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Transhipment hub port selection: competition in the Southern African container port system

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Transhipment hub port selection: Competition in the Southern African container port system

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ABSTRACT

In recent decades, shipping liners have started shifting away from direct call services in favour of hub-and-spoke and relay liner network structures. These developments marked the advent of intermediacy in container shipping. Container terminals expanded and progressed rapidly to serve the growing transhipment market, leading to increased competition among container terminals for regional and global hub port status. This study analyses the competitive dynamics between the main Southern African transhipment hub port rivals situated along the Cape passage, namely Ngqura and Port Louis. The two ports are compared on total transit times and generalised shipping cost for an extensive list of shipping routes in both hub-and-spoke and relay liner network structures. The results show that Port Louis is the optimal hub port in to serve as an intermediate node along the Cape passage in the short term. The findings also highlight the challenges both ports will face in attaining global hub port status and the potential impacts of anticipated maritime regulations and other market forces that may come in to play in the medium and long term.

CONTENTS

1. INTRODUCTION 1

1.1 Research Background 1

1.2 Problem Statement 5

1.3 Research Question and Objectives 5

1.3.1 Research question 5

1.3.2 Research objectives 5

1.4 Report Structure 6

2. LITERATURE REVIEW 7

2.1 Optimal Hub Port Selection 7

2.1.1 Stakeholders involved in the decision of hub port selection 7

2.1.2 Previous theoretical approaches to the problem of port competition and hub port selection 7

2.1.3 Hub port selection criteria 12

2.2 Notteboom's (2012) study parameters and findings: the competitive position of the Cape passage 16

2.2.1 Trade route profiles 16

2.2.2 Findings: Base year of assessment 18

2.2.3 Critical assessment of the route profiles and study parameters 18

3. RESEARCH METHODS 21

3.1 Research Design 21

3.1.1 Transit distance analysis 22

3.1.2 Transit time analysis 29

3.1.3 Generalised cost analysis 32

3.2 Data Collection Procedure 36

3.3 Research Tool 36

3.4 Validation and Verification 36

4. DATA 38

4.1 Port productivity indicators 38

4.1.1 Berth occupancy 38

4.1.2 Average pre-berthing delays 39

4.1.3 Quay crane productivity 39

4.1.4 Berth productivity 40

4.2 Cost Components 41

4.2.1 Port fees and marine charges 41

4.2.2 Cargo dues and container handling rates 42

4.2.3 Vessel time charter rates and bunker fuel cost 43

5. SUB-ANALYSIS RESULTS 44
5.1 Transit Distance Results 44
5.1.1 Relay liner network 44
5.1.2 Hub-and-spoke liner network 45
5.2 Transit Time Results 48
5.2.1 Relay liner network 48
5.2.2 Hub-and-spoke network 50
5.2.3 Sensitivity analysis: transit time model 51
5.3 Generalised Cost Results 54
5.3.1 Relay liner network 57
5.3.2 Hub-and-spoke network 57
5.3.3 Sensitivity analysis: cost model 58

6. RESULTS AND ANALYSIS 61
6.1 Port Competition Results 61
6.1.1 Relay liner network 61
6.1.2 Hub-and-spoke liner network 62
6.2 Model Validation 64
6.3 Analysis 67
6.3.1 Vessel speed increases: Relay liner network 68
6.3.2 Vessel speed increases: Hub-and-spoke liner network 69

7. DISCUSSION 71
7.1 Relay Liner Network 72
7.2 Hub-and-Spoke Liner Network 73

8. CONCLUSION AND FUTURE WORK 75
8.1 Conclusion 75
8.2 Study Limitations 76

9. REFERENCES 78

10. APPENDICES 84
APPENDIX A 85
APPENDIX B 86
APPENDIX C 91
APPENDIX D 94
APPENDIX E 95

LIST OF FIGURES

Figure 1-1: IMO's pathway to the reduction of maritime CO^2 emissions..... 1
Figure 1-2: Liner network structures..... 3
Figure 1-3: Map of the Emerging Global Maritime Freight Transport System. 3
Figure 1-4: The report structure for this study. 6
Figure 2-1: Market potential of the Cape route. 16
Figure 2-2: Feeder port system considered by Notteboom (2012). 19
Figure 3-1: Methodology for evaluating the relative competitiveness of the transhipment hub ports. 21
Figure 3-2: Sub-analysis in transhipment hub port competition analysis. 22
Figure 3-3: Relay network routes. 23
Figure 3-4: Hub-and-spoke network feeder ports.. 26
Figure 3-5: Hub-and-Spoke network trunk and feeder routes. 28
Figure 3-6: Partitioning of total transit time. 30
Figure 4-1: Quay crane productivity – Average moves per GCH trend. 39
Figure 4-2: Berth productivity – Berth occupancy vs average moves per SWH trends. 40
Figure 5-1: Hub-and-spoke liner network transit distance profiles 46
Figure 5-2: Hub-and-spoke liner network – trade with SAEC. 47
Figure 5-3: Relay liner network transit time results. 48
Figure 5-4: Relay liner network - Jawaharlal Nehru-Santos total transit time. 49
Figure 5-5: Hub-and-Spoke liner network transit time results. 51
Figure 5-6: Jawaharlal Nehru relay route - impact of vessel speed on transit times. 52
Figure 5-7: Jawaharlal Nehru relay route - impact of vessel utilisation rate on transit times 52
Figure 5-8: Hub-and-spoke liner network - impact of vessel utilisation rate on transit times. ... 53
Figure 5-9: Cost breakdown of a 1700 TEU vessel. 56
Figure 5-10: Jawaharlal Nehru relay route - impact of vessel speed and utilisation rate on the cost/TEU. 58
Figure 5-11: Hub-and-spoke liner network - impact of vessel speed on the cost/TEU. 59
Figure 5-12: Hub-and-spoke liner network - impact of vessel utilisation rate on the cost/TEU. 60
Figure 6-1: Competition between Ngqura and Port Louis – relay liner network. 62
Figure 6-2: Competition between Ngqura and Port Louis – hub-and-spoke liner network. 63
Figure 6-3: 2019 Container market share between Port Louis and the Port of Ngqura. 64
Figure 6-4: Model Validation. 66
Figure 6-5: Scenario analysis – relay liner network. 68
Figure 6-6: Scenario analysis – hub-and-spoke liner network. 69
Figure 10-1: Fuel consumption by container ship size and speed. 94

LIST OF TABLES

Table 2-1: Hub port selection criteria emphasised in previous studies. 11
Table 2-2: Comparison of the container terminal infrastructure. 14
Table 2-3: South Africa and Mauritius LSBCI for the 2019 calendar year. 15
Table 2-4: Port origin-destination pairs. 17
Table 3-1: Relay liner network origin-destination ports. 24
Table 3-2: Relay routes - O/D pairs.. 24
Table 3-3: Hub-and-spoke liner network: feeder route O/D pairs. 25
Table 3-4: Hub-and-spoke liner network – trunk route O/D pairs.. 27
Table 3-5: Hub-and-spoke liner network – O/D relations. 28
Table 4-1: Individual port productivity indicators for 2019. 38
Table 4-2: Cargo dues and container handling rates. 42
Table 4-3: Vessel time charter rates and bunker fuel cost 43
Table 5-1: Transit distance profiles – relay liner network. 44
Table 5-2: Transit distance profiles – hub-and-spoke liner network. 45
Table 5-3: Relay liner network total port call time. 49
Table 5-4: Transit time analysis – hub-and-spoke liner network total port call time. 50
Table 5-5: Average feeder and trunk route sailing distances. 53
Table 5-6: Generalised shipping cost over a fixed sailing distance. 55
Table 5-7: Relay liner network generalised cost analysis – cost per TEU. 57
Table 5-8: Hub-and-spoke liner network generalised cost analysis – cost per TEU 58
Table 10-1: Calling patterns of the main container carriers at Southern African Ports. 85
Table 10-2: Hub-and-spoke network - Full transit distance analysis for cargo originating from the African West Coast. 86
Table 10-3: Hub-and-spoke network - Full transit distance analysis for cargo originating from South Africa. 88
Table 10-4: Hub-and-spoke network - Full transit distance analysis for cargo originating from the African East Coast 90
Table 10-5: Relay liner network routes - cost group breakdown (cost per TEU) 92
Table 10-6: Hub-and-spoke liner network services - cost group breakdown (cost per TEU) 93
Table 10-7: MPA – Daily port situation 16/10/2020. 95
Table 10-8: MPA – Daily port situation 06/01/2020. 96
Table 10-9: Ngqura container terminal – Vessel berthing schedule 19/10/20. 97
Table 10-10: Ngqura container terminal - Vessel berthing schedule 06/01/20 98

LIST OF ACRONYMS

AIS	Automatic Identification System
AEC	African East Coast
AHP	Analytic Hierarchy Process
AWC	African West Coast
CHCL	Cargo Handling Corporation Limited
CO_2	Carbon dioxide
D2D	Door-to-Door
EEDI	Energy Efficiency Design Index
GCH	Gross Crane Hour
GT	Gross Tonnage (metric)
Ha	Hectare
IMO	International Maritime Organisation
LoS	Level of Service
MPA	Mauritius Ports Authority
mt	Metric ton
NM	Nautical Mile
O/D	Origin-Destination
P2P	Port-to-Port
PWHC	PricewaterhouseCoopers
RFID	Radio Frequency Identification
SA	South Africa
SAEC	South American East Coast
SEEMP	Ship Energy Efficiency Management Plan
STS	Ship-to-Shore
SWH	Ship Working Hour
TAT	Turnaround Time
TEU	Twenty-Foot Equivalent Unit
TNPA	Transnet National Ports Authority
TPT	Transnet Port Terminals
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
VTS	Vessel Traffic System

1. INTRODUCTION

1.1 Research Background

Seaborne trade is the predominant mode of transport for international trade, accounting for roughly 80% of global trade volumes. In the last 18 years, port container traffic has nearly quadrupled (The World Bank, 2020). The standardisation of containers has allowed for quicker ship turn-around time in ports, with a median of 23.5 hours compared to 2.05 days for dry bulk carriers (United Nations Conference on Trade and Development (UNCTAD), 2019). The rise of containerised cargo has thus significantly reduced port congestion, shortening shipping time whilst also reducing losses from damage.

