A comparative study of operational performance of container seaports in South Africa

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KEYWORDS

i. Containers ports
ii. Operational performance
iii. Terminal operations
iv. Ship turnaround time
v. Port terminal operator

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CTOC	Container Terminal Operations Contracts
DCT	Durban Container Terminal
GCH	Gross Crane Moves per crane per hour
MOPS	Marine Operator Performance Standards
NCT	Ngqura Container Terminal
PRSA	Ports Regulator of South Africa
SOC	State Owned Company
STAT	Ship turnaround time
SWH	Ship Working Hour
TEUs	Twenty-foot Equivalent Units
TNPA	Transnet National Ports Authority
TOPS	Terminal Operator Performance Standards
TPT	Transnet Ports Terminal

CHAPTER 1. INTRODUCTION

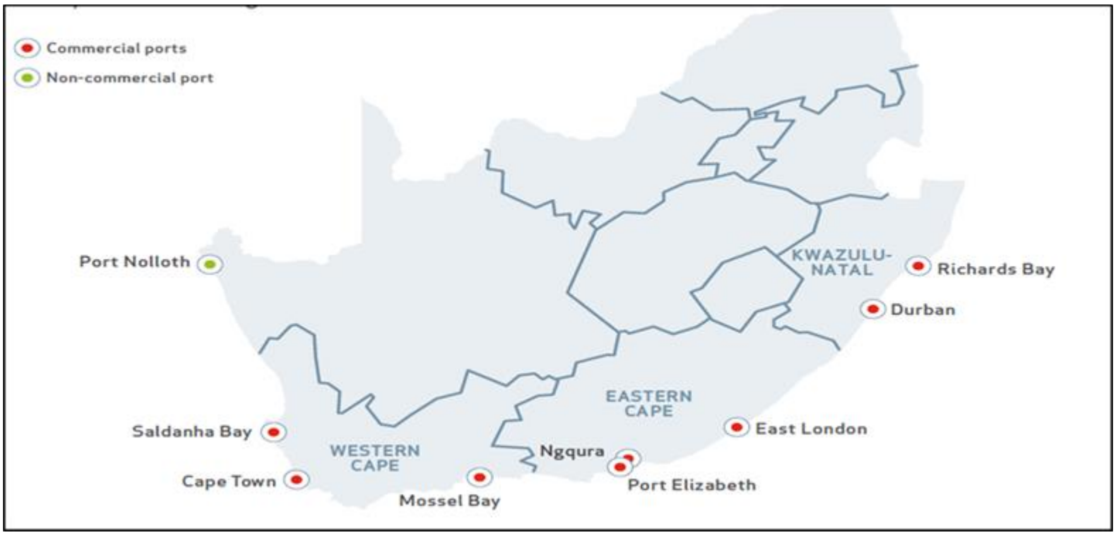
1.1 Statement of purpose

This research study compares the operational performance of the four major container seaports in South Africa.

1.2 Background of the study

South Africa has eight commercial seaports that are managed by Transnet SOC through the Transnet National Ports Authority (Meyiwa & Chasomeris, 2016). The Transnet National Ports Authority (TNPA) is an operating division of Transnet SOC, a state-owned enterprise (Transnet SOC, 2023). TNPA operates as a landlord and regulator whilst providing marine services such as pilotage, towage and berthing of ships (Ports Act, 2005). As a landlord and regulator, TNPA provides port infrastructure and regulates its use by issuing operating licenses to port users and terminal operators through concession agreements (Bichou, 2021). Figure 1 below, illustrates locations of the eight commercial seaports along the South African coastline.

Figure 1: The South African Port System



Source: (Transnet National Ports Authority, 2022)

South Africa's diverse economy relies on its ports to link key sectors such as mining, manufacturing, agriculture, energy and tourism to other countries (Petterson, 2021). Thus, the South African port system is positioned as an enabler for socio-economic development (International Transport Forum, 2014).

South African seaports handle different cargo types and commodities including containers (Ports Regulator of South Africa, 2020/21). Container traffic is handled across most South African ports. However, only the ports of Durban, Cape Town, Ngqura and Port Elizabeth have dedicated superstructures to handle containers (Dlamuka, 2022). Table 1 below shows major cargo types at each port.

Table 1: Cargo types at each port in South Africa.

Cargo Type	Major Commodities	2014 Throughput	Current Annual Capacity	Main Port(s)
Containers	General Cargo	4,6 million TEUs	7 million TEUs	Durban, Ngqura, Cape Town and Port Elizabeth
Dry Bulk	Coal	76 Mtpa	95 Mtpa	Richards Bay and Durban
	Iron Ore	53 Mtpa	60 Mtpa	Saldanha
	Manganese	10 Mtpa	36 Mtpa	Durban and Port Elizabeth
	Other	21 Mtpa		Richards Bay, Durban and Cape Town
Liquid Bulk	Crude and Refined Fuels	40 million kl	71 million kl	Saldanha, Durban and Mossel Bay
Break Bulk	General Cargo	11 Mtpa	25 Mtpa	Richards Bay, Durban and Cape Town
Automotive	Ro-Ro Cargo	660 000 units	1,5 million units	East London, Port Elizabeth and Durban

Source: (Transnet SOC, 2016)

According to section 56 of the National Ports Act of 2005, TNPA grants operating licenses to port terminal operators for the provision of cargo handling services. Port terminal operators provide cargo storage, loading and offloading services to ships, rail and road transport at the port (Transnet Port Terminals, 2023). In the case of South African container ports, all operating licences for container terminal operations are granted to Transnet Port Terminals (TPT), another operating division of Transnet SOC (Bichou, 2021). Thus, container ports are managed and operated as a complementary system with no competition among them (Dlamuka, 2022). Table 2 below illustrates terminals operating at the container ports.

There is one terminal operator at each port except for the port of Durban with two terminals as it accounts for over 60% of the local container port volumes (International Transport Forum, 2014).

Table 2: South Africa Major Container Seaports and Terminals

Container Seaports	Port Terminals
Durban	Durban Container Terminal Pier 1 (DCT Pier 1)
	Durban Container Terminal Pier 2 (DCT Pier 2)
Port Elizabeth	Port Elizabeth Container Terminal (PECT)
Cape Town	Cape Town Container Terminal (CTCT)
Ngqura	Ngqura Container Terminal (NCT)

Source: (Ports Regulator of South Africa, 2022/23)

1.3 Research problem

Most literature studies compare operational performance of South African container ports to their African or global counterparts. The global container ports selected for performance comparisons with the local ports have different operating features and governance models (Bichou, 2021). The ownership model of a ports' authority and the container terminal operations by the state is one of the few in the world (Bichou, 2021). The local container port ownership model is centrally controlled by the state compared to many global models, which involve greater private sector participation.

There are limited studies available comparing operational performance of the local container ports relative to each other. Available literature falls short in identifying better performing container ports, and articulate lessons from such ports for others. Therefore, a comparative study on container seaports in the South African context is required.

1.4 Research objectives

The primary objectives of this study are:

i. To conduct a comparative analysis of operations performance of the four South African container ports.

ii. To identify better performing container ports and determine key factors contributing to port operations performance.

iii. To identify lesson from better performing ports.

1.5 Rationale

According to Dlamuka (2022), container trade is the fastest growing trade within the maritime sector. Therefore, container seaports will continue to play a pivot role in global supply chains and trade (World Bank Group, 2022). Port performance informs decisions for shipping lines in choosing container seaports (Nottenboom, 2008). Therefore, a comparative study is necessary to help enable better performance for South African ports to continue to play a significant role in the global supply chains.

A research study from Motau (2015) compares the waterside and landside productivity of Durban, Cape Town and Ngqura container terminals. The study tracks actual monthly performance against set targets for the 2014/15 financial year, from March 2014 to April 2015. However, this study falls short in identifying better performing ports but simply focuses on whether each port achieved the set targets or not during that period. The ship turnaround time performance in Motau (2015) focuses on the Durban container terminal (DCT) and Ngqura container terminal (NCT) only.

Furthermore, Dlamuka (2022) assesses performance of the Durban terminals against the Ngqura, Cape Town and Port Elizabeth container terminals. The study uses the change in performance from the 2017/18 to the 2018/19 financial years in comparing performance of local container terminals. This study compares performance trends of the port of Durban and does not provide sufficient information on the other ports to compare them among each other.

Finally, Gong (2023) used data envelopment analysis (DEA) to assess port efficiencies to rank the ports of Durban, Cape Town, Ngqura and Port Elziabeth based on performance from 2016 to 2021. This study compares the four container ports on four types of efficiencies, i.e., Technical efficiency (TE), Scale efficiency (SE), Pure Technical Efficiency (PTE) and Return to Scale (RS). Port efficiencies are influenced by the amount of resources utilised during operations (Gong, 2023).

The available studies, though sufficiently discussing port challenges and reasons for inadequate performance, fail to identify better performing ports and what enabled such performance. This leaves a void for a study to assess better performing ports and identify contributing factors to such performance.

Thus, the aim of this study is to further contribute to the conversation on the operational performance of South African container seaports. Furthermore, the study is aimed at benefiting port users, the ports' authority, cargo owners, and the South African government as both the policy maker and a shareholder.

1.6 Delimitations of the study

Port operations include waterside, stacking yard and landside activities with an array of players such as rail, road, marine and terminal operators (International Transport Forum, 2014). However, this study only focuses on the waterside operations of marine and terminal operators at the ports of Durban, Cape Town, Port Elizabeth and Ngqura. The study excludes yard, rail and road operators and activities. The research on the performance of other port users and activities can be the focus of subsequent studies.

1.7 Definition of terms

- **Anchorage** – refers to a designated area of the port where ships can drop anchor and wait before entering the port for operational services.

- **Berthing window** – an agreed port opening to offer a service to a ship (World Bank Group, 2022).
- **Gross Crane mover per hour** – number of containers loaded/offloaded by each crane per hour.
- **Moves -** containers handled during discharge, loading or re-stowed (World Bank Group, 2022).
- **Marine operator –** service providers for ship navigation such as pilotage and towage at the port.
- **Terminal operator** – service provider for cargo handling services such as loading, offloading and storage of containers.
- **Towage** - the use of **tugboats** to assist ships in manoeuvring during docking and undocking by guiding, pulling and pushing the ship within the port.
- **Parcel size** – the amount of volume carried by a ship that is to be handled at the port during a single visit.
- **Pilotage** – is a service provided by a port's marine pilot who boards the ship to help navigate it safely into, out of, or within a port
- **Port call** – a ship's visit for services at a port

1.8 Assumptions

Firstly, the performance of container seaports is comparable due to similar operational processes, equipment and superstructures. Furthermore, the key performance indicators are defined and measured the same way to quantify port performance. These assumptions have significant implications on the study outcomes as they inform how container port performance is determined.

