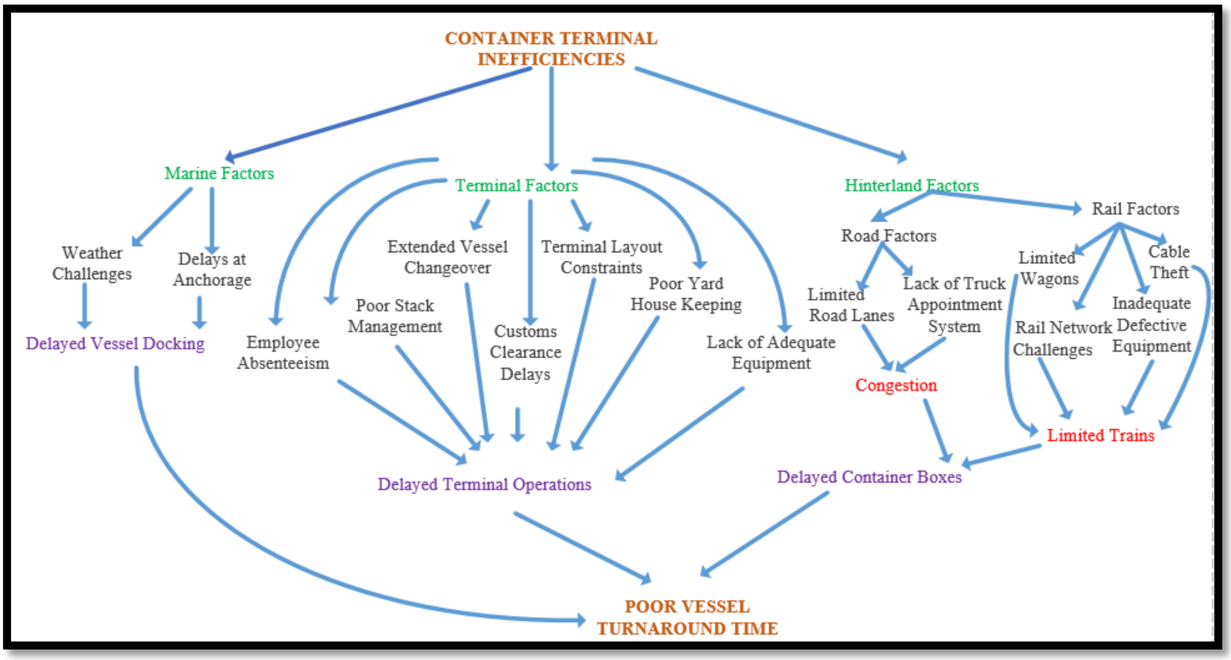

Figure 7.2: Factors Contributing to the Inefficiencies of the Container Terminal

7.2.1.1 Marine Factors

According to 60% of the shipping lines, the vessels in the Port of Durban experience berthing delays ranging from one day to 5 days waiting at anchorage before berthing. The waiting delays come with extra costs considering the additional charter costs incurred on top of the berthing fees, transhipment costs as a result of skipping ports and extra bunker fuel fees to get to another port. SL4 indicated that this is a multiplier effect, where the costs keep on increasing, while SL2 expressed that they cannot afford these additional costs due to low freight rates experienced.

Key informants from the Port Terminal and Shipping Lines indicated that some of the delays are related to weather conditions due to high winds. However, SL2 indicated that the whole world is prone to wind challenges and problems encountered at the Port of Durban are never experienced in other ports worldwide. SL2 suggested that mitigation measures must be put in place to minimise weather challenges.

7.2.1.2 Terminal Factors

According to the key participant (PT1) from Port Terminal, the terminal is congested and never able to recover the slots considering the number of vessels calling the port resulting in the terminal not meeting Container Terminal Operations Contract agreements and not generating the expected revenue. The inefficiencies are caused by employee absenteeism, poor stack management, extended vessel changeover period which end up lasting for 6-10 hours *versus* 4 hours; poor housekeeping resulting in straddle carriers running long distances to move cargo including back stacking containers. The customs box clearance process was specified as another element resulting in the bottleneck in the terminal leading to nomination of transport taking longer. The problem identified with the customs process was alluded to by Govender and Mbhele (2014) as creating problems associated with transportation.

According to SL2, the inadequate resources results in delays and bottlenecks in the port. The inefficiencies experienced result in the longer dwell time of the ship in the port leading to huge financial loss as a result of skipping ports, chartering vessels and burning more bunker fuel. This research outcome is confirmed by Pieterse et al. (2016), who state that performance at DCT is aggravated by inadequate container stacking space, low productivity and bottlenecks at the gate leading to longer vessel waiting times. Soares and Neto (2016) further add that container terminals are commonly challenged by a huge number of containers in the stacking space and their dwell time in the terminal affects productivity of the terminal.

7.2.1.3 Hinterland Factors

Key respondents from Shipping Lines (SL2, SL3, SL4), Port Terminal (PT1), Port Authority (PA1), Rail Division (R1, R2) and Road Hauliers (RH1) indicated that most inefficiencies experienced from a hinterland perspective are due to the ineffectiveness of the rail service. According to PT1, only 15% of cargo is moved by road. The freight division cannot meet the targets of moving 11 trains as done in previous years, but only move between seven (7) to eight (8) trains between Durban and Johannesburg, as stated by SL4. At the same time, R3 indicated that the terminal is failing to adhere to the committed rail loads for both Pier 1 and Pier 2. SL2 further indicated that customers do not want to book cargo on rail as it is always delayed by up to 9 days opting to move cargo by road as it more efficient. A study by Pieterse et al. (2016) confirmed that the unreliability of rail transport due to delays and cancellations was the major reason for users to change to road transport.

The respondent from the Rail Division (R3) stated that the challenge experienced with Pier 1 is space as the terminal use the same space for road trucks and rail wagons creating congestion at the port. Similarly, with equipment, the terminal uses straddles and mafia trailers used to load truck are also utilised to load wagons, impacting on the turnaround time of wagons. Similar problems are being experienced with respect to stack management, where a common stack is used for road trucks and rail leading to shuffling of containers which contributes to the delays and the wagon turnaround time. This creates inefficiencies on the entire system; hence there are no wagons available on certain times. A key informant from a Shipping Fraternal (SL5) further suggested that the terminal should deploy nine (9) straddles per tower to do 9 moves for improved turnaround of trucks. A study by Schroder (2013) and the Journal of Commerce (2014) state that adequate resources must be deployed for container handling to maximise operations. Based on these findings, it is critical for the terminal to review the space for stack management and overall terminal operations, including terminal equipment, in the interest of improved efficiencies.

According to the interviewer from Rail Division (R3), lack of availability of wagons is due to non-adherence to the schedule plan for stacking as the early arrivals are likely to be stuck until the stack opens affecting wagon turnaround and efficiencies within the port. The other challenge that comes with stacking is the change of stack dates by customers impacting on the wagon availability, considering that in many cases containers would have been moved for loading as alluded by the research participant. This means that one customer decision can impact two (2) to three (3) customers, impacting the entire system. The other challenge is that the Freight Division do not pack containers according to the terminal stack date, leading to inefficiencies as indicated by PT1. R3 also stated that the freight division contributes to the inefficiencies as a result of defective equipment from the port side leading to the longer dwell time of cargo.

A key respondent from the Freight Rail Division (R3) alluded to the fact that the different shift system from Port Terminal and Rail Division is impacting operations, as two to three hours get lost at the beginning of every shift. The participant suggested that shifts from both companies need to be aligned. Some of the problems with rail according to participants from Freight Rail Division and Port Terminal are cable theft and network issue leading to late arrival of export boxes. The rail division experiences up to 2 incidences of cable theft resulting in the suspension of the service of about 6 hours, meaning there is no train running for 6 hours as stipulated by R3. The impact of these delays is the re-nomination of the vessel, meaning that the late cargo will have to go with another vessel. Pieterse et al. (2016) further add that customers choose to dispatch high value goods on road to meet the vessel to avoid penalties which are costly.

According to the key respondents from Port Terminal (PT1) and Shipping Line (SL2) from a trucking perspective, the truck waiting time to pick up a container ranges from 12 hours to 36 hours leading to a huge congestion at the port. A Port Authority (PA1) participant indicated that some of the road traffic problems emanate from truck drivers who do not want to use a truck booking system. They come to the port with no booking slot and disorganise the system causing inefficiencies in the port from a hinterland perspective. A study by Navarro et al. (2015) conducted a sensitivity analysis to assess the behaviour of container flow in order to resolve port congestion. The study commended use of a truck booking system to decrease congestion. The research findings suggest that a compulsory truck appointment system should be deployed to improve truck turnaround and efficiencies within the port.

Key respondents from shipping fraternal (SL2) and Port Authority (PA3) indicated that another challenge from a trucking perspective is that customers arrange for picking their containers at the last moment leading to inefficiencies. This results in other containers from other vessels being piled on it requiring some reshuffling and shifting when the box has to be collected. This is compounded by the fact that depots, warehouses, factories etcetera are not open during the weekend to bring or collect cargo to the port leading to congestion during the week. A suggestion is for the role players to promote a shipping business which is open 24 hours for 7 days a week from a hinterland perspective similar to port working hours.

The other cause of inefficiency from a trucking perspective as outlined by the Port Terminal participant (PT1) is the limited road infrastructure leading to the terminals which only has two (2) lanes. The impact of this limitation affects among other things reaction time to breakdowns which impacts operations. The suggestion is to have the Bayhead Road being widened. According to Van Tonder (2015), some of the immediate initiatives to be considered with respect to road accessibility are extra traffic lanes both in Langeberg and Bayhead Roads.

According to the Shipping Line (SL4), the berthing delays and terminal inefficiencies result in the introduction of surcharges which escalate costs. The consequences are increased cost of doing business in the country and loss of business throughout the logistics chain which impacts job security and jeopardise opportunities for increased business and creation of additional jobs. This is directly impacting the economy of the country negatively. These research outcomes are supported by Gidado (2015) when stating that port congestion is linked with long queues, delays, longer stay of vessels and cargo in the port which has unintended outcomes on the overall supply chain with respect to additional costs, disruption of services and loss of business.

7.2.2 Key Factors for Improving Productivity of the Container Terminal

The following subthemes were found to be the critical input elements from a systems approach contributing to the productivity of the container terminal to ensure optimised maritime, terminal and hinterland operations. A systems approach study by Bianchi and Williams (2015) was instrumental in determining causal and effect factors accompanying social distortions connected to the City's performance. It enabled the system designers to shape and execute reliable performance measures that can be utilised by the government sector to drive a viable organisational learning and expansion thereof. Similarly, the critical input elements for improved container performance identified in this study became the foundation for development of CLDs and rich pictures are presented and discussed in the next chapter of this thesis. Figure 7.3 reflects the shared themes which were recognised from the interviews as being fundamental to the productivity of the container terminal at the Port of Durban.

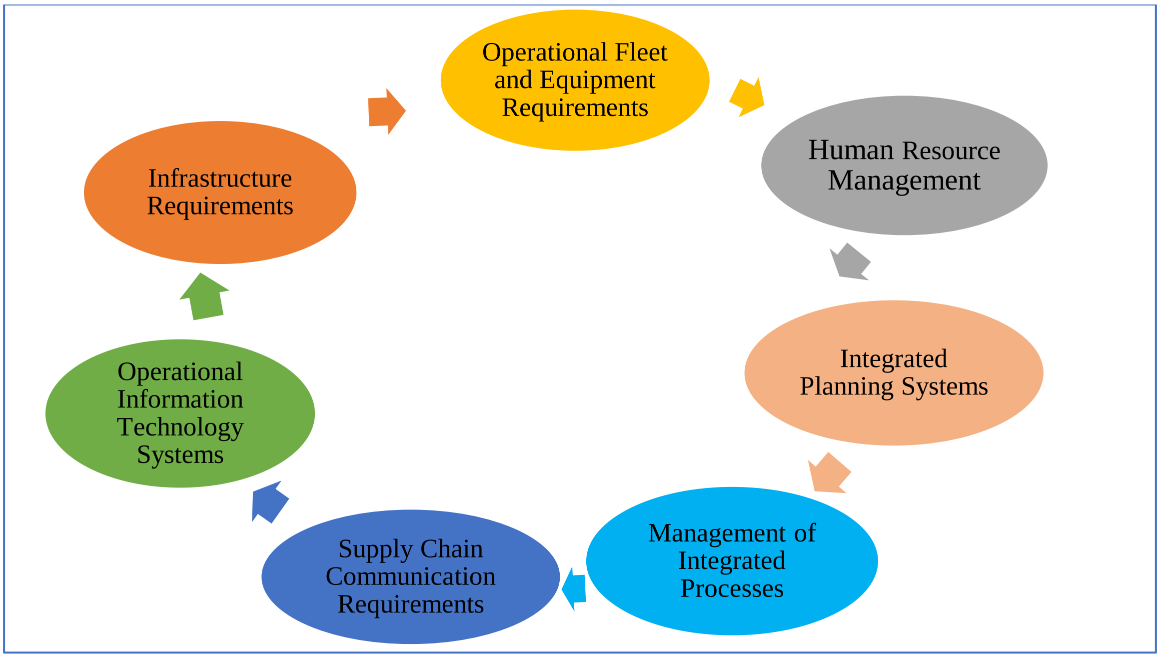

Figure 7.3: Critical Factors for Improving Productivity of the Container Terminal

The findings from each factor were categorised into a series of blocks with the intention to streamline the interaction within the boundaries considering the system complexity in line with the systems approach (Bala et al., 2017). Each factor was discussed within either the maritime, terminal or hinterland sectors or blocks.

7.2.2.1 Infrastructure Requirements

The key infrastructure input elements for improving productivity of the container from a systems approach were identified as port, terminal, rail and road infrastructure, including back of port facilities.

7.2.2.1.1 Port Infrastructure

The key informants from the Port Authority (PA4) and Port Terminal (PT1) stated that berth availability is the essential key input element for container terminal operations. According to PT1, deeper berths are required for smooth operations. A study by Lu and Park (2013) that determined some of the greatest delicate performance indicators affecting container performance by conducting a sensitivity analysis using Data Envelop Analysis and Regression Analysis found that the overall quantity of berths and resources deployed during operations impact container terminal productivity. This implies that an increased number of deeper container berths in the port are necessary to improve efficiencies.

7.2.2.1.2 Terminal Infrastructure

The key informants from Port Terminal (PT1 and PT2), Port Authority (PA3), Shipping Lines (SL1) and Road Hauliers (RH1) alluded to the fact that the terminal footprint needs to be expanded to increase storage and stacking space. There is a need to have sufficient space for segregation of units when loading and discharging cargo from vessels. SL1, PA3 and RH1 stated that the port needs to be extended, where the import cargo is moved to a facility away from the quay side where it can be dispatched through road and rail to the hinterland. This will allow the area close to the dock to focus only on export and transhipment cargo thereby, decongesting the yard. According to Rodrigue et al. (2014), among other factors such as port bottlenecks and ineffectiveness of the terminal, limited land availability for stacking purposes result in longer waiting time of ships at anchorage leading to increased costs.

A proposal by RH1 and PT2 is to utilise the South African Container Depot (SACD) site to extend the terminal in order to acquire additional capacity. RH1 further indicated that SACD site together with the unutilised space of Kingsrest Marshalling Yard can be used as an import terminal, while empty boxes can be dispatched to Prospecton or Edwin Swales. The facility should still form part of the terminal to be cleared by Customs. These research results are supported by a study of Nze and Onyemechi (2018) who recommend expansion of storage capacity at yards as one of the initiatives to reduce bottlenecks in African ports.

The other problematic issue raised by stakeholders PT2 and SL4 which restrict operational efficiencies is the Z-shape configuration of Pier 2 of the Container Terminal. According to PT2, the Z shape "limits the stacking capacity up to three levels high and for the terminal to straddle operation only". The key respondent from SL4 indicated that whilst the truck and trailer operation in conjunction with the straddle operation is being implemented on the East Quay of Pier 2; it cannot be done on the South Quay, requiring this dock to be reconfigured. Operating a combination of truck and trailer with straddle operations at South Quay is disastrous and creates more problems in terms of efficiencies, as stated by SL4. According to Scholtz (2017), there needs to be transformation of stacking operation from straddle carriers to RTGs at Pier 2 of the Container Terminal for improved capacity. However, Schroder (2013) also states that the straddle carrier operation is beneficial due to its ability to handle multiple boxes for stacking purposes and transferring to them to either trucks or trains.

7.2.2.1.3 Rail Infrastructure

According to five respondents (PT1, SL1, SL2, PA3 and R1), there needs to be adequate rail infrastructure to improve operational efficiencies. Investment on side railings should be actioned to allow flow of cargo to the port. The Port Authority respondent (PA1) stated that the Rail Division should be reviewing whether the rail infrastructure available is adequate and sound considering the period in which the rail lines were erected. The respondent further proposed that faster and longer trains should be explored in order to handle all available containers. The Shipping Line (SL1) respondent added that the improved rail capacity will assist with the reduction of road traffic. This research opinion is reiterated by Maharaj (2013), pointing out that the deployment of rail versus road will assist in elevating bottlenecks in the supply chain as the rail cost and inefficiencies have increased the use of road transport. However, De Villiers (2017), also indicates that facilitation of cargo from rail to road needs to be complemented by establishment of inland terminals positioned at strategic areas for cost optimisation.

The key informants from the Rail Division (R1 and R2) and Port Authority (PA1) emphasised the need for the rail network between Johannesburg and Durban to be upgraded to ensure fluidity and timeous arrival of containers to the port. The rail network needs to be revitalized or renewed. According to the respondents, there are various challenges affecting the network, including cable theft and speed restrictions impacting on the train turnaround time. R3 stated: "If we can have a fluid network and try to mitigate cable theft, we will perform better".

A paper by George et al. (2018) highlights that the surge of theft and destruction to rail infrastructure contributes to the rail inefficiencies and requires improved protection to ensure reliability of the service. The paper further indicate that the Rail Division needs to upgrade ancient and dilapidated rail infrastructure and ensure upkeep of the network to advance rail performance.

7.2.2.1.4 Road Infrastructure

About 5 respondents (SL2, PT1, PT2, SL3 and PA3) indicated that the road network leading to the Container Terminal needs to be upgraded to allow free flow to terminals. According to SL2 and PT1, the available lanes leading to the terminal are not feasible and require widening of the roads (Bayhead and Langeberg) and increased lanes, considering that a huge percentage (±85%) of cargo moves by road leading to a long waiting time (10-12 hours) of truck drivers on the road. The key respondents from the Shipping Lines Association (SL2) and Port Terminal (PT2) alluded to the fact that shipping lines are bringing bigger vessels and volumes have increased over the years, demanding additional capacity for movement of cargo on the hinterland. Van Tonder's (2015) paper alludes to the fact that some of answers with respect to road problems facing South African ports require improvement by provision of additional road linkages, revamp of current road and effective management of traffic.

The key informant from the Port Authority (PA3) asserted that trucks going to the terminal have to pass through heavy traffic going to the city and indicated the following: "We need a dedicated road to the port so that it does not interfere with the general traffic so that you can start seeing the flow of cargo". Maharaj (2013) also indicates that traffic use by both freight industry and passengers needs to be managed considering that road-based traffic is still expected to increase by 100% by year 2030. The research outcomes are reinforced by Gidado (2015), who states that the upgrade of hinterland networks such as road connections including rail and traffic management in the port boundary, will assist in eradicating congestion in ports. Felicio et al. (2015) agree that for ports to improve productivity, there should be capital investments on the hinterland which will allow additional access, thereby facilitating improved terminal operations.

7.2.2.1.5 Back of Port Facilities

The key informants from the Rail Division (R1) and Port Authority (PA3) stated that it is critical to develop back of port facility in order to support the port business to ensure efficiencies. According to R1, there is a need to acquire storage space within a short distance from the rail yards and ports to create back of port facility. This will assist with quick transfer of boxes as soon as the stack date is open at the Container Terminal which will ensure that containers are received timeously for export market. According to de Villiers (2015), the development of inland terminals is essential for relief of congestion in the port and for value-added logistics. This allows productive use of the port space for primary activities and not secondary or support functions.

The key respondent from the Port Authority (PA3) indicated that there is a need for more intermodal terminals for transfer of cargo to and from the port or hinterland, in order to decongest the port which can be developed by the Private Sector. UNCTAD (2017) suggests that investments which involve public-private partnerships should not be made only on ports but also on the intermodal connections. UNCTAD (2017) further states that there are enormous advantages to involving private sector in terminal operations such as capital investment, skills transfer and new technology. Based on the findings of this research, it is critical that the private sector is involved in development of intermodal terminals that support port operations for improved efficiencies.

7.2.2.2 Operational Fleet and Equipment Requirements

The key operational fleet and equipment requirements from a systems approach were identified from a maritime, terminal and hinterland perspectives.

7.2.2.2.1 Marine Craft and Equipment Requirements

According to respondents from Port Authority (PA1, PA2, PA3, and PA4), Port Terminal (PT2) and Shipping Line (SL4), the key input marine craft and equipment requirements are tug boats, helicopter, pilot boats and passenger launches. For PA1, passenger launches are required for the berthing services which are used when it is difficult for the berthing staff to get into smaller areas of the port where they cannot use ground transport. The key participants from the Port Authority (PA1, PA2 and PA3) emphasised the need for adequate, operational and sound marine craft to ensure quick turnaround of vessels. PA2 further indicated there must be an additional two (2) tug boats to ensure that crafts are released for maintenance based on schedule. According to SL4, the Port of Durban is well- resourced with respect to the marine craft and the service is always available. There is always availability of a pilot boat in case challenges are experienced with the helicopter. Research findings by Oktafia et al. (2017), revealed that the seaport undertakings cannot be fulfilled well without the tug and pilotage services from a maritime dimension. This clearly articulates the importance of the required fleet and equipment as critical factors to provide pilotage and tug services timeously for seamless port operations.

7.2.2.2.2 Terminal Fleet and Equipment Requirements

The eight respondents from the Port Authority (PA1, PA2, PA3), Shipping Lines (SL2, SL3, SL4), Port Terminal (PT1) and Rail Division (R2) listed quay cranes, RTGs, straddle carriers, mafia trailers and ship to shore gantries as the key input elements for terminal operations. A study by Lu and Park (2013) that investigated the sensitivity analysis with respect to determining the most important elements of productivity in a container terminal, found that Terminal Cranes and Yard Tractors are critical factors impacting productivity. According to SL2, SL3, SL4 and RH1, these resources are available at the terminal, however they are not adequate to service all shifts consistently to ensure quick turnaround of vessels.