With the constant growth of seaborne trade, the maritime industry has put greater effort towards preserving the marine environment and reducing greenhouse gas emissions from international shipping. The maritime industry governing body, the International Maritime Organisation (IMO), adopted the vision of the initial strategy to reduce CO2 emissions in 2018 in support of the United Nations' (UN) sustainable development goals. The plan is to reduce CO2 emissions by 40% or more remarkable by 2030 (IMO, 2021). Figure 1-1 illustrates the CO2 emissions reduction pathway to achieve this goal. Mandatory energy efficiency regulation for new vessels have already been implemented since January 2013 (IMO, 2021), in the form of the Energy Efficiency Design Index (EEDI) measure, while guidelines in operation measures are also prescribed in the Ship Energy Efficiency Management Plan (SEEMP). Though at this stage, the use and implementation of the SEEMP guidelines are voluntary.

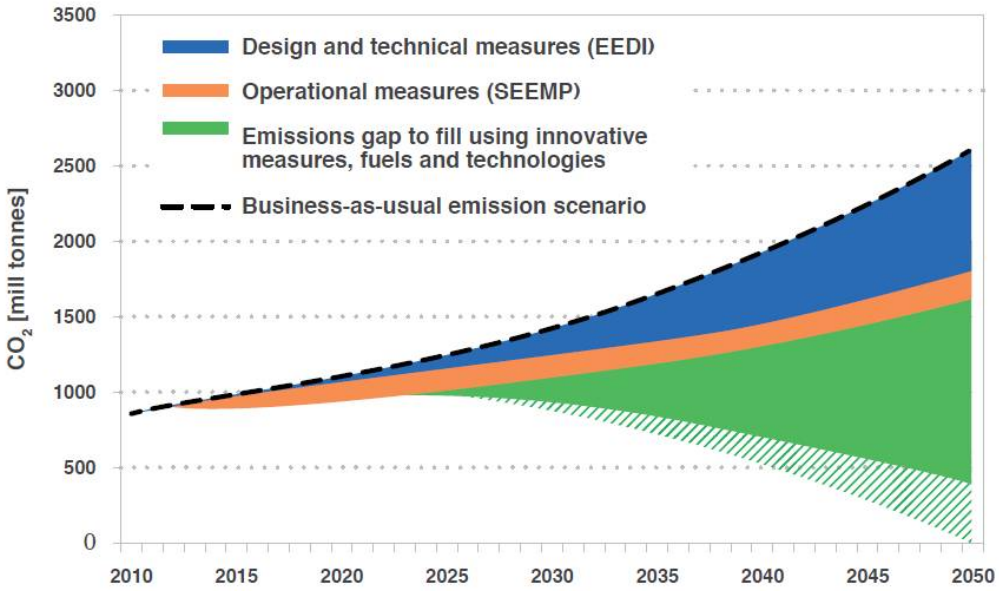


Figure 1-1: IMO's pathway to the reduction of maritime CO² emissions. (IMO, 2021).

Many have argued that the reduction of vessel operating speeds through slow steaming practices will significantly enhance the positive effects of the EEDI (Clean Shipping Coalition, 2012; GL Reynolds, 2019; Tsimplis, et al., 2012). A 10% reduction in vessel speed reduces the shaft power requirements by approximately 27% (Tsimplis, et al., 2012). Nevertheless, the IMO has not shown interest in making such measures mandatory (Martin, 2019). Perhaps because, from a technical point of view, ships would be operating out of design conditions during slow steaming (Tsimplis, et al., 2012). Despite the technical drawback, however, slow steaming practices have been widely adopted with the deployment of larger container ships (Sand, 2013).

The rise of mega-ships started after the 2008 financial crisis as carriers sought better fuel efficiency and the benefits of economies of scale (JOC Group, 2021). Each time a ship size is doubled, the capacity is tripled (Rodrigue, 2020). The increased vessel sizes thus reduced the container slot costs; however, it has also prompted a cascading effect of change across the transport logistics supply chain. Terminal operators were forced to respond with large and rapid infrastructure investments to handle the new vessel sizes (Cullinane and Khanna, 2000). Various liner shipping network structures emerged to circumvent the operational and capacity shortcomings faced with direct call services (Kavirathna, et al., 2018), such as hub-and-spoke and relay liner networks. These networks have given rise to container transhipment, the fastest growing sector of the ocean freight container market (Baird, 2006).

With the development of intermediacy in container transportation, the efficiency and geographical coverage of maritime shipping networks improved immensely (Notteboom, Pallis and Rodrigue, 2021). Hub ports emerged and function as connection centres amid several origin and destination pairs. They also play a critical role in serving smaller seaports with infrastructure limitations and poor nautical accessibility through feeder networks (Notteboom, Pallis and Rodrigue, 2021). The technical definition of “hub” is not consistent across different transportation modes, but the function of intermediacy is particularly relevant to all (Rodrigue, 2020). Intermediacy in container transportation focusses on nodes where the activity of container transhipment is performed. Depending on the literature reviewed, these nodes can be referred to as hubs, transhipment ports, transhipment hub ports or intermediate ports. Not all hub ports exclusively handle transhipment consignments, but transhipment is the prime functionality of a hub port (Rodrigue, 2020). The exact role of hub ports varies depending on the liner network structure.

The liner network structures that have arose in the era of container transhipment is shown in Figure 1-2. Figure 1-2a illustrates a hub-and-spoke liner network while Figure 1-2b represents a typical relay liner network. In a hub-and-spoke operation, mainline vessels transport large container consignments to intermediate/hub ports, and smaller feeder vessels provide the shorter onward connections. In cargo relay, the hub port acts as a point of interface between mainline vessels operating along the same maritime range but calling at different ports (Notteboom, Pallis and Rodrigue, 2021). These developments, along with strategic alliances between shipping lines, have led to increased competition between container ports for hub port status (Kavirathna, et al., 2018).

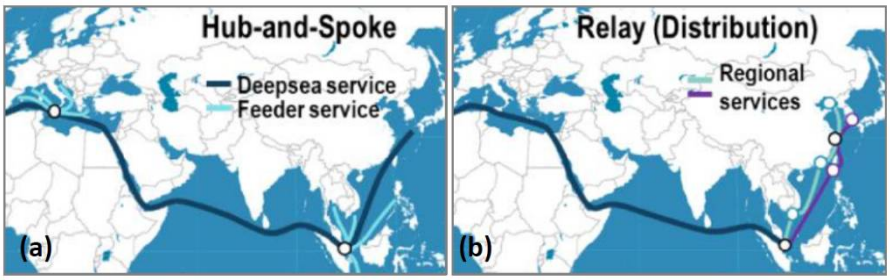


Figure 1-2: Liner network structures. (Notteboom, Pallis and Rodrigue, 2021).

Transhipment hubs tend to naturally develop around strategic passages or locations with low deviation distances from the main shipping trade lanes, as illustrated in Figure 1-3 (Notteboom, Pallis and Rodrigue, 2021). The circum-equatorial route, illustrated by the light blue line in Figure 1-3, is the shortest path around the globe. Coupled with the high levels of trade between Asia and Europe, the route offers a viable market profile for the development of transhipment hub ports.

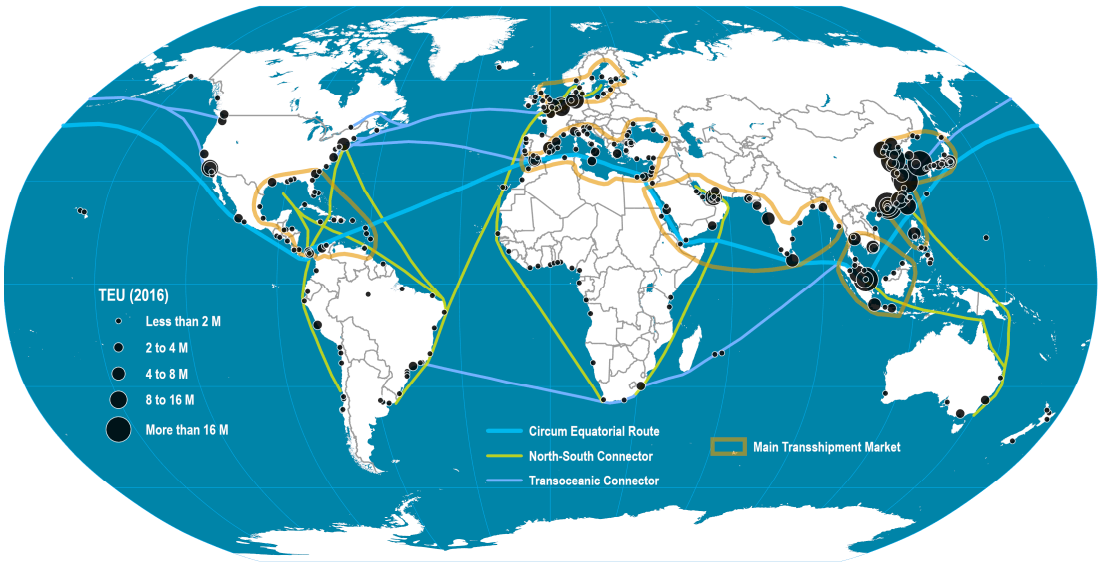


Figure 1-3: Map of the Emerging Global Maritime Freight Transport System. (Rodrigue, 2020).

Regional competition and hub port selection along this main equatorial route has been extensively researched (Aversa, et al., 2005; Baird, 2006; Kavirathna, et al., 2018; Tai, 2005; Tongzon and Sawant, 2007). The competitive dynamics between the lesser developed and called on Southern African transhipment hubs, situated along the transatlantic connector/Cape passage, are not well researched. The Cape passage became a strategic maritime passageway after the Portuguese and several other fleets successfully rounded Africa's southern tip in the late 15th century. Following the Suez Canal opening in 1869, however, the Cape route's previous significant role started diminishing (Ingpen, 2020). Nonetheless, the prospects of the Cape passage are looking favourable again with rising Suez Canal transit fees along with the growing threat of piracy along the Gulf of Aden (Fraser and Notteboom, 2012).

The Southern African region features a wide range of container port types and sizes from the five coastal countries: Namibia, South Africa, Mozambique, Madagascar and Mauritius. Many of the Southern African ports have either implemented or are planning to implement significant infrastructure investments and expansions, but not every port has the prospects of developing into a global or regional transhipment hub (The World Bank, 2018). Of the major ports in the region, there are currently only two container ports that primarily handle transhipment cargo flows, namely the Port of Ngqura in South Africa and Port Louis in Mauritius (Fraser and Notteboom, 2012; Department of Transport, 2011). Port Louis is the main port of Mauritius, and Ngqura was commissioned in 2009 as South Africa's main transhipment hub port. Both these ports boast a transhipment incidence of roughly 50% of overall container throughput (Mauritius Ports Authority (MPA), 2020c; Transnet National Ports Authority (TNPA), 2020c).