1.9 Chapter Outline

This research paper consists of five chapters, outlined as follows: Chapter 1 highlights the study background, scope and purpose including the research problem and objectives. Chapter 2 provides a survey of available literature and the analytical framework. Chapter 3 discusses the research approach, study design, data collection process and the research instrument. Chapter 4 is a descriptive statistical analysis and discussion of the results. Chapter 5 concludes with major findings and recommendations based on the data analysis.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

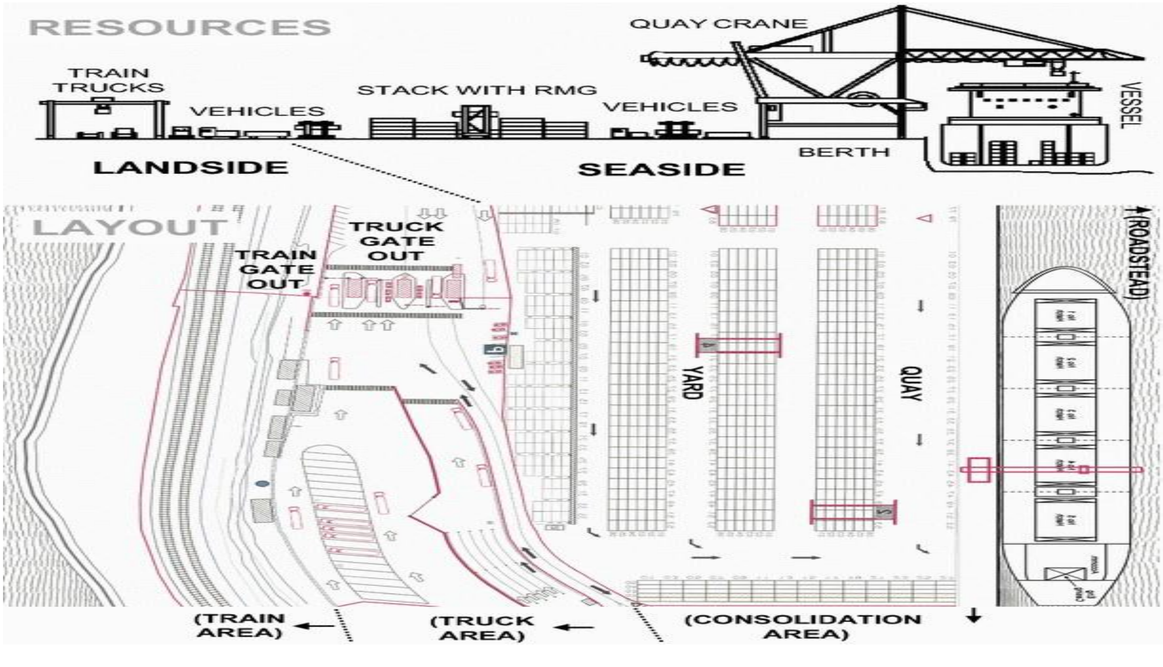
This chapter presents theories on key concepts of the study and discusses applicable frameworks from available literature.

2.2 Definition of topic

2.2.1 Container ports

Seaports facilitate trade through a multimodal freight system of rail, road and ships (Notteboom, Pallis, & Rodrigue, 2022). Furthermore, container seaports have specialised superstructures that distinguish them from other ports (Ports Regulator of South Africa, 2023/24). Figure 3 below illustrates container port superstructures, essential infrastructure, facilities and equipment.

Figure 2: Container Ports Infrastructure and Superstructures

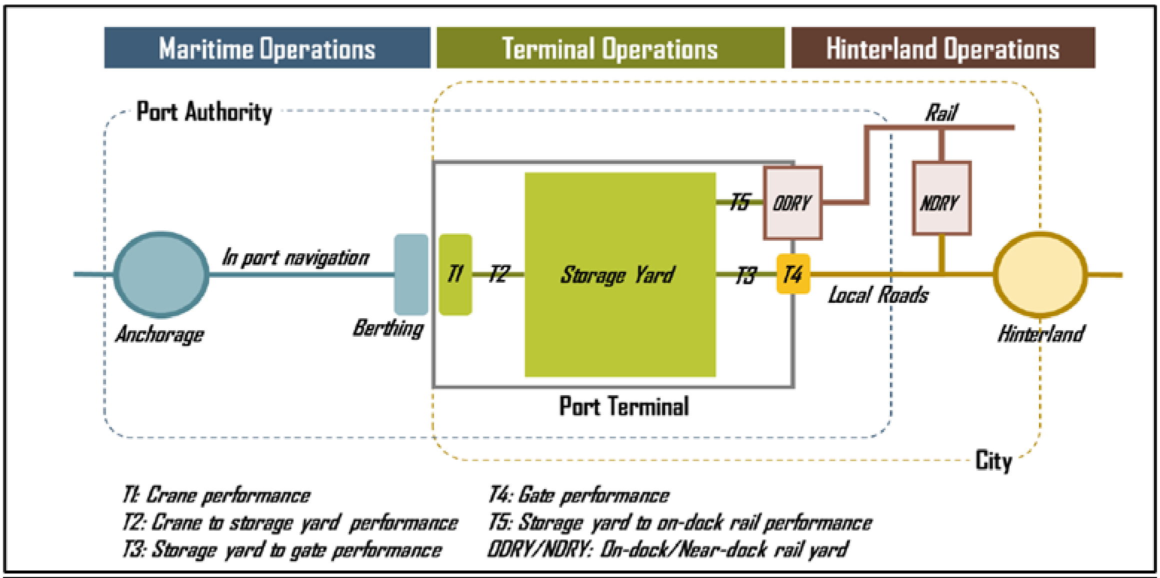


Source: (Cimino, et al., 2017)

2.2.2 Seaport Operations

Port operations are characterised by the type of commodities that are handled which in turn informs the port infrastructure and superstructure (Notteboom, Pallis, & Rodrigue, 2022). The operations of a port cover a continuum that includes marine, terminal and hinterland operations (International Transport Forum, 2014). Therefore, there are several role players that impact operations at the port. These include the port's authority, port terminals, shipping lines, shipping agents, cargo owners, road and rail operators (Boile, Theofanis, & Spasovic, 2006).

Figure 3: Port Operations Spectrum



Source: (International Transport Forum, 2014)

2.2.2.1 Marine Operations

The components of marine operations include ship pilotage, towage and berthing services (International Transport Forum, 2014). These services are provided by the port's authority or marine operators for ships' navigation at the port (International Transport Forum, 2014). The key indicator of performance for marine operations is anchorage waiting time and ship turnaround time (International Transport Forum, 2014).

2.2.3.2 Terminal Operations

Port terminal operators are concessioned by the Port's Authority to provide cargo handling services within the port (Bichou, 2021). Terminal operations are made up of the waterside and landside operational activities (International Transport Forum, 2014). Common measures for waterside terminal operations are gross crane moves per hour (GCH) and moves per ship working hour (SWH) (International Transport Forum, 2014). Landside operations include the storage, collection and delivery of containers by road and rail transporters (International Transport Forum, 2014). Container storage dwell times, road and rail transport turnaround times measure effectiveness of the landside operations (International Transport Forum, 2014).

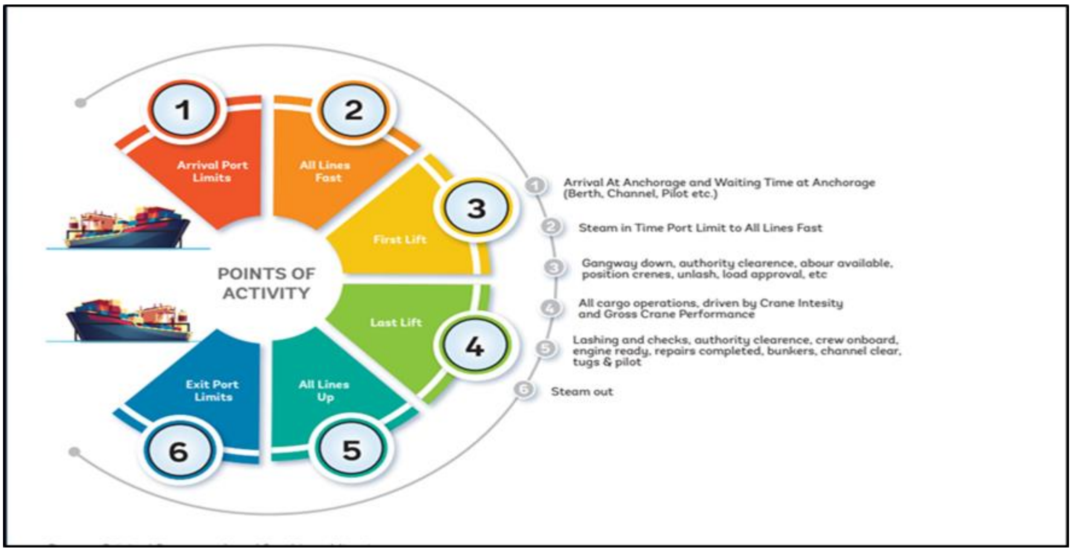
2.2.3.3 Hinterland Operations

Hinterland operations link ports and domestic economic centres through local road and rail network to enable the distribution of containers (International Transport Forum, 2014).

2.2.3 Measuring Port Operations Performance

Dlamuka (2022) defines operational port performance as an output from utilisation of port resources. Port operations performances can be evaluated using several measures such as the speed of cargo handling operation, duration of ships' port-stay including inland transport turnaround time (De Monie, 1987). The ships' port stay is measured by ship turnaround time (STAT) which is concerned with ship productivity from arrival to departure (Motau, 2015). World Bank (2022) refers to STAT as a primary measure of port performance. Thus, port performance is measured by average STAT and the ships' daily throughput (Nottenboom, 2008). Figure 4 below illustrates the six elements of STAT (World Bank Group, 2022).

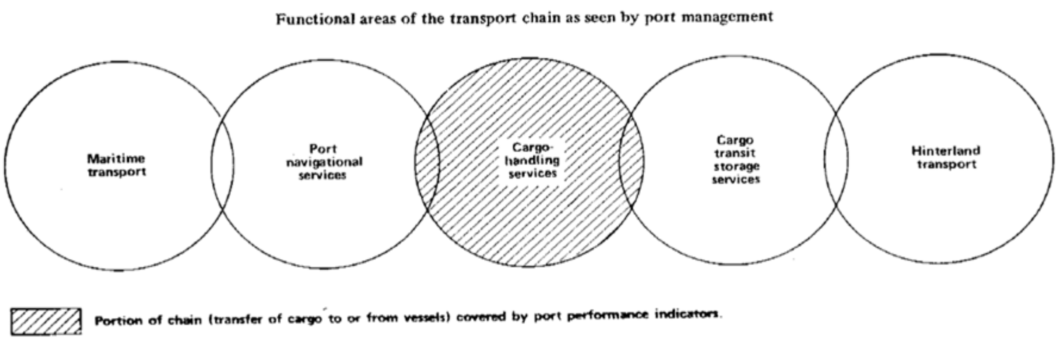
Figure 4: Elements of Ship Turnaround Time



Source: (World Bank Group, 2021)

Points two and five in Figure 4 above are marine operations whereas three and four are terminal container handling activities (World Bank Group, 2022). Terminal operations account for the major portion of port operational performance (Pallis & Syriopoulos, 2007). Terminal operators provide the most essential services within a seaport and thus are at the centre of port value chain and performance (De Langen, Nijdam, & van der Horst, 2007). Figure 5 below illustrates the position of terminal operations within the port value chain.