The key respondents from Shipping Lines (SL2, SL3 and SL4) stated that the terminal requires about 84 to 120 straddle carriers per shift in order to function optimally. SL4 further stated that for each gantry, 4 straddles are required on the waterside. According to SL2, PA2 and PA3, the number of cranes deployed per vessel is a key component in improving productivity considering the huge size of vessels serviced. This outcome is aligned to the proposal by Hangga and Shinopa (2016), who alluded to the fact that terminal operators should provide and deploy appropriate resources policies for productivity improvements. SL2 further stated: "…it is vitally important that we add extra cranes to each vessel because the more cranes on a ship, the better productivity... quick turnaround of the ship will be realised and more vessels will be serviced by the port".

A study by De Langen and Helminen (2015) stated that crane productivity determines the turnaround time of the vessel; however, productivity is dependent also on the type of cranes deployed and expertise of crane operators. The research findings by Govender et al. (2017) on the impact of multi- trailer system on terminal operations revealed that operational costs can be minimised at DCT at Pier 1 with the deployment of multi-trailer systems with capacity to handle four 6-meter containers. It is therefore necessary for the terminal to continuously review the type and number of cranes deployed to ensure terminal productivity.

PT1 and R2 indicated that some of the equipment is very old, faulty and dilapidated. PA1, R1 and R2 indicated that reliability of machines and the fleet is problematic. R2 further indicated that terminal does not deploy adequate fleet and equipment as per the ship plan because of the defective equipment. PA2 suggested that automated tracking systems must be in place to measure the performance of each crane in order to pick up any slowdown without anyone reporting it. The cranes should have a sensor to ring an alarm bell if the crane drops to a certain loading/discharging rate. PA2 further indicated that terminal should review if the current machinery used is still fit for the big vessel sizes in terms of the loading rates and whether it is it keeping up with the trend or not. A study by Nze and Onyemechi

(2018) recommends investment on required infrastructure and contemporary equipment to eliminate bottlenecks in African Ports.

The key participants from Port Authority (PA2) and Port Terminal (PT1) stated that the terminal needs to invest in new generation RTGs that can also withstand weather challenges. PA2 further stated: “We must take climate change into consideration when buying such crafts and machinery to be built for the African and Tropical Weather conditions”. Research by Ducruet and Merk (2013) further indicates that terminal operations can be improved by ensuring that there is use of latest state of the art equipment which allows double handling and lifting of several cranes at the same time. It is thus necessary for the terminal to ensure that relevant and adequate equipment for the Port of Durban is deployed for terminal operations to improve ship productivity.

According to PA3, the terminal needs to do a simulation to determine the ideal operation among the Ship to Shore, Straddle Carrier and Haulier Operation. The capability of these operations needs to be determined and whether using a combination of these will be ideal. A study by Schroder (2013) conducted a simulation which determined the amount and type of equipment required to ensure smooth operations at the container precinct in Durban. The results revealed that the Pier 1 at DCT requires about four TTUs and four RTGs in order to improve efficiencies, while Pier 2 requires four straddle carriers for each quay crane considering parameters involved in the project.

While the study managed to determine the amount of equipment required per quay crane, the gap to in terms of determining the ideal operation for the Port of Durban context, remains unanswered. Hence it is critical that a further simulation be conducted to determine the ideal equipment fit for Durban. A study by Soares and Neto (2016) found a SD model to be a useful tool in determining the handling methods, including operational strategies fit for Brazilian Association of Public Container Terminals for enhanced productivity and cost effectiveness.

7.2.2.2.3 Hinterland Fleet and Equipment Requirements

About 60% of the respondents from Port Authority (PA1, PA3), Shipping Lines (SL2, SL3, SL4), Port Terminal (PT1), Rail Division (R1 and R2) and Road Hauliers (RH1) listed trains, rail wagons, locomotives, rail mounted gantry cranes, straddle carriers, mafia trailers as critical key equipment and fleet required for smooth hinterland operations. According to SL5, the number of trains between City Deep in Johannesburg and Durban has been reduced from eleven trains to about seven to eight trains per day, creating bottlenecks in the value chain. SL2, SL3 and R2 further indicated that there needs to be adequate number of train and rail wagons to move cargo from Johannesburg to Durban and *vice versa* to ensure timeous arrival of cargo. Locomotives need to be roadworthy and effective to move both import and export cargo to and from Johannesburg. De Villiers (2015) alludes to the fact that the overall supply chain should be capacitated to make provision for the increased number of container volumes moving through trains and trucks from the terminal.

From a road perspective, according to SL3, R2, SL4, RH1 and PA, the terminal needs to deploy adequate equipment for loading and delivering cargo on to trucks and terminal. According to SL3, SL4 and PA3, the inadequacy of equipment on the landside limits the delivery and upliftment of containers causing a huge delay for export boxes and truck congestion within the port limits. The export boxes end up not making it to the vessel stack due to the bottlenecks experienced as a result of insufficient equipment. Yeo (2015) stipulates that as the vessel sizes increases, deployment of adequate terminal handling equipment becomes a necessity. SL4 indicated that Pier 2 of the Container Terminal has three towers and therefore proposed that each tower is equipped with straddle carriers around the clock. SL4 further stated: “If each tower is equipped with 9 straddles around the clock, there will be no congestion on the road. The nine (9) straddles per tower to do nine (9) moves an hour are required to ensure quick turnaround of trucks”.

7.2.2.2.4 Maintenance of Operational Fleet and Equipment

About 67% of the respondents from Port Authority **(**PA1, PA2, PA3, and PA4), Shipping Line (SL2, SL3, and SL4), Port Terminal (PT2) and Rail Division (R2 and R3) emphasised the need for adherence to maintenance plans specifically for the terminal equipment and rail wagons. PA4 also stated that there must be acquisition of adequate equipment to ensure that release of machinery for maintenance so that operations are not affected. According to R2, SL2, SL3 and SL4, the terminal experiences a huge number of breakdowns on a daily basis, resulting in more straddle carriers, rail mounted gantry cranes and shunting locomotives being out of commission.

PA2 further indicate that when there are many breakdowns, the terminal is left with few cranes leading to poor vessel productivity. On the landside, there are minimal loads that are sent to Johannesburg compared to planned loads due to rail mounted gantry crane failures as stated by the respondent from the Rail Division (R2). This research view has also been alluded by Zangwa (2018), who stated that equipment failures contribute to poor performance at DCT leading to long dwell time of vessel in the port which prohibit operational efficiencies. The study (2018) further recommends use of "intelligent crane management system" to assist with efficiencies regarding equipment breakdowns to assist with continuous maintenance on a short-term basis. The system acts as an investigative instrument that gives early signal of equipment problems. The system therefore permits prognostic maintenance to detected areas and this information is used to project future maintenance plans.

The key respondents from Shipping Lines (SL3 and SL4) highlighted a need for 24/7 hours maintenance program to minimise disruptions to vessel and land operations. According to respondents from Shipping Lines (SL4), the terminal needs to employ people to ensure 24/7 maintenance operation which is fully resourced across all shifts. Research participants from Shipping Line (SL2) and Port Authority (PA4) stated that there is a need to acquire people with the necessary expertise and technical knowledge to ensure rigorous maintenance of the equipment as it is also purchased at a high price. The informant from the Port Authority (PA1) also insisted: "It is about the quality of work that is done to service this equipment". Zangwa (2018) further indicates that good upkeep of equipment is a necessity to ensure smooth cargo operations, thereby improving the equipment life-cycle and productivity.

7.2.2.3 Human Resources Management

The essential human resource requirements for enhancement of container terminal operations from a systems approach perspective were elicited from marine, terminal and hinterland dimensions.

7.2.2.3.1 Maritime Human Resource Management

One of the key input elements mentioned by the key research participants with respect to improving container terminal productivity, are the critical skills required for operations from the marine perspective. The essential skills alluded to by the key informants from the Port Authority (PA1, PA2 and PA3), Shipping Lines (SL2 and SL2) and Port Terminal (PT1 and PT2) are pilots, port control staff, berthing crew, tug masters, second engineers, marine engineering officers (MEOs), chief marine engineering officers (CMEOs), general purpose ratings (GPRs), motorman, coxswain and pilot boat master.

According to the Port Authority key informants (PA1, PA2 and PA3), personnel in marine are important because of the specialised qualification required for this operation and the scarcity of the applicable skills. The respondents indicated that there is scarcity of skills with respect to the Marine Engineers, Chief Marine Engineers, Tug Masters and Pilots with Open Licences, which is a national challenge. The unavailability of Marine Engineers, Chief Marine Engineering Officers and Tug Masters render the tug unfit for duty or out of commission. These skills take longer to produce as they are acquired after five to seven years whilst in the maritime sector. Hence, a retention strategy to retain these critical skills should be developed as stipulated by the Port Authority informant (PA2).

The key respondents from Port Terminal (PT1 and PT2) also indicated that the port requires more pilots with open licences to berth all sizes of ships as the vessels currently docked are huge. The research findings by Oktafia et al. (2017), revealed that the Port of Tanjung Priok was in need of additional pilots to ensure reliable service for berthing of vessels in the port. This implies that the Port Authority must work on building a pipeline to ensure that the port has adequate resources to service the vessels and the retention of the scarce resources.

7.2.2.3.2 Terminal Human Resource Management

The key challenge stated by respondents from Port Authority (PA1 and PA2), Shipping Lines (SL3 and SL4) and Rail Division (R1 and R3) is the shortage of manpower to mend the equipment leading to the inefficiencies at the port. According to SL4, the minimum requirement of gangs is 14, while the maximum number is 16; however, the terminal provides either 12 or 13 gangs per shift. SL3 further indicate there is no consistency in the manner in which the vessels are worked across shifts. SL3 and R3 stated that the lack of achievement of business targets could be affected by employee or managerial issues, including absenteeism. According to PA2 and SL4, there is a need for the terminal to employ more gangs as the vessels are getting bigger requiring more cranes and gangs to work their vessels to improve productivity. Other than the adequate number of gangs, there must be resources and skilled staff who need to be accountable, as alluded by SL2. A study by Wilmsmeier et al. (2013) stated that labour is a critical input feature on terminal productivity unless operations are fully automated and port terminals need to continuously review the quantity of resources deployed during terminal operations in order improve efficiencies.

Buchari and Basri (2015) further indicate that human resource development is the foundational challenge directly impacting various areas. Within a port environment, the technical ground staff members handling equipment are critical for productivity improvements. It is thus important for them to have the relevant expertise to use the heavy weight equipment such as cranes and RMGs which are managed by port workers. The available equipment must be supported by the skilled staff members to ensure contribution to improved loading and discharge process, reduced waiting of vessels at anchorage and efficient berth utilisation.

The key respondents from Port Terminal (PT1), Road Hauliers (RH1) and Shipping Lines (SL1) emphasised that employees need to be trained to ensure they upgrade their skills to perform better with respect to the number of container moves. One area mentioned which requires further training is usage of Navis Terminal Operating System. This research verdict is supported by Ducruet and Merk (2013), who state that terminal operations can be improved by ensuring that there is skilled labour with the capability to drive maximum crane productivity levels. Zangwa (2018) also emphasised the importance of training and education to ensure that operators are skilled to perform their responsibilities, which demands organisations to develop training policies. The training assists with enhanced efficiencies but furthermore stimulates human resource capacity development. The positive consequences of training are skilled and motivated workforce resulting in improved performance. The training and development initiative is also supported by Nwaeke and Onyebuchi (2017) as a critical tool to advance productivity and performance, thereby increasing organisational competitiveness. However, they further state that the training and development plan must be developed on the basis that there is a need to advance employee skills to attain organisational goals.

The other aspect raised by informants from Shipping Lines (SL3 and SL4) and Port Authority (PA3 and PA4) was a need to educate employees (crane operators, hauliers and straddle drivers) about the importance of the current jobs and its impact on the overall efficiency of the port and the economy. Employees need to understand that if they do not perform, it will eventually negatively affect them, their families and the economy at large and the opposite will happen if they perform. They should rather look at the collective gain instead of the individual gain. SL4 further stated: “Employees need to be educated about the value chain how it works and the impact thereof”. These research views were mutual with the opinion by (Nwaeke and Onyebuchi, 2017) when articulating that organisations need to vigorously train and develop their employees to achieve business goals and heighten organisational productivity.

The issue of payment of incentives to employees was raised by respondents from Port Terminal (PT1 and PT2), Port Authority (PA2), Road Hauliers (RH1) and Shipping Lines (SL4). All correspondents emphasised the need to incentivise employees. Rodrigue et al. (2014) allude to the fact that labour factors with respect to performance incentives contribute to disruptions when it comes to productivity of container terminal operations. The respondents from Port Authority (PA2) and Port Terminal (PT2) stated that the company took away the incentives which used to be paid on a monthly basis to a half-year payment structure. According to a respondent from Shipping Lines (SL4), it is important for the container terminal to incentivise the number of moves to give boost to productivity. SL4 further stated: "You can change all teams or anything you want to do but as long as you do not incentivize the container terminal, you will never see growth". However, according to PA1, the incentives should be paid on merit based on individual performance rather than based on the revenue generated by the organisation. The bonus should be paid after each individual surpasses the planned operation targets with respect to the number of expected container moves. A study by Kassim et al. (2017) concluded that the incentive measures are closely linked to employee performance, thereby impacting on productivity measures; however, these enticement processes should be made on fair and standardised practice based on benchmarks and evaluations.

The other measures to boost employee morale as alluded by respondents from Port Terminal (PT1 and PT2), Shipping Lines (SL1) and Port Authority (PA3) are improved working conditions through provision of safe working equipment, filling of vacant positions, clear strategy on succession planning, delivery on promises and shared vision. According to research participants from Port Terminal (PT1 and PT2), the general staff morale contributes to poor performance of achieving less than 25 Gross Crane Hour as the equipment capabilities are not fully utilised to their maximum capacity. The respondent from Port Authority (PA3) further indicated that employee attitude plays a critical role considering that the terminal has a manual yard which is dependent on employees for the work to continue. It is therefore critical for the terminal to enhance the human resource management aspect with respect to adequately resourcing the operations appropriately, and capacitating employees with training and development programs that will upgrade their skills and incentivising them to achieve operational goals.

7.2.2.3.3 Hinterland Human Resource Management

According to the key respondents from the Rail Division (R1, R2 and R3), the train crew (train drivers and assistants) and yard officials are the critical resources for smooth operations. The yard officials need to ensure that load is available on time whilst the train crew need to guarantee that cargo is transported timeously to and from the port. Respondents R1 and R3 further indicated that in order to manage performance, they ensure adherence to performance contracts and enforce policies for employees to comprehend why they are in the organisation. However, correspondent R3 elaborated that training and change management on the value chain is required for employees on the ground, as some of the employees have been employed over 40 years doing the same jobs. Hui et al. (2019) support this research opinion when indicating that employees need to be engaged and supported with change management programs to ensure that key performance indicators are met.

7.2.2.4 Integrated Communication of the Supply Chain

According to respondents from Shipping Lines (SL1) and Rail Division (R3), the Transnet Divisions, TNPA, TPT and TFR, need to work in an integrated way to service customers. They should work holistically to bring a solution to customer issues instead of working in isolation. According to the Sustainability Laboratory (2019), the level of interface among factors causes a system to be complex due to the high level of interdependency which makes it exceedingly difficult to assess the impact of changes of one variable to the rest. Hence, it is therefore critical to facilitate communication in an integrated approach through a systematic approach. The critical areas of communication that require integration from a systems approach were identified from a maritime, terminal and hinterland perspectives.

7.2.2.4.1 Integrated Communication from a Maritime Perspective

The key respondents from Port Authority (PA1 and PA4) and Shipping Lines (SL1, SL2 and SL4) highlighted the need for enhanced communication between Port Authority and Port Terminal to ensure that vessels are serviced timeously. The Port Control needs to be in consistent communication with the Compliance Side of the terminal where information is shared in relation to the vessel arrival and departure of ships. The consistent communication will allow gaps to be identified in advance and mitigation plans to be put in place which will eliminate any delays on the vessels. Port Control needs to align themselves with the terminal and communicate concise information regarding the berthing of a vessel at any point in time to shipping lines, as alluded to by SL1.

The research opinion is aligned with the paper by Oktafia et al. (2017), who stated that the successful berthing and undocking of the vessel gets fulfilled through collaboration with various stakeholders including pilotage tower, marine pilots, tug services, vessel agent and administration. All activities have to be synchronised with each other for proper coordination to ensure smooth operation and customer satisfaction. This implies that communication must be enhanced to eliminate unnecessary delays and in parallel ensure timeous vessel berthing and sailing.

7.2.2.4.2 Integrated Communication from a Terminal Perspective

According to respondents from Port Authority (PA4), Port Terminal (PT2) and Shipping Line (SL1), communication is critical among TNPA, TPT, Customs and Stevedores to ensure flow of information for prompt decision-making and vessel working. Communication is required with Customs for vessel clearance while the terminal needs to provide resources for vessel working as indicated by respondent PA4. The participant from Shipping Lines (SL1) further indicated that Port Control needs to ensure that the terminal is ready with all the necessary equipment before deploying pilots and tugs to bring a vessel to berth to avoid any unproductive move. The respondent further stated that Port Control needs to play a bigger role to liaise with all stakeholders to improve operational efficiencies. According to Stahlbock and Voß (2008), there is a need for the cutting-edge information systems including communication technology to facilitate implementation of optimum approaches of various terminal areas. Hector et al. (2012) further stated that for inefficiencies to be minimised, they require collaboration by all stakeholders within a supply chain as no one organisation could resolve them on its own.

7.2.2.4.3 Integrated Communication from a Hinterland Perspective

About 53% of the respondents from Shipping Lines (SL1, SL2 and SL3), Port Authority (PA1 and PA4), Port Terminal (PT1) and Rail Division (R3) stated that close collaboration and integration is required between TPT and TFR with the intention of servicing the vessel better. There seems to be a communication gap between the two parties which results in cargo not meeting the vessel planned. According to R2, there is no understanding of the operations of each party, and further stated: "It seems the way the port is working is too different from the way rail is working". Sentiments by Acciaro and McKinnon (2013) indicate that significant enhancements can be achieved when the container terminal, hinterland transport modes including dry ports collaborate. Based on these research outcomes supported by the literature, it is critical that the interface between inland terminal and terminal be managed efficiently to ensure effectiveness of terminal operations and productivity thereof.

According to SL1 and SL3, the gap sits over City Deep, where cargo is accepted knowingly that the cargo will not reach the vessel or the cargo will be late resulting in a vessel delay. The Shipping Line (SL2 and SL3) respondents further indicated that the Rail Division needs rather to be upfront with clients regarding the dispatch of their cargo whether it will be delivered on time or not. This communication will assist with alternative plans as cargo gets planned for a particular vessel and end up not reaching the vessel or delaying the vessel which is undesired and have operational implications. This research finding is aligned with study the by Pieterse et al. (2016), who state there are recurrent train interruptions and cancellations pointing to the challenges experienced at intermodal rail yards leading to late arrival of cargo in the port or cargo not meeting the planned vessel. This implies that there needs to be common goal which is communicated and agreed on by customers, the Rail Division and the port on cargo dispatch to ensure timeous arrival of cargo to the vessel for export purposes.

The other challenge experienced as stated by informants from Port Authority (PA1), Port Terminal (PT1) and Rail Division (R3) is the variance between operating model for the terminal and the rail company. The Rail Division focuses on tonnage with respect to handling containers whilst the terminal handles all boxes as their charges are based on TEUs. These differences have a huge influence on the planning as it creates challenges like shortage of empty boxes and influx of full containers impacting operations negatively. According to PT1 and R3, there must be synergies between the two parties where the key performance indicators are aligned in order to balance the value chain and improve the efficiencies. There must be therefore a concerted effort by the container terminal and the rail division to align strategies for the purpose of the value chain and improved efficiencies.

7.2.2.5 Operational Information and Technology Systems

The key informants from Port Authority (PA1, PA2 and PA4), Port Terminal (PT1 and PT2) and Shipping Lines (SL2 and SL4) identified Integrated Port Management System (IPMS), Navis Terminal Operating System, Internet, Port Community Systems as critical information technology systems required for enhancing productivity of the Container Terminal. According to PA1 and PA4, the IPMS system is useful for shipping lines and the terminal to book slots to ensure on time berthing of vessels. PT2 further indicate that the IPMS System should assist with visibility and access. Heilig and Voß (2017) concur that port technology is critical for port operations ensuring gathering, interchange, analysis and transfer of imperative information with various stakeholders. A study by Azab and Eltawil (2016) introduced innovative information system to facilitate enhanced communication levels between trucking organisations and ports with the intention of managing congestion and TTT at container terminals in Egypt. The benefits of the proposed interactive information technology system should not only provide linkage between seaports and road hauliers but also assist with scheduling of trucks, tracking of containers including maximisation of various resources.

The key participants from Port Terminal (PT1) and Shipping Lines (SL2 and SL4) alluded to the fact that Navis Terminal Operating provides useful tools to ensure that operations run smoothly. However, according to SL2 and SL4, this tool has 30% utilisation by the terminal and the 70% remains unutilised. In the views of PT1 and SL4, terminal employees need to be continuously trained on the Navis Terminal Operating System until the system has 80% utilisation. Respondents from Port Authority (PA1 and PA4) further indicated that optimisation of the IPMS System is required to ensure on time berthing of vessels and provide real time updates on the system. A study by Premathilaka (2018) highlighted the need to optimise all existing features of the terminal operating systems for productivity improvements by limiting manual work. These findings clearly indicate that the port and terminal needs to intensify use of the operational technology systems in order to improve productivity.

Other respondents from Shipping Lines (SL4) and Port Authority (PA2) suggested that the terminal introduces automated system specifically movement of containers from cranes to RTGs with the intention of improving efficiencies in the port. The respondents further indicated that automation will eliminate human intervention considering the number of containers moved per hour and will assist with maximisation of space considering land constraints. The research feedback is supported in a study by Huang et al. (2012), who recommend technology upgrade in order to increase the port efficiencies considering that it will improve the handling rate at container terminals. However, research by Moreno and Camarero (2013) indicate that maximum automation of a terminal does not always have positive impact on operations and financial performance as there are other factors that are critical for maximising terminal productivity. This implies that semi-automation may be ideal for other terminal operations as opposed to full automation.