In Namibia, the Port of Walvis Bay used to attract a substantial portion of the regional transhipment market share but has since experienced a significant year-on-year decline in transhipment volumes, amounting to -63% in the 2018/19 financial cycle (Namport, 2020). Furthermore, while the Port of Durban offers a competitive position to develop into a major transhipment hub (The World Bank, 2018), it already operates at near capacity levels as the premier gateway cargo port and busiest port in Sub-Saharan Africa (Transnet Port Terminals (TPT), 2020a). Ports generate more revenue from captive cargo operations, and therefore priority of gateway cargo over transhipment cargo flows at the Port of Durban is likely to continue.

This study aims to evaluate and compare Port Louis and the port of Ngqura to determine the optimum Southern African transhipment hub port for both hub-and-spoke and relay liner networks. These ports are ideally situated along the major south-south trade routes between Asia

and West Africa and Asia and South America (Notteboom, 2012). Though other ports may become more competitive in the future, they will face greater difficulty attaining similar liner shipping connectivity indexes of early adopters (Notteboom, 2010).

1.2 Problem Statement

The search for the optimal port to serve transhipment markets is a challenge all ocean carriers are faced with sooner or later (Baird, 2006). There are currently no global transhipment hubs in Sub-Saharan Africa (The World Bank, 2018), but the transhipment incidence for Southern African ports is rising (Notteboom, 2012). Notteboom (2012) identified various trade routes for which the Cape passage offers a viable alternative to the Suez passage. Further research is, however, required to evaluate the competitiveness of the individual transhipment hubs in the region.

Other works have looked at rivalry among African hub ports (Fraser and Notteboom, 2012; Notteboom, 2011; The World Bank, 2018; Van Dyck and Ismael, 2015), and the opportunity for increasing container transhipments in the region (Department of Transport, 2011; Notteboom, 2010). Though to date, few studies investigated the prospects of both the port of Ngqura and Port Louis simultaneously. Moreover, none of the studies encompassed a comprehensive port competition modelling exercise of these two Southern African hub ports.

1.3 Research Question and Objectives

1.3.1 Research question

How do the competing Southern African ports of Ngqura and Port Louis compare in terms of optimal transhipment hub port status?

1.3.2 Research objectives

The objectives of this research report are to:

a. Explore and identify the key criteria for optimal transhipment hub port selection.
b. Develop a model to compare and evaluate the relative competitiveness of the Southern African ports of Ngqura and Port Louis in the context of *hub-and-spoke* and *relay liner networks*.
c. Determine the optimum transhipment hub port for the Southern African region.

1.4 Report Structure

The report structure for this study from Chapter 1 through Chapter 8 is outlined in Figure 1-4.

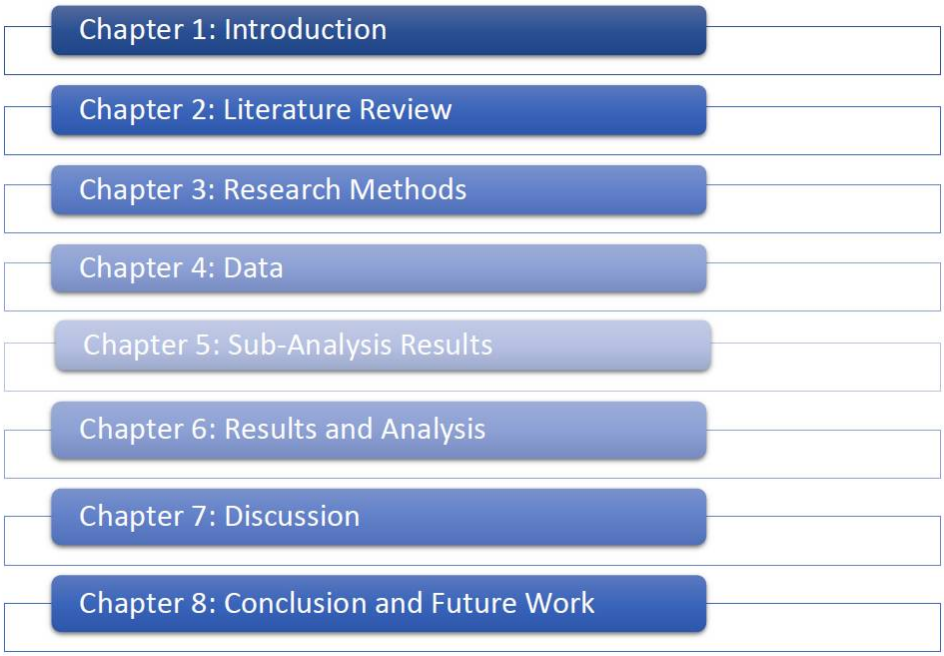


Figure 1-4: The report structure for this study.

2. LITERATURE REVIEW

The literature review conducted in this chapter consists of two main parts. This chapter's primary focus is to establish the theoretical framework and key criteria for selecting the optimum transhipment hub port. Secondary to that, Notteboom's (2012) study parameters and findings on the Cape passage's competitive position are critically assessed. The first part will begin with an overview of the principal decision agents involved in port selection before investigating previous theoretical approaches to port competition and hub port selection. After that, the critical port selection criteria identified, and the relevant indicators used to measure each criterion is investigated.

2.1 Optimal Hub Port Selection

2.1.1 Stakeholders involved in the decision of hub port selection

The three stakeholders who are the decisions agents in container transportation are carriers or shipping liners, shippers and port administrators (Zan, 1999). The maritime industry is cost-driven (UNCTAD, 2016), and several interactions occur among the stakeholders: shippers want to minimize the cost of transportation while carriers want to maximize revenue (Zan, 1999). Aversa's (2005) deliberation on this is that port selection and competition models must consider the decision agent's perspective: port, carrier or shipper. Carriers make operational decisions such as route selection (Zan, 1999), which invariably includes the choice of intermediate port. On the other hand, the shippers value the choice of port based on the impact it has on cost and transit time. Through the interactions between shippers and carriers, selecting a good transhipment hub results in a higher market share allocation to the port administrator. (Veldman and Bückmann, 2003).

2.1.2 Previous theoretical approaches to the problem of port competition and hub port selection

Transhipment cargo is not necessarily bound to a specific port, as is the case with gateway cargo linked to a specific hinterland (Rodrigue, 2015). To serve the purpose of intermediacy, hub ports naturally develop around strategic passages in locations with low deviation distances from the main shipping lanes (Notteboom, Pallis and Rodrigue, 2021) with viable market profiles (Notteboom, 2010). However, geographic location alone will not guarantee a high transhipment incidence. A transhipment hub port must offer a competitive alternative to rival seaports, with many factors influencing a port's competitive position. These influential factors have been widely researched and discussed from various perspectives in previous literature.

Most studies related to port choice and competition have a narrow geographical focus, however, Gohomene, et al. (2016) showed that port choice results would vary across geographical regions. The authors found that the critical criteria for determining West African ports' attractiveness differed substantially from those in other regions. Very few studies have considered port selection in the African context. Moreover, most of the past literature relate to container ports in the West African region (Caschili and Medda, 2015; Gohomene, et al., 2016; Icaza and Parnell, 2018), and not hub ports specifically. Though hub and gateway ports' roles are not mutually exclusive, the importance of the different selection criteria would differ. Good hinterland connectivity is essential for gateway terminals, whereas pure transhipments hubs shift containers from one ship to another, and therefore do not rely on intermodal connections. With the lack of relevant research on African transhipment hubs, the classical works reviewed in this section covers an extensive geographical range. Various stakeholder perspectives and study methods were considered.

For hub port selection along the East Coast of South America, Aversa (2005) regarded shipping cost as the primary hub choice determinant and developed a mixed-integer programming model aimed at minimising the total system cost. The author found that hub port charges accounted for 39% of the total transport cost, while shipping cost accounted for only 18%. Thus, demonstrating the significance of port dues in the decision. Likewise, Baird (2006) focussed on the cost components of transhipment. The author explored the economic aspects of developing an offshore transhipment facility in Northern Europe and compared the competing seaports on transport distances and the associated shipping cost.

To gain more insight into the carrier's hub port selection perspective, Tongzon and Sawant (2007) developed a model to determine the shipping liners' preferences in Singapore and Malaysia's competitive environment. The study identified the shippers' revealed preference and compared it with their stated preference in order to assess if there is consistency between the two. In the stated preferences port efficiency was considered the most important, connectivity and port charges tied in second, location was third and infrastructure fourth. In the revealed preference model, the authors determined that for ports at the threshold of efficiency and with overlapping markets adequate infrastructure, lower port charges and value-added services are vital. Adequate infrastructure had the highest statistical significance in the revealed preference model.

Correspondingly, Tai (2005) conducted a questionnaire survey among the top 20 shipping lines to identify the possible influential criteria on hub port choice in East Asia. The author's results indicated that the most important factors influencing a liner's choice of hub port in ascending

order of relevance are frequency of scheduled feeder services, harbour draft (infrastructure), savings in operation cost, port efficiency, and cargo source of hinterland. Kurt, et al. (1999) applied the Analytic Hierarchy Process (AHP) to analysis hub port selection in the Mediterranean Sea. The authors designed a selection model evaluating five main criteria and 16 sub-criteria to determine the optimal hub port. Based on their assessment, the top three ports all had low deviation distances to the main shipping routes. Port location was thus deemed to be the most critical factor in the decision. Connectivity, operational performance and infrastructure capacity also ranked high.

Lirn, et al. (2003) also applied the Analytical Hierarchy Process to analyse transhipment hub selection behaviour of largescale Taiwanese container carriers. The carriers surveyed include some of the most prominent international shipping lines. The four major criteria identified that influence the carrier's hub port choice, ranked from highest weighting to lowest, were port location, cost, port management (berth handling rates), and physical characteristics (hinterland connections and port facilities). Nir, et al. (2003) focussed on the shippers' port choice behaviour in Taiwan. A questionnaire was designed to gather the port demand attributes from 309 shippers. The authors then used a multinomial logit model to determine the significance of each decision variable. Their results revealed that transit time and cost affect shippers the most, thus supporting Zan's (1999) hypothesis.