Figure 5: Port operations value chain



Source: (UNITED NATIONS, 1976)

In South Africa, TNPA as a marine operator and TPT as a terminal operator have the most influence on STAT (Dlamuka, 2022). In its role as a landlord ports authority, TNPA introduced operational performance monitoring standards for local ports (Dlamuka, 2022). This is aimed at evaluating and improving performance of all South African ports (Motau, 2015).

The port performance standards are grouped into Terminal Operator Performance Standards (TOPS) and Marine Operator Performance Standards (MOPS). The TOPS standards include container storage, GCH, SWH, road and rail transport turnaround times. The anchorage waiting time, average ship turnaround time and are part of the MOPS standards (Dlamuka, 2022). Each of the four container ports is unique, thus the targets on the standards are different and informed by the distinct features such port infrastructure, capacity, superstructure and resource configuration (Dlamuka, 2022).

2.2.4 Comparing South Africa Container Port Operations Performance

This section expands on available literature on comparing local container ports' performance.

i. Port of Durban

This is the largest port in South African with a capacity of over 3 million twenty-foot equivalent unit (TEU's) per annum and water depth of 12.8 meters (International Transport Forum, 2014). The port of Durban recorded high anchorage waiting time in 2015, this significantly reduced its competitiveness (Humphreys, Stokenberga, Dappe, Iimi, & Hartmann, 2019). Furthermore, during the 2014/15 financial year Durban container terminals (DCT) averaged a GCH of 24 crane moves against a target of 28 and an SWH of 58 moves compared to the set target of 62 moves for the period (Motau, 2015). This led to increased berthing time and lengthy STAT (Ports Regulator of South Africa, 2015/16). The prolonged STAT is explained by a decline in operational efficiencies and compounded by the larger-size ships that have become prominent at the port of Durban.

However, the standard deviation calculation showed that DCT experienced less STAT volatility than NCT (Motau, 2015). This can be contributed to the fixed berthing windows which contractually obliges both the shipping line and terminal to set arrival and departure times (Motau, 2015). These agreements are referred to as container terminal operations contracts (CTCO) (Motau, 2015).

In the 2018/19 financial year, the Durban port showed improvements on the STAT and anchorage waiting time from the 2017/18 period (Dlamuka, 2022). This improvement could be attributed to a decline in ships calling at the port of Durban as the shipping lines divert more ships to the ports in the Eastern and Western Cape (Dlamuka, 2022). Thus, the performance improvement is not due to improved port productivity but to less ships calling at this port. One of the fundamental causes for traffic diversion from the port of Durban is water depth, which is shallow compared to ports of Ngqura and Cape Town. Thus, the shallow depth limits the port of Durban’s ability to accommodate the new larger ships that have become prominent in the marine sector.

Despite the performance improvements in 2018, the Container Port Performance Index (CPPI) by the World Bank’s Transport Global placed the port of Durban among the worst performing ports in the world (World Bank Group, 2023). However, the CPPI report does not consider port of Durban’s container dwell time performance which is among the best in the world (van der Merwe, 2024). Thus, the South African container ports are arguably not the worst in the world as claimed in the CPPI.

ii. Port of Cape Town

The third largest container port in terms of capacity at 900 000 TEU’s and depth of 15.5 metres (Motau, 2015). Like the Durban port, the port of Cape Town experienced performance decline on anchorage waiting time and STAT (Humphreys, Stokenberga, Dappe, Iimi, & Hartmann, 2019). The Cape Town Container terminal (CTCT) achieved an average GCH of 31.8 crane moves against a set target of 32 for the 2014/15 financial year (Motau, 2015). On SWH performance, the terminal recorded 48 moves against the target of 52 moves indicating poor performance (Motau, 2015). In 2018/19 financial year, the port achieved a 3.6% and 66.7% improvement on STAT and anchorage waiting time respectively, including a 6.6% improvement on SWH compared to 2017/18 (Dlamuka, 2022).

This port recorded the highest anchorage waiting time of 120 hours by 2019, the worst performance among the four container ports (Ports Regulator of South Africa, 2022/23). As such, the CCPI placed the port Cape Town in the last position on the 2023 list of container ports' performance (World Bank Group, 2023). The inclement weather conditions compounded by system challenges have led to port congestion and performance decline (Potgieter, Leila , & Havenga, 2020).

iii. Port of Port Elizabeth

The smallest container handling facility among the four container ports with a capacity of 375 000 TEU's and draft of 12.2 metres (Motau, 2015). The STAT performance improved by 5% in 2018/19 from the 2017/18 financial year (Dlamuka, 2022). There was also an anchorage waiting time improvement of 19.7% in 2018/19 from 2017/18 (Dlamuka, 2022). However, in 2018/19 the SWH performance declined by 9.7% from the previous financial year (Dlamuka, 2022).

Compared to the other three container ports, Port Elizabeth received the highest ranking on the World Bank's 2022 CPPI (Richardson, 2024). However, the PRSA port benchmark report observed a performance decline on SWH and GCH (Ports Regulator of South Africa, 2022/23).

iv. Port of Ngqura

The port has a design capacity of 1.3 million TEU's and a 16.5 metre water draft, making the second largest and deepest container port in South Africa (Motau, 2015). In the 2014/15 financial period, NCT failed to achieve the set targets of 30 crane moves and 51 moves per hour on GCH and SWH respectively (Motau, 2015). However, compared to 2017/18 the port showed a performance improvement of 20.5% on STAT in 2018/19 (Dlamuka, 2022).

During 2018/19 the port of Ngqura experienced a 2% performance decline on anchorage waiting time, meaning that ships stayed longer in 2018/19 than in 2017/18 (Dlamuka, 2022). This was contributed to more ships diverted from

Durban to Ngqura because of its depth to accommodate the new generation vessels. Among the local container ports, the port of Ngqura is one of the better performing container facilities compared to the port of Durban and Cape Town (Richardson, 2024). What sets this port apart from rest is its ability to accommodate large ships (Motau, 2015).

2.3 First research objective: Comparing operational performance of the four major container ports in South Africa

There is limited research comparing South African container ports against each other to identify performance relative to one-another.

2.3.1 *Proposition 1*

Operational performance for the ports of Durban, Ngqura, Cape Town and Port Elizabeth is comparable.

2.4 Second research objective: Identify better performing local container ports and determine key drivers of port performance.

Port operational performance is influenced by several factors both within and outside the control of a port (Bichou, 2021). Port performance is depended on how each port manages these factors or leverage some of them for success.

2.4.1 *Proposition 2*

Factors that contribute to port performance are similar across the four major container ports.

2.5 ANALYTICAL FRAMEWORK

The analytical framework is an integrated overview of the theoretical and empirical concepts of this study.

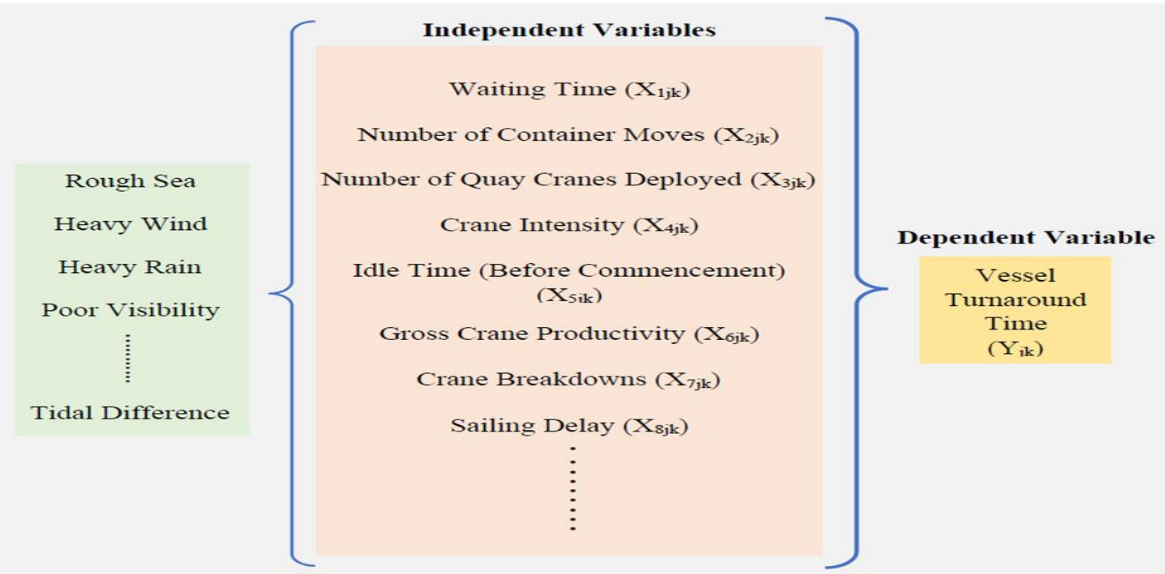
2.5.1 *Theoretical Framework*

According to Notteboom, Pallis, & Rodrigue (2022), port performance is concerned with the speed at which containers are handled at port terminal. This determines how fast the port turns the ships around (Notteboom, Pallis, & Rodrigue, 2022). However, De Langen, Nijdam & van der Horst (2007) define port performance as growth in port throughput. To remain competitive and achieve throughput growth, ports need to turn ships around quicker, thus STAT is the ultimate measure of port performance (World Bank Group, 2022). Therefore, the definition of port performance from World Bank (2022) is more relevant for this study.

2.5.2 *Conceptual Framework*

A conceptual framework is a model of the theoretical data demonstrating a link between different variables (Leshem & Trafford, 2007). Several variables of port performance are interdepended and thus relationships exist between them (International Transport Forum, 2014). Thus, port performance as measured by STAT is the total of all the different variables combined (Dayananda, Vijayanand, & Dwarakish, 2021). Figure 6 below illustrates the framework for STAT**.**

Figure 6: Input and Output variables



Source: (Premathilaka, 2018)

2.6 Conclusion of Literature Review

This chapter presents comprehensive literature review on comparative studies of the relative performance of South African container ports. Furthermore, discusses literature on standard measures of operations performance for container ports. Lastly, outlines the analytical framework for port performance.

CHAPTER 3. RESEARCH METHODOLOGY

This chapter outlines the research approach, design and data collection method. undertaken. Furthermore, this section describes the research instrument including the data collection and analysis procedure. Finally, the quality assurance and ethical considerations for this study are outlined.