The key participants from Port Terminal (PT2) and Port Authority (PA2) suggest that the port community systems should be put in place to ensure transparency and real time monitoring of operations. The Port Authority (PA2) informant stated that Information Technology systems need to be integrated to allow access by all stakeholders, including the Port Authority, Terminal, Rail, Customs, SARS and Immigration. The participant further stated that international ports have similar systems which facilitate quick turnaround of vessels in the port. These systems will eliminate bottlenecks as the challenges are likely to be seen in advance which will allow mitigation plans to be put in place. The Journal of Commerce (2014) indicates that modern terminals attain maximum productivity levels required for mega ships through deployment of the latest technology. Furthermore, Li and Lu (2019) state that the future developments for the container industry is with robotic and smart container handling systems, where manual work will be reduced through the use of advanced technology and machinery. Hence, it is critical for ports and terminals to embrace technology and ensure its maximum use to advance productivity.

7.2.2.6 Integrated Planning Systems

Planning was identified as critical area that require to be enhanced in order to enhance improve efficiencies. According to ITF (2018), in order to ensure thorough planning, port planners need to have a full comprehension of future needs of customers with respect to import and export cargo flows and this seems to be the area that is lacking. Pieterse et al. (2016) also indicated that the Port Authority is not the only stakeholder to resolve the congestion problems but the solution requires improved planning by all stakeholders involved in the container operations including cargo nodes and corridors to and from sea ports. Hence, planning was unpacked from a systems approach.

7.2.2.6.1 Integrated Planning from a Maritime Perspective

The respondents from the Port Authority (PA1) and Shipping Lines (SL2) emphasised the need for the marine division to have a thorough plan to service the vessels by providing marine resources timeously, such as the berthing crew, pilots, helicopter, tug crew working in conjunction with Port Control and Berth Planning. The respondent from the Port Authority indicated that the transport taking the berthing crew to berth needs to be efficient and determine the best route to take given traffic, to ensure that the vessel is serviced timeously. According to Shipping Line respondent (SL2), the ship must be serviced within a maximum of one hour of the arrival of the ship at anchorage and after completion of cargo at the terminal. Oktafia et al. (2017) emphasise that planning is critical for effective pilotage service as the pilot need to consider various factors before a service is provided. The factors to be explored include the draught and the pathway of the vessel. Furthermore, the pilot needs to liaise with the berthing staff with respect to the mooring service, shipping agent regarding the vessel's anchor and position including crew members and documentation and the terminal in relation to berth readiness. There must be a coordinated plan with the pilots, berthing gang, and shipping agent for berthing of the vessel. Based on these research outcomes, there must be an integrated planning within the Port Authority considering the resources required from the Harbour Master's Office, Marine Division and Port Control, and liaison with other external involved stakeholders is critical to ensure the smooth arrival and sailing of the vessel in and out of the port.

The respondent from Port Authority (PA2) further indicated that Port Control and Berth Planning needs to enhance their planning schedule by being proactive and planning ahead for the weather sensitive and deep drafted vessels. The applicable departments should take an opportunity to trace and prioritise to service those vessels prior to their schedule based on the prevalent needs and weather conditions. Further correspondent, from the Port Authority (PA3) proposed that the port needs to acquire tools to predict with accuracy the arrival of the ship and the resources required to service it. This will allow the port to be proactive and to plan for the ship well in advance.

A study by Zhen et al. (2017) emphasised the importance of planning as critical, also in determining the schedule of mega ships considering that they are dependent on tide patterns for navigating through the port channel for berthing and sailing purposes. The scheduling of tidal vessels can be projected earlier based on the anticipated tide patterns including vessel drafts. This means the port needs to plan in advance for berthing of tidal vessels based on the forecasted tide pattern.

7.2.2.6.2 Integrated Planning from a Terminal Perspective

The key informants form Port Authority (PA2 and PA4) and Shipping Lines (SL2 and SL4) stated that there must be proper planning of resources and terminal readiness to receive the vessel in order to ensure no delays to ships. According to Shipping Line respondent (SL4), it was critical for planning of the terminal and yard to be enhanced as the port is a growing import and export gateway with limited terminal space. Heilig and Voß (2017) concur that a radical plan is required to ensure terminal activities are processed efficiently considering the necessary services and equipment. They further indicate that movement of cargo should be planned optimally to warrant the smooth flow of cargo within the operational areas. The respondents from Port Authority (PA4) and Shipping Line (SL2) emphasised the need to deploy adequate resources such that vessels are able to sail at the scheduled time, since this is the time committed by the terminal as per contractual obligations. The Port Authority (PA4) respondent further indicated that back up resources need to be planned and flexibility of deployment of resources should be done based on the size of the vessel. As per the research outcomes, the terminal should guarantee adequate resources with respect to terminal equipment and gang availability to ensure the quick turnaround time of vessels.

According to the Port Authority informant (PA2), the vessel is at times worked only after 2 to 3 hours after berthing with inadequate cranes and gangs. Both the respondents from Shipping Line (SL2) and Port Authority (PA2) state that this is unexpected considering that the terminal knows well in advance the details of every vessel coming to the port with respect to the size and number of containers to be loaded and unloaded. This means that terminal should have known in advance the number of cranes and gangs that will be required to work each vessel. The other lack of planning is visible when the terminal only starts realising when loading the vessel that there are containers that are missing of which are still on the way to the port which impact on the vessel turnaround time, as stated by the Port Authority (PA2) respondent. The respondent further recommended that pre-planning of the vessel should not happen when the vessel is already alongside the berth. These research results concur with the findings by Kurapati et al. (2016), who stated that terminals must plan proficiently with respect to relocations of cranes and yard planning to guarantee the quick turnaround of vessels.

7.2.2.6.3 Integrated Planning from a Hinterland Perspective

The key respondents from Port Terminal (PT2), Rail Division (R3) and Shipping Line (SL3) stipulated that there must be coordinated planning of inland terminal and terminal planning to ensure the timeous arrival of cargo at the port to meet the vessel stack. The process flow of the trains and terminals from the inland terminals to the port must be aligned to the port load vessel and layout of the yard. According to the Port Terminal (PT2) respondent, the alignment of plans will eliminate the disorganisation caused by the enthusiasm to achieve individual company goals instead of considering the overall picture and impact to the end user, where the rail division is only focusing on railing heavy cargo and not concerned with the arrival time of cargo. A paper by Acciaro and McKinnon (2013) states that there are significant improvements that can be realised through cooperation of container terminals, transportation modes and dry ports through better management of road and rail transport.

SL3 further indicated that this misalignment impacts on the planning of the ship as it becomes difficult to plan for the boxes unless those rail boxes are physically in the export stack yard. A study by Hu et al. (2018) developed a model that integrates inter-terminal transportation of containers with rail freight terminal and transport operations. The model with an integrated planning process proved improved operations with cost reduction with container transport and railway operational costs. Considering this research outcome, the terminal should consider working on a model that will facilitate integrated planning of port terminal operations with inland terminal. Furthermore, Rodrigue et al. (2015) also state that the planning of port and transportation mode infrastructure requires a rigorous process: the responsibility for this is managed under different jurisdiction, which is the case for the Durban-Gauteng corridor. Considering the research by Rodrigue et al. (2015), it is very clear that the joint planning of port and transportation mode is a necessity from an operational point of view but also from an infrastructure development perspective.

Another area of planning that requires attention is the planning of the yard as specified by the respondent from the Port Authority (PA3). The respondent stated that the terminal needs to minimise the number of times the container is lifted and dropped, that is, reshuffling by planning in advance to place in the area where it will only be touched when is required to. The reshuffling slows landside operations which can impact on the container movements to the vessel resulting in poor vessel turnaround. The respondent from the Port Authority (PA1) further indicated that the shared rail lines by passengers and cargo require vigorous planning to ensure that both aspects are serviced efficiently. A simulation was conducted by Colak et al. (2018) to determine the appropriate stack planning that will eliminate inefficiencies within a container terminal. The study recommended a mathematic modelling to obtain an optimal design for a container port. This implies that layout could pose restrictions to operational efficiencies, hence it is critical for ports to determine the ideal layout to improve efficiencies.

7.2.2.6 Management of Integrated Processes

Based on the research interviews conducted, key processes that could be enhanced in order to improve container terminal operations were identified. The processes include Oversight Role by the Port Authority, Use of the Truck Appointment Systems, Stack Management Process, Cargo Storage Days, Customs Processes, Rail Turnaround Times and 24-hour Operation of Depots, as discussed next.

7.2.2.7.1 Oversight Role by the Port Authority

The role by the Port Authority to exercise its oversight role was stipulated as one process that could enhance terminal operations as stated by respondents from Port Authority (PA1), Port Terminal (PT2) and Shipping Lines (SL2 and SL3). According to Juhel (2017), one measure for enhancing productivity is for the Port Authority to play an oversight role on operators by analysing operational performance indicators which are agreed on by shipping lines during the planned port community meetings. According to the key participants from the Shipping Lines (SL2 and SL3) and Port Terminal (PT2), the Port Authority needs to play its oversight role in ensuring that key performance indicators for terminal operators and the rail division are set and adhered to, to ensure that the port operates optimally and competitive. The respondents from the Port Terminal (PT1 and PT2) also stated that the Port Authority needs to deal with all non-compliance by all stakeholders. Some of the deviations include non-adherence to truck appointment systems by terminals, rail bound international maritime dangerous goods (IMDG), consistency of rules with handling IMDG Cargo and non-adherence by shipping lines to their shipping schedule. A study by Nze and Onyemechi (2018) recommends that ports in Africa must heighten the regulatory framework and advance capacity and efficiencies in order to minimize the port bottlenecks.

According to the Port Authority informant, penalties should be put across the board for non-compliance, directed at employees for non-achievement of the expected targets, shipping lines for incorrect stacking of containers inside the vessel, truckers for not abiding to the booking system, and the rail division for not adhering to container delivery schedules. The Road Haulier (RH1) representative also proposed that penalties should be imposed for liners who discharge cargo with unassigned boxes as it results in longer dwell time of cargo in the port thereby creating bottlenecks. A study by Calderon and Rojas (2019) found that the Port Authority has a regulatory mandate to penalise businesses that do not adhere to the concession agreement. This implies that it is up to the Port Authority to introduce penalties for non-compliance in the port.

7.2.2.7.2 Use of the Truck Appointment System

About 53% of respondents from Port Authority (PA1, PA2 and PA3), Port Terminal (PT2), Road Hauliers (RH1), Shipping Line (SL3) and Rail Division (R1 and R3) emphasised the need for the terminal to use a compulsory truck booking system in order to improve efficiencies at the terminal. According to respondents from Shipping Lines (SL3), Port Authority (PA1 and PA2), Port Terminal (PT2), non-use of a truck booking system creates disorganisation and congestion in the port. The recommendation aligns with research findings by Zhang et al. (2013), who suggested an appointment system as a model that should be utilised reduce the TTT. Their research findings revealed that the extent of time apportioned for the booking time is the critical element influencing the truck turn time. Furthermore, a study by Ramírez-Nafarrate et al. (2017) applied a simulation model together with a heuristic procedure to determine the impact of the truck appointment systems on turnaround period of trucks. The results of the study specify that improved TTT will be realised with the implementation of the truck booking system.

The respondent from Port Terminal (PT2) indicated that industry need to agree to the principle of using a truck booking system and suggested that change management should be considered. A study by Navarro et al. (2015) conducted a sensitivity analysis to assess the behaviour of container flow in order to resolve port congestion. The study commended use of a truck booking system to decrease congestion. Azab and Eltawil (2016) also conducted a simulation to determine the impact of inflow patterns of truck on the TTT and arrival enhancement strategies thereof. The simulation results revealed that the TTT can be improved by the deployment of a truck appointment system which will assist with the elimination of congestion at port gates without reducing truck arrivals. Azab et al. (2017) also used a simulation model to develop an innovative truck booking system to resolve container terminal gate and yard bottlenecks leading to extended TTT. The research outcomes revealed the reduction of average gate waiting time and TTT by 21% and 23% respectively. The improvement in both port gate waiting time and TTT assisted with terminal workload and rescheduling occurrence which was beneficial for both the terminal and trucking companies. It is thus critical for the Port of Durban to deploy the truck appointment system for reduction of bottlenecks and improved efficiencies.

A correspondent from Shipping Lines (SL4) further recommended that the terminal needs to introduce a system that will encourage trucks to move at night as opposed to moving boxes only during the day. A respondent from Road Hauliers (RH1) also stated that configurations for A Check and Bayhead Road should be considered with dedicated lanes for particular cargoes and licencing of truck drivers to ensure efficiencies within the port precinct. A report by Botes and Buck (2018) also suggest that coordinated traffic plans could alleviate port congestion by assigning particular road lanes to freight vehicles during peak periods. Research by Bentolila et al. (2016) investigated the promotion of shifting truck day traffic to night traffic coupled with incentives at the Port of Haifa in Israel. The results revealed that this operation is viable for only large-scale clients who are able to convince their suppliers to consider a night service. Based on these findings, the development of an incentive to encourage large scale customers to divert movement of cargo during the night should be considered.

7.2.2.7.3 Stack Management Process

The key informants from the Port Authority (PA1, PA3 and PA4), Shipping Lines (SL1 and SL4) and Road Hauliers (RH1) emphasised the need for the terminal to enhance stack management process. A study by Ramírez-Nafarrate et al. (2017) which applied a simulation model together with a heuristic procedure to assess the contribution of the truck appointment systems on terminal operations, revealed that container reshuffling will be minimized. This implies that the hinterland operations have a significant impact on terminal operations, hence productivity improvements require a holistic review of operations from all dimensions.

According to PA1 and SL4, the terminal should maximise use of the Navis Terminal Operating System to ensure proper stack management, given the space constraints in the terminal. The system has the necessary tools to stack boxes as per the urgency or system requirement such that it does not require any reshuffling. Both respondents indicated that stack planning is the crux of terminal operations and is central to the success of the business as it enhances productivity. A study by Rahman et al. (2016) investigated a new solution to container stacking to counteract limited yard space. The research outcome was a container stowage system that allows stacking of up to 15 containers on vertical and 10 on horizontal blocs without boxes requiring to be reshuffled. This system triples the yard capacity and reduces the amount of work to be done. It is thus critical for the Port of Durban to explore alternative ways of stacking to increase efficiencies.

According to the correspondents from the Port Authority (PA3 and PA4), the terminal needs to adhere to the scheduling of stack dates. A respondent from Rail Division (R3), customers are changing stack dates impacting on the wagon availability thereby impacting on either 2 or 3 customers which has an impact on the overall system. The Shipping Line (SL1) respondent also indicated that the terminal needs to stack boxes according the allocated crane slips so the stacking mirrors the loading plans. The respondent further suggested for the cargo to be sent from Johannesburg (City Deep) to the port before the stack opens to avoid congestion and to ensure that cargo reaches the vessel.

7.2.2.7.4 Cargo Storage Days in the Port

According to 60% of the respondents, the terminal should not be used as a storage area as it creates bottlenecks in the system. This outcome is ratified by a study of Gidado (2015), when he points out that a long cargo dwell time of import cargo in the port is the major contribution of bottlenecks as it directly impacts port efficiency negatively, thereby causing port congestion which can hamper economic growth. The current number of 3 days for keeping cargo in the port was agreed as the reasonable stay, while it was suggested that a longer dwell time should be penalised by introducing extra charges as stipulated by respondents from Shipping Lines (SL1, SL2, SL4) and Port Authority (PA3). UNCTAD (2017) further states that improving productivity and the period cargo stays in the port are essential for cost reduction and port attractiveness.

However, according to respondents from Shipping Lines (SL2 and SL4), the terminal can adhere to 3 days storage days provided there are no inefficiencies experienced in the terminal caused by weather conditions and poor TTT. The issue of poor truck turnaround time was raised as another issue that compels a longer dwell time, as the port sometimes do not meet the 90 minutes target and truckers end up waiting for six (6) to eight (8) hours resulting in an extension of cargo storage days. The respondent from Port Terminal (PT1) also indicated that extension of storage is caused by truckers who only come to fetch cargo on the last day of the three (3) days, while a Road Haulier (RH1) representative indicated that unassigned boxes result in longer cargo dwell time of boxes, generally caused by indecisiveness regarding whether cargo will be dispatched through road or rail. A study by Kgare et al. (2011), which investigated cargo dwell time in the Port of Durban, revealed that the number of days cargo remains in the port can be further reduced. The research further indicates this process is strictly driven by private sector; however, institutions like the Port Authority and Customs can put measures to control the number of days cargo remains in the port.

Furthermore, respondents from Shipping Lines (SL2 and SL3) indicated that storage days could be reduced to two (2) days provided that terminal provides adequate equipment and manpower as there are space constraints especially during the peak season, where reefer containers are handled. According to the Port Terminal (PT1) respondent, the 3 days storage days should start from the day the container is released from the ship rather than the last day the last box is released from the vessel. The reduction of cargo dwell time is recommended by Nze and Onyemechi (2018), who cited this initiative as critical in minimising bottlenecks in African ports by encouraging cargo owners to move their cargo timeously from the terminal. This finding implies that the terminal must introduce initiatives to encourage quick dispatch of cargo from the port.

7.2.2.7.5 Customs Process

The key research participants from Port Authority (PA3 and PA4), Port Terminal (PT1) and Shipping Line (SL2) highlighted that Customs processes should be improved to avoid any delays that impact on the ship turnaround time. According to a Shipping Line (SL2) and Port Terminal (PT1) respondents, Customs does not arrive on time to clear the cargo once the vessel is on berth, or the clearing process takes longer, resulting in nomination of transport taking longer which then creates inefficiencies at the terminal. Maharaj (2013) allude to the fact that among many factors, inefficient customs processes contribute to inefficient supply chains other than ship berthing delays, road bottlenecks, limited rail supply, including supply disruptions of power and water.

The Port Authority (PA3) respondent suggested that either the terminal or Customs need to invest in technologies that will facilitate clearance of cargo while the vessel is at anchorage, instead of surveying the ship when it is already moored alongside berth. The suggestion is supported by Nyema (2014), whose paper indicated that non-availability of Information Technology System is a threat to container terminal performance as it results in delays in Customs clearance processes. A report by Botes and Buck (2018) also suggests that customs and other legislative processes should be streamlined by ensuring paperless systems in order to minimise bottlenecks.

7.2.2.7.6 Back of Port Facilities

According to the respondents from Road Hauliers (RH1) and Shipping Lines (SL2 and SL3), all facilities that are supporting the port business such as warehouses, depots, parking stations, factories and manufacturing plants need to operate on a twenty-four (24) hour basis for seven (7) days. This will avoid a situation where transporters only come from Monday to Friday to pick up cargo from the port, thereby creating bottlenecks. According to Shipping Line respondents (SL2 and SL3), transporters should be encouraged to pick up containers also during the weekends as the port is operational and the roads are not congested considering that there is no public transport operating. According to the respondent from the Road Haulier (RH1), communication with shipping liner operators owning depots and other related companies should be done to encourage depots to be operational 24/7 hours to ensure consistent dispatch of cargo throughout the week to reduce bottlenecks. These outcomes concur with the findings of Bentolila et al. (2016), that the flexibility to move trucks outside of the normal working times can be promoted by the opening of extended hours of depots outside the ports. The extended hours offer flexibility for trucks to organise their drop off and pick up of containers from ports during the off-peak hours.

7.2.2.7.7 Other Critical Processes for Improved Container Terminal Operations

Other processes that were considered critical for enhanced container terminal operations are improved rail capacity and service as alluded by respondents from Shipping Lines (SL1) Port Authority (PA1, PA2 and PA3), Rail Division (R1, R2 and R3) and Port Terminal (PT2). These research outcomes are supported by a study of Pieterse et al. (2016), who indicated that unreliability of rail transport due to delays and cancellations was the major reason for users to change to road transport. These delays result in the late arrival of goods to customers as well as inability to provide track and trace systems of cargo at any particular time which is generally provided by road hauliers. This means that the Rail Division needs to step up its operations and service provision in order to be competitive and relevant to the supply chain.

7.2.3 Impact of Productivity Initiatives

About 73% of the participants highlighted that productivity will be improved in various aspects including achievement of port key performance indicators such as gross crane moves per hour, TTT, improved vessel turnaround time and rail turnaround time. According to a Rail Division (R2) participant, there will be 100% execution of planned trains, on time arrival and departure trains, and achievement of 11 trains per day with 50 wagons as per set targets. Cheon et al. (2017) assert that one of the critical measures for port's appeal is its capability to process cargo within a reliable and expected time frame. It is thus critical for the Port of Durban to drive productivity with respect to the key performance indicator to ensure port competitiveness.

According to participants from Port Authority (PA2, PA3 and PA4), Shipping Line (SL2) and Rail Division (R1) stated that the port will be decongested from the waterside and landside. There will be fewer delays and reduced waiting time of vessels at anchorage. A correspondent from the Port Authority also indicated that automation will allow the available space to be used optimally as compared to the manual operation. This is confirmed by a study by Govender and Mbhele (2014), who state that technology has a positive impact on the transfer of containerised cargo as it assists with synchronisation of outgoing and incoming scheduling systems on both terminal and hinterland operations.

The key respondents from Shipping Lines (SL1, SL2, SL3 and SL4) and Port Authority (PA3) indicated that port business growth will be realised, as the port will service more vessels and volumes which will generate increased revenue. The increased business in the port will result in job creation and bring more investment in the country. According to participants from Port Authority (PA4) and Port Terminal (PT1 and PT2), employee trust will be improved, which will facilitate employees working according to set moves and ensure that everyone is accountable. According to UNCTAD (2017), port efficiency plays a critical role in trade competitiveness and capacity of the ports to contend in difficult and changing market structure, which is aligned to this research outcome.