Veldman and Bückmann (2003) also used a logit model to quantify the routing choice and the port choice in the West European hub-port market. The authors found cost, number of feeder vessel port calls, and market share to be statistically significant port choice variables. The transit time variable had little impact on their model because of the insignificant differences in transit times between the region's ports. In the Southern African context, Fraser and Notteboom (2012) suggest that a competitive advantage between rival ports can be achieved through operational efficiency, lower transhipment tariffs and a flexible transhipment container storage plan. Others have also studied port competition of Africa container ports. Van Dyck and Ismael (2015) evaluated the competitiveness of the West African container port system. They found port efficiency to be the most important criteria, followed by port cost, political stability and port infrastructure.

Kavirathna, et al. (2018) indicated that the transhipment hub port selection criteria would not only vary across geographical regions but would also differ for the various liner network types. The authors differentiated between transhipment hub port selection criteria for hub-and-spoke

liner networks and relay liner networks, respectively. A port performance index was developed based on monetary, time, location, operational efficiency, port traffic and liner connectivity related factors. For hub-and-spoke liner networks, port traffic, location, efficiency and liner related factors were found to be considerably less important than the monetary and time categories. In the relay network case, the authors found that the levels of difference between the categories varied less than with the hub-and-spoke network. However, the time category had a significantly higher mean score than the rest.

Table 2-1 summarises the research findings from the previous works on hub port selection. Cost is regarded as the most crucial factor in four of the studies reviewed, transit time in three, and location and port efficiency each in two. Port location and transit time are highlighted interchangeably in the literature reviewed. In terms of a quantitative measurements and comparison, the two criteria closely resemble one another since sailing time is an implicit feature of nautical accessibility. The lower the distance from main maritime routes, and the closer the hub is to the main captive container markets, the lower the transit time is (The World Bank, 2018).

The literature reviewed denote the variability in selection criteria across different geographical regions, perspectives and liner network structures. Despite the differences, though, the majority of the studies emphasised the economic aspects of the decision. In terms of the number of times each criterion is listed as a prime factor in hub port selection, cost is emphasised the most, followed by transit time-related factors. This is not surprising, given that a single call strategy must offer cost saving benefits for carriers to shift from a multiport to a hub configuration (Baird, 2006; Notteboom, 2010). Port efficiency, adequate infrastructure, and frequency of liner services / connectivity are also considered to be essential attributes of transhipment hub ports. The critical hub port selection criteria identified, how it is assessed, and how it relates to this study will be explored in the next section.

Table 2-1: Hub port selection criteria emphasised in previous studies. Authors own elaboration based on cited studies.

	Hub Port Selection Criteria									
Works / Source:	Cost	Transit time	Port Location (Nautical accessibility)	Port Efficiency	Adequate Infrastructure	Liner related / connectivity	hinterland Connections	Political Stability	Value added services	Market share
Aversa (2005)	*									
Baird (2006)	*		▪							
Fraser and Notteboom (2012)	▪			▪					▪	
Kavirathna, et al. (2018)										
• *Hub-and-spoke liner network*	*	*								
• *Relay liner network*		*								
Kurt, et al. (1999)			*	▪	▪	▪				
Lirn, et al. (2003)	▪		*	▪	▪		▪			
Nir, et al. (2003)	*	*								
Tai (2005)	▪			▪	▪	▪	*			
Tongzon and Sawant (2007)										
• *Stated preference model*	▪		▪	*	▪	▪				
• *Revealed preference model*	▪				*				▪	
Van Dyck and Ismael (2015)	▪			*	▪			▪		
Veldman and Bückmann (2003)	▪					▪				▪
Number of times the criteria is emphasised in the literature:	11	3	4	6	6	5	2	1	2	1

** Cited as the most important criteria*

2.1.3 Hub port selection criteria

Transhipment cost

Higher trade cost has historically been a barrier to trade expansion in Africa (African development report, 2010). Moving a single container unit from Africa is 1.5 to 3.5 times more expensive than for high-volume trade routes when compared over similar sailing distances (PricewaterhouseCoopers (PWHC), 2018). Theoretically, one can expect trade costs in Africa to decline with increased trade volumes because of the economies of scale that can be realised, with other port factors being equal. PWHC (2018) emphasises that other trade barriers must first be addressed, such as port efficiency.

The generalised cost components of container transhipment are port dues (and other marine charges), cargo dues, terminal handling charges, cargo time cost, ship time charter rates and bunker rates (Notteboom, 2010). The costs of making a single port call are fixed and relatively small compared to the transhipment handling charges, provided that the size of the container exchange is substantial (Baird, 2006). The first three sets of charges are within the control of port authorities, whereas the bunker cost and time charter rates tend to fluctuate and depend on market drivers. Cargo time cost falls somewhere in the middle. It is a cost factor related to the capital's opportunity cost tied up in the goods (Notteboom, 2010). There is also the potential of penalties further along the transport logistics network in the event of delays at one port which may result in missed connections or bookings further along the trade route. Extensive data requirements and computational effort will be required to quantify the cargo time cost and penalties not directly correlated with the intermediate port of call. The other cost components can easily be computed from real cost data.

Transit time

Nautical accessibility is a crucial feature of transhipment hubs. The distance to the main maritime routes indicates the distance that a vessel must deviate from its route to call at the scheduled port. Container transhipment and the related liner network structures emerged as a means to circumvent the operational and capacity constraints of direct call services. When the number of ports calls in a mainline service is reduced, the voyage time shortens and the number of feasible trips per year increases (Notteboom, 2010). The shorter the transit time, the lower the associated shipping cost (The World Bank, 2018). Consequently, reduced transit times are highly desirable.

In the shipping environment, transit time refers to the port-to-port (P2P) ocean transit or sailing days (Harrison and Fichtinger, 2013). In a broader context, transit time can be calculated on a

door-to-door (D2D) basis. By virtue, this includes the dwell time at the intermediate hub port. Shippers are mostly concerned with the overall D2D transit and the accompanying variability. With captive cargo, container dwell time is generally influenced by the efficiency of hinterland connections, customs regulations and terminal productivity. However, for transhipment cargo, the container dwell time is predominantly a function of the number and frequency of feeder services. Liner connectivity complicates transit time management (Du, et al., 2016); an unreliable service or delay at the port interface stage can results in a missed connection, meaning the container will have to be shipped with the next vessel days (Harrison and Fichtinger, 2013). A missed connection negatively impacts terminals as containers will have to be stored for an extended period, which reduces the overall terminal capacity. The adverse effects of delays on transit time and cost also negatively impact shippers.

Operational efficiency

Port inefficiencies delay ships and can interfere with scheduled connections onwards. If a vessel spends more time waiting outside the port for the next available berth or moored at the quay due to low terminal productivity, the cost and time factor of cargo transportation increases (UNCTAD, 2016). Such inefficiencies can diminish the feasibility of a transhipment strategy.

There are many ways to measure port performance and operational efficiency (Ducruet, et al., 2014), but few empirical studies are about time efficiency (Suarez-Aleman, et al., 2013). Hub ports must have fast vessel turnaround times to be attractive. Port statistics are not always clear about the meaning of vessel turnaround time (TAT), i.e. whether it is the time a vessel is moored along the quay or the entire trip from the start of queuing to the time of departure (Ducruet, et al., 2014). Ducruet, et al. (2014) argued that short port stays could be due to refuelling, whereas long port stays may be due to repairs or large containers consignment. The authors recommend using productivity indicators such as berth utilization rates, crane productivity rates and other comparative information in relation to containers transferred.

Port infrastructure

High quay crane productivity does not make a port operationally efficient when ships are left outside the port at anchorage waiting for a berthing slot. Available berths and quay cranes are critical to ensure that ships are serviced on time and stay on schedule. According to the Ports Regulator of South Africa (2016), increased time at anchorage is an indicator of port congestion.

Apart from availability, transhipment hub ports require the infrastructure to accommodate the new generation mega container ships (Post Panamax, New Panamax, Ultra Large Container Vessel). PWHC (2018) specified adequate draught, quay length, stack capacity and high capacity equipment as prerequisites for competitive hub port facilitation. Table 2-2 provides an overview of the respective container terminal infrastructure of the two hub ports. Port Louis and Ngqura both meet the modern-day berthing and drafting requirements (15m > draft, 13 000 TEU > ships). Their respective number of high capacity yard equipment, quayside equipment and annual terminal twenty-foot equivalent unit (TEU) throughput capacities are comparable, with Ngqura edging ahead of Port Louis. Ngqura is better equipped with larger ship-to-shore (STS) cranes, more containers berths, a greater overall quay length and terminal area for container stacking. It is important to note, however, that good infrastructure cannot compensate for poor operational efficiency.

Table 2-2: Comparison of the container terminal infrastructure. Based on MPA (2020a), TNPA (2020b) and Liebherr (2020).

Container Terminal Infrastructure	Transhipment Hub	
	Port of Ngqura	Port Louis
Maximum permissible draft (m)	15.5	15
Vessel capacity (TEU)	13,000	13,000
Container berths (number of)	4	3
9000 TEU post panamax vessels berths: 360m length	3	2
Quay length (m)	1300	800
Turning basin diameter (m)	600	450
Installed capacity (TEU's/annum)	1,300,000	1,000,000
Stacking capacity (TEU's)	55,370	unknown
Terminal area (ha)	72.9	34.5
Reefer points	1,652	576
STS quay cranes (number of)	8	7
Mega-max STS cranes: 65m outreach	8	0
Super Post Panamax STS cranes: 53m outreach	0	2
Post Panamax cranes: 45m outreach	0	5

Frequency of feeder services

Liner shipping adheres to strict schedules to allow for the complex logistics of meeting onwards connections on time. The higher the frequency of liner services, the lower the associated shipping cost of container storage in yards and the time cost of the cargo transported. Better connectivity, therefore, increases the competitiveness of a port. Port authorities also benefit from better connectivity as lower yard dwell times means less stacking capacity is required for a given annual throughput volume.

The frequency of feeder services is of particular relevance to hub-and-spoke liner networks, yet it is difficult to quantify for the ports considered in this study. Neither of the two port authorities differentiates between mainline and feeder vessel calling patterns in their published reports. Furthermore, while Transnet publishes the average transhipment container dwell times, the Mauritius Ports Authority (MPA) does not. Another potential answer to measuring this parameter is the Liner Shipping Bilateral Connectivity Index (LSBCI). The LSBCI seeks to capture a port or country's level of integration into the existing liner shipping network by measuring the trade flows between pairs of countries (UNCTAD, 2020). Table 2-3 shows that for the LSBCI, South Africa measures higher than Mauritius; but whereas Port Louis has the only dedicated container terminal in Mauritius, the South African LSBCI accounts for both the ports of Durban and Ngqura. The Port of Durban has well-established liner service connections (The World Bank, 2018), and its strong influence on the index value cannot be refuted.