3.1 Research approach

This study is a combination of qualitative and quantitative approaches. A quantitative approach reduces data into a numerical figure and a qualitative study uses non numerical data for analysis (Gelo, Braakmann, & Benetka, 2008). Combining both approaches ensures a statistical analysis of the numerical performance data and collection of non-numerical data for factors contributing to performance. This approach is suitable to measure performance difference and relationships among various factors of performance for container ports. As such, key performance standards for port operational performance were identified and statistically compared. Whilst the qualitative aspect of the study was suitable in further identifying causal effects to the phenomenon.

3.2 Research design

This is a desktop study using secondary data to compare operations performance of container seaports in South Africa. The performance data was collected from published company annual reports and previous research work. Collecting data from publicly available sources was to shorten the time for gathering data whilst ensuring the information is from audited and reliable sources.

The dissertation contains a comprehensive Literature Review in Chapter 2 to highlight what previous scholars have discussed in relation to comparing performance of local container ports including a conceptual framework. Chapter 3 discusses data sampling and the type of research instrument for data collection including data analysis strategies. Chapter 4 presents the descriptive statistical analysis comparing performance data and discusses the causals-and-effect relationships between the various factors and port performance. Finally, Chapter 5 concludes the dissertation summarizing the analysis carried out, discussing key findings and providing recommendations for consideration.

3.3 Data collection methods

The study uses secondary data from published Transnet SOC, TNPA, TPT annual reports and other research work on container ports. TNPA port statistics database including maritime industry reports were also instrumental. The information used in this research is from 2012 to 2023. These reports contained standard performance information on port operations including set targets and achieved performance.

3.4 Population and sample

The population and sample are drawn from the South African container seaports.

3.4.1 *Population*

The study population is the four South African container ports.

3.4.2 *Sample and sampling method*

The sample is drawn from the operational performance of the of the container ports. The sample size includes a 12-year STAT, GCH, SWH and anchorage waiting time performance information from 2012 to 2023. This is sufficient to provide performance view and impact from before and after 2020 COVID pandemic. A systematic sampling was applied for selecting annual performance information. This is the type of probability sampling where selected elements of the sample are separated on fixed intervals (Mweshi & Sakyi, 2020).

3.5 The research instrument

A data collection check sheet is used as a research instrument. This is appropriate in ensuring that all the required data is completed. The check sheet provides easy visibility in identify missing information that is required for analysis. The check sheet used is reflected in the attached Appendix A.

3.6 Procedure for data collection

The research data collection procedure entailed defining objectives for the data, develop data collection plan and gathering of data. During data collection, the research data was captured from the various sources onto and the checklist ensuring that all required boxes are completed. This procedure was suitable in ensuring that performance data was captured sufficiently.

3.7 Data analysis strategies and interpretation

Descriptive statistics and time series plot have been useful in analysing the quantitative data. A fishbone diagram was used as an instrument in the assessment of qualitative data. These were sufficient in providing detailed analysis to address the research questions and draw a meaningful conclusion. Appendix B illustrates data collection and analysis methods in line with the research questions and propositions. Microsoft Excel's XLMiner Analysis ToolPak was used for the statistical tools and graphical illustrations.

3.8 Possible limitations and challenges of the study

One of the possible weaknesses is the adequacy of analysis method in identifying all possible factors of port performance.

3.9 Quality Assurance

In quantitative research, the term validity and reliability refer to the ability of the measuring instrument to measure what it is supposed to, consistently (Black & Champion, 1976).

3.9.1 *External validity OR transferability*

External validity for this study is the measure to which study findings can be applied to container ports other than the four South African ports identified for this study. This research meets the transferability criteria in that the findings can be applied to other container ports with similar infrastructure, superstructure and operational processes. This is the ultimate test of generalisability of the research findings (Winter, 2000).

3.9.2 *Internal validity OR credibility*

This study meets the internal validity criteria in that the identified variables are related, and through this study a relationship between then was established. According to Winter (2000), internal validity relates to whether the research output variable is related to the input variables. STAT as the output variable is influenced by GCH, SWH and anchorage waiting time.

3.9.3 *Reliability OR dependability*

Reliability refers to the ability of another researcher to reproduce the result should the study be repeated and done under similar conditions (Roberta Heale & Twycross, 2015). This study meets the reliability criteria as the results can be reproduced where data is collected from container seaports with similar infrastructure, superstructures, resource configuration and operational processes.

3.10 Ethical considerations

This was a desktop study and thus provides for limited contact with humans. The ethical considerations were maintained by ensuring that only publicly available and audited information is used in this research. This further alleviates data integrity issues.

3.11 Proposed schedule and timelines

Appendix C shows the detail timelines of this study.

3.12 Chapter Conclusion

This chapter presented research methodology including data sampling, collection and analysis methods. The research approach and design were discussed, including quality assurance and ethical considerations for this study.

CHAPTER 4. DATA REPRESENTATION AND ANALYSIS

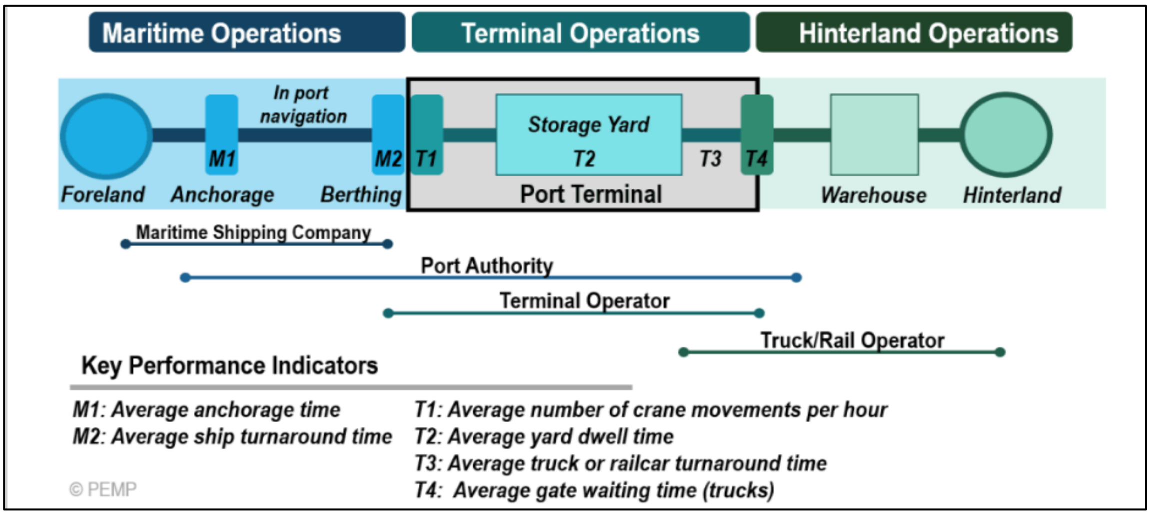
4.1 Introduction

The purpose of this chapter is to present data analysis and interpret the results.

4.2 Research Data

The data for this study was collected from the Transnet, TPT and TNPA annual reports for the period from 2012 to 2023. The scope of this study includes waterside activities only and thus focuses on the marine and terminal operations as key contributors to port operations performance. Therefore, the data contains ship turnaround time (STAT) as a measure of port operations performance. Furthermore, included in the data is the anchorage waiting time, container moves per hour (SHW) and gross crane moves per hour (GCH) as enablers of STAT. Figure 7 below illustrates key performance standards for port performance.

Figure 7: Port Key Performance Indicators



Source: (Notteboom, Pallis, & Rodrigue, 2022)

4.3 Presentation of results

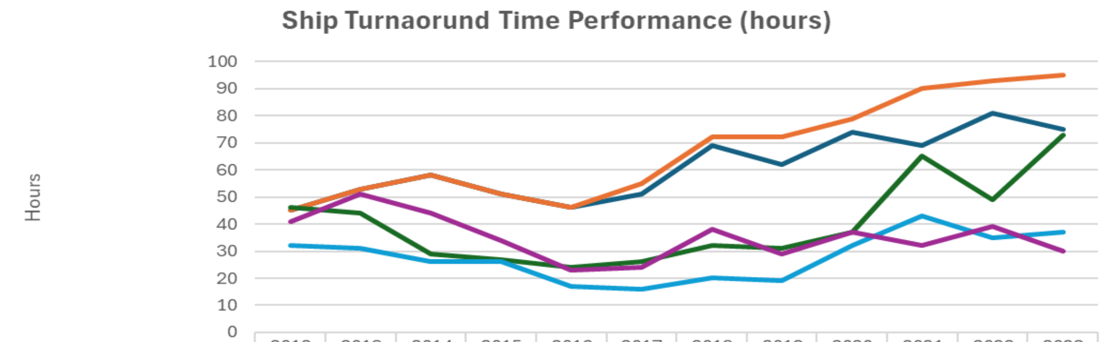
Below is the presentation of the statistical analysis and interpretation of results on STAT including its elements such as, anchorage waiting time, SWH and GCH.

The statistical tools used for data analysis are the time series plot, descriptive statistics and a fishbone diagram.

4.3.1 Time Series Plot

A time series plot was used to help determine a performance trend over the 12-year observation period. Figure 8 below is a graphical illustration of the ship turnaround time performance at the four container ports.

Figure 8: Time Series Plot for Ship Turnaround Time (STAT)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
DCT 1	45	53	58	51	46	51	69	62	74	69	81	75
DCT 2	45	53	58	51	46	55	72	72	79	90	93	95
Port of Cape Town	46	44	29	27	24	26	32	31	37	65	49	73
Port of Port Elizabeth	32	31	26	26	17	16	20	19	32	43	35	37
Port of Ngqura	41	51	44	34	23	24	38	29	37	32	39	30

Source: (Transnet SOC, 2012;2023)

i. Port of Durban

This port consists of two container terminals, the Durban container terminal 1 (DCT 1) and Durban container terminal 2 (DCT 2). The port of Durban experienced a significant increase in STAT by 2023 from 2012, meaning that the port takes longer in turning ships around. This increase in STAT became evident from 2018 at both at DCT 1 and DCT 2.