The reduced cost of doing business was identified as key achievement not only to Shipping Lines, but also to the entire industry by respondents from Port Authority (PA1) and Shipping Lines (SL2 and SL4). According to the Port Authority (PA1) and Shipping Line (SL4) respondents, there are savings realised by shipping lines when there is no waiting time of vessel at anchorage and no need to full steam to the next port, meaning that they do not need to use more diesel to get to the next port. They can glide using wind to go to the next port. A Shipping Line (SL2) respondent indicated that shipping lines will incur lower costs and freight rates, which will result in the transportation of goods in a cost-effective manner with positive economic implications for all. Furthermore, the respondents from the Rail Division (R1 and R3) and Shipping Lines (SL1) stated that customer satisfaction will be improved, reflected in the reduction of customer queries. According to UNCTAD (2017), improved productivity results in reduced costs, impacting the overall supply chain including shipping lines, port authorities, terminals, cargo owners, cities and the country as a whole, thereby facilitating business growth. Furthermore, a study by De Villiers (2015) stated that the low hanging fruits with respect to improving competitive edge on the logistics performance is the rail shuttling, as compared to road trucks and barges (where applicable), which entails a significant contribution to cost reduction.

7.3 Conclusion

Chapter 7 of this thesis has detailed the research findings of the semi-structured interviews which were conducted to determine the context and problematic situation of the research study, with the intention to improve performance of the container terminal using a systems approach. The semi-structured interviews facilitated discovery of variables contributing to the operations of the container terminal. The research process resulted in identification of key themes starting with outlining factors that contribute to the inefficiencies of the container terminal. The second theme outlined critical factors for improving productivity of the container terminal, unpacking seven sub-themes essential for improved efficiencies. Lastly, the impact of productivity initiatives for the container terminal was expounded. This chapter contributed to the identification of critical input elements which became the foundation for the development of CLDs and rich pictures presented and discussed in Chapter 8 of this thesis. In the next chapter, the researcher presents the findings of the focus group workshops done from Causal Loop Analysis and SSM perspectives depicting CLDs, rich pictures, root definition, CATWOE Analysis and the conceptual mode for performance improvement of a container terminal.

CHAPTER EIGHT:

FINDINGS AND DISCUSSION OF FOCUS GROUP INTERVIEWS

8.1 Introduction

The main aim of the study was to investigate how the performance of a container terminal can be improved using a systems approach with respect to aspects of SD and SSM. This chapter reflects the findings of the focus group interviews, which were conducted in the form of SSM and Causal Loop Analysis Workshops.

8.2 Findings from Focus Group Interviews

There are instruments that are used to portray qualitative analysis acquired through interviews, focus groups and various forms of qualitative data within the systems approach. The Focus Group Interviews for the purposes of this study were analysed using aspects of the SSM process and Causal Loop Analysis, where perspectives of various stakeholders in relation to challenges, causal variables and improvement plans for container terminal operations, from a systems perspective, were reviewed. The findings are presented based on the two workshops conducted, this being the SSM and Causal Loop Analysis.

8.2.1 Causal Loop Analysis

In the light of the research collected through causal loop analysis workshop, CLDs were used to visualise the dynamic complexity that the container terminal operations consist of, including the various factors affecting container productivity. According to The Sustainability Laboratory (2019), the CLDs demonstrate the causal and impact relations of a problematic situation or behavioural pattern. They illustrate why certain behaviour exists and the practicability of proposed solutions. Reynolds and Holwell (2010) indicate that CLDs emanate from SD and are used to reflect the interconnection of various factors in a situation or environment. The CLDs were developed during a workshop where detailed deliberations were conducted with the research participants from the Port Authority, Port Terminal, Shipping Lines, Freight Rail and Haulier Operators. In a case where some participants could not make it to the workshop due to operational reasons, separate meetings were held with stakeholders to give input to the diagrams. CLDs drawn by the research participants in the workshop were later compared to the input that came from the semi-structured interviews with the intention of enhancing the drawings drafted during the workshop.

The diagrams drawn revealed the critical input elements from a systems perspective and linkages thereof, including the impact on each variable contributing to the ship turnaround time (STAT) of the vessel. A study by Soares and Neto (2016) found a SD model to be a useful tool in determining productivity and showing the underlying factors behind the system behaviour through simulation. According to Williams and Hummelbrunner (2010), CLDs have the capability to examine complex interconnections in a situation through use of feedback loops, which facilitate identification of areas of influence leading to a solution or understanding of underlying factors. The CLDs were drawn reflecting all factors impacting productivity of the container terminal from various dimensions including marine operations, terminal operations and hinterland operations.

8.1.1.1 Causal Loop Analysis for Marine Operations

The CLD for marine operations was drawn together with stakeholders during the Causal Loop Analysis Workshop as per the process outlined in the methodology chapter (Chapter 5) of this thesis.

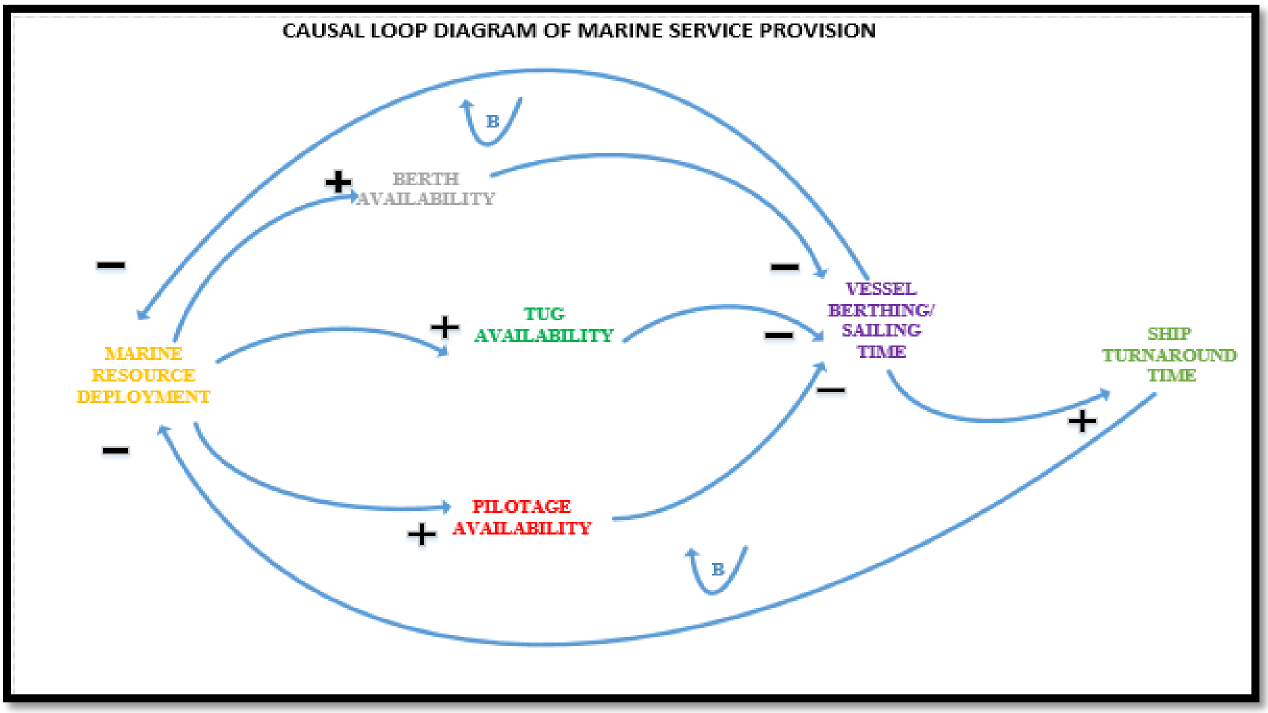

Figure 8.1: Causal Loop Diagram of Marine Service Provision and STAT

Figure 8.1 indicates that the marine resource deployment mainly driven by berth availability, pilotage and tug services, is crucial for the success of marine service provision to ensure improved STAT. The management of these resources is critical to ensure that the vessel is serviced timeously when arriving and sailing to and from the port. The positive management of these resources contributes positively to the quick turnaround of vessels in the port.

The results of the diagram are echoed by Rodrigue et al. (2014) and De Langen and Helminen (2015), who state that STAT is affected by multiple variables including berthing slot, terminal efficiencies, bunkering, ship chandelling services, pilotage and tug availability. Oktafia et al. (2017) further allude to the fact that pilotage and tug services are critical for berthing of vessels in the port. The causes of its unpredictability are the availability of pilots, fleet maintenance requirements, weather challenges including readiness of tugs and concurrent arrival of ships in the port. According to Zhang et al. (2020), pilotage remains an essential service for the navigation of vessels considering the complexity of the port situation which is affected by various factors, including crew, equipment and managerial challenges. This causal loop diagram has clearly shown the interdependencies existing within the maritime service provision for the successful berthing and sailing of the vessel which contributes to the improved STAT of the vessel.

8.1.1.2 Causal Loop Analysis for Waterside Operations of a Container Terminal

The CLD for the waterside operations is a result of a joint interactive input from research participants involved during the Causal Loop Analysis Workshop, as explained in Chapter 5 of this thesis.

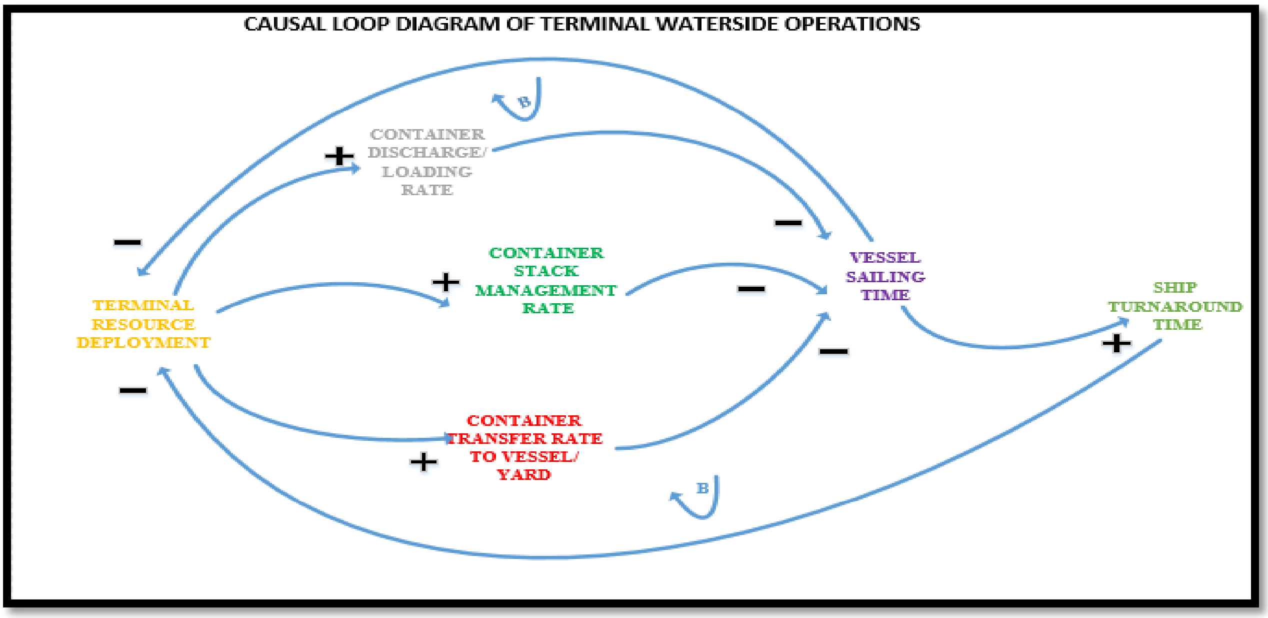

Figure 8.2: Causal Loop Diagram of Terminal Operations (Waterside) and Ship Turnaround Time

Figure 8.2 reveals that the positive management of terminal resources such as cranes, information technology systems (Navis System), ground staff, customs, stevedores and stacking space have an impact on container discharge and loading rate, stack management and container transfer rate. The deployment of terminal resources determines the container loading/offloading rate, transfer rate and stack management efficiency. The positive management of these resources facilitates a positive relationship with the dispatch/loading rate, transfer rate and stack management efficiency, which contributes positively to the STAT of the vessel. The research findings are supported by Ridwan and Noche (2016), who conducted a causal loop analysis of port operations and productivity levels using SD with the intention of developing enhancement initiatives to minimise the vessel idle time and organisational failure costs. The research outcomes revealed that the deployment of cranes determines the productivity rate of discharging and loading cargo at any particular time. The results also indicate that improved crane productivity will result in reduction in the vessel waiting time.

The research findings by Nyema (2014) also indicate that various factors influencing container productivity, among them yard capacity, crane performance, infrastructure and custom processes. De Langen and Helminen (2015) indicate that crane productivity, including its causal elements, such as the type of cranes and skill set of drivers, are critical components of productivity. Schroder (2013) and the Journal of Commerce (2014) emphasise the need for accurate and adequate equipment to maximise operations, and avoid bottlenecks. The findings as per Figure 8.2 and in the literature review, reflect that an improvement in one area of the system yields positive results in another area, clearly implying interlinks of the system which affect the overall outcome, in this case, ship dwell time.

8.2.1.3 Causal Loop Analysis for Hinterland (Landside) Operations

The causal loop diagram in Figure 8.3 concluded with stakeholders, shows that there are various factors from a hinterland perspective impacting on the STAT of a vessel, including rail and road aspects. The aspects from rail perspective vary from train slot availability, wagon availability, equipment availability, train crew, yard staff, shunting crew and fluid rail line that impact on efficiency of the movement of cargo from various destination including inland terminals to the port. The container transfer efficiency rate influences the arrival of cargo in the port which automatically impact on the sailing time of the vessel and subsequently, the turnaround time of the vessel. An investigation by Chen et al. (2016) examined the hinterland connectivity of the container terminal in Malaysia considering transportation linkages and inland terminals. The study recommends that among other initiatives, the improved road to rail modal split, rail capacity and train services should be advanced as part of strategies to augment hinterland connectivity.

This investigation by Chen et al. (2016) is aligned to the research findings as per Figure 8.3, indicating that the improvement in rail services will ensure efficiencies in arrival of cargo in the port impacting on enhanced terminal operations. The diagram clearly demonstrates the causal impact of rail service provision on the STAT.

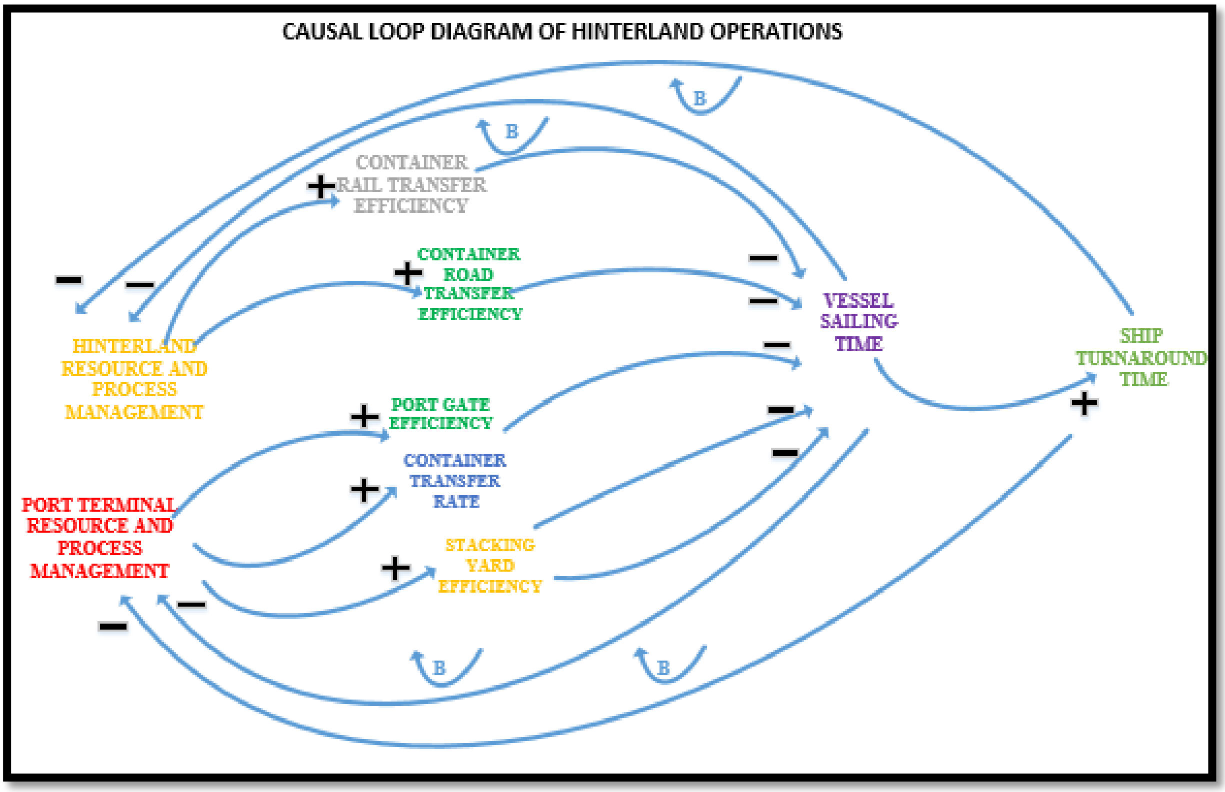

Figure 8.3: Causal Loop Diagram of Hinterland Operations (Landside) and STAT

From a trucking perspective, the critical input elements are truck availability, truck drivers, fluid road network and use of a truck booking system. A study by Zhang et al. (2013) recommended use of the truck appointment system as a tool to positively manage the TTT. Management of rail and road transport resources ensures that cargo is dispatched timeously to nearby port rail yards and port gates, which facilitate transfer of containers to the stacking yard. From a terminal perspective, the availability of the equipment and gang availability including IT systems guarantee a positive stack management which will ensure a smooth flow of containers from the stack yard to the ship contributing to the desired results of the improved STAT. Ramírez-Nafarrate et al (2017) utilised a simulation model and a heuristic process to investigate implementation of truck appointment system on container terminal operations and turnaround times. The research results revealed that terminal operations including TTT will be impacted positively.

De Villiers (2015) further alludes to the fact that the overall supply chain should be capacitated to make provision for the increased number of container volumes moving through trains and trucks from the terminal. The focus in increasing capacity must not only be on the quay side but also on the inland terminals, where the value-added logistic functions can be executed.

The diagram together with literature has outlined that the terminal resource and process management will yield positive results on terminal operations with respect to port gate, container transfer and stack management efficiency with improved outcomes on both the vessel sailing time and STAT. Similarly, the hinterland resource and process management bring progressive outcomes to road transport container transfer rate which has influence on the vessel sailing time and eventually on STAT.

8.2.1.4 Joint Causal Loop Analysis for Container Terminal Operations reflecting Marine, Terminal and Hinterland Perspectives

The combined CLD reflecting overall container terminal operations was concluded through input of the various stakeholders attending the Causal Loop Analysis Workshop held.

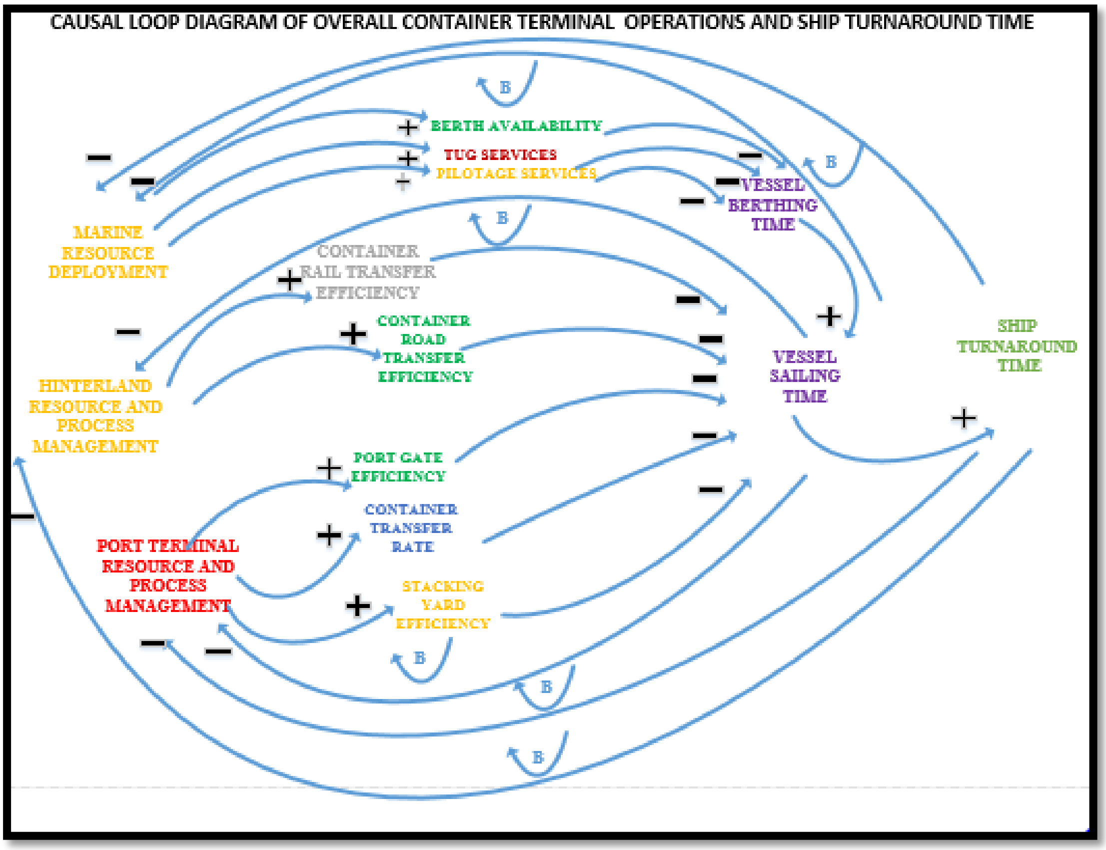

Figure 8.4: Causal Loop Diagram for Overall Container Terminal Operations and STAT

Figure 8.4 indicates that the operations from a maritime, terminal and hinterland perspectives are critical for achieving improved STAT in the port. According to Ridwan and Noche (2016), the vessel dwell time is influenced by the efficiency of tug services, together with crane utilisation, considering that productivity of cranes determines container handling rate. The results are also supported by Felicio et al. (2015), who state that port and terminal features including infrastructure and port services, contribute to the competitiveness of the port and have to be reviewed systematically to guarantee improvement in service reliability. The picture shows that the positive management of marine resources will contribute towards timeous berthing and sailing of a vessel which impact STAT positively. The progressive management of container terminal resources and processes will ensure smooth operations with respect to process of trucks at port gate, yard stack management and cargo transfer from yard to vessel. From a hinterland perspective, the resource management of rail and road transport contributes positively towards transfer of containers from hinterland to the port for loading of cargo on the ship. Acciaro and McKinnon (2013) further state that it is vital that the hinterland is capacitated with adequate infrastructure and optimal transport services to advance the effectiveness of the overall supply chain. They further indicate that the areas of focus in the advancement of hinterland supply chain are dry ports, container transfer by road and rail and port gate systems, which are aligned to the finding of this study.