Table 2-3: South Africa and Mauritius LSBCI for the 2019 calendar year. (UNCTAD, 2020).

Country / Economy	LSBCI (2019)
Mauritius	29.67
South Africa	31.16

The criterion as a single factor is not crucial to the analysis. The two shipping companies with the largest container ship fleets, Maersk and MSC, along with their subsidiaries, dominate trade within the Sub-Saharan port system. Given that both the port of Ngqura and Port Louis still have relatively low trade volumes and gateway traffic linked to hinterlands, these shipping lines can easily shift transhipment consignments from one port to the other. How the number and frequency of ship visits relate to transit time, however, is of importance. Due to the lack of comparative data, this criterion cannot be assessed.

2.2 Notteboom's (2012) study parameters and findings: the competitive position of the Cape passage

Notteboom (2012) contended that the Cape route could progress into a competitive alternative to the commonly sailed Suez route. The author compared the two passages (Suez Canal and Cape route) on total transit time and associated shipping cost to test his hypothesis. The dark lines in Figure 2-1 depict the major south-south trade lanes analysed by the author. The author selected two base ports at the relevant trade regions' extremes to constitute the various origin-destination (O/D) pairs. In the costing model, Notteboom (2012) considered the real costs in the base year of assessment (2008), along with three future costing scenarios. In the future costing scenarios, the main variants were rising bunker fuel cost and slow steaming practices.

While slow steaming practices have become a common operational aspect of today's shipping market, oil prices have plunged since 2008 (UNCTAD, 2010; World Bank Group, 2015, 2018). Bunker fuel prices are therefore considerably lower than the prices assumed by the author in the future costing scenarios. This critical review of Notteboom's (2012) work will thus only cover the costing scenario in the base year of assessment.

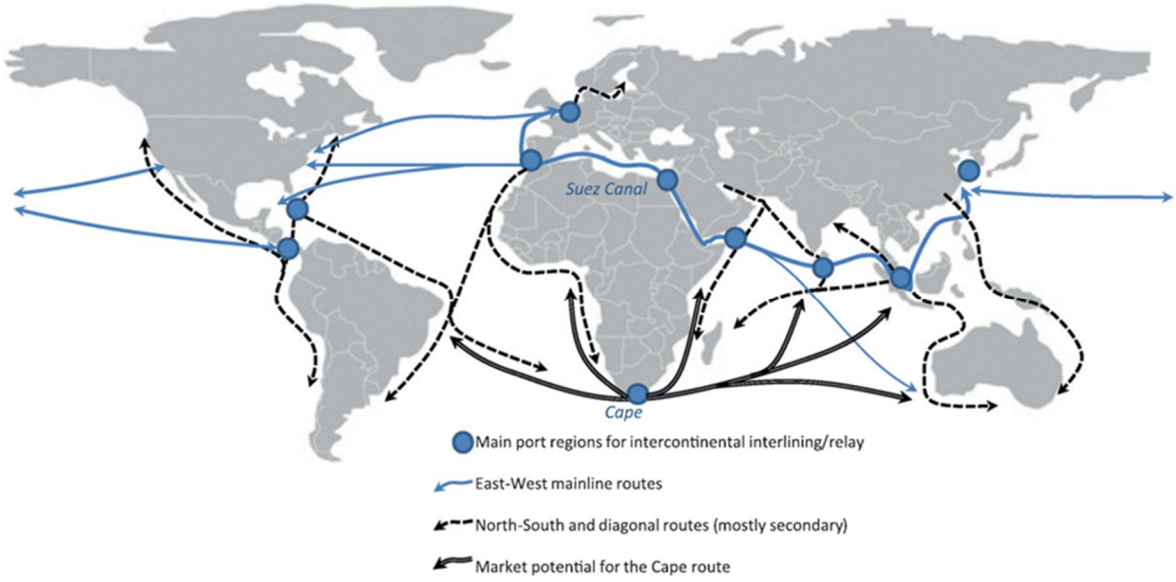


Figure 2-1: Market potential of the Cape route. (Notteboom, 2012, p.177)

2.2.1 Trade route profiles

The trade regions which constituted the basis of Notteboom's (2012) initial transit distance assessment are West Africa, East Africa, South Asia, South East Asia, East Asia, The Middle East, Oceania, South American East Coast (SAEC), America East Coast / Gulf of Mexico. When linked up by the relevant trade routes, the regional pairings resulted in 14 O/D relations.

Depending on the base ports considered in the O/D pairs, Notteboom's (2012, p.167) initial transit distance assessment yielded mixed results on some trade lanes. The author identified 11 viable regional trade pairs in the initial transit distance assessment. For the relay routes, the viable O/D relations were (Notteboom, 2012, p.167):

- South Asia - SAEC
- South East Asia - SAEC
- East Asia - SAEC
- Middle East - SAEC
- SAEC – Oceania

For the hub-and-spoke liner network, the potentially viable O/D relations were (Notteboom, 2012, p.167):

- SAEC – East Africa
- West Africa – Oceania
- West Africa – South East Asia
- West Africa – South Asia
- West Africa – East Asia
- West Africa – East Africa

Table 2-4: Port origin-destination pairs. (Notteboom, 2012).

Region	Port forming the O/D pairs	Country
SAEC	Buenos Aires Georgetown	Argentina Guyana
South Asia	Mumbai Calcutta	India Pakistan
South East Asia	Singapore Kaohsiung	Singapore Taiwan
East Asia	Shanghai Tokyo	China Japan
Oceania	Perth Auckland	Australia New Zealand
East Africa	Muqdisho Maputo	Somalia Mozambique
West Africa	Dakar Douala	Senegal Cameroon

Table 2-4 summarises the ports that constituted the O/D pairs of the 11 viable regional trade pairs. Following the transit distance assessment, the author compared the two routing alternatives, the Suez route and the Cape route, on the 11 O/D relations. The findings of the assessment are discussed in Section 2.2.2.

2.2.2 Findings: Base year of assessment

In the relay liner network assessment, Notteboom found that the Cape passage outperformed the Suez Canal on the SAEC-Oceania service. Furthermore, the author concluded that the Cape passage offered a viable alternative to the Suez passage on the South Asia-SAEC service, the South East Asia-SAEC service, and to a lesser degree, the Middle East-SAEC service. In terms of the hub-and-spoke liner network, Notteboom determined that the Cape passage is the optimal routing choice on the West Africa-East Africa, West Africa-Oceania and SAEC-East Africa services. Furthermore, the author observed strong competition between the two routing solutions on the West Africa-South Asia services.

2.2.3 Critical assessment of the route profiles and study parameters

Despite Notteboom's (2012) findings on the Cape passage's favourability for SAEC-Oceania relay routes, none of the main shipping liners' itineraries includes services between SAEC and Oceania. The lack of SAEC-Oceania services may be related to the low trade volumes emanating from/destined to Oceania (*UNCTAD, 2019)*, but it could also be on account of the relatively minor container ports considered by the author; Perth and Auckland. The three busiest container ports in the region are Melbourne and Sydney in Australia, and Tauranga in New Zealand. These ports are situated towards the far East and have shorter sailing distance profiles along the Trans-Pacific passage. Nonetheless, under the current prevailing multiport itineraries, shipments from Oceania are routed via Singapore (Maersk, 2020b; MSC, 2020). Similar routing schedules were observed with the hub-and-spoke liner network, whereby mainline vessels call at the port of Singapore instead of direct services to Oceania ports.

As for the relay services between SAEC and South East/East Asia, most are direct call, but several are routed via the Cape corridor (Maersk, 2020c; Hapag-Lloyd, 2020). At the time of writing, shipments from South Asia and the Middle East to SAEC (and vice versa) are routed via the port of Algeciras, while traffic from East Asia is typically routed via Singapore. Both Singapore and Algeciras are world-class container terminals, and thus the argument for relay activities at the relatively minor ports of Ngqura and Port Louis is not compelling. Nevertheless, as Notteboom (2012) stated, container shipping is a highly dynamic market; shippers and carriers continuously reassess and optimise their distribution network designs.

The main limitation of the hub-and-spoke liner network assessment carried out by Notteboom (2012) was the feeder network configuration. Figure 2-2 depicts the ports Notteboom (2012) considered for the feeder services. The author considered two regions to constitute the feeder network, West Africa and East Africa. Southern African ports were excluded from Notteboom's analysis, undoubtedly because the region is too distant from the Suez Canal. Therefore, routing shipments to/from Southern African container ports via the Suez passage would not be sensible. Despite the exclusion, Maputo's port, situated in the Southern African region, was incorporated in Notteboom's (2012) feeder network as part of the East Africa region.



Figure 2-2: Feeder port system considered by Notteboom (2012). Adapted from PNG Item (2020).

With the visual depiction of the feeder network, the hub-and-spoke network analysis's main limitation becomes apparent: the feeder network comprised only four ports. Notteboom acknowledged this limitation in the initial transit distance analysis. Consequently, the author proceeded with the overall transit time and cost comparison on the trade lanes that yielded mixed transit distance results. But with the limited number of ports considered, the ports' locations significantly influenced the outcome of the analysis. Both West African ports, Dakar and Douala, are situated north of the equator line, thereby reducing the Cape passage's competitive position

on shipments originating from West Africa. A more detailed assessment of the African feeder port market is necessary to capture the Cape passage's true prospects and the competitive positions of the transhipment hub ports competing in the region.

3. RESEARCH METHODS

The previous chapter discussed the available literature on hub port competition, the key criteria considered in transhipment hub port selection and the study findings and limitations of the study by Notteboom (2012). In this chapter, the development of the model to compare and evaluate the relative competitiveness of the Southern African ports of Ngqura and Port Louis is explained. The rationale behind the critical criteria selected was briefly discussed in Section 2.1.3 and will be further elaborated on in this section.

3.1 Research Design

The purpose of this study was to further the research work of Notteboom (2012) by investigating the individual competitiveness of the main transhipment hub port rivals situated along the Cape passage, Ngqura and Port Louis, for hub-and-spoke and relay liner network structures. A quantitative analysis was selected to achieve the purpose of this study; comprehensive transit time and generalised cost models were developed to calculate the transit times and the cost of shipping via the respective hub ports. Figure 3-1 sets out the research methodology followed in this quantitative analysis. The approach is similar to earlier work by Baird (2006) and Notteboom (2012) whereby the concept of market position is investigated by weighting up the decision's economic aspects.