Figure 8 above shows a 67% and 111% increase in STAT from 2012 to 2023 at DCT 1 and DCT 2, respectively. This reflects an average increase of 89% for the port of Durban. Increasing STAT shows a decline in port operational performance, as shipping lines calling at a port prefer shorter turnaround times

(World Bank Group, 2022). The decline in STAT performance continued downward from 2018 to 2023 at the port of Durban as illustrated in Figure 8. This is indicative of a decline in the quality of service provided to port users. This means that in 2018, ships calling at this port stayed longer than they did in 2017. In 2023 STAT at DCT 1 and DCT 2 was 30 and 50 hours longer than in 2012, an increase of up to two days in port stay.

ii. Port of Cape Town

Figure 8 above shows a 75% increase in 2021 from the 2020 STAT performance. Between 2014 to 2019, this port was able to turn ships around in just over 24 hours. However, by 2023 there was a 59% increase in the total ship port stay from 2012. This means that by the end of 2023, ships calling at the port of Cape Town stayed 27 hours or one day longer than they did in 2012. This shows a port performance decline in the last 12 years. The most significant shift in performance was in 2021 where the port saw STAT double that of prior years.

iii. Port of Port Elizabeth

This is one of the two container ports based in the province of the Eastern Cape. Figure 8 above shows that between 2014 to 2019, the port was able to turn ships around in less than 24 hours. However, by 2023 the ship port stay had increased by 15% from the 2012 baseline. Thus, by 2023 ships calling at Port Elizabeth port stayed 5 hours longer than in 2012.

iv. Port of Ngqura

This is the newest and deepest container port in South Africa having commenced operations in 2009 (Ports Regulator of South Africa, 2022/23). It is evident from Figure 8 that this is the only port that has shown performance improvement over the 12-year period. The port of Ngqura was able to achieve a 27% decrease in STAT in 2023 from 2012. A decrease in STAT shows that ships spent less time than planned at the port, an ideal scenario for customers and shipping lines. In 2023, ships calling at the port of Ngqura stayed 11 hours less than in 2012. Though the port experience performance challenges between 2020 and 2022, performance improvements have been evident.

4.3.2 Descriptive Statistics

Container ships operate on a fixed schedule and thus require predictability and a consistent level of port services to adhere to planned berthing windows (World Bank Group, 2022). Thus, shipping lines and customers prefer limited deviation to planned ship stay at a port. Deviation from planned ship stay is a result of high variation in STAT which leads to port congestion, missed berthing windows and additional costs for shipping lines.

Therefore, the use of descriptive statistics aids in determining performance variation across the four container ports. Descriptive statistics use variance and standard deviation as measures of variation. Thus, for the purpose of this study, a standard deviation is used to explain performance spread from the average STAT at each port. Table 3 below is the summary of descriptive statistics illustrating the standard deviation for each port. A high standard deviation indicates inconsistency of services offered to customers at the ports.

Table 3: Descriptive Statistics for Ship Turnaround Time (STAT)

	DCT 1	DCT 2	Cape Town	Port Elizabeth	Ngqura
Mean	61.167	67.417	40.25	27.833	35.167
Standard Error	3.533	5.353	4.558	2.483	2.364
Median	60	65	34.5	28.5	35.5
Mode	69	72	73	32	51
Standard Deviation	**12.239**	**18.545**	**15.789**	**8.601**	**8.189**
Sample Variance	149.788	343.902	249.295	73.970	67.061
Kurtosis	-1.413	-1.506	0.284	-0.964	-0.175
Skewness	0.186	0.338	1.078	0.119	0.267
Range	36	50	49	27	28
Minimum	45	45	24	16	23
Maximum	81	95	73	43	51
Sum	734	809	483	334	422
Count	12	12	12	12	12
Largest(1)	81	95	73	43	51
Smallest(1)	45	45	24	16	23
Confidence Level(95%)	7.776	11.783	10.032	5.465	5.203

Source: (Transnet SOC, 2012;2023)

i. Port of Durban

The standard deviation for DCT 1 and DCT 2 is 12.239 and 18.545, respectively and is indicative of a level of dispersion from STAT over the 12 years. There is more variation in DCT 2 performance compared to DCT 1. Thus, DCT 2 is the largest contributor to the unpredictable service at the port of Durban.

From an average STAT of 61 hour at DCT 1, ships stayed between 49 and 73 hours, and DCT 2 took between 50 and 85 hours to turn ships around. This indicates that ships either left the port 15 hours earlier or 15 hours later than the average departure time. If a ship leaves later than anticipated, this leads to missed berthing windows at the next port or having to burn more fuel to make up for the lost hours to adhere to a berthing slot. If ships leave the port 15 hours earlier, they must wait outside at anchorage at the next port thus contributing to port congestion. Therefore, high variation in port stay contributes to planning challenges for customers and shipping lines which equates to poor port services.

ii. Port of Cape Town

Table 3 above indicates a standard deviation of 15.789, thus a 15-hour variation from the average STAT performance in the last 12 years. Therefore, ships calling at the port of Cape Town experienced an average of 15-hours delays. Furthermore, this means that ships were turnaround between 25 and 55 hours when calling at this port. During the observation period, ships were turnaround 15 hours earlier or 15 hours later than the average STAT.

iii. Port Elizabeth

Performance variation is less than that of ports of Durban and Cape Town as indicated by the standard deviation of 8.601. Ships calling at the port of Port Elizabeth experienced just over 8 hours of delays from the average STAT. The standard deviation of 8.601 hours means that in the last 12 years ships were turned around between 36 and 19 hours. Thus, ships left the port by 8.6 hours earlier or 8 hours later than planned time as illustrated on Table 3 above.

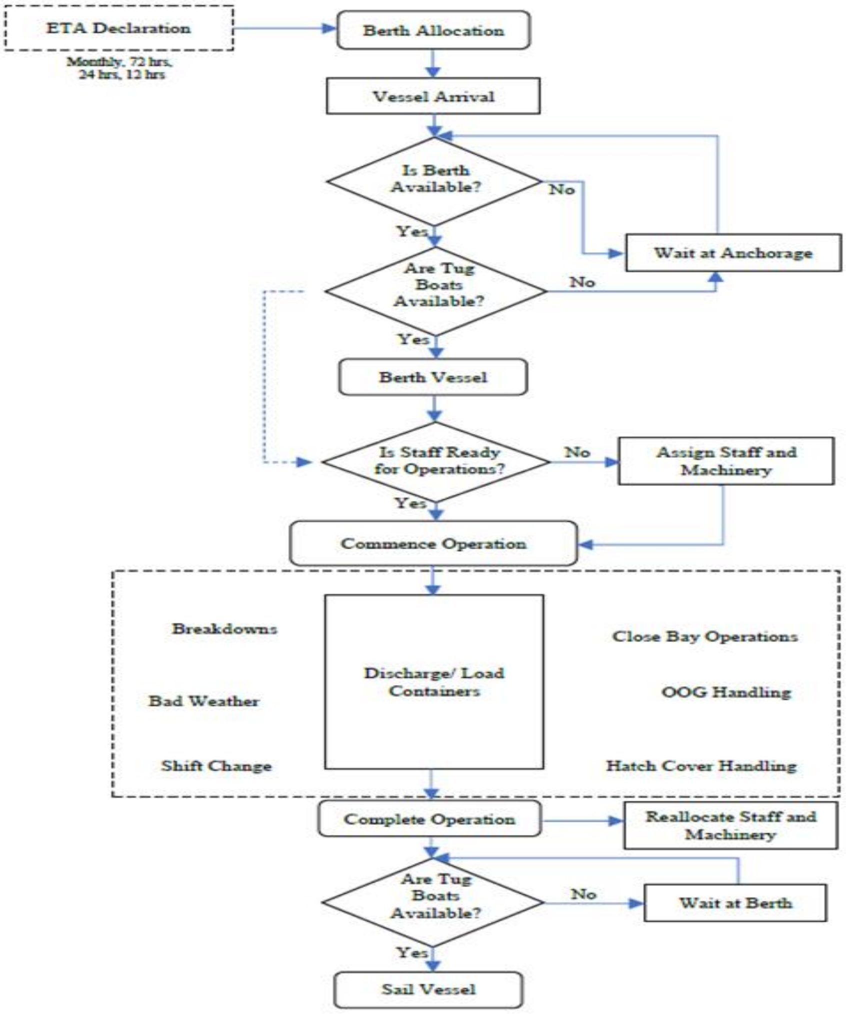
iv. Port of Ngqura

The port of Ngqura showed the least spread compared to the other three container ports. Thus, ships experience less delays and less variation in port services when calling at this port. Table 3 above shows a standard deviation of 8.189, meaning that ships left the port 8.2 hours earlier or later than planned.

4.3.3 Measuring the elements of Ship Turnaround Time

When ships call at a port, they request marine services which includes pilotage, towage and berthing (International Transport Forum, 2014). Thus, the response time for the port in providing such services is one of the determining factors for STAT. Delays in the provision of marine services leads to long anchorage waiting time. Furthermore, once marine services have been provided and ships are berthed, terminal operations commence. The start of terminal operations is depended on the availability of a berth, customer instructions and terminal resources (Motau, 2015). The duration of terminal operations is determined by the rate of work as measured by SWH and GCH. Therefore, anchorage waiting time, SHW and GCH are all elements of STAT. Figure 9 below is a process flow of a container ship's call at a port.

Figure 9: Process flow Diagram

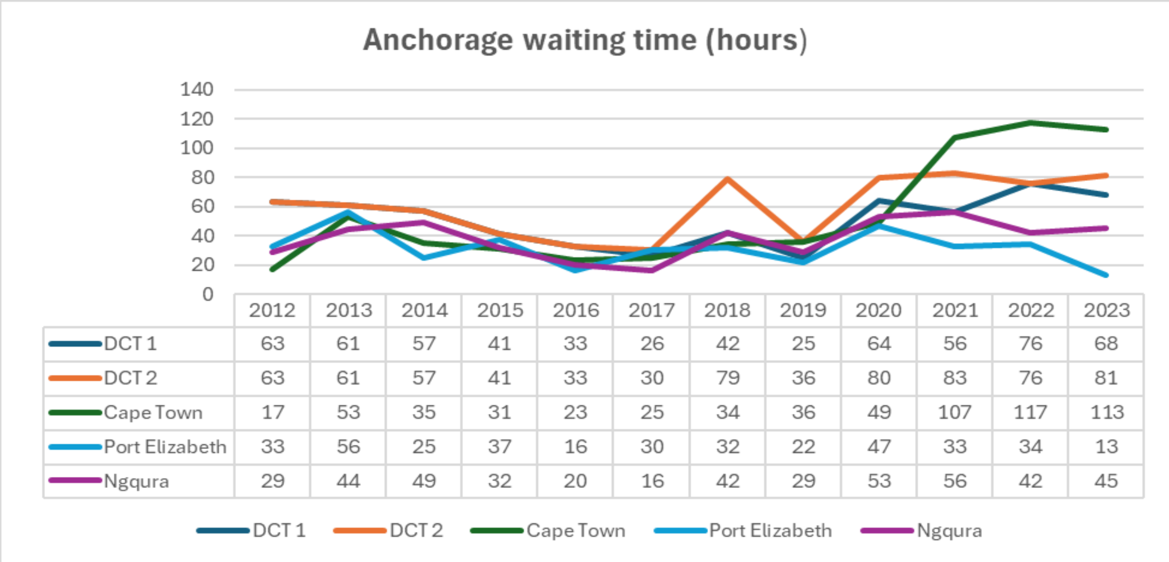


Source: (Premathilaka, 2018)

a) *Anchorage Waiting Time*

Anchorage waiting time is a measure of how long ships wait outside for port services**.** This can be influenced by several factors such as availability of berths, marine resources availability, severe weather conditions and other factors outside the control of the port. Figure 10 analyses the performance trends and comparisons on anchorage waiting time.