This analysis shows that the effective management of maritime, terminal and hinterland dimensions are all critical for the successful management of container terminal operations which guarantee quick turnaround time of a vessel. A gap from one dimension will have an impact on the overall operations, resulting in STAT targets not being met. The analysis is supported by the National Research Council (1986), which stated that marine terminal operations have linear processes, implying that each process is critical for the succeeding activity and the productivity for dimension depends on the interaction with other developments. Furthermore, Williams and Hummelbrunner (2010) emphasise that SD facilitate analysis of the overall supply chain and assist with identification of gaps, thereby making provision for emergence of innovative solutions within the logistics chain. They indicate that having a full comprehension of underlying factors between variables enables recognition of areas of leverage that could result in a solution and a grasp of why an alteration in one area can result in changes in the interactions of the overall circumstances at hand.

The CLDs of the overall container terminal operations show the dynamic relationships among various variables within the port ship working period which facilitate the identification of enhancement initiatives for improving productivity of the container terminal. Soares and Neto (2016) allude to the fact that the port activities involved in container handling are dynamic and require SD in exploring the input and output elements considering its usefulness in examining complex processes for development of strategies. The development of the systems dynamics model enabled classification of critical elements contributing to the productivity of the container terminal through the use of feedback loops with the intention of developing a strategy for enhancing competitiveness of the port.

Williams and Hummelbrunner (2010) endorse CLDs as valuable tools for displaying and analysing close connections of any environment while distinguishing the fundamental reasons behind the *status quo*. The study developed the CLDs for the three operational dimensions impacting on the productivity of the container terminal, namely, marine, terminal and hinterland. An overall CLD showing how each dimension from marine, terminal and hinterland perspective of port operations contribute towards STAT of vessels was created. The CLDs were diagrammed using Microsoft Visio which is a computer software that enables network diagrams, charts and layouts to be drawn with text showing various linkages among various variables. Williams and Hummelbrunner (2010) state that SD facilitates a process for identification of the critical variables in an environment and investigates their connection and how they impact each other. Diagramming of container terminal operations through systems dynamics enabled identification of key factors contributing towards productivity of the container terminal, having identified the STAT as the main output indicator of port performance.

8.2.2 Soft Systems Methodology

The researcher deployed only first three (3) SSM process steps to conduct this research, as discussed in Chapter One of this research, as the research objectives focused on enhancing container terminal productivity rather than developing a systems model. The first step involved findings of the semi-structured interviews which were utilised to ascertain the context and problematic situation of the research study as per the content contained in Chapter Seven. According to Walker and Steinfort (2013), SSM is an ideal instrument to illustrate chaotic multifaceted problems with the intention to comprehend the background. The second step involved defining the challenging circumstances through the development of rich pictures showing processes, stakeholders, their complaints, and interrelationships. The third step incorporated identification of critical relevant perspectives from the problem themes and development of a root definition, CATWOE and conceptual model for the main issue.

The second and third steps were conducted through the SSM workshop held, where detailed discussion ensued with the research participants from the Port Authority, Port Terminal, Shipping Lines, Freight Rail and Hauler Operators. The researcher took on the role of facilitator during the workshop and took the lead in order to create an environment where participants were able to express their opinions freely and to produce rich and useful information from various stakeholders for the development of rich pictures, root definitions, CATWOEs and conceptual models. A study by Proches and Bodhanya (2015) endorsed the importance of SSM tools with respect to facilitating discussions while engaging participants. SSM enabled identification of differing objectives for the stakeholders and problematic areas within the sugar industry, thereby affording an opportunity for the team to come with a strategy that will advantage all players. A study by Dalkin et al. (2018) also suggests that SSM provides an opportunity for stakeholders to outline complex problems and facilitate a process for resolving the multifaceted challenges encountered. They argue that the exceptional contribution of SSM is the joint use of stakeholder engagement through qualitative research and mapping through CATWOE analysis. The use of the SSM process brought significant value through stakeholder engagement and mapping in both studies by Proches and Bodhanya (2015) and Dalkin et al. (2018), hence it was considered as a useful tool for this research.

Checkland and Poulter (2020:210) stated that development of rich pictures allows capturing of the key subjects, structures, processes and perspectives of the environment and challenge under investigation. Through engagement of people in interviews, rich pictures facilitate in-depth discussions as it reflects various relationships that have to be managed over time. They are found to be instrumental in articulating critical associations which serve as underlying subjects of discussions. Rich pictures were used to display the various elements involved in the container terminal operations and their relationships and connections. In a case where some participants could not make it to the workshop due to operational reasons, separate meetings were held with the stakeholders to give input to the rich pictures. The rich pictures drawn revealed the complexity of the situation and the dynamic nature of linkages and interdependencies contributing towards the ship turnaround of the vessel.

A study by Feldman and Kirkham (2017) used rich pictures to comprehend the participant's role for the period of the Enterprise Systems Advancement Decisions. Utilisation of rich pictures provided the required insights and confirmed the value of stakeholder engagement for decision-making on Enterprise Systems Advancement which can be used to develop the conceptual framework for the system. The pictures were drawn together with stakeholders as per the process outlined in the research methodology, where participants provided available organisational process maps which were reviewed and enhanced to come with the required pictures covering all dimensions of port productivity. The process was found to be complex by partakers but fulfilling, as it assisted with unpacking critical details that ensure that the actual operations are implemented fully without hurdles. It also assisted with identifying gaps that exist in each subsystem where there are interconnections from one stakeholder to another. The rich pictures were drawn considering all dimensions of container terminal productivity, including marine operations, terminal operations and hinterland operations.

8.2.2.1 Rich Picture Analysis for Marine Operations

The rich picture in Figure 8.5 depicts the marine operations starting from the period the ship arrives at port anchorage to the point when the vessel is docked along the berth. It reflects the various elements and processes that are undertaken to dock the ship and the problematic situation impacting operations. From a marine perspective, the shipping lines encounter vessel queues at anchor wondering when their vessels will be serviced. These delays are costly as some liners have chartered these vessels. There are various dependencies for the vessel to be docked timeously which is reliant on the berth, berthing crew, pilotage and tug availability. The pilotage availability is dependent on the readiness of pilots and the helicopter, alternatively the pilot boat master and pilot boat. Tug availability is reliant on the critical skills being available such as Tug Masters, Chief Marine Engineering Officers and Marine Engineering Officers. The berthing crew requires the availability of General-Purpose Rating, Motorman and Coxswain. Without all the resources and processes being in place, the vessel will not be serviced timeously with respect to berthing and sailing.

A study by Oktafia et al. (2017) indicated that collaboration is required between the administration office, tugs and pilots in order to ensure that the berthing and unberthing procedure is effective. This process requires both the pilotage and tug service providers to be available at the same time for it to be actioned. Without the two providers collaborating, there will be no good service delivery, resulting in customer complaints.

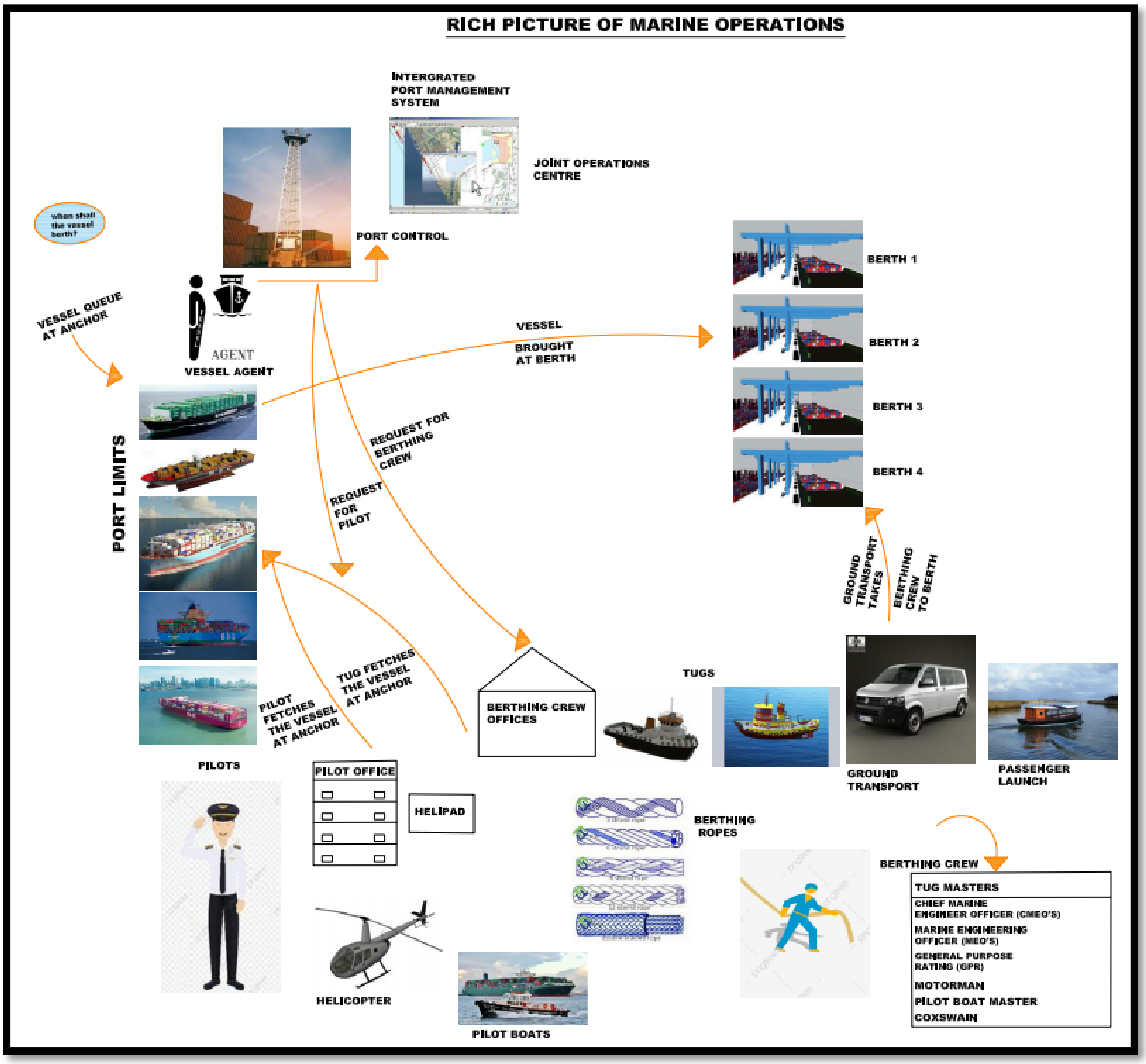

Figure 8.5: Rich Picture of Port Marine Operations

8.2.2.2 Rich Picture Analysis for Terminal (Waterside) Operations

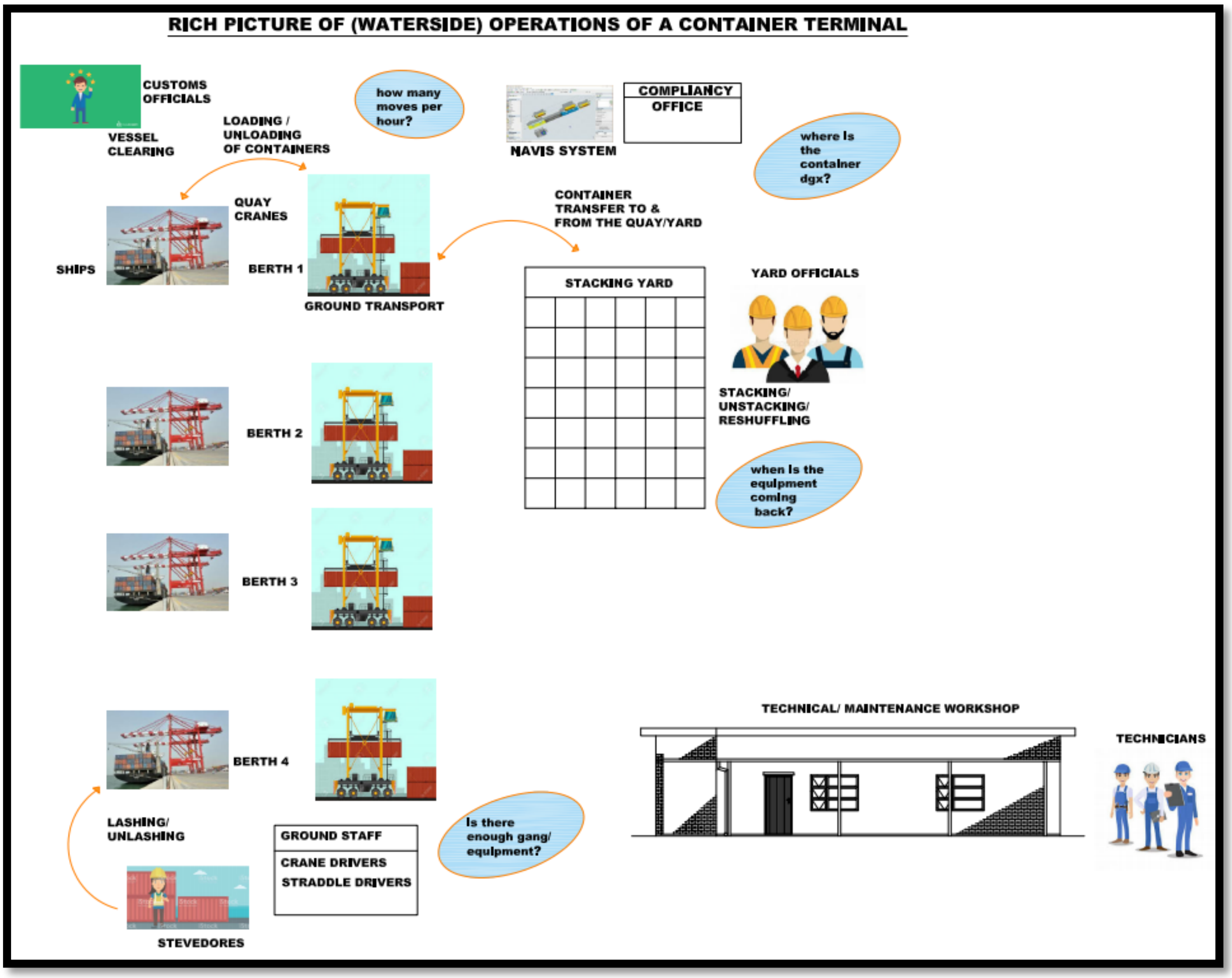

Figure 8.6: Rich Picture of Waterside Operations of a Container Terminal

The rich picture in Figure 8.6 depicts the waterside operations of the container terminal, starting from the period when the vessel is docked along the berth to unload containers to a time when it has loaded containers and is ready to leave the berth. It shows the various input elements and processes essential for container handling and the challenges encountered during this process. The ship turnaround time from a container handling perspective is dependent on stevedore readiness to lash and unlash the vessel, customs response time clearing the vessel, Operational Navis System, crane and gang availability and stack management. The shipping lines are concerned with the number of container movements per hour on their vessel to facilitate the quick turnaround time of their vessel. Crane availability is dependent on gang availability including the response time for maintenance work, as some cranes do not come back to operation timeously, impacting on the vessel operations. With respect to stack management, there is a lot of reshuffling of containers resulting in delays with boxes that need to be loaded on the vessel, which impacts on the ship dwell time.

8.2.2.3 Rich Picture Analysis for Hinterland (Landside) Operations

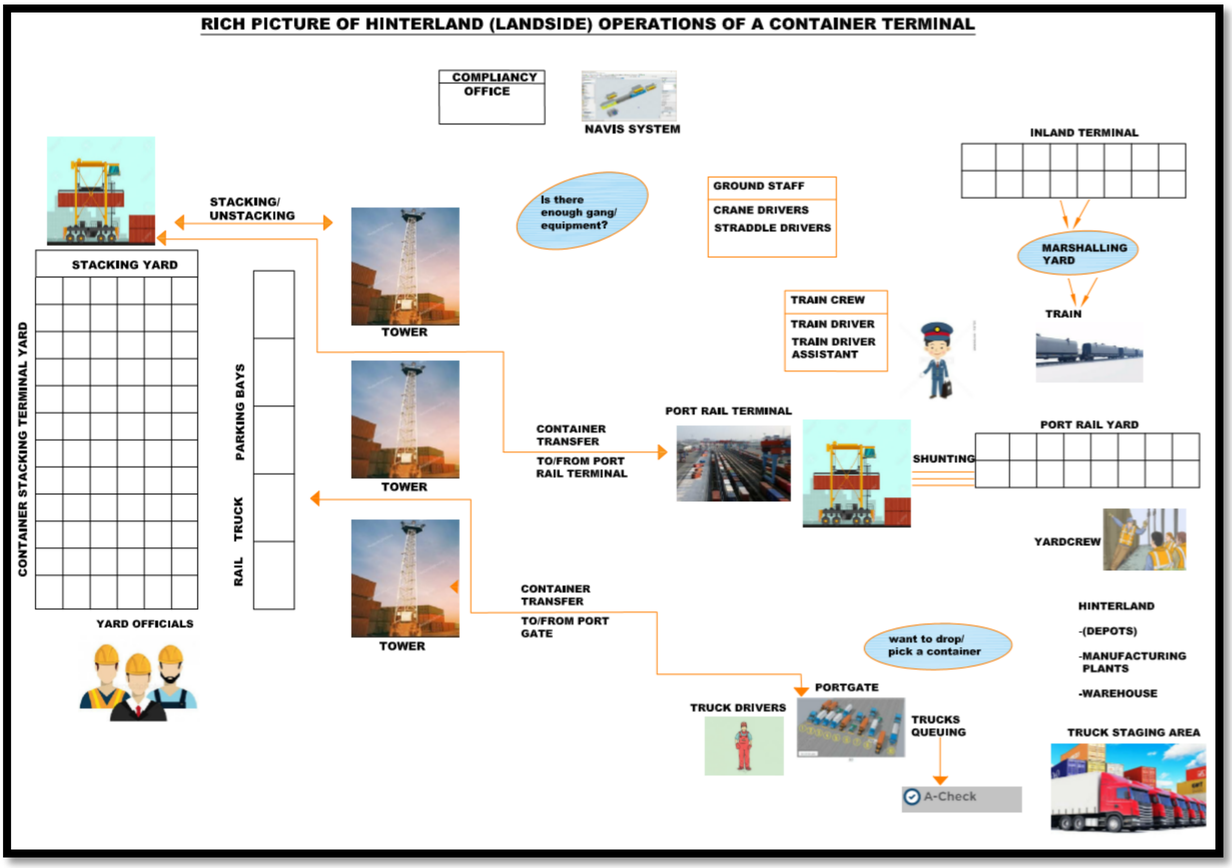

Figure **8.7: Rich Picture of Land Side Operations of a Container Terminal**

The rich picture in Figure 8.7 shows the landside operations of the container terminal starting from the period when cargo leaves the hinterland mainly inland terminal, manufacturing plants and warehouses, to the point where containers are stacked at the terminal. There are various dependencies for this operation, including rail resources and road transport availability. The rail transport gets affected by various challenges such as availability of wagons and cable theft, affecting arrival times of containers to the terminal. From a trucking perspective, the truckers are challenged with road congestion within port parameters, wondering when they will get a turn to drop or pick up a container from the terminal. From a terminal perspective, specifically landside operations, the resource availability from equipment and human resource perspective for transfer of cargo from road and rail transport to stacking yard is problematic. A paper by Acciaro and McKinnon (2013) states that there are three major parts of the hinterland dimension contributing to value creation of the container terminal operations: port gate systems, transportation mode and dry ports.

A paper by Chen et al. (2016) assessed the seaport-hinterland connectivity of the container terminal in Malaysia, considering transportation modes and inland freight terminals. The study proposed that hinterland connectivity be improved by deploying strategies that will advance rail capacity and service and debottlenecking road networks including expansions of inland terminals. The study by Chen et al. (2016) reflects on the critical components for enhancing hinterland operations which contribute to terminal productivity and aligns with the study, as reflected in Figure 8.7.

8.2.2.4 Rich Picture Analysis of Overall Container Terminal Operations

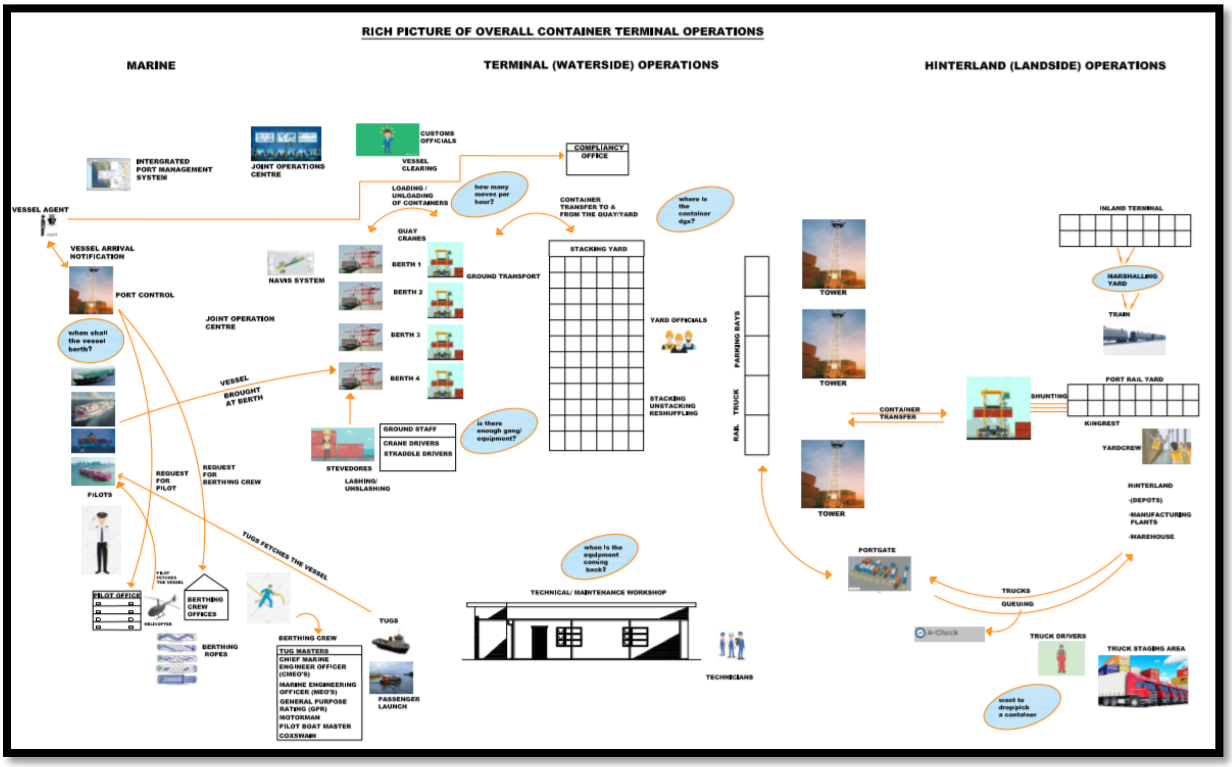

Figure 8.8: Rich Picture of Overall Port Container Terminal Operations

Figure 8.8 reflects the various input elements involved in the container terminal operations from a system perspective with respect to marine, terminal and hinterland dimensions. A study by Fadhil et al. (2018) used rich pictures to define the problematic environment from various dimensions reflecting process framework and interrelations, including areas of misunderstanding and uncertainty within a Gayo Coffee Agro Industry.