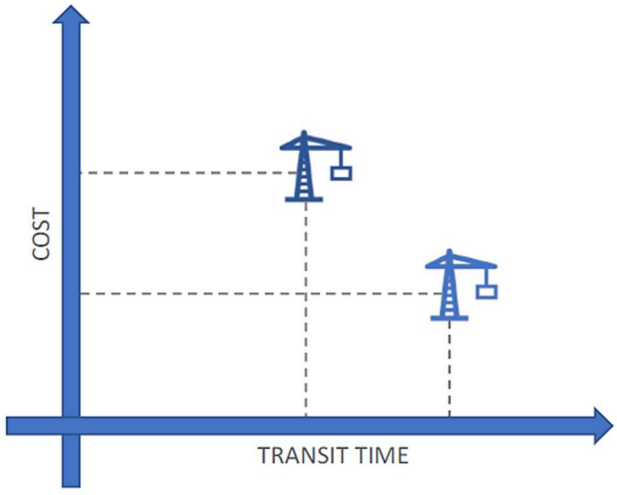


Figure 3-1: Methodology for evaluating the relative competitiveness of the transhipment hub ports.

Figure 3-2 briefly describes the three main parts of the sub-analysis. The method employed sought to combine factors that are within the control of Port authorities (such as port tariffs, infrastructure and operational efficiency) and those that are mostly beyond their control (transit distances, ship operating costs and delays caused by factors such as inclement weather). Since delays due to port congestion or inefficiency affect the total transit time and the cost of shipping, factors related to

operational efficiency and port infrastructure were selected to be incorporated in the model. A detailed explanation of the sub-analysis is given in Section 3.1.1- Section 3.1.3 of this chapter.

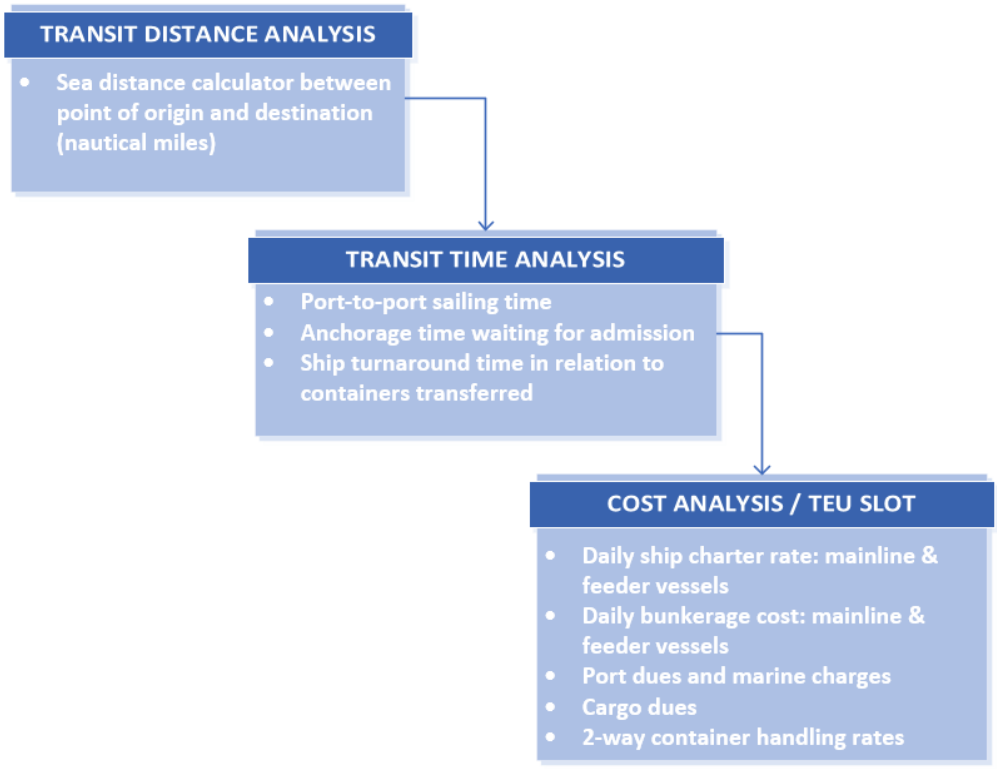


Figure 3-2: Sub-analysis in transhipment hub port competition analysis. Adapted from Notteboom (2012, p.166).

3.1.1 Transit distance analysis

The first task in the evaluation process was to identify the applicable trade lanes and routes to analyse for each liner network configuration. The major south-south trade lanes analysed by Notteboom (2012), as depicted in Figure 2-1 on page 16, formed the basis of the route profile investigation. Given the drastic decline in bunker fuel cost and the study limitations discussed in Section 2.2, the relevant trade lanes were not based on the final results of Notteboom's (2012) study. Instead, the O/D relations that formed the basis of the author's assessment, excluding the routes for which unfavourable sailing distance profiles were clearly demonstrated, were considered.

The following factors were also considered in the route configuration:

- The main ports of call in the various regions; refer to Appendix A for a list of the main container carriers considered.
- The annual TEU throughput volumes at individual port level.
- The current multiport routing schedules of the leading container shipping liners which served as a guide for the selection of the appropriate trade routes between regions.

After establishing the applicable trade routes, the transit distances (in nautical miles) were determined using Searoutes Distance Calculator (2020) for both mainline and feeder vessels, taking into consideration the intermediate stop at each respective transhipment hub. The relay and hub-and-spoke liner network designs are discussed in the next section.

Relay route profile

The SAEC-Oceania O/D relation was omitted from the relay route profile due to the reasons listed in Section 2.2.3. So too was the SAEC-Middle East trade lane for which the Cape passage was not found to be in strong contention with the Suez passage. The remainder of the O/D relations on which the ports of Ngqura and Port Louis may in future compete over pure relay traffic are thus:

- South Asia - SAEC
- South East Asia - SAEC
- East Asia – SAEC

Though the argument for relay services along the Cape passage on the listed services is not very compelling, carriers may in future take advantage of the strategic position of the Southern African container ports; the two Southern African ports are well-positioned for relay services on these trade lanes. Figure 3-3 illustrates the viable trade lanes for cargo relay at either Ngqura or Port Louis.



Figure 3-3: Relay network routes. Adapted from Free design file (2020).

For the base ports considered in this analysis, the two leading ports within each region were selected, provided that the ports are not less than 200 nautical miles (NM) from one another. For ports situated closer to one another, the sailing distance profiles are very similar, and no value is added by including a second port in the analysis. Thus, in the instance where all the main ports are clustered within a small area, the port with the greatest annual TEU throughput was then selected. With its annual throughput volume of almost 40 million TEU (Maritime and Port Authority of Singapore, 2020), Singapore attracts most of the trade within the South East Asian region and was, therefore, the only port considered for the region. Table 3-1 summarises the ports of call for the four regions while Table 3-2 captures the resultant 10 O/D pairs.

Table 3-1: Relay liner network origin-destination ports. Author's own elaboration.

Region	Port forming the O/D pairs	Country
SAEC	Buenos Aires	Argentina
	Santos	Brazil
South Asia	Jawaharlal Nehru	India
	Colombo	Sri Lanka
South East Asia	Singapore	Singapore
East Asia	Shanghai	China
	Hong Kong	China

Table 3-2: Relay routes - O/D pairs. Authors own elaboration.

	Departing port	Arriving port	O/D Pair
1	Colombo	Santos	Colombo-Santos
2	Colombo	Buenos Aires	Colombo-Buenos Aires
3	Jawaharlal Nehru	Santos	Jawaharlal Nehru-Santos
4	Jawaharlal Nehru	Buenos Aires	Jawaharlal Nehru-Buenos Aires
5	Singapore	Santos	Singapore-Santos
6	Singapore	Buenos Aires	Singapore-Buenos Aires
7	Hong Kong	Santos	Hong Kong-Santos
8	Hong Kong	Buenos Aires	Hong Kong-Buenos Aires
9	Shanghai	Santos	Shanghai-Santos
10	Shanghai	Buenos Aires	Shanghai-Buenos Aires

Hub-and-spoke route profile

Under a hub-and-spoke network configuration, feeder vessels will deliver cargo from the African region to the transhipment hub. The cargo will then be bundled at the transhipment hub port and shipped via a mainline vessel to its final destination. Similarly, mainline carriers will deliver large container consignments to the transhipment hub port, and feeder vessels will collect smaller consignments and complete the onwards journey.

The feeder O/D pairs considered in this study were expanded as the limited number of O/D pairs considered by Notteboom (2012) was identified as the author's main limitation in the feeder network configuration. The current multiport routing schedules of the leading container carriers (refer to Appendix A) served as a guide in identifying the appropriate trade routes and ports of call.

Feeder vessel routes and ports of call

To simplify the feeder network configuration, ports were aggregated by locality as opposed to region: African West Coast (AWC), South Africa (SA) and African East Coast (AEC). Four pivotal container ports were selected from the broader African West Coast and African East Coast regions and the two main container ports from the South African port system. The base ports offering the most routing solutions via the Cape passage for the feeder network are summarised in Table 3-3 and visually depicted in Figure 3-4.

Table 3-3: Hub-and-spoke liner network: feeder route O/D pairs. Author's own elaboration.

Region	Port forming the O/D pairs	Country
African West Coast	Abidjan	Côte d'Ivoire
	Tincan Island Port	Nigeria
	Pointe Noire	Congo
	Walvis Bay	Namibia
South Africa	Cape Town	South Africa
	Durban	South Africa
African East Coast	Maputo	Mozambique
	Toamasina	Madagascar
	Dar es Salaam	Tanzania
	Mombasa	Kenya

For the African West Coast, the port of Abidjan is the most distant port for which a service along the Cape passage is still favourable (Maersk, 2020b; MSC, 2020). Tincan Island Port and Pointe Noire, both with high market shares in the region, serve as good intermediate locations, with

Walvis Bay further down the coastline completing the list. On the Eastern side of Africa, there were fewer container ports for which a transhipment routing solution was feasible in this analysis. The three main ones are: Maputo, Dar es Salaam and Mombasa. The port of Toamasina was included to represent trade originating from the three island ports in the region: Madagascar, Réunion and Mauritius.