Figure 10: Time Series Plot for Anchorage Waiting Time



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
DCT 1	63	61	57	41	33	26	42	25	64	56	76	68
DCT 2	63	61	57	41	33	30	79	36	80	83	76	81
Cape Town	17	53	35	31	23	25	34	36	49	107	117	113
Port Elizabeth	33	56	25	37	16	30	32	22	47	33	34	13
Ngqura	29	44	49	32	20	16	42	29	53	56	42	45

Source: (Transnet SOC, 2012;2023)

i. Port of Durban

There has been a significant increase in 2020 on anchorage waiting time at DCT 1 and DCT 2 as is reflected in Figure 10 above. The port of Durban continued this negative trajectory until 2023. On average, ships calling at the port of Durban waited outside at anchorage 40 hours more in 2020 compared to 2019. In 2023, ships waited outside for port services an additional 20 hours more than in 2012 at DCT 2. An increase in anchorage waiting time is an indication of performance decline and could thus signify delays in marine and terminal services. Figure 10 above shows that in 2023, ships spent up to three days on average waiting outside at anchorage at the port of Durban.

ii. Port of Cape Town

Figure 10 shows an increase in anchorage waiting time in 2020 from 2019. Between 2012 and 2020, the port averaged just over 30 hours on anchorage waiting time. In 2023 ships calling Cape Town spent 96 hours more on anchorage than in 2012. This is an additional four days that ships spent outside in 2023 compared to 2012. This is a result of the increase to 113 in 2023 from 17 hours in 2012 indicating a performance decline and longer port stays.

iii. Port of Port Elizabeth

This port showed a reduction in anchorage waiting time in 2023 from 2012 as illustrated in Figure 10, though there was a significant increase of 14 hours in 2020 because of government regulations for less personnel at the workplace. Performance had improved by 34 hours in 2023 from the 2020 period. By 2023, the port of Port Elizabeth was one port that achieved the lowest anchorage waiting time. While other ports showed an increase in anchorage waiting time during the 12 years, this is one port that has managed to minimize anchorage delays. This is a major achievement, indicating that shipping lines spent less time at anchorage and would receive services within 13 hours of arriving at the port.

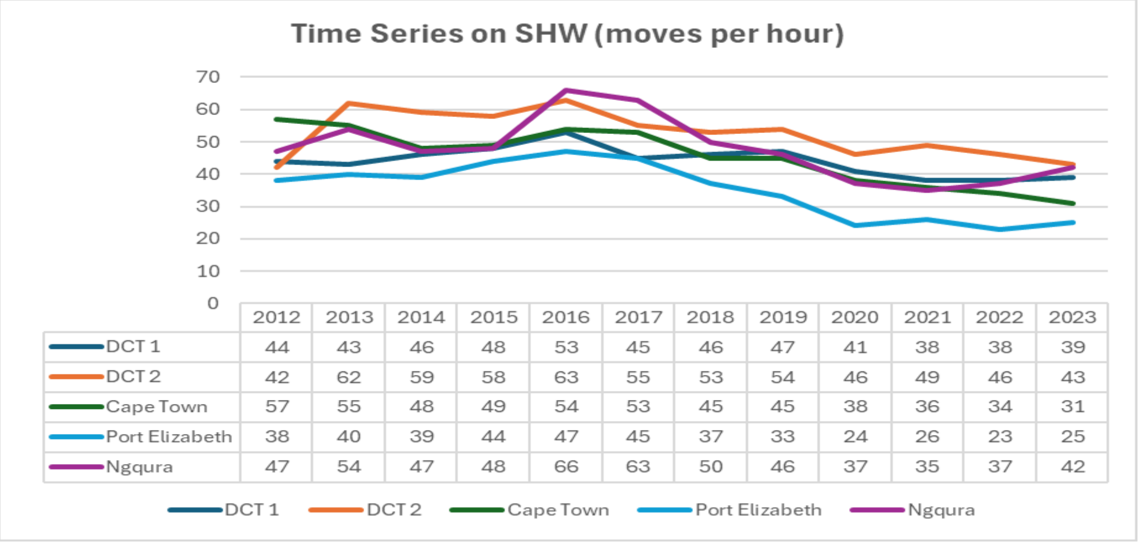
iv. Port of Ngqura

Figure 10 shows that anchorage waiting time increased by 16 hours in 2023 from 2012. The port of Ngqura is one of the three ports that experienced performance decline in anchorage waiting time between 2012 and 2023. The major decline became evident in 2020, with a 24 hour increase in anchorage waiting time from 2019. In 2023, ships calling at the port of Ngqura had to wait 45 hours for services; an average of two days.

b) Ship Working Hour

Port container hourly throughput is referred to as hourly moves (Notteboom, Pallis, & Rodrigue, 2022). The ship working hour (SWH) is a measure of average number of containers handled during a ship working hour (Motau, 2015). Figure 11 below shows a 12-year trend on container loading rates at each of the four container ports. The SWH is one of the major contributors to STAT.

Figure 11: Ship Working Hour (SWH) Performance



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
DCT 1	44	43	46	48	53	45	46	47	41	38	38	39
DCT 2	42	62	59	58	63	55	53	54	46	49	46	43
Cape Town	57	55	48	49	54	53	45	45	38	36	34	31
Port Elizabeth	38	40	39	44	47	45	37	33	24	26	23	25
Ngqura	47	54	47	48	66	63	50	46	37	35	37	42

Source: (Transnet SOC, 2012;2023)

i. Port of Durban

The port of Durban had a decline in SHW from 2012 to 2023 as illustrated in Figure 11 above. The port experienced a significant decline in container loading rates from 2020 to 2023. A decline in SWH signifies a decrease in terminal productivity and thus a drop in operational performance. A low SWH leads to prolonged time for the ship at berth and at the terminal and thus results in longer port stay. Durban has been severely impacted by shortage of port resources, equipment breakdown and inclement weather (Transnet National Ports Authority, 2023).

ii. Port of Cape Town

Figure 11 shows that the port of Cape Town experienced a decline in performance between 2012 and 2023. There was a 46% drop in SWH in the last 12 years. The most significant decline was at 43% from 2016 to 2023. Performance at the port of Cape Town dropped from 57 container moves per hour in 2012 to averaging 31 moves. This indicates a significant decline in performance as result of severe weather condition and equipment failures (Transnet Port Terminals, 2023).

iii. Port of Port Elizabeth

In 2023, the port achieved an SWH performance of 34% less than in 2012, showing a significant decline in performance in the last 12 years. The decline in SWH became more evident from 2016 and the negative trend continued throughout to 2023.

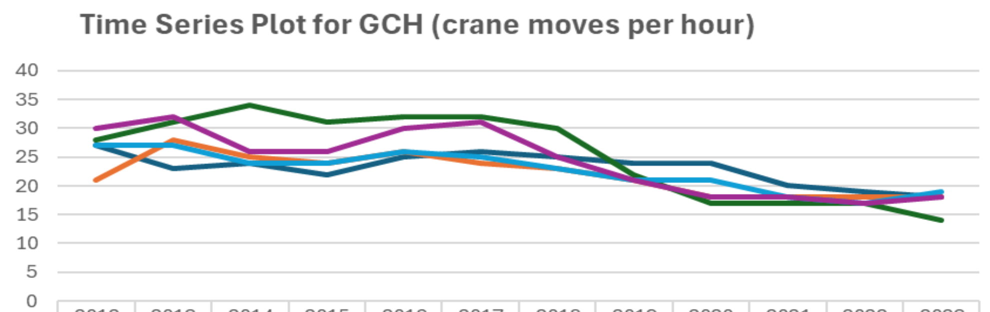
iv. Port of Ngqura

The port of Ngqura had the least decline in SWH performance over the 12-year study period. There was an SWH reduction of 11% between 2012 to 2023, with a significant decline between 2019 and 2022. The port showed some improvement in 2023.

c) Gross Crane Moves per Hour (GCH)

Container terminals deploy ship to shore (STS) cranes to load and offload containers from ships (Notteboom, Pallis, & Rodrigue, 2022).Thus, GCH measures crane productivity as indicated by the average number of containers handled by each crane during a ship working hour. Figure 12 below shows a trend for the GCH over the 12 years.

Figure 12: Port Performance on Gross Crane Moves per hour (GCH)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
DCT1	27	23	24	22	25	26	25	24	24	20	19	18
DCT 2	21	28	25	24	26	24	23	21	18	18	18	18
Cape Town	28	31	34	31	32	32	30	22	17	17	17	14
Port Elizabeth	27	27	24	24	26	25	23	21	21	18	17	19
Ngqura	30	32	26	26	30	31	25	21	18	18	17	18

DCT1 DCT 2 Cape Town Port Elizabeth Ngqura

Source: (Transnet SOC, 2012;2023)

i. Port of Durban

The port of Durban had a 33% and 14% GCH decline at DCT 1 and 2, respectively, between 2012 to 2023, as is illustrated in Figure 12. The port experienced a significant decline in crane productivity between 2019 and 2023. A decline in GCH signifies a drop in crane productivity which leads to prolonged time for the ship at berth and thus longer port stay. In 2023, the loading rates at port of Durban had decreased from an average of 26 moves in 2012 to 18 crane moves per hour. Insufficient resource configuration, equipment challenges and inclement weather has been identified as key factors (Transnet Port Terminals, 2023).

ii. Port of Cape Town

Figure 12 shows that the port of Cape Town experienced the worst decline in performance between 2012 and 2023. There was a 50% drop in GCH in the last 12 years. The most significant decline was at 56% between 2016 and 2023. The port of Cape Town achieved 14 moves in 2023 from an average of 28 moves per hour in 2012. This indicates a significant decline in the quality of port services. Equipment breakdown and severe weather conditions have been cited as major contributors (Transnet National Ports Authority, 2023).

iii. Port of Port Elizabeth

The port achieved a 30% decline in crane productivity between 2012 and 2023. The performance of the port of Port Elizabeth declined from an average of 27 crane moves in 2012 to an average of 19 containers loaded an hour in 2023. This signifies a major decline in the productivity of the equipment as shown in Figure 12. This decline has been attributed to aging equipment that is prone to frequent breakdowns (Transnet Port Terminals, 2023).