Engagement in the rich picture transformed an unstructured problem situation into an expressed situation, and enabled the selection of relevant systems from the problem themes. Some of the relevant systems that emerged from the problem themes are as follows:

1. Reduction of Port Vessel Delays
2. Elimination of Port Congestion
3. Prevention of Introduction of Surcharges
4. Reduction of Rail Delays
5. Improved Delivery Times of Cargo to destinations
6. Improved Container Terminal Productivity
7. Reduced Cost of doing business in SA
8. Creation of an efficient supply chain from the waterside to the hinterland
9. Improved Ship Turnaround Time

Out of the various system issues discussed, improved ship turnaround time at the container terminal emerged as the main system model that required prioritisation. The process to be followed after the emergence of the main theme for resolution was the development of root definition and conceptual model and unpacking of the CATWOE analysis. The SSM approach incorporating rich picture, CATWOE analysis, root definition and a conceptual model, was used to describe and develop a structure for the Ministry of Petroleum in Iran in resolving cancer problem. The SSM facilitated a process of constructing framework to improve the condition by identifying system structure, main players and customers, including their interactions through various engagements with affected departments (Sepehrirad et al., 2017).

8.2.2.5 Root Definition, CATWOE and Conceptual Model

Tables 8.1 and 8.2 and Figure 8.9 respectively present the root definition, CATWOE and conceptual model, corresponding to a system for the improved ship turnaround time at the container terminal. According to Zlatanović and Mulej (2015), the practical tools for SSM are conceptual models, root definitions and rich pictures. A conceptual model which is an action to be assumed in order to form a system which can be benchmarked with the actual reality in order to improve the problem area was developed, as per Figure 8.10. Rich pictures as depicted in Figures 8.5 to 8.8 were used to identify relevant insights, norms, principles and stakeholders, for consideration in the development of root definitions. Root definitions as per Figure 8.9 were developed taking into account key issues and principles that would result in innovation for the improvement of the problematic area.

8.2.2.5.1 Root Definition of the Improved Container Terminal

The discussion that took place during the development of the rich picture and CATWOE analysis assisted with the development of the root definition and conceptual model. As stakeholders were engaging on mapping the CATWOE, the process assisted with outlining what problem requires to be solved and who were the critical actors and owners of the system to ensure transformation which is aligned with the worldview considering all environmental considerations. This process managed to produce the root definition as per Table 8.1.

Table 8.1: Root Definition of the Improved STAT at the Container Terminal

A port and terminal owned system operated by the Port Authority, Port Terminal, Road Haulers and Freight Rail to ensure quick turnaround of container vessels based on agreed performance targets through provision of adequate resources from equipment and human resource perspective from maritime, terminal and hinterland perspective subject to weather conditions.

8.2.2.5.2 CATWOE Analysis of the Improved STAT

The CATWOE for the improved Ship Turnaround Time of the Container Vessel as per Figure 8.2 indicated that the main direct **customers** serviced are the shipping lines. It was noted that different research participants who are stakeholders in the port had different customers; however, shipping lines were identified as the key stakeholders as they are the ones who are directly affected by the service provided. Stakeholders such as the Port Authority, Port Terminal, Freight Rail, Road Haulers and Inland Terminals are considered as the main **actors** as they play a significant role in ensuring that the ship is worked efficiently.

The process of **transformation** was to ensure that there is improved ship turnaround time which was considered as the main output element. It was noted that the key input elements are the motivated workforce and adequate machinery and equipment from a maritime, terminal and hinterland perspectives. The process should involve automation of some of the operations, integration of Information Technology Systems, alignment and cohesion of key stakeholder strategies, introduction of barge operations, development of back of port facilities and changes in rail service design. The changes in rail service design incorporates introduction of longer trains (100-wagon train) to compliment the bigger ships which are bringing the large parcel sizes in the port.

The main **owners** for the process were considered to be the Port Authority, Port Terminal and Freight Rail as they hold key game changing initiatives for the transformation of the identified problem. Considering the **worldview,** the solution for the problem under investigation will have a positive impact on communities surrounding the port, the businesses that are dependent on port for their existence, the importers and exporters of cargo, local and foreign investors and the competitiveness of the country.

The problem issue resides within an **environment** that has different landscapes such as political, business and socio-economic conditions. The political environment is impacted as the ports fall within the state under the Ministry of Public Enterprise whose mission is also to drive a socio-economic mandate. The performance of ports can also be prohibited by the social aspect which the governments need to fulfil for the country. In the process, the business environment can be affected considering that non-delivery by ports could result in loss of business in various aspects. Shipping lines are likely to change trade routes and avoid including the port in their voyage, which will result in loss of market share for the South African Port System. The port inefficiencies experienced result in late delivery of cargo to the various destination including the manufacturing plants whose business gets affected, leading to loss of jobs and businesses. The economy will be directly and negatively impacted, as the inefficiencies result in the increased cost of doing business which has consequences for the competitiveness of the country.

The CATWOE analysis allowed key customers, main actors and owners to be identified for the key problem being experienced. This process also enabled the process of transformation to be outlined, reflecting on the output and input elements. Defining the worldview and explaining the environment was critical to see the impact of the resolution of the problem and the environment in which the problem exist. Key themes emerged from the various stakeholders as the CATWOE analysis was unpacked. The use of SSM is supported by Kulikov et al. (2019), who used the approach to describe a complex problem and developed a framework that enabled identification of the source of the issue and relevant solutions to knowledge gap within the Information Technology Graduates through a CATWOE analysis. Salavati and Mirijamdotter (2017) also indicate that SSM does not only assist with outlining and configuring multifaceted problems, the methodology allows a holistic view of the situation, delineating a number of areas and emerging issues.

Table 8.2: CATWOE of a port and terminal-owned system

C	Shipping Lines
A	Port Authority, Port Terminal, Freight Rail, Road Haulers, Inland Terminals
T	Ensure improved ship turnaround time
W	Follow the best port practices to ensure improved ship turnaround time to facilitate the port and country's competitiveness
O	Port Authority, Port Terminal, Freight Rail
E	Available input resources, weather, political landscape, social and economic environment

8.2.2.5.2 Conceptual Model for a System for Improved STAT of the Container Vessels

Through the various stakeholder engagements, the problem definition and project goals were identified as follows:

i. Problem Definition: Poor Ship Turnaround of Container Vessels in the Port of Durban
ii. Project Goals: To improve the vessel turnaround time of container vessels in the port

The developed conceptual model in Figure 8.9 for the improved ship turnaround time identifies required activities needed to improve marine, terminal and hinterland activities within the port and terminal owned system. The management of marine resources to berth a vessel, terminal resources for handling of containers and hinterland activities for transfer of cargo, are critical in ensuring improved ship turnaround time. A study by Hildbrand and Bodhanya (2017) used SSM and the Viable System Model to determine how these methodologies can assist in defining the complexity entailed in the sugarcane supply chain. The outcomes of this study aided with the identification of soft issues which can serve as a source for improvement within the sugarcane systems.

A study by Toukan and Chan (2018) utilised SD to develop a conceptual model that depicts causal relationships within the Jordan's container transportation chain with the intention to evaluate the influence of alternative solutions to the challenges experienced. The results revealed that the third alternative solution, being a combination of investments on hinterland and use of technology for minimising documentation processing period, was more significant as compared to the first and second alternative solutions. However, while the third initiative was effective, the other effect was increased fleet deployment which resulted in terminal congestion, requiring a holistic view by decision-makers when considering implementation of the solution. This study emphasises the need to review the situation holistically in order to implement a solution that will be beneficial to the overall system. The proposed activities for improvement of marine, terminal and hinterland operations may need to be simulated to determine the impact of the proposed solutions.

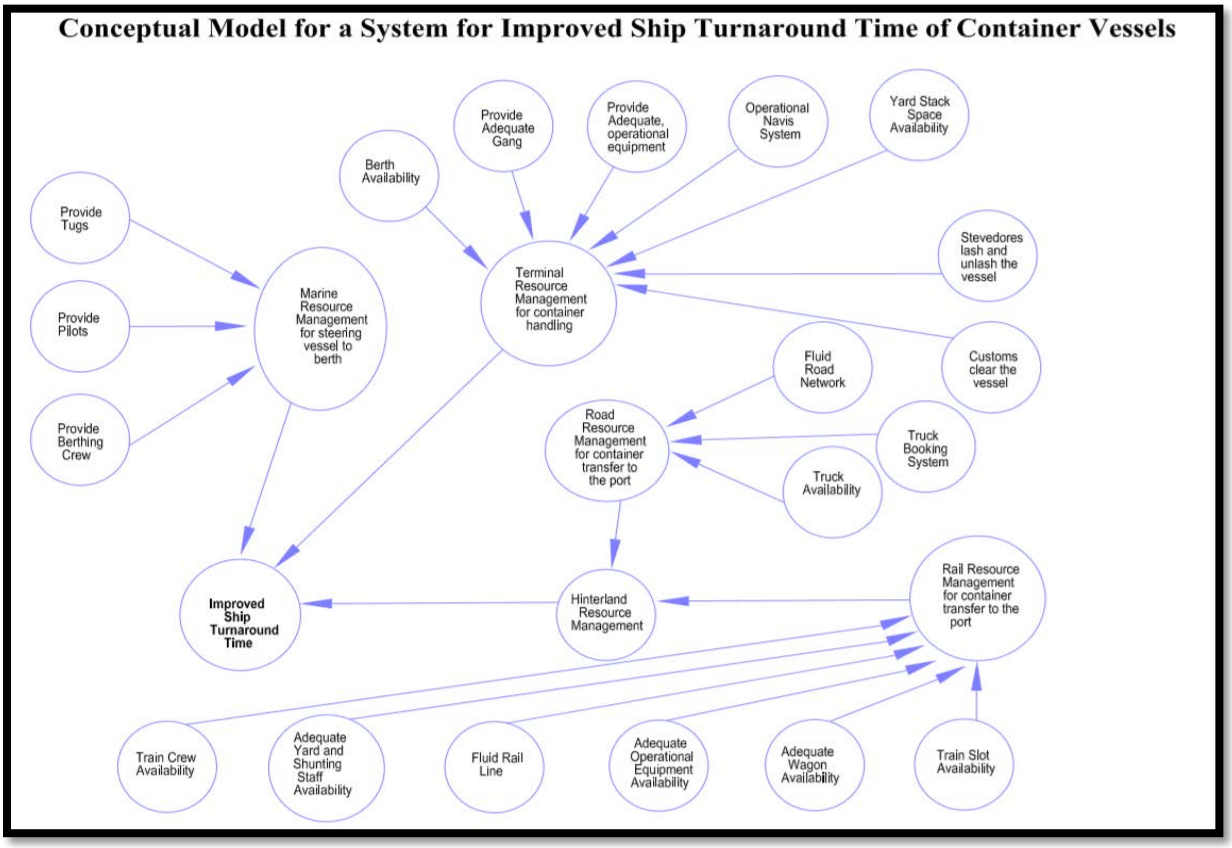

Figure 8.9: Conceptual Model for an Improved STAT in a Container Terminal

In the midst of complex issues and chaotic environments encountered at the container terminal, it is sometimes not easy to identify the real problem that require resolution. This is caused by the various problematic variables that impact on each other. When the situations are looked at in isolation, it is easy to identify the problem that one is confronted as the main problem, with a big picture behind the problem. A study by Abdel-Fattah (2013) resolved berth allocation and quay crane apportionment challenges by applying a SD through use of a conceptual model to solve the problem.

The conceptual framework was useful in determining how factors impacting system behaviours, including but not limited to resource utilisation and productivity levels, can be elevated. The model delivered an optimisation strategic direction which could be utilised for enhancement of container terminal productivity. Williams and Hummelbrunner (2010) indicate that a full comprehension of underlying factors between variables enables recognition of areas of leverage that could result in a solution and a grasp of why an alteration in one area can result in changes in the interactions of the overall circumstance at hand. Shepherd (2014) further stated that a holistic methodology is required when resolving the transport challenges being faced by the industry.

This exercise enabled the research participants to unpack the various problematic areas within the port environment from different perspectives. It assisted the research participants to identify the critical areas that require attention. It also facilitated discussion to discover the real problem underlying the various messy impacts in the port. A study by Fadhil et al. (2018) used the SSM approach to investigate the improvement of the quality management system of Gayo Coffee Agro Industry. The study discovered solutions to enhance the quality management system of the industry by involving various stakeholders through development of rich pictures, root definition, conceptual model and CATWOE analysis.

8.3 Linkage of Research Findings between Causal Loop Diagrams and SSM Processes

The aspects of the systems approach utilised in this research, that is, CLDs and SSM process steps, played a complementary role with respect to research findings of this study as each approach and step played its unique role in assisting to come with the required research outcomes. The CLDs facilitated a process of determining causal relationship within the maritime, terminal and hinterland dimensions. Moreover, they also established causal and effect factors impacting one dimension to another, thereby discovering the fundamental elements contributing towards the overall system, in this case, productivity of a container terminal.

On the other hand, the SSM process steps also played their distinct role with the development of the root definition, CATWOE Analysis, rich pictures and conceptual model. Through the root definition, the process assisted with identification of problem definition and project goals, thereby outlining the system together with its elements considering all situational conditions. The rich pictures enabled identification of critical input elements contributing towards container terminal productivity, while the CATWOE analysis allowed critical stakeholders, factors and processes for the project goal to be identified in terms of customers, actors, owners, transformation processes and environmental considerations.

8.4 Conclusion

This chapter has provided a detailed presentation of the findings of the focus group interviews which were conducted in the form of SSM and Causal Loop Analysis Workshops with the intention of improving performance of the container terminal using the Systems Approach. The findings of the research were presented in two forms: firstly, findings arising from the SD perspective and secondly, findings arising from the SSM. The findings from the SD perspective were reflected in the form of CLDs indicating how different variables in a system are interrelated. The SSM results were projected in the form of the rich pictures, root definitions, CATWOE Analysis and the conceptual model. The proposed solution is to develop an improvement plan from the three dimensions, that is, marine, terminal and hinterland, with the intention to improve the ship turnaround. In the next chapter, the researcher outlines the conclusion and recommendations of the study.

CHAPTER NINE:

CONCLUSION AND RECOMMENDATIONS OF THE STUDY

9.1 Introduction

The intention of the study was to investigate and explore the relevant aspects of a systems approach and how the performance of a container terminal can be improved using this methodology, with particular focus on elements of a soft system methodology and systems dynamics. A sensitivity analysis determining critical performance indicators influencing productivity of the container terminal from a marine, terminal and hinterland perspective, was also conducted. Further to that, a systematic approach to acquire expert opinion through semi-structured interviews to determine the problem and ascertain the critical factors impacting the system behaviour was conducted. Lastly, the aspects of the two methodologies of a systems approach, that is, SD and SSM, were used to analyse container terminal operations using CLDs, conceptual models, root definitions and rich pictures with the intention to ensure terminal productivity improvements. This chapter provides the conclusions of the study based on the findings of the research which were elicited from literature review, secondary data analysis, semi-structured interviews and focus group interviews. Additionally, the chapter incorporates recommendations to improve container terminal productivity through a systems approach. Finally, it shows how the study has contributed to new knowledge and offers suggestions for future research.

9.2 Conclusion of the Study

The conclusion of the study is provided, based on the findings from the secondary data analysis, semi-structured interviews, and focus group interviews, coupled with the literature review, as follows:

9.2.1 Secondary Data Analysis of Port Key Performance Indicators

The main aim of this section was to conduct a sensitivity analysis to determine the critical performance indicators influencing productivity of the container terminal from a marine, terminal and hinterland perspective, using secondary data. It must be noted that the sensitivity analysis conducted is not part of the systems methodology; however, the process allowed analysis of key performance indicators within a system considering all subsystems affecting productivity of the container terminal, thereby providing input to the overall research enquiry. A regression and multiple regression analysis were conducted with all key variables being monitored by the shareholders from a maritime, terminal and hinterland perspective for the period under the investigation. The variables investigated were STAT, Anchorage Waiting Time, GCH, SHW, TTT and RTT, where STAT was considered as the main output element while the rest of the key performance indicators were regarded as input variables.

The results of the regression analysis between the ship turnaround time and each independent key performance indicators revealed that every variable had some contribution towards the ship dwell time with each variable having R squared of less than 50%. However, the coefficient results of GCH, SWH and RTT generated values of -4.274301, -1.367773, -6.615887 respectively, while the results of anchorage waiting time and TTT generated positive coefficients of 0.2908472 and 0.358152. The results of the Multiple Regression Analysis from each Dimension of Port Productivity illustrated that of the three dimensions, the terminal perspective contributed the most to port productivity with an R squared of almost 50%.

The multiple regression analysis results of all dimensions combined from marine, terminal and hinterland perspectives demonstrated that about 79.17% changes in STAT are explained by anchorage hours, GCH, SWH, RTT and TTT. However, the coefficient result of GCH, SWH and RTT have negative coefficients of -2.50502, -0.2317731 and -5.14768 respectively, while the results of anchorage hours and TTT generated positive coefficients of 0.2037635 and 0.1362358, which is aligned to the outcomes of the regression analysis.

The sensitivity study concludes that the most delicate input elements for the Port of Durban in order to develop the relevant enhancement strategies to improve ship turnaround time emanate from both a terminal and hinterland perspectives with emphasis on enhancing GCH, SWH and RTT. The improvement in GCH, SHW and RTT has a significant contribution on the STAT leading to a reduced dwell time of ships in the port. There is no significant relationship between the STAT and anchorage waiting time as this variable cannot be considered as a variable that contributes to the ship dwell time: it is counted once the vessel passes the port breakwater. The statistically insignificant results between STAT and TTT are not aligned with theoretical knowledge, hence require further investigation. The study further concludes that of the three dimensions impacting productivity of the terminal, the terminal perspective contributes the most accounting to almost 50% of port productivity, followed by hinterland activities which account for nearly 45%.

9.2.2 Semi-Structured Interviews

Through semi-structured interviews, the study established the context and problematic situation of the research study which facilitated a process of ascertaining the critical factors impacting the system's behaviour and fundamental dynamics for improving terminal productivity and their impact.

9.2.2.1 Critical Factors Impacting the Behaviour of the Port System

The study outlined some of the factors contributing to inefficiencies from a marine perspective as berthing delays ranging from one day to 5 days and weather conditions due to high winds. These delays have a multiplier effect on costs considering additional charter costs incurred on top of the berthing fees, transhipment costs as a result of skipping ports, and extra bunker fuel fees to get to another port.

From a terminal perspective, the bottlenecks experienced ranges from employee absenteeism, poor stack management, poor housekeeping in the terminal yard, customs box clearance process, terminal layout and inadequate equipment. The extended vessel changeover period ends up lasting for 6-10 hours *versus* 4 hours, while poor housekeeping results in straddle carriers running long distances to move cargo, including back stacking containers. The subsequent outcome of inefficient custom clearance process is late nomination of transport leading to delays with pick up of cargo and bottlenecks in the port system. The Z shape of the terminal limits the stacking capacity up to three levels high and to straddle operations only on certain quays. The inefficiencies experienced results in the longer dwell time of the ship in the port, leading to huge financial loss as a result of skipping ports, chartering vessels and burning more bunker fuel to get to other ports on schedule.

The study found that the inefficiencies experienced from a hinterland perspective emanate from the ineffectiveness of rail service, terminal bottlenecks and management of road transport logistics. The issues experienced from a rail perspective relate to lack of availability of wagons, change of stack dates by customers, inland containers not packed as per the terminal stack date, defective equipment, cable theft and network challenges leading to delayed export boxes and less than targeted number of trains. The other problem experienced is the different shift system from Port Terminal and Rail Division, resulting in the loss of two to three hours at the beginning of every shift, thereby impacting operations.

The terminal bottlenecks impacting hinterland operations relate to constraints with space, equipment, and stacking. The container terminal uses a common space for road trucks and rail wagons, creating congestion at the port. Similarly, the terminal uses common equipment such as straddles and mafia trailers which are used to load truck and also utilised to load wagons impacting on the turnaround time of wagons and trucks. The common stacking yard is also used for road trucks and rail leading to shuffling of containers, which contributes to the delays including wagon turnaround time and TTT.

The research further concluded that road transport challenges experienced at the Port of Durban are due to limited road lanes leading to the terminals, lack of use of truck appointment system and picking up of containers at the last moment. These issues are compounded by the fact that depots, warehouses, factories and other facilities are not open during the weekend to bring or collect cargo to the port, resulting in congestion during the week. All these factors result in extended truck waiting times and huge congestion at the port in peak hours on particular days.

9.2.2.2 Fundamental Dynamics for Improving Terminal Productivity

The fundamental input elements that were found to contribute to the productivity of the container terminal to ensure optimised maritime, terminal and hinterland operations, are port infrastructure, operational fleet and equipment, human resource management, integrated planning systems, management of integrated processes, supply chain communication and operational information technology systems.