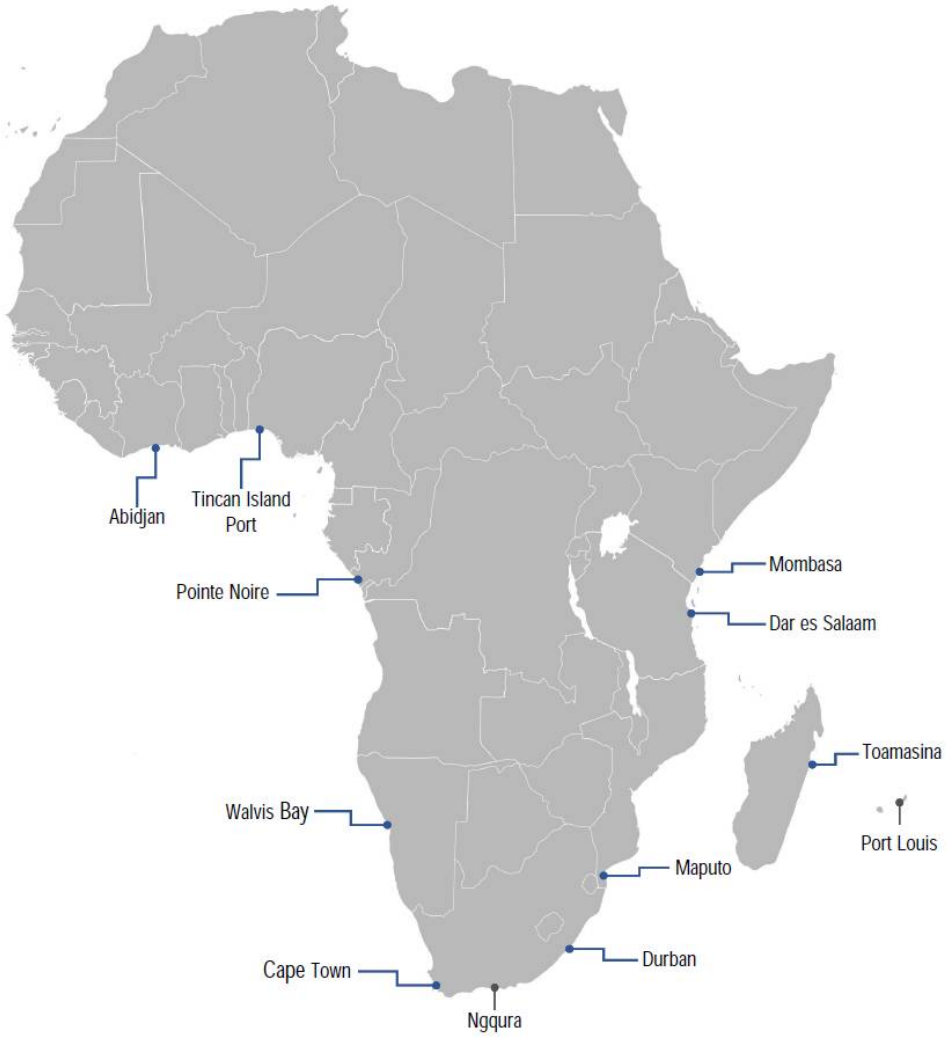


Figure 3-4: Hub-and-spoke network feeder ports. Adapted from PNG Item (2020).

South Africa was also included in the analysis given that the country has the second-largest container throughput volume in Africa, with an annual throughput of 4 892 400 TEUs recorded in 2019 (UNCTAD, 2020). If trade were to be shifted from a multiport strategy to that of a single hub call at either Ngqura or Port Louis, the pivotal South African ports of Durban and Cape Town might well be relegated to feeder ports. Ngqura is remote to the central business centres of South Africa and does not have well-established hinterland connections, so a coastal feeder service to and from Cape Town and Durban is realistic.

Trunk routes and ports of call

With the established feeder network O/D pairs, trade with the following five regions is feasible for routing via the Cape passage:

- SAEC
- Middle East
- South Asia
- South East Asia
- East Asia

Trade with Oceania was once again excluded from the analysis due to the reasons listed in Section 2.2.3. Although a relay service around the Cape passage is not favourable for Middle East - SAEC trade, some of the feeder network ports listed in Table 3-3 have favourable routing profiles when linked with trunk routes to the Middle East. But the ports of Dar es Salaam and Mombasa, for instance, are closer to the Middle East and South Asia than both Ngqura and Port Louis, and a direct call service is more sensible. Similar scenarios were encountered with some of the other routes considered in this analysis. This was taken into consideration for the configuration of the O/D pairs. The trunk routes were configured to and from the pivotal ports listed in Table 3-4. The two leading ports in the region were once again selected on the same principles described earlier.

Table 3-4: Hub-and-spoke liner network – trunk route O/D pairs. Author's own elaboration.

Region	Port forming the O/D pairs	Country
SAEC	Buenos Aires	Argentina
	Santos	Brazil
Middle East	Jeddah	Saudi Arabia
	Jebel Ali	United Arab Emirates
South Asia	Jawaharlal Nehru	India
	Colombo	Sri Lanka
South East Asia	Singapore	Singapore
East Asia	Hong Kong	China
	Shanghai	China

The resultant hub-and-spoke network configuration is depicted in Figure 3-5 and summarised in Table 3-5. A feeder service between AWC-AEC and SA-AEC was also assumed. Given the location of the two transhipment hubs and the South African ports of Durban and Cape Town in relation to the AWC-AEC service, it was not necessary to analyse a separate AWC-SA service.

A total of 17 services constituting 96 origin-destination pairs (refer to Appendix B for the full list) were analysed for the hub-and-spoke liner network configuration.

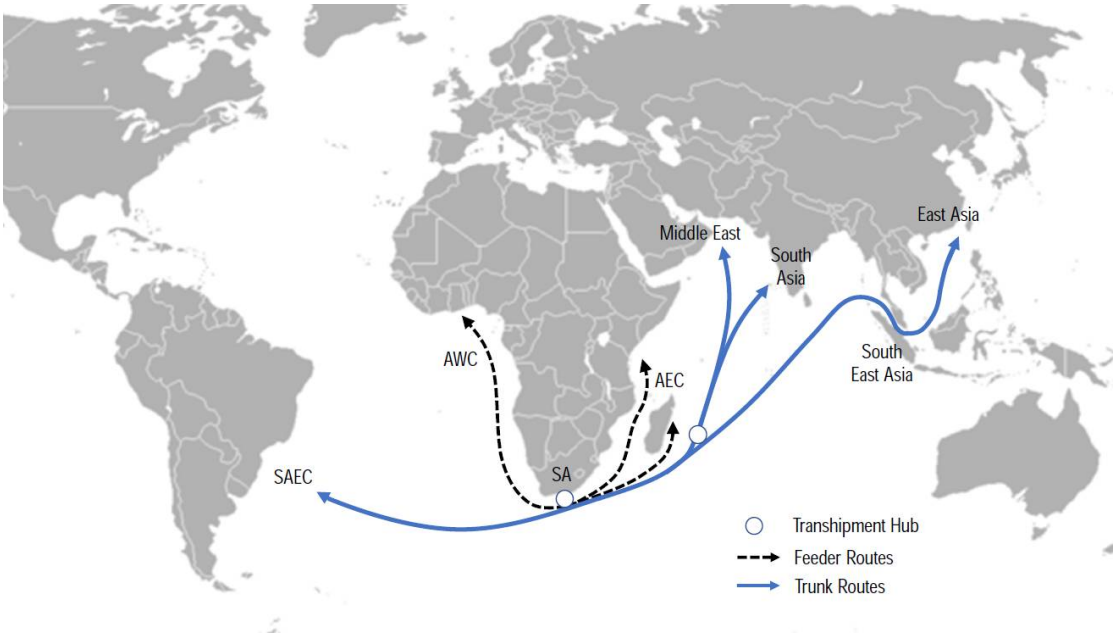


Figure 3-5: Hub-and-Spoke network trunk and feeder routes. Adapted from Free design file (2020).

Table 3-5: Hub-and-spoke liner network – O/D relations. Authors own elaboration.

	Departing from (Region)	Arriving at (Region)	O/D Relation (Service)
1	AWC	East Asia	AWC-East Asia
2		South East Asia	AWC-South East Asia
3		South Asia	AWC-South Asia
4		Middle East	AWC-Middle East
5		AEC	AWC-AEC
6		SAEC	AWC-SAEC
7	SA	AEC	SA-AEC
8		East Asia	SA-East Asia
9		South East Asia	SA-South East Asia
10		South Asia	SA-South Asia
11		Middle East	SA-Middle East
12		SAEC	SA-SAEC
13	AEC	East Asia	AEC-East Asia
14		South East Asia	AEC-South East Asia
15		South Asia	AEC-South Asia
16		Middle East	AEC-Middle East
17		SAEC	AEC-SAEC

Note: SAEC = South American East Coast, AWC = African West Coast, AEC = African East Coast, SA = South Africa, O/D = Origin-Destination

3.1.2 Transit time analysis

In the transit time analysis, the two routing alternatives (i.e. routing via Ngqura and routing via Port Louis) were analysed for the various O/D pairs under consideration in each liner network. As stated in Section 2.1.3, shippers are mostly concerned with the overall D2D transit time and the accompanying variability. However, given that MPA do not publish the mean container dwell time in their annual port statistics, the ports could not be compared on a full D2D transit time analysis. Instead, the transit times were calculated at a disaggregated level comprising all aspects of the total transit time, apart from the container dwell time in the yard. This is not to be confused with a P2P transit time calculation; a P2P transit time calculation does not include the landside movements. The partitioning of the transit time is best represented by Álvarez (2012). In the author's model, the total transit time is decomposed into three units:

- Sailing time ($\frac{l_r}{u_r}$ / $\frac{l_s}{u_s}$): the time containers spend on a vessel travelling from port to port.
- Time for port calls (m_r / n_s): this is the time spent waiting for admission at the hub port, pilotage and mooring, ship turn-around time (TAT) unloading/loading containers.
- Container dwell time in the yard: The time a container is stored in the yard waiting to be loaded on the next vessel.

The dark line in Figure 3-6 illustrates the total transit time, as per Álvarez (2012), of cargo travelling from port *i* to port *c* with one intermediate stop at the transhipment hub *j*. Voyage *R* depicts the first part of the journey from port *i* to port *j* on vessel *r*. Voyage *S* depicts the second part of the journey from port *j* to port *c* on vessel *s*. The time spent at the intermediate hub port is generally made up of several components, including vessel pilotage and mooring. For both ports analysed in this study, the pre-berthing delay/anchorage waiting time is the delay encountered by a vessel from its time of arrival at the port to the time the vessel is berthed. Hence this time reflects the time for pilotage and mooring, along with any weather-related delays at the port.