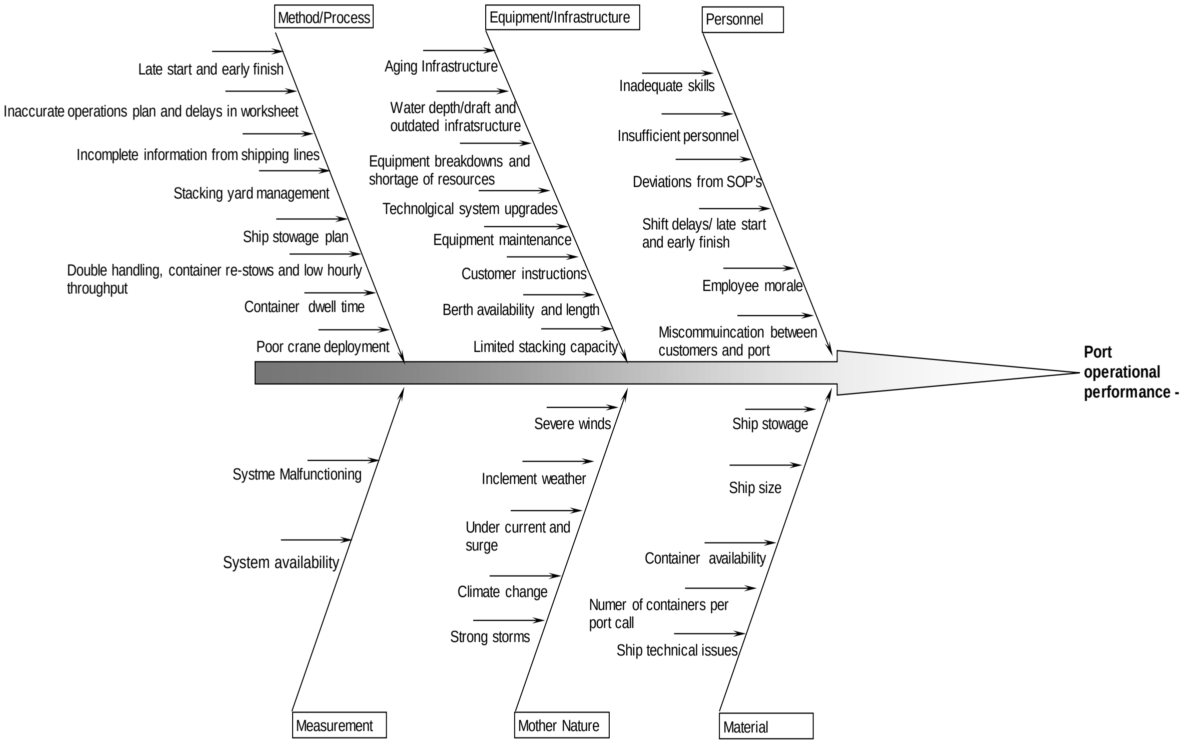
iv. Port of Ngqura

The GCH performance at the port of Ngqura was no different from the other three ports. This port had a 40% decline in GCH between 2012 to 2023, and the largest reduction was from 2018 to 2023.

4.3.4 Factors contributing to port operational performance

Port operational performance as indicated by STAT can be influenced by several factors. These are reflected on Figure 13, the fish bone diagram below.

Figure 13: Fishbone Diagram



Source: (Dlamuka, 2022) and (Motau, 2015)

A fishbone diagram provides a snapshot of the various factors that impact container port performance. These are classified into six categories that include effects from processes, machines, personnel, weather, material and measurement instruments.

a) Method/Processes

Ship turnaround is depended on the port achieving operational norms which are further influenced by the number of operational hours worked. A reduction in operational hours because of late start up and early finish reduces the total hours assigned to a container ship call. Operations start and finish time is influenced by the quality of an operations plan. An inadequate operations plan leads to insufficient deployment of resources and slow rate of ship operations. This can be attributed to incomplete and late information from shipping lines (Motau, 2015). The completeness and accuracy of the plan is depended on the information supplied by shipping lines regarding the quantity and position of containers. This information is used by the port to prepare containers for loading and thus minimise delays from searching for containers during operations. This preparation is referred to as yard management.

Furthermore, shipping lines advise on the loading sequences and positioning of containers onboard a ship. This is referred to as stowage plan (Motau, 2015). A stowage plan is ship’s layout that guides operations on a particular ship. Therefore, any deviation and inconsistency from the stowage plan results in operational delays. Such deviations are a result of changes from the shipping lines or a ship arriving with stowage plans different from what was communicated to the port. In such instances, ports must adapt and adopt the new loading sequence which results in double handling and container re-stows onboard the ship. This slows down the loading and offloading rate, reducing the ports hourly throughput and impact the overall ship turnaround time.

Container ships operate on fixed berthing windows based on agreed operations hours and resource deployment. Once operating hours are exhausted, a container ship will leave the port without necessarily having loaded all the planned containers. This further results in additional storage days for remaining containers. Long container dwell time reduces stacking capacity for arriving boxes (Dlamuka, 2022). Finally, when a port fails to assign enough cranes to a ship, this leads to inefficient operations and poor STAT performance.

b) Machines, Infrastructure and Technology

Aging superstructure and equipment are prone to frequent breakdowns, thus reducing operating hours which prolongs the port stay for ships (Dlamuka, 2022). Some of the ports have outdated infrastructure in form of insufficient water depth and draft to accommodate the new larger ships. The draft at the port of Durban is not as deep as other ports in the country and therefore ships must wait outside during high tide (Motau, 2015). This leads to long anchorage waiting time and port stay. Furthermore, these larger ships also require longer berths, thus leading to one ship assigned to two berths at a time which constrains the berthing capacity. This results in unavailability of berths for arriving ships and extends their anchorage waiting time.

South African container ports are characterised by shortage of equipment and poor maintenance (Transnet Port Terminals, 2023). This leads to less equipment deployed to operations which impacts container handling rates. Container ports are also highly automated and thus rely on latest technology to enable operational efficiencies. Outdated technology is prone to system failures and thus impede operations as the ports often must divert to manual settings which slows down operations. Lastly, the stacking yard of container ports is depended on the technological systems to manage container dwell times. System failures lead to the inability of the port to locate containers which results in long container storage days and reduced stacking capacity (Transnet National Ports Authority, 2023).

c) Personnel

Shortage of personnel is one of the reasons for the decline in port operation performance (Transnet Port Terminals, 2023). This leads to insufficient deployment of personnel to operations impacting the achievement of operational norms. Operational performance norms for container ports are based on predetermined number of personnel and equipment deployed. However, the local container ports have been challenged to meet the required number of resources to achieve the required STAT. Furthermore, container ports rely on well trained personnel to operate the highly automated and advanced operational equipment. As such employee training is necessary to close skills gaps and enable operational performance.

South African ports have reported a fair share of labour strikes over the years which has contributed to performance decline (Transnet SOC, 2012;2023). These strikes have been triggered by low employee morale leading to operational stoppages resulting in long ship port stays. Employee behaviour further impacts performance because of employees' late start and early finish because of shift change challenges leads to reduced operations hours (Dlamuka, 2022).

Furthermore, customers have a direct effect on operations as they contribute to the operation plan by communicating the location of containers and the loading sequence (Motau, 2015). This requires communication and coordination between the port personnel and customers. Failure to communicate effectively leads to port delays and thus impact performance.

d) Material

The condition of a ship calling at a port contributes immensely to port performance. Ships calling at a port with technical issues lead to operational delays and port inefficiencies. Larger ships require more berthing space thus leading to unavailability of berths for other ships resulting in long anchorage waiting time. Water depths is another requirement for the new generation ships; shallow berths lead to inability for ports to accommodate these vessels especially during high tide. Therefore, ships must wait outside at anchorage.

Furthermore, a ship stowage plan has an impact on the port performance as it guides the sequence of loading and offloading containers. Incorrect stowage leads to delays and slow rate of operations.

Finally, availability and condition of containers to be offloaded or loaded onto the ship impact port performance. Incorrect or damaged containers lead to delays, as the ports must stop operations and consult customers on how to proceed with the cargo.

e) Mother Nature

Climate change is a major contributor to the declining performance of South African container ports (Gong, 2023). Inclement weather from severe winds and storms to under currents lead to operational stoppages and port closures. These result in ships staying longer at ports, thus increase ship turnaround time. The ports of Durban, Cape Town and Ngqura have challenges with severe weather conditions resulting in operational delays (Transnet National Ports Authority, 2023). The results in a slow rate of operations or port closures as a safety precaution. In 2023, the port of Durban experienced severe storms that led to infrastructure damages and operational stoppages (Transnet Port Terminals, 2023).

f) Measurement

Container ports are primary automated and thus depend on the systems such as NAVIS to determine port performance (Zangwa, 2018). Measurement of port performance is a complex phenomenal, as there are various stakeholders operating at a port environment. Thus, technology is important to be able to track operational activities. Port performance is thus depended on the efficient operation of the NAVIS to reflect performance correctly. Owing to system challenges, ports occasionally revert to manual processes which result in slower rates of work. Furthermore, lack of systems for tracking and tracing containers leads to ineffective management of container dwell time. When container dwell time is not managed properly, the port encounters storage constrains and limited ability to accommodate more containers

CHAPTER 5. CONLUSION AND RECOMMENDATIONS

5.1 Introduction

The study objectives are to conduct a comparative assessment of the container ports in South Africa and to identify better performing ports. To conduct the comparative study, ship turnaround time (STAT) has been identified as a key measure of port operations performance. Furthermore, anchorage waiting time, ship working hour (SWH) and gross crane moves per hour (GCH) have been identified as key elements of STAT. However, STAT has been used as a key indicator to identify better performing ports. Lastly, several factors that impact port operations performance have been identified and explained. This resulted in the identification of major finding and recommendations as outlined in the sections below.

5.2 Major findings

The STAT performance analysis from the time series plot revealed a significant decline in performance at the ports of Durban, Cape Town and Port Elizabeth during the twelve year-period under comparison. To the contrary, the port of Ngqura showed performance improvements and a reduction in ship turnaround time hours. On the STAT performance, the port of Ngqura performed better compared to the other three container ports.

The analysis further showed that ships calling at the port of Durban spent an additional two days in 2023, compared to 2012. The decline in performance has been compounded by inclement weather, equipment breakdowns, shortage of resources and water depth that constrain the port from accommodating large ships. As a result of weather delays and resource shortages, ships stayed an additional day in 2023 at the port of Cape Town, compared to 2012. In 2023 ships at the port of Port Elizabeth experienced an additional five hours of port stay, compared to 2012. To the contrary, the port of Ngqura managed to reduce the ship turnaround time by 11 hours in 2023 compared to 2012. This can be attributed to yard management, compliance with stowage plans, reduction in cargo dwell time and favorable draft to accommodate the new bigger ships.

To enhance the understanding of the results from the time series plot, descriptive statistics analysis was conducted. The descriptive statistics analysis enabled comparison of standard deviation for the four ports.

In comparing the standard deviations, the port of Durban had the highest variation at 18.545 followed by the Cape Town port at 15.789. This means that ships were either delayed by over 15 hours or departed from the two ports 15 hours ahead of schedule at both ports. Shipping delays results in missed berthing windows, while early departure leads to long anchorage waiting time and congestion at the next port of call.

The two ports in the Eastern Cape showed the least variation at 8.601 hours and 8.189 hours for the port of Port Elizabeth and port of Ngqura, respectively. Based on the standard deviation, ships calling at the port of Ngqura experienced 8-hour delays at most or departed ahead of time 8 hours. In terms of process variability, the port of Ngqura performed better than the other three ports. Therefore, on the STAT comparison, the port of Ngqura showed the most improved performance with minimum operational delays among the four ports.