The underlying vital elements that were found critical for a port system infrastructure are the quantity of available deeper berths from maritime perspective, size of the terminal footprint and reconfiguration of the terminal layout from a terminal perspective. Furthermore, adequate rail infrastructure with side railings, fluid road network with additional lanes, back of port facilities and inland terminals, is critical for efficient operations. The study also concluded that the essential operational fleet and equipment requirements for a port system are tug boats, helicopter, pilot boats and passenger launches from a marine dimension, while the terminal operations require quay cranes, RTGs, straddle carriers, truck and trailers and ship-to-shore gantries. Additionally, the key input elements for smooth hinterland operations are trains, wagons, locomotives, rail mounted gantry cranes, straddle carriers and mafia trailers.

The critical skills required from a human resource perspective from a systematic approach are Marine Engineers, Chief Marine Engineers, Tug Masters and Pilots with Open Licences from the marine perspective. Additionally, adequate manpower to mend the equipment from a terminal perspective and train crew and yard officials for smooth container terminal operations are critical. Integrated communication between Port Authority and Port Terminal from a maritime perspective and enhanced cohesion among Port Authority, Port Terminal, Customs and Stevedores from a terminal perspective, are vital to ensure flow of information for prompt decision-making and vessel working. Furthermore, close collaboration and integration are required between Port Terminal and Rail Division specifically with inland terminal with the intention to service the vessel better.

The Integrated Port Management System (IPMS), Navis Software and Port Community Systems were identified as critical operational information technology systems required for enhancing productivity of the Container Terminal from a systematic view. An integrated planning within the Port Authority considering the resources required from the Harbour Master's Office, Marine Division and Port Control is critical for the marine division, while proper planning of resources for terminal readiness is essential from a terminal perspective. Furthermore, coordinated planning of inland terminal and port terminal to ensure timeous arrival of cargo to meet the vessel stack is vital.

Some of the other critical management processes which required enhancement for efficient port operations were the oversight role by the Port Authority, use of the truck appointment systems, stack management process, cargo storage days, customs processes, rail turnaround times and 24-hour operation by back of port facilities.

9.2.2.3 Impact of Productivity Initiatives

With the recommended initiatives from a systems approach, it is concluded that that productivity will be improved in various aspect including achievement of port key performance indicators such as gross cranes moves per hour, TTT, rail turnaround time and vessel turnaround time. As a result of improved container terminal productivity, there will be reduction in cost of doing business to various stakeholders, which will boost customer satisfaction and port attractiveness. Port business growth incorporating increased vessel calls and cargo volumes will be realised.

9.2.3 Focus Group Interviews

The focus group interviews were instrumental in unpacking interrelatedness and interdependencies of various elements from a systems approach using CLDs and SSM, as follows:

9.2.3.1 Causal Loop Analysis Workshop

Through a causal loop analysis workshop, the study developed the causal loop drawings for the three operational dimensions impacting on the productivity of the container terminal, namely marine, terminal and hinterland and an overall CLD showing correlation among the three dimensions of the container terminal operations.

The development of the causal loop diagram enabled classification of critical elements contributing to the productivity of the container terminal through the use of feedback loops which are useful for development of a strategy to enhance terminal competitiveness. This process also revealed the interdependencies of the three system dimensions, that is, maritime, terminal and hinterland, for the successful management of container terminal operations with improved vessel turnaround.

The causal loop diagram from a marine perspective revealed that the effective strategic management of critical resources such as pilotage, tugs and berthing crew for marine service provision will facilitate on time berthing of vessel which is critical for terminal operations to happen to ensure quick vessel turnaround. The causal loop diagram from a terminal perspective indicates that the positive management of terminal resources such as berths, cranes, information technology systems such as Navis, ground staff, customs, stevedores and stacking space, facilitate a positive relationship with the process of dispatching containers to and from the vessel. The timeous loading and unloading of containers from the vessel would ensure that containers are transferred to and from the quay side to the yard seamlessly, which contributes positively to the STAT of the vessel subject to timeous marine resource service provision.

The causal loop diagram from a hinterland perspective shows the various factors impacting the ship turnaround of vessel stems from both rail and road hauler aspects. The rail factors include train slot availability, wagon availability, equipment availability, train crew, yard staff, shunting crew and fluid rail line that impact on the movement of cargo from various destinations, including inland terminals. From a trucking perspective, the critical input elements are truck availability, truck drivers, fluid road network and the use of a truck booking system.

9.2.3.2 Soft Systems Methodology Workshop

An SSM workshop facilitated development of rich pictures considering all dimensions of container terminal productivity including marine, terminal, hinterland and an overall depiction displaying association with all three dimensions of container terminal productivity. The rich pictures drawn displayed the various elements involved in the container terminal operations and revealed the complexity of the situation and the dynamic nature of linkages and interdependencies contributing towards the ship turnaround of the vessel. The engagement in rich pictures transformed an unstructured problem situation into an expressed situation and enabled selection of improved ship turnaround time as the main system model requiring priority from the relevant systems that emerged from the problem themes.

Furthermore, the development of root definition, conceptual model and unpacking of the CATWOE analysis was conducted for the improved STAT. The developed conceptual model identified required activities needed to improve marine, terminal and hinterland activities within the port and terminal owned system. The CATWOE analysis allowed key customers, main actors and owners to be identified for the key problem being experienced. This process also enabled the process of transformation to be outlined, defining the worldview and explaining the environment in which the problems exist. The root definition was developed considering key issues and principles that would result in innovation for the improvement of STAT for container operations.

9.3 Recommendations of the Study

The recommendations of the study with the intention of developing enhancement strategies to maximise container terminal productivity based on the findings of secondary data analysis, semi-structured interviews and focus group interviews, together with the literature review, were derived, using a systematic approach from a maritime, terminal and hinterland dimensions, are summarised in Figure 9.1.

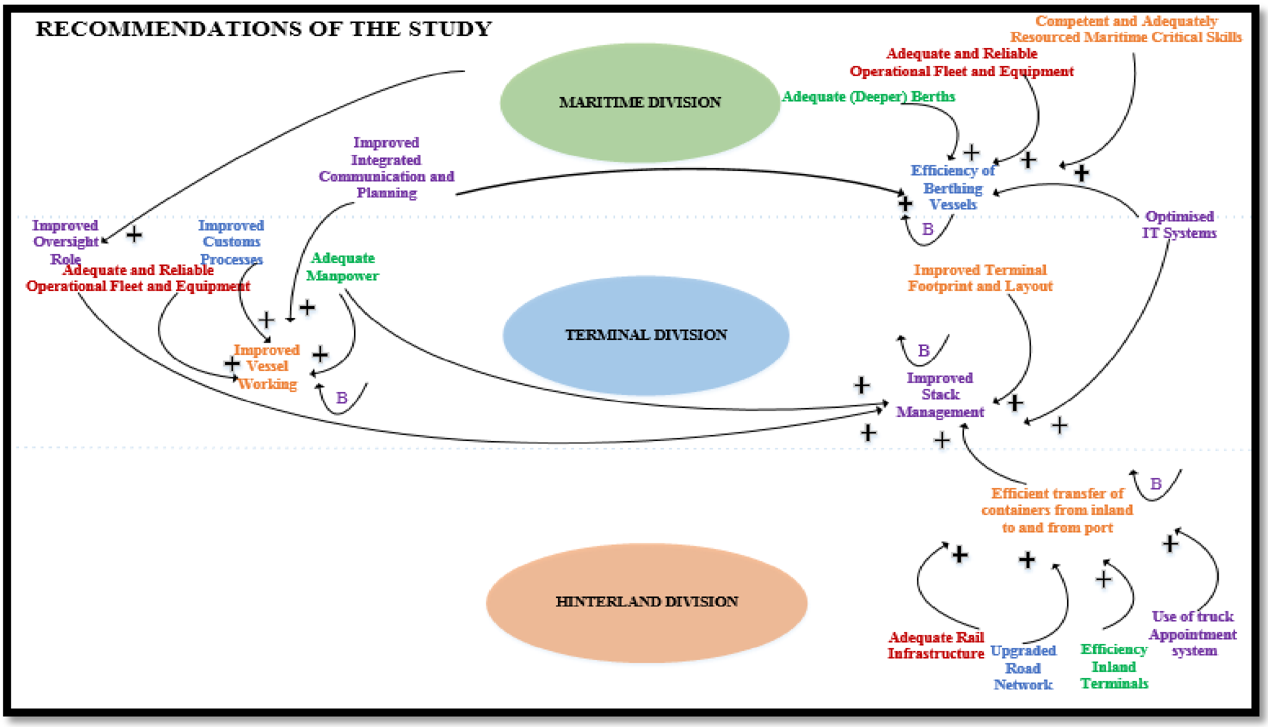

Figure 9.1: Summary of Recommendations of the Study

9.3.1 Recommendations from a Maritime Perspective

The study recommends the following initiatives to be implemented from a maritime perspective for enhanced terminal operations:

9.3.1.1 Port Infrastructure

- An increased number of deeper container berths in the port is necessary to improve efficiencies.
- A cconfiguration for Bayhead Road should be considered with dedicated lanes for particular cargoes to ensure efficiencies within the port precinct.

9.3.1.2 Operational Fleet and Equipment

- Adequate, operational and sound marine craft should be provided to ensure quick turnaround of vessels.
- There should be an additional two (2) tug boats to ensure that crafts are released for maintenance, based on schedule.

9.3.1.3 Human Resource Management

- A retention strategy is needed to retain critical skills to be developed with respect to the Marine Engineers, Chief Marine Engineers, Tug Masters and Pilots with Open Licences.
- The Port Authority must work on building a pipeline to produce more pilots with open licences to berth all sizes of ships.

9.3.1.4 Integrated Communication

- Port Control needs to needs to play a bigger role to liaise with all stakeholders in ensuring that the terminal is ready with all the necessary equipment before deploying pilots and tugs to bring a vessel to berth to avoid any unproductive move and improve operational efficiencies.

9.3.1.5 Operational Information Technology Systems

- Optimisation of the IPMS System is required to ensure on time berthing of vessels and provision of real time updates on the system.
- Port community systems should be put in place to ensure transparency and real time monitoring of operations.

- Information Technology systems need to be integrated to allow access by all stakeholders, including the Port Authority, Terminal, Rail including Customs, SARS and Immigration, to eliminate bottlenecks and enhance efficiencies.

9.3.1.6 Integrated Planning

- Port Control and Berth Planning needs to enhance their planning schedule by being proactive and planning ahead for weather-sensitive and deep-drafted vessels.
- The port needs to acquire tools or information to predict with accuracy the arrival of the ship and the resources required to service it.

9.3.1.7 Integrated Management Processes

- The Port Authority needs to enhance its oversight role by ensuring that key performance indicators for terminal operators and the rail division are set and adhered to, to ensure that the port operates optimally and competitively.
- The Port Authority needs to heighten the regulatory framework for all stakeholders within the port through introduction of penalties for all non-compliance in order to minimize the port bottlenecks.
- Licensing of truck drivers is needed with clear conditions on the operational agreement/licence to ensure efficiencies within the port precinct
- Mitigation measures should be put in place to minimise weather challenges considering the weather delays experienced in the Port of Durban. The Port of Durban needs to benchmark against other international ports on methods to counteract wind challenges for smooth terminal operations.
- Based on the secondary data analysis conducted coupled with the literature review, it is recommended that pilotage and tug availability are included among the key critical factors to be monitored by shareholders, as they are considered to be essential input elements contributing to the productivity of the container terminal.

9.3.2 Recommendations from a Terminal Perspective

Based on the findings of the study conducted, it is recommended that the port improves terminal operations as this dimension contributes the most to port productivity from a systems perspective. The study recommends following initiatives to be implemented from a terminal perspective for enhanced terminal operations:

9.3.2.1 Port Infrastructure

- The terminal footprint needs to be expanded to increase storage and stacking space. The expansion should incorporate the South African Container Depot (SACD) site to extend the terminal footprint for use as an import terminal.
- The terminal layout (Z-shaped) at Pier 2 should be reconfigured to ensure flexibility of the terminal for a combination of handling methods of multiple containers.

9.3.2.2 Operational Fleet and Equipment

- Deployment of adequate fleet and equipment as per the ship plan to service all shifts consistently to ensure quick turnaround of vessels, is necessary.
- It is important that additional cranes to each vessel be installed for improved productivity and quick turnaround of the ship and for more vessels to be serviced by the port.
- The use of state-of-the-art equipment to allow double handling and lifting of several cranes, as well as a multi-trailer system with capacity to handle four 6-meter containers, would enhance quay crane productivity.
- The terminal needs to invest in new generation rubber tyre gantries that can also withstand weather challenges
- Automated tracking systems for cranes should be in place to measure the performance of each crane in order to pick up any slowdown without anyone reporting it. The cranes need to have a sensor to provide an indication if it drops to a certain loading/discharging rate.
- The terminal needs to do a simulation to determine the ideal operational handling method and its capability, considering the Port of Durban context.

9.3.2.3 Human Resource Management

- It is essential to adequately resource operations appropriately, as the vessels are getting bigger and require more cranes and gangs to work their vessels to improve productivity.
- Capacitating employees with operational training and development programs that will upgrade their skills to perform better and drive maximum productivity levels, is critical.
- There is a need to educate employees (crane operators, haulier operators and straddle drivers) about the value chain and the importance of their current jobs and their impact on the overall efficiency of the port and the economy.
- It is important for the container terminal to incentivise the number of moves to give boost to productivity to achieve operational goals.
- It is necessary to boost employee morale through improved working conditions

9.3.2.4 Operational Information Technology Systems

- Maximum utilisation of the Navis Software Systems to ensure improved terminal operations is essential.
- The semi-automation of terminal operations with the intention of maximising space considering land constraints and improving efficiencies in the port, is recommended.

9.3.2.5 Integrated Planning

- Planning of the terminal and yard to be enhanced since the port is a growing import and export gateway with limited terminal space, is needed.
- Planning of adequate resources such that vessels are able to sail at the scheduled time as per contractual obligations, must be done.
- Back up resources need to be planned and flexibility of deployment of resources should be done considering the size of the vessel.
- Pre-planning of the vessel should not happen prior to vessel arrival alongside the berth.

9.3.2.6 Integrated Management Processes

- The terminal should maximise use of the Navis System to ensure proper stack management, also considering the space constraints in the terminal.
- It is critical for the Port of Durban to explore alternative ways of stacking such as a container stowage system that allows stacking of multiple containers on both horizontal and vertical bases.
- The terminal needs to adhere to the scheduling of stack dates and stack boxes according to the allocated crane slips to ensure that stacking mirrors the loading plans.
- It is further commended that the terminal reviews the space for stack management and overall terminal operations for its adequacy in the interest of improved efficiencies.
- The terminal and customs office should invest in technologies that will facilitate clearance of cargo while the vessel is at anchorage, instead of surveying the ship when it is already moored alongside berth.
- It is commended that the terminal develops and implements initiatives that will enhance performance of key indicators such as gross crane hour and the SWH, with the intention of improving ship turnaround time thereby enhancing container terminal productivity. This process incorporates deployment of modern equipment and adequate working equipment which is functional both technically and mechanically to ensure improved SWH and gross crane hour.

9.3.3 Recommendations from a Hinterland Perspective

The study recommends following initiatives to be implemented from a hinterland perspective for enhanced terminal operations:

9.3.3.1 Rail Infrastructure

- Investment on side railings should be actioned to allow flow of cargo to the port.
- The rail network between Johannesburg and Durban should be upgraded to ensure fluidity to ensure timeous arrival of containers to the port. The rail network needs to be revitalized or renewed.
- Strategies need to be developed to mitigate cable theft for improved protection of rail network to ensure reliability of the service.
- It is essential to ensure the upkeep of the network to advance rail performance.

9.3.3.2 Road Network

- The road network leading to the Container Terminal needs to be upgraded to allow free flow of cargo.
- The widening of Langeberg and Bayhead Roads is recommended with the intention to develop additional lanes for road accessibility to the terminals.

9.3.3.3 Back of Port Facilities

- It is critical to develop back of port facilities in order to support the port business to ensure efficiencies. Additional storage space needs to be acquired within a short distance from the rail yards and ports to create back of port facilities.
- More intermodal terminals for transfer of cargo to and from the port or hinterland with the intention to decongest the port should be developed. The development of inland terminals is essential for relief of congestion in the port and for value-added logistics. This allows productive use of the port space for primary activities and not secondary or support functions.
- It is critical that the private sector is involved in development of intermodal terminals that support port operations for improved efficiencies.
- Back of port facilities should be operational 24/7 hours to ensure consistent dispatch of cargo throughout the week to reduce bottlenecks.

9.3.3.4 Operational Fleet and Equipment

- Faster and longer trains should be considered in order to handle maximum containers to and from the port.
- The study suggests that reliability of rail transport must be improved with a special focus of improving rail commitments from seven (7) to eight (8) trains to 11 trains per day/shift in the Natal Corridor.
- There needs to be an adequate number of rail wagons to move cargo from Johannesburg to Durban and *vice versa* to ensure the timeous arrival of cargo.
- Locomotives need to be roadworthy and effective to move both import and export cargo to and from Johannesburg and the port.
- The terminal needs to deploy adequate equipment for loading and delivering cargo on to trucks and terminal. Each tower needs to be equipped with 9 straddle carriers 24/7 to ensure nine (9) moves per hour for quick turnaround of trucks.
- Similarly, the terminal needs to acquire separate equipment for loading trucks and wagons with the intention to improve the turnaround time of wagons and trucks.

9.3.3.5 Maintenance

- Adherence to maintenance plans specifically for the terminal equipment and rail wagons is a necessity to ensure smooth cargo operations thereby improving the equipment lifecycle and productivity.
- Acquisition of adequate equipment is recommended to ensure that release of machinery for maintenance so that operations are not affected
- There is a need for 24/7 maintenance programme to minimise disruptions to vessel and land operations.
- The terminal needs to employ people with the necessary expertise and technical knowledge to ensure rigorous maintenance of the equipment and guarantee a 24/7 maintenance operation which is fully resourced across all shifts.

9.3.3.6 Human Resource Management

- Training and change management on the value chain is required for employees on the ground to drive performance.

9.3.3.7 Integrated Communication

- Close collaboration and integration are required between Port Terminal and Freight Rail specifically inland terminals on cargo dispatch to ensure the timeous arrival of cargo with the intention of servicing the vessel better.
- There must be synergy and alignment between the Rail Division and Port Terminal with respect to key performance indicators in order to balance the value chain and improve the efficiencies.

9.3.3.8 Integrated Planning

- The planning of containers moving on the train from inland terminals to the port must be aligned to the port load vessel and layout of the yard.
- The terminal should consider working on a model that will facilitate integrated planning of port terminal operations with the inland terminal.
- Joint planning of port and transportation mode activities is a necessity from an operational point of view but also from an infrastructure development perspective.
- Intelligent planning of the yard to minimise container reshuffling is a necessity.

9.3.3.9 Integrated Management Processes

- A compulsory truck appointment system should be deployed to improve truck turnaround and efficiencies within the terminal.
- The terminal needs to introduce an incentive system to encourage large scale customers to divert movement of cargo during the night as opposed to moving boxes during the day to eliminate bottlenecks during peak hours.
- The terminal must ensure configurations for A Check to facilitate efficiencies within the port gate
- A longer dwell time should be penalised by introducing extra charges, provided there are no inefficiencies experienced in the terminal caused by weather conditions and poor TTT.
- The 3-days storage should start from the day the container is released from the ship rather than on the last day the last box is released from the vessel.
- It is also recommended that the terminal develops a separate stacking yard for rail and road transport containers and parking space and for road trucks and rail wagons, thereby circumventing shuffling of containers and terminal congestion.
- It is suggested that a shipping business which is open 24 hours for 7 days a week from a hinterland perspective, similar to port working hours should be promoted.
- It is recommended that the different shift system by the Port Terminal and Rail Division should be aligned to avoid delays in operational hours.

- Based on the sensitivity study conducted, it is recommended for the port to come up with initiatives from a hinterland perspective that will strengthen the rail turnaround time with the objective of improving ship turnaround time thereby enhancing container terminal productivity.
- It is essential to have modern rail to road intermodal terminals with sufficient infrastructure and efficient rail service.

9.4 Contribution of this study to new knowledge

This study contributed to new knowledge by investigating container terminal productivity using a systems approach and exploring all three dimensions that impact efficiencies, that is, maritime, terminal and hinterland aspects, using a case study of the Port of Durban. A systems approach using a combination of aspects of soft system methodology and system dynamics investigated how the performance of the container terminal can be improved. While only certain aspects of SSM and SD were utilised, the approach has been shown to have value in an environment where there is no formal systems application. The original contribution of this research is in planting the seeds of a systems approach for the enhancement of container terminal productivity. A sensitivity analysis which examined productivity performance indicators across all three dimensions of port productivity, incorporating marine, terminal and hinterland key performance indicators revealed that the critical elements for enhanced productivity at the Port of Durban are GCH, SWH and RTT. A systems approach facilitated the development of CLDs, rich pictures, root definitions, a conceptual model and CATWOE Analysis for improved terminal operations with a focus on improved ship turnaround time. The study also recommended initiatives to be implemented as part of the development of the relevant systems approach strategy from the maritime, terminal and hinterland perspectives for improved container terminal productivity.

9.5 Lessons derived from investigating container terminal productivity through a Systems Approach framework

The systems approach benefited the investigation in many aspects, including the following:

- It assisted with tools to understand the context and problematic situation of the research study and ascertain the critical factors impacting the system behaviour within container terminal operations.
- The methodology enabled unpacking of the various problematic areas within the port environment from different perspectives, considering participants from stakeholders from all dimensions of terminal operations.
- In the midst of complex issues and chaotic environments encountered at the container terminal, the systems approach facilitated the discussion to discover the real problem underlying the various messy impacts on the port.

- The engagement in the rich picture transformed an unstructured problem situation into an expressed situation, and enabled the selection of relevant systems from the problem themes and identification of the improved ship turnaround time, as the emergent phenomena that required to be resolved.
- The causal loop analysis was instrumental in determining causal and effect factors contributing to the inefficiencies of the Container Terminal, depicting how different variables in a system are interrelated.
- It facilitated discovery of key variables contributing to the operations of the container terminal with the intention to improve performance of a container terminal to ensure optimised maritime, terminal and hinterland operations.
- The SSM approach facilitated a process of constructing framework to improve the condition by identifying system structure, main players, customers, including their interactions through various engagements with affected departments
- The conceptual model enabled identification of required activities needed to improve marine, terminal and hinterland activities within the port and terminal-owned system.
- The CATWOE analysis allowed key customers, main actors and owners to identify the key problem being experienced. This process also enabled the process of transformation to be outlined, including defining the worldview and explaining the environment in which the problems exist.

Furthermore, the study successfully contributed to the development of the conceptual model for enhanced terminal operations at the Port of Durban as per Figure 9.2, through the various sub-systems (sensitivity analysis, semi-structure interviews, causal loop analysis and aspect of SSM process) used to conduct study, even though it was not the initial intention of the investigation.

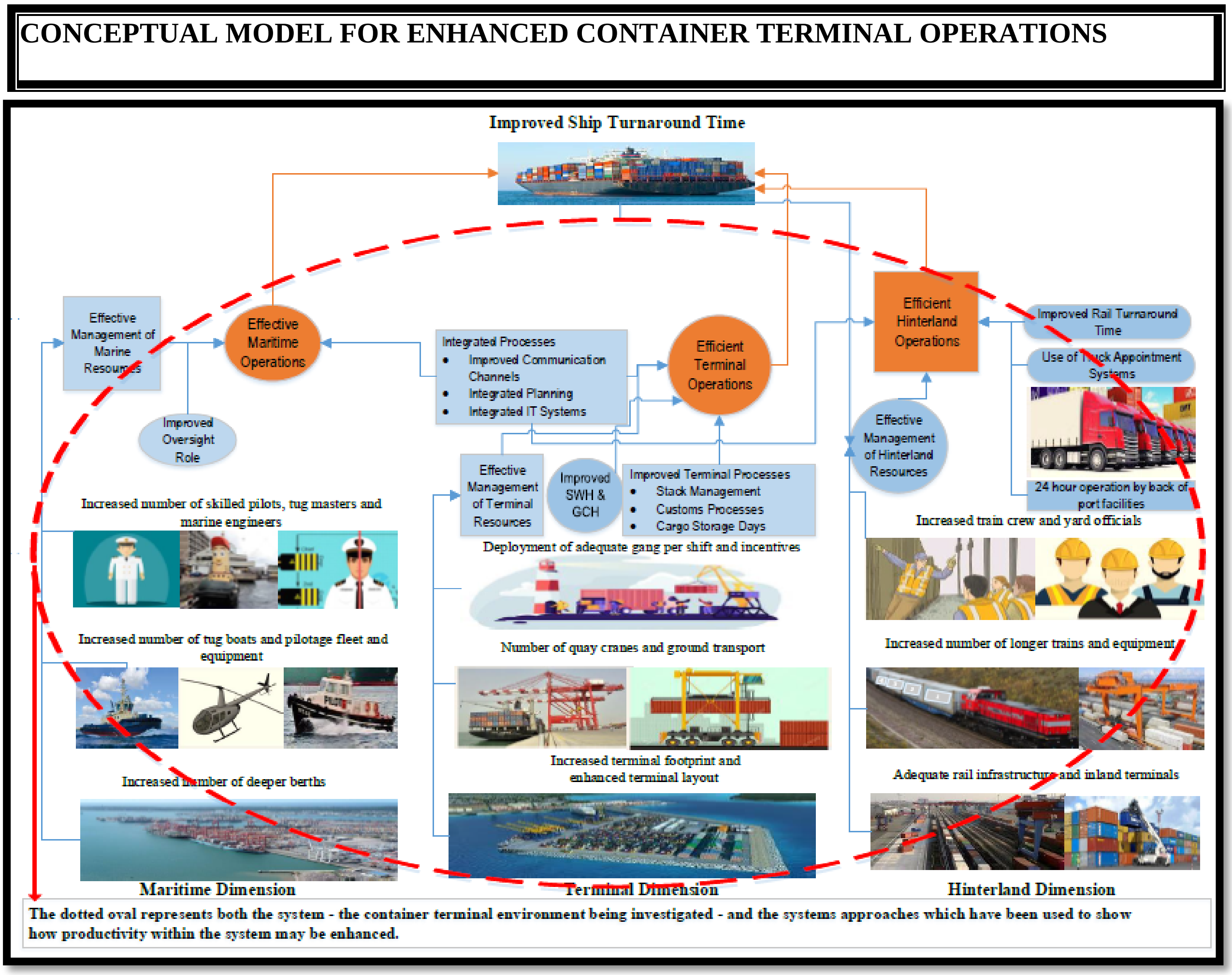

Figure 9.2: Conceptual Model for enhanced container terminal operations in the Port of Durban

9.6 Suggestions for further research

Based on the sensitivity analysis conducted, it is recommended that other input key performance indicators which are not part of this regression model be further investigated to explain changes in the ship turnaround time for the model to complete the 79% to 100%. Other input elements to be investigated include berth productivity, cargo dwell time, pilotage and tug availability. Future research could also determine the impact of STAT on the AWT of vessels in the port. Finally, the impact of TTT on STAT also requires further analysis, as the results are not aligned with theoretical expectations.

From a systems approach perspective, it is recommended that other methodologies such as VSM, SODA, and CSH methodologies be investigated to determine how the performance of a container terminal can be improved with these approaches. Furthermore, simulation studies from a systems approach to determine the ideal operational handling method and its capability, considering the configuration of the Port of Durban, are necessary for enhanced terminal operations. Further studies using SFDs could be explored to explain the structural complexity of container terminal operations and improvements thereof.

9.7 Conclusion

This chapter has provided the conclusions of the study based on the findings of the investigation into how container terminal operations can be enhanced using a systems approach. A conclusion on the sensitivity analysis with respect to critical performance indicators influencing productivity of the container terminal from the marine, terminal and hinterland perspectives, has been outlined. Conclusions of the research outcomes of the semi-structured interviews determining the context and problematic situation of the research study from a systems approach, were detailed. Additionally, the conclusions of the findings of the focus group interviews which were conducted in the form of SSM and Causal Loop Analysis Workshops with the intention of improving performance of this specific container terminal using a Systems Approach, was presented. This chapter also provided recommendations on strategic initiatives to maximise container terminal productivity using a systematic approach from a maritime, terminal and hinterland dimension. Lastly, for further development of knowledge and contribution to the systems approach studies and container terminal productivity, recommendations for future research were outlined.

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APPENDIX ONE: SET OF SECONDARY DATA FOR SENSITIVITY ANALYSIS

KEY PERFORMANCE INDICATORS

1. SHIP TURNAROUND TIME

2014/15		2015/16		2016/17	
Month	**STAT**	**Month**	**STAT**	**Month**	**STAT**
April 2014	44	April 2015	44	April 2016	46
May 2014	46	May 2015	45	May 2016	51
June 2014	46	June 2015	47	June 2016	45
July 2014	51	July 2015	50	July 2016	52
August 2014	57	August 2015	52	August 2016	57
September 2014	59	September 2015	43	September 2016	58
October 2014	55	October 2015	41	October 2016	57
November 2014	46	November 2015	46	November 2016	47
December 2014	55	December 2015	44	December 2016	55
January 2015	54	January 2016	43	January 2017	60
February 2015	49	February 2016	42	February 2017	53
March 2015	49	March 2016	47	March 2017	54
Average	**51**	**Average**	**45**	**Average**	**53**

2017/18		2018/19	
Month	**STAT**	**Month**	**STAT**
April 2017	54	April 2018	63
May 2017	60	May 2018	62
June 2017	61	June 2018	63
July 2017	65	July 2018	74
August 2017	74	August 2018	71
September 2017	76	September 2018	65
October 2017	85	October 2018	63
November 2017	89	November 2018	78
December 2017	81	December 2018	77
January 2018	69	January 2019	72
February 2018	69	February 2019	75
March 2018	62	March 2019	61
Average	**70**	**Average**	**69**

2. ANCHORAGE WAITING TIME

2014/15		2015/16		2016/17	
Month	**Anchorage Hours**	**Month**	**Anchorage Hours**	**Month**	**Anchorage Hours**
April 2014	36	April 2015	27	April 2016	30
May 2014	35	May 2015	18	May 2016	35
June 2014	38	June 2015	36	June 2016	24
July 2014	54	July 2015	36	July 2016	30
August 2014	49	August 2015	47	August 2016	72
September 2014	37	September 2015	25	September 2016	40
October 2014	57	October 2015	25	October 2016	49
November 2014	36	November 2015	33	November 2016	30
December 2014	49	December 2015	28	December 2016	33
January 2015	40	January 2016	61	January 2017	50
February 2015	40	February 2016	22	February 2017	25
March 2015	21	March 2016	38	March 2017	31
Average	**41**	**Average**	**33**	**Average**	**37**

2017/18		2018/19	
Month	**Anchorage Hours**	**Month**	**Anchorage Hours**
April 2017	16	April 2018	18
May 2017	63	May 2018	21
June 2017	17	June 2018	31
July 2017	37	July 2018	38
August 2017	62	August 2018	32
September 2017	84	September 2018	30
October 2017	74	October 2018	40
November 2017	123	November 2018	44
December 2017	141	December 2018	52
January 2018	97	January 2019	32
February 2018	77	February 2019	26
March 2018	60	March 2019	55
Average	**71**	**Average**	**35**

3. GROSS CRANE HOUR

2014/15		2015/16		2016/17	
Month	**GCH**	**Month**	**GCH**	**Month**	**GCH**
April 2014	24	April 2015	24	April 2016	26
May 2014	23	May 2015	24	May 2016	25
June 2014	23	June 2015	24	June 2016	26
July 2014	23	July 2015	24	July 2016	24
August 2014	22	August 2015	25	August 2016	20
September 2014	22	September 2015	26	September 2016	22
October 2014	23	October 2015	27	October 2016	22
November 2014	23	November 2015	25	November 2016	24
December 2014	22	December 2015	26	December 2016	23
January 2015	23	January 2016	25	January 2017	24
February 2015	23	February 2016	26	February 2017	24
March 2015	23	March 2016	25	March 2017	24
Average	**23**	**Average**	**25**	**Average**	**24**

2017/18		2018/19	
Month	**GCH**	**Month**	**GCH**
April 2017	24	April 2018	24
May 2017	21	May 2018	22
June 2017	23	June 2018	21
July 2017	21	July 2018	19
August 2017	22	August 2018	20
September 2017	21	September 2018	21
October 2017	23	October 2018	21
November 2017	23	November 2018	21
December 2017	23	December 2018	18
January 2018	24	January 2019	20
February 2018	24	February 2019	20
March 2018	24	March 2019	20
Average	**23**	**Average**	**21**

4. SHIP WORKING HOUR

2014/15		2015/16		2016/17	
Month	**SWH**	**Month**	**SWH**	**Month**	**SWH**
April 2014	61	April 2015	58	April 2016	61
May 2014	59	May 2015	56	May 2016	54
June 2014	65	June 2015	54	June 2016	54
July 2014	50	July 2015	54	July 2016	53
August 2014	48	August 2015	56	August 2016	45
September 2014	48	September 2015	65	September 2016	49
October 2014	52	October 2015	64	October 2016	51
November 2014	57	November 2015	65	November 2016	58
December 2014	52	December 2015	61	December 2016	50
January 2015	48	January 2016	55	January 2017	51
February 2015	53	February 2016	67	February 2017	55
March 2015	56	March 2016	59	March 2017	54
Average	**54**	**Average**	**60**	**Average**	**53**

2017/18		2018/19	
Month	**SWH**	**Month**	**SWH**
April 2017	55	April 2018	63
May 2017	50	May 2018	57
June 2017	52	June 2018	55
July 2017	49	July 2018	48
August 2017	51	August 2018	52
September 2017	52	September 2018	55
October 2017	49	October 2018	55
November 2017	46	November 2018	53
December 2017	51	December 2018	47
January 2018	49	January 2019	50
February 2018	57	February 2019	48
March 2018	61	March 2019	50
Average	**52**	**Average**	**53**

5. RAIL TURNAROUND TIME

2014/15		2015/16		2016/17	
Month	**RTT**	**Month**	**RTT**	**Month**	**RTT**
April 2014	4.4	April 2015	3.4	April 2016	2.3
May 2014	4.1	May 2015	3.0	May 2016	3.2
June 2014	3.9	June 2015	3.5	June 2016	3.1
July 2014	3.8	July 2015	2.7	July 2016	3.4
August 2014	3.1	August 2015	2.8	August 2016	4.0
September 2014	3.2	September 2015	2.3	September 2016	4.2
October 2014	3.5	October 2015	2.0	October 2016	3.6
November 2014	2.6	November 2015	2.4	November 2016	3.7
December 2014	3.7	December 2015	2.1	December 2016	4.4
January 2015	2.9	January 2016	2.3	January 2017	3.6
February 2015	2.9	February 2016	2.3	February 2017	3.3
March 2015	3.2	March 2016	2.6	March 2017	2.8
Average	**3**	**Average**	**3**	**Average**	**3**

2017/18		2018/19	
Month	**RTT**	**Month**	**RTT**
April 2017	1.8	April 2018	1.6
May 2017	2.0	May 2018	1.9
June 2017	1.9	June 2018	1.8
July 2017	1.9	July 2018	2.1
August 2017	2.4	August 2018	2.0
September 2017	2.3	September 2018	2.0
October 2017	2.3	October 2018	1.8
November 2017	2.2	November 2018	2.2
December 2017	2.2	December 2018	2.4
January 2018	2.0	January 2019	2.2
February 2018	2.0	February 2019	2.2
March 2018	1.9	March 2019	1.9
Average	**2**	**Average**	**2**

6. TRUCK TURNAROUND TIME

2014/15		2015/16		2016/17	
Month	**TTT**	**Month**	**TTT**	**Month**	**TTT**
April 2014	33	April 2015	34	April 2016	49
May 2014	36	May 2015	37	May 2016	56
June 2014	35	June 2015	37	June 2016	56
July 2014	44	July 2015	40	July 2016	99
August 2014	52	August 2015	43	August 2016	84
September 2014	47	September 2015	38	September 2016	101
October 2014	52	October 2015	41	October 2016	75
November 2014	54	November 2015	41	November 2016	77
December 2014	49	December 2015	43	December 2016	76
January 2015	42	January 2016	41	January 2017	94
February 2015	39	February 2016	45	February 2017	90
March 2015	37	March 2016	38	March 2017	89
Average	**43**	**Average**	**40**	**Average**	**79**

2017/18		2018/19	
Month	**TTT**	**Month**	**TTT**
April 2017	79	April 2018	60
May 2017	73	May 2018	63
June 2017	77	June 2018	66
July 2017	66	July 2018	68
August 2017	72	August 2018	67
September 2017	87	September 2018	71
October 2017	77	October 2018	66
November 2017	60	November 2018	63
December 2017	71	December 2018	85
January 2018	70	January 2019	76
February 2018	61	February 2019	82
March 2018	68	March 2019	70
Average	**72**	**Average**	**70**

APPENDIX TWO: INFORMED CONSENT LETTER

UNIVERSITY OF KWAZULU-NATAL

GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

PHD Research Project

Researcher: Dineo Faith Mazibuko (0832435212)
Supervisor: Professor K Pillay (031-2608300)
Research Office: Ms Z Ximba (031-2603587)

Dear Respondent,

I, Dineo Faith Mazibuko, am a PhD student in the Graduate School of Business and Leadership at the University of KwaZulu-Natal. You are invited to participate in a research project entitled: **Enhancing Productivity in a Container Terminal through a Systems Approach: A case study of the Port of Durban**

The aim of the study is to investigate how the performance of a container terminal can be improved using Systems Approaches with respect to Systems Dynamics and the Soft Systems Methodology. It involves a case study of the Port of Durban. The main significance of this study is its contribution to the development of the relevant systems approach strategy with respect to Systems Dynamics and Soft Systems Methodology for the Container Terminal in the Port of Durban.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this project. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, UKZN. If you have any questions or concerns about participating in this study, please contact me or my supervisor at the numbers listed above.

It should take you about 30-45 minutes to complete the interview. I hope you will take the time to participate in the interview.

Sincerely

Researcher’s signature_________________________________ Date________________

This page is to be retained by the research participant

UNIVERSITY OF KWAZULU-NATAL

GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

PHD Research Project

Researcher: Dineo Faith Mazibuko (0832435212)

Supervisor: Professor K Pillay (031-2608300)

Research Office: Ms Z Ximba (031-2603587)

CONSENT

I____ (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

I hereby consent / do not consent to have this interview recorded.

____________________   ____________________

Signature of Participant   Date

This page is to be retained by researcher

APPENDIX THREE: RESEARCH INSTRUMENTS

FACE-TO-FACE INTERVIEW SCHEDULE

Theme 1: To determine which input productivity elements from the systems dynamics approach could be investigated to ensure optimised maritime, terminal and hinterland operations in a container terminal.

Research Question 1: Which critical performance indicators of productivity from the systems approach that could be investigated to ensure optimised maritime, terminal and hinterland operations in a container terminal?

Questions:

- Which are the marine productivity input elements essential for your operations for quick turnaround of vessels in the Port of Durban?
- With respect to terminal operations, what do you consider as key factors contributing towards efficient operations?
- With respect to hinterland operations, what are the underlying elements required for smooth operations at the Container Terminal for your operations?

Theme 2: To analyse the container terminal productivity concept using conceptual models, root definitions and rich pictures with the intention to ensure terminal productivity improvements.

Research Question 2: How can container terminal scenarios be analysed using conceptual models, root definitions and rich pictures to improve terminal productivity?

Questions:

- What is your opinion on how the maritime productivity input elements should be connected to ensure improved ship turnaround of vessels?
- How should resources (equipment and human resources) be deployed to fast track handling of containers at the container terminal?

- How should the container terminal arrange containers within the terminal in order to allow free flow of cargo and improve efficiencies in a terminal?
- What should be in place from a rail perspective to ensure that the vessel receives containers on time for export market?
- How should trucks be arranged for import and export cargo to avoid congestion at the port gate and surrounding areas within the port?
- How should the operations be improved from vessel arrival, to vessel berthing, to loading and unloading from ship to shore, to transfer of cargo from shore to wagons and trucks, and warehouses?

Theme 3: To conduct a sensitivity analysis to determine correlation and impact of each input productivity element on the overall efficiency of the container terminal using secondary data.

Research Question 3: What is the correlation and impact of each key performance indicator element on the overall productivity of the container terminal?

No questions were asked to respondents on this theme as secondary data was used to respond to the below questions. However, the secondary data needed to respond to the questions below:

- How have the key measures of productivity performed over a 5 year period in the Port of Durban?
- How has each input element of productivity impacted the other input element of productivity?
- Which performance measures impacted the overall performance over this period of time?

Theme 4: To determine the relevant systems approach strategy for improving productivity at the container terminal in the Port of Durban.

Research Question 4: What is the relevant systems approach strategy for improving productivity of the Container Terminal in the Port of Durban?

Questions

- From your perspective, please advise what are some of the key strategies that should be implemented in order to improve productivity of the container terminal in the Port of Durban?
- What resources will be required to achieve the recommended approach?
- What impact will this new approach achieve in terms of productivity?

FOCUS GROUP RESEARCH INTERVIEW SCHEDULE

Theme 1: To determine which input productivity elements from the systems dynamics approach could be investigated to ensure optimised maritime, terminal and hinterland operations in a container terminal.

Questions:

- What are the critical productivity input elements from the Maritime Operations which contribute to efficient vessel performance?
- What are the main productivity elements from the Terminal Operations which result in a quick turnaround of vessel operations?
- What are the essential factors to be considered from road haulers and rail to ensure improved container operations?

Theme 2: To analyse the container terminal productivity concept using conceptual models, root definitions and rich pictures with the intention to ensure terminal productivity improvements.

Questions:

- How should the container terminal be arranged to ensure efficient operations in the Port of Durban?
- How should container activities be depicted from marine, terminal and hinterland operations to ensure efficiency in the Port of Durban?
- How should the operations be improved from vessel arrival, to vessel berthing, to loading and unloading from ship to shore, to transfer of cargo from shore to wagons and trucks, and warehouses?

Theme 3: To conduct a sensitivity analysis to determine correlation and impact of each input productivity element on the overall efficiency of the container terminal using secondary data.

Questions

No questions were asked to respondents on this theme as secondary data was used to respond to the below questions.

- How have the key measures of productivity performed over a 5 year period in the Port of Durban?
- How has each input element of productivity impacted the other input element of productivity?
- Which performance measures impacted the overall performance over this period of time?

Theme 4: To determine the relevant systems approach model for improving productivity at the container terminal in the Port of Durban.

Questions

- What are the essential key strategies that the Port of Durban should implement for improvement of efficiencies at the Container Terminal in the Port of Durban?
- What are some of the essential resources that will be required to achieve the proposed strategy?
- How will the new strategy affect operations at the Container Terminal?

APPENDIX FOUR: EDITOR'S CERTIFICATE

THE WRITING STUDIO

Writing and Editing Practice

Certificate 2020/9

14 September 2020

TO WHOM IT MAY CONCERN

This dissertation, entitled **Enhancing productivity in a container terminal through a systems approach: A case study of the Port of Durban, by Dineo Faith Mazibuko**, has been edited and reviewed to ensure technically accurate and contextually appropriate use of language for research at this level of study.

Yours sincerely

[redacted]

CM ISRAEL, BA Hons (UDW) MA (UND) MA (US) PhD (UNH)
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APPENDIX FIVE: TURNITIN REPORT

Turnitin Originality Report
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From General Submissions (My Submissions)

- Processed on 14-Sep-2020 3:57 AM CAT
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- Word Count: 83370

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APPENDIX FIVE: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

29 August 2018

Mrs Dineo Faith Mazibuko (205519132)
Graduate School of Business & Leadership
Westville Campus

Dear Mrs Mazibuko,

Protocol reference number: HSS/0381/018D
Project Title: Enhancing Productivity in a Container Terminal through a Systems Approach: A case study of the Port of Durban

Approval Notification – Expedited Application

In response to your application received 08 May 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]..

Dr Shamila Naidoo (Deputy Chair)

/ms

Cc Supervisor: Professor Kriben Pillay
Cc Academic Leader Research: Professor Muhammad Hoque
Cc School Administrator: Ms Zarina Bullyraj

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1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: Edgewood · Howard College · Medical School · Pietermaritzburg · Westville