Lastly, some key findings from the fishbone diagram analysis identify several causes contributing to port performance. These comprise of internal and external factors. Key to internal factors is yard management, container dwell, water depth, sufficient resources, equipment maintenance and adoption of technological advancements. External factors outside the control of the port include the ship stowage plan, size of the ship, inclement weather customer behavior. These factors affect all the four container ports, and the difference is how each port manages them. Through the container terminal operations contract (CTOC) agreements with customers, ports can manage some of these factors and minimize negative impact to operations (Motau, 2015).

5.3 Recommendations

The detailed analysis conducted, enabled the identification of the best performing port and lesson for other ports as outlined below.

Port performance is a complex phenomenal, thus requiring input from all stakeholders to improve and maintain performance. Key to these stakeholders is shipping lines, port's authority and port terminals. Port terminals sign CTOC agreements with shipping lines where performance requirements and expectations from both sides are outlined (Motau, 2015). One of the fundamentals for these agreements is for shipping lines to comply to the agreed number of container storage days at the port. It is the responsibility of both the terminal and shipping lines to ensure that containers exit the port to maintain minimum dwell time. Thus, port terminals are responsible for enforcing evacuation of containers from the port by shipping lines. This can be done through continuous monitoring of dwell time per customer and implementation of measures to ensure compliance to CTOC agreements on container dwell times. Containers that remain in storage for longer periods lead to storage constraints, double handling and congestion at the stacking yard which results in operational inefficiencies. Therefore, to improve performance, the ports of Durban, Cape Town and Port Elizabeth should focus on monitoring and reducing container dwell times through the CTCO agreements. This is one of the factors that enabled improved performance at the port of Ngqura.

Secondly, yard management is another important contributor to improved port performance. Yard management entails retrieval of containers from storage and their organisation in a holding area in preparation for loading operations. This minimises effort and time wasted from searching for containers during operations. All the planned containers for a particular ship are organised together based on the ship loading sequence. Sufficient preparation for operations is important as it enables the port to avoid delays during operations. This is another lesson to be considered from the port of Ngqura by the other three ports.

Lastly, port water depth or draft play a major role in the dynamic marine environment. Container ships are getting bigger, and the water depth is instrumental to enable a port to accommodate these larger ships. The major advantage for the port of Ngqura is its draft of 16.6 metres, compared, for instance, to 12.8 metres for the port of Durban (Motau, 2015). For the ports to improve performance, it is recommended that they consider deepening their berths to accommodate the new generation of ships. This is more so for the ports of Durban and Port Elizabeth which have shallower berths compared to the ports of Ngqura and Cape Town.

5.4 Future Research Recommendations

Port performance is influenced by several stakeholders which includes, the ports authority, terminal operators, shipping lines, freight forwarding agents, marine service operators, stevedores, customs, rail and road operators. Although this study focused on marine and terminal operators as contributors to port performance. This does not exonerate other stakeholders from having an enormous impact on the overall performance of the port and ultimately its competitiveness.

Therefore, is it is recommended that future research explores the impact of other stakeholders on port performance. There are limited studies available on the contribution of other stakeholders toward South African container port performance, hence there is an opportunity for future research. Most of the available work is only focusing on the terminal operators.

APPENDIX A

Consistency table: research questions, propositions, data collection and data analysis

RQ #	State Research Objective	Proposition #	State Proposition	Data collection detail	Data analysis method
1	Compare STAT of the four major container ports in South Africa.	1	There are similarities in STAT performance between the ports of Durban, Ngqura, Cape Town and Port Elizabeth.	Use data from Transnet National Ports Authority Annual Reports and complete a checklist	• Process Mapping • Time series • Descriptive Statistics
2	Determine key factors contributing STAT performance	2	Factors that contribute to STAT across the four ports are the same	Capture data on a check list from Marine databases, TPT, TNPA and PRSA Annual Reports	• Fishbone Diagram

APPENDIX B

Research Instrument

DATA COLLECTION CHECK SHEET														
KPI's	PORTS		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Anchorage	Durban Pier 1	Target	45	46	46	40	40	32	28	30	25	30	30	40
		Actual	63	61	57	41	33	26	42	25	64	56	76	68.4
	Durban Pier 2	Target	45	46	46	40	40	40	36	40	30	40	40	30
		Actual	63	61	57	41	33	30	79	36	80	83	76.5	81.2
	Cape Town	Target	35	35	35	34	34	32	28	28	25	40	40	40
		Actual	17	53	35	31	23	25	34	36	49	107	117	113
	Port Elizabeth	Target	39	35	34	30	33	30	30	30	35	40	35	35
		Actual	33	56	25	37	16	30	32.6	22	47	33	34	16.3
	Ngqura	Target	58	52	44	45	45	32	28	28	28	35	28	28
		Actual	29	44	49	32	20	16	42.1	29	53	56	42	45.2
Ship turnaround time	Durban Pier 1	Target	40	40	59	59	55	43	55	55	74	55	55	55
		Actual	45	53	58	51	46	51	69	62	74	69	81	75
	Durban Pier 2	Target	40	40	59	59	55	53	53	53	79	59	53	53
		Actual	45	53	58	51	46	55	72	72	79	90	93	95
	Cape Town	Target	27	46	30	30	29	27	27	27	37	50	50	50
		Actual	46	44	29	27	24	26	32	31	37	65	49	73
	Port Elizabeth	Target	36	34	26	26	28	28	20	20	37	30	30	30
		Actual	32	31	26	26	17.1	16	20	19	32.2	43.8	35.6	37
	Ngqura	Target	40	42	29	45	43	30	28	30	34.3	30	30	30
		Actual	41	51	44	34	23	24	38	29	37	32	39	30.5
SWH	Durban Pier 1	Target	50	53	53	45	46	53	53	50	50	48	48	48
		Actual	44	43	46	48	53	45	46	47	41	38	38	39
	Durban Pier 2	Target	68	55	68	62	64	70	70	65	65	60	60	60
		Actual	42	62	59	58	63	55	53	54	46	49	46	43
	Cape Town	Target	46	48	55	52	55	55	56	56	56	50	50	50
		Actual	57	55	48	49	54	53	45	45	38	36	34	31
	Port Elizabeth	Target	38	38	45	43	40	40	36	36	36	36	36	35
		Actual	38	40	39	44	47	45	37	33	24	26	23	25
	Ngqura	Target	44	50	55	51	56	65	66	66	56	50	50	50
		Actual	47	54	47	48	66	63	50	46	37	35	37	42
GCH	Durban Pier 1	Target	30	30	28	26	26	26	26	26	26	25	25	25
		Actual	27	23	24	22.2	25	26	25	24	24	20	19	18
	Durban Pier 2	Target	28	28	30	28	30	32	32	32	32	26	26	26
		Actual	21	28	25	24	26	24	23	21	18	18	18	18
	Cape Town	Target	25	32	32	32	32	32	33	33	28	24	24	24
		Actual	28	31	34	31.8	32	32	30	22	17	17	17	14
	Port Elizabeth	Target	25	25	27	25	25	25	25	25	25	22	22	22
		Actual	27	27	24	24	26	25	23	21	21	18	17	19
	Ngqura	Target	30	32	32	30	30	32	32	32	28	26	26	25
		Actual	30	32	26	26.8	30	31	25	21	18	18	17	18

APPENDIX C

Timelines and activities

WBS	Tasks	Plan Start	Plan Finish
	Research Study Timelines		
1	**Data Collection**	**17-Jun-24**	**30-Nov-24**
1.1	Data Collection for Port Elizabeth	17-Jun-24	20-Jul-24
1.2	Data Collection for Durban	22-Jul-24	20-Aug-24
1.3	Data Collection for Ngqura	20-Aug-24	19-Sep-24
1.4	Data Collection for Cape Town	20-Sep-24	17-Oct-24
2	**Data Analysis**	**19-Oct-24**	**30-Nov-24**
2.2	Time series and Descriptive Statistics for STAT per port	19-Oct-24	23-Oct-24
2.3	Performance Analysis for Anchorage Waiting time per port	24-Oct-24	28-Oct-24
2.4	Performance Analysis for Ship Working Hour (SWH)	29-Oct-24	10-Nov-24
2.5	Performance Analysis for Gross Crane Moves per Hour (GCH)	12-Nov-24	18-Nov-24
2.6	Fishbone diagram	20-Nov-24	30-Nov-24
3	**Findings**	**3-Dec-24**	**10-Jan-25**
3.1	Translate the analysis	3-Dec-24	8-Dec-24
3.2	Present finding	10-Dec-24	16-Dec-24
3.3	Consolidate recommendations	16-Dec-24	6-Jan-25
3.4	Complete chapter 4	8-Jan-25	10-Jan-25
4	**Conclusion**	**11-Jan-25**	**3-Feb-25**
4.1	Prepare conclusion and recommendations	11-Jan-25	17-Jan-25
4.2	Complete Chapter 5	17-Jan-25	20-Jan-25
4.3	Complete ARP Report	21-Jan-25	23-Jan-25
4.4	Submisison to supervisor	24-Jan-25	29-Jan-25
4.5	Incporporate inputs from Supervisor	29-Jan-25	30-Jan-25
4.6	Final submission to supervisor	30-Jan-25	31-Jan-25
4.7	Final submission to school	31-Jan-25	3-Feb-25

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Graduate School of Business Administration
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Wits Business School Ethics Committee

10/07/2024

Ethics clearance number: **Not available.**
This letter is only valid with a legitimate ethics clearance number and signed by the Researcher (below).

RE: Ms. Siziwe Batyi

To whom it may concern

Ms. Siziwe Batyi (2537329) is currently registered as a MBA (Research Article) student at the Wits Business School, University of the Witwatersrand, Johannesburg.

This letter is to confirm that, at the time of writing, Siziwe Batyi does not need ethical clearance for the study entitled:

A comparative study of operational performance at container ports in South Africa

This decision has been reached based upon a description of the project supplied by Siziwe Batyi to the Wits Business School Ethics Committee, constituted as a subcommittee of the University Human Research Ethics Committee (Non-Medical), which has been evaluated by the subcommittee chair. This decision has then been ratified by the University Human Research Ethics Committee (Non-Medical).

If, however, Siziwe Batyi changes the methods of data collection and analysis for this project, this decision may no longer be valid. If such changes take place, this should be communicated to the Wits Business School Ethics Committee.

Please feel free to contact me or the supervisor should you require any further information.

Yours sincerely,

Ethics Chairperson
Dr Ayanda Magida
+27 11 717 3953
ayanda.magida@wits.ac.za

Supervisor:
Professor Rossouw
Jannie Rossouw

Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature

11/07/2024
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A comparative study of operational performance of container seaports in South Africa

Siziwe Batyi