The following port productivity/efficiency indicators, as recorded in 2019, were used to calculate the time for port calls:

- Anchorage waiting time (average hours).
- The cargo handling time in relation to the volume of containers being transferred (average hours).

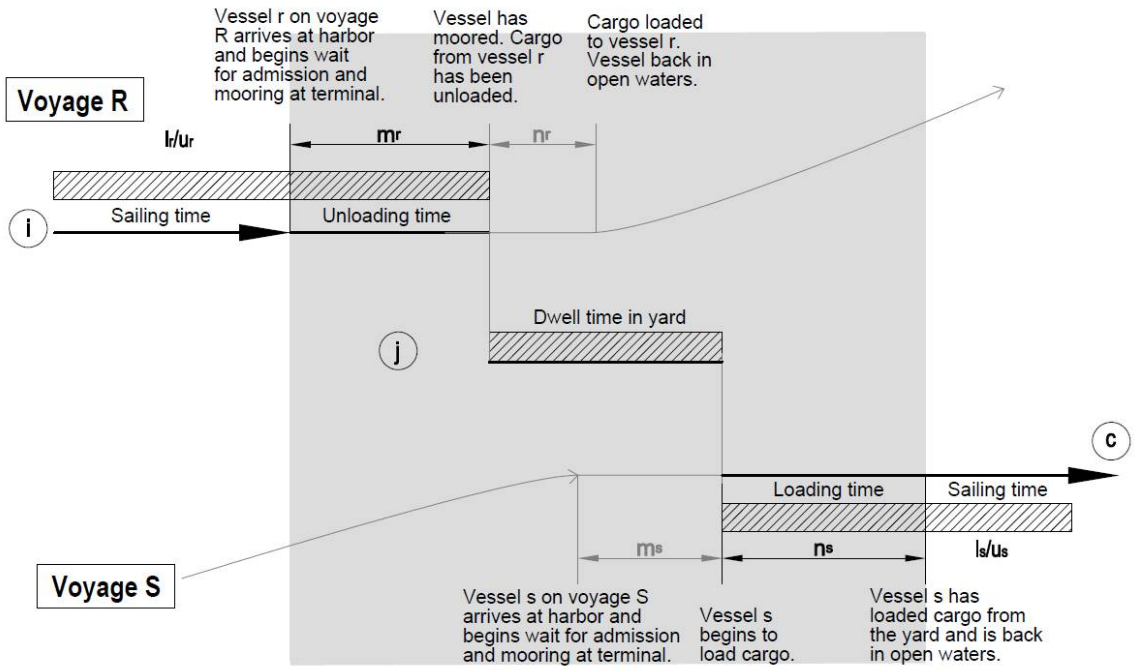


Figure 3-6: Partitioning of total transit time. Adapted from Álvarez (2012, p.711).

Álvarez (2012) developed a two-tier model in which he considered the quantity of merchandise being transhipped by the total fleet deployed on each voyage over the entire evaluation period to determine the level of service (LoS) under different fleet configurations. The LoS expression was captured in the lower tier model to calculate the container dwell time for a synchronised service. However, the lower tier calculation is not required to compare two competing hub ports on actual transit times as per this study. It is also not necessary to include the handling time at the port of origin i, and the destination port j, nor is it necessary to include the handling times n_r and m_s related to different shipments altogether. Therefore, the transit time formulation proposed in this study differs slightly from the transit time model proposed by Álvarez (2012).

So, to summarise, the total transit time of cargo travelling from port i to port c (as defined in this study) comprises the following elements:

- The total sailing time of the vessel r from port i to port j.
- The port call time of vessel r at the intermediate hub comprising the anchorage waiting time and cargo handling time (hereinafter referred to as the ship TAT) unloading x_r amount of transhipment TEUs.
- The port call time of vessel s at the intermediate hub comprising the cargo handling time (ship TAT) loading x_s amount of transhipment TEUs.
- The total sailing time of vessel s from port j to port c.

The transit time (in days) on voyage *R*, for vessel size *r* (T_{rx}), is then defined as:

$$T_r(i,j) = \frac{l_r}{u_r} + m_r \quad (1)$$

With l_r the sailing distance, in nautical miles, from the originating port *i* to the hub port *j*; u_r is the cruising speed of vessel *r; m_r* is the port call time of vessel *r*, made up of the anchorage waiting time and the ship TAT time, which was defined as follows:

$$m_r = \frac{x_r}{Ah_j} + Aw_j \quad (2)$$

With x_r denoting the number of transhipment TEUs unloaded from vessel *r*; Ah_j the average container moves per ship working hour at hub *j*; and Aw_j the average anchorage waiting time at hub *j*. Ah_j and Aw_j thus represent the port productivity indicators. In this mathematical expression, the relationship between the volume of containers loaded and the ship TAT is stressed.

The transit time (in days) on voyage *S*, for vessel size *s* (T_s), is defined as:

$$T_s(j,c) = \frac{l_s}{u_s} + n_s \quad (3)$$

With l_s the sailing distance, in nautical miles, from the hub port *j* to the destination port *c*; u_s is the cruising speed of vessel *s*; n_s the port call time of vessel *s*, which in the case of vessel *s* on voyage *S* constitutes the ship TAT only. n_s (in days) was calculated using the given formula below:

$$n_s = \frac{x_s}{Ah_j} \quad (4)$$

With x_s denoting the number of transhipment TEUs loaded on vessel *s* and Ah_j the average container moves per ship working hour recorded by hub *j* in the study year. Though voyage *S* may also experience pre-berthing delays, the delay forms part of the port call time, m_s, related to a different shipment. As indicated in Figure 3-6, this time component would typically form part of the container dwell time in the yard, which was not considered in this study's transit time model. Thus, the formulation of the total transit time (*T*) in days is:

$$T(i,c) = T_r(i,j) + T_s(j,c) \quad (5)$$

The assumptions made and premises of the transit time formulation were:

- The vessel inter-arrival times and level of service (LoS) are not relevant when the container dwell time is omitted from the transit time calculation and was therefore not considered.
- Homogeneous carrier performance was assumed.
- A mainline vessels speed of 20 knots and feeder vessel speed of 18 knots applied.
- The handling of standard twenty-foot equivalent units (TEU) applied; and the vessel TAT was based on the number of TEUs transhipped.
- Due to the proximity of Ngqura to Port Louis, ocean movement variability with seasonality was not considered. Sailing delays due to poor weather conditions is relatively low compared to delays at the port (Harrison and Fichtinger, 2013)
- Considering yard capacity constraints fell outside the scope of this analysis.
- The two-way ship handling and sailing distance of each vessel were not considered; the study was only concerned with each leg of the journey from the origin to destination.

3.1.3 Generalised cost analysis

The objective of the generalised cost model was to quantify the cost of the overall transport movement from port *i* to port *c*, for the situation in 2019, in monetary terms. The focus was placed on the following measurable maritime shipping cost components:

- Port fees and other marine charges which include port dues, berth dues, pilotage services, tug assistance and any other relevant charges levied by the corresponding port authority.
- Cargo dues levied by the port authority.
- Container handling charges: the two-way terminal container handling charges for offloading vessel *r* and loading vessel *s*, as levied by the terminal operator.
- Vessel time charter rates.
- Bunker fuel cost.

Though port authorities generally charge fees for the storage of containers in the yard, the ports analysed in the study both offer free storage periods. Ngqura offers a free period of 7 days (TPT, 2019b), while Port Louis offers a free period of 10 or 14 days (CHCL, 2017), depending on the container status. Since the container dwell times were not considered in the transit time analysis, it did not form part of the cost analysis either. Nonetheless, transhipment containers dwell times are normally within the free storage periods (TPT, 2020b).

The generalised cost model proposed in this study is very similar to the cost models proposed by Notteboom (2010, 2012) and Baird (2006); the main difference is on how the cost of delays are ascribed. If a port is inefficient or heavily congested, and the resultant delays are common, the average anchorage waiting time and ship TAT increases. And as the time factor of shipping increases, so does the shipping cost. The charges associated with delays are however difficult to quantify, since the cost of delays are not merely equal to the daily ship charter rate multiplied by the delay time (Baird, 2006). Baird (2006) therefore argued that it is appropriated to ascribe charges substantially in excess of the daily ship charter rate of the individual vessel.

Notteboom (2010) proposed an economic model where the depreciation of the goods, insurance cost, leasing cost of the container and the opportunity cost of the goods transported are estimated over the transportation time period. But such an in-depth analysis falls outside the scope of this assessment. Instead, emphasis was placed on the readily computable maritime shipping cost components. As discussed, some of the charges are time related; the outputs of the transit time analysis are inputs in the cost model. This included the average pre-berthing delays, as recorded by each port in 2019, as well as the estimated ship TAT. The cost per TEU carried from port *i* to port *j* on vessel *r (*C*r)*, and transhipped at hub *j*, was thus calculated as follows:

$$C_r(i,j) = c_{cr}.T_r + \cdot t_{i\to j} \cdot c_{bx}^{ur} + \cdot 0.05 \cdot c_{bx}^{ur} \cdot m_r + c_{pu(r)} + c_{tu} \cdot x_r \quad (6)$$

With T_r the total transit time of vessel *r* in days; c_{cr} is the daily ship charter rate per TEU carried on vessel *r*; c_{br}^{ur} is the daily bunkerage cost per TEU carried on vessel *r* travelling at a speed of u_r; $t_{i\to j}$ is the sailing time (in days) between port *i* and hub *j*, represented by $\frac{l_r}{u_r}$ in equation (1); m_r is the port call time in days of vessel *r*; $c_{pu(r)}$ is the port access and marine charges levied by the port authority on vessel *r*; c_{tu} are the cargo dues and container handling rates charged per TEU handled; and x_r is the total number of TEUs offloaded from vessel *r*. During non sailing days the fuel consumption decreases, still, auxiliary power is still required for systems such as electrical generation, fire fighting equipment, refrigeration, bow thrusters and stabilizers (Molland. ed., 2008). The 0.05 figure represents the bunker fuel consumption during non sailing days which is assumed to be 5% of the consumption at sea. This assumption is reasonable given that the handling of reefer containers with high energy requirements were not considered in the study.

The cost per TEU carried from port *j* to port *c* on vessel *s (*C*s)*, and transhipped at hub *j*, was calculated as follows:

$$C_S(j,c) = c_{cs}.T_s + \cdot t_{i\to j} \cdot c_{bs}^{us} + \cdot 0.05 \cdot c_{bs}^{us} \cdot n_s + c_{pu(s)} + c_{tu} \cdot x_s \quad (7)$$

With T_s the total transit time of vessel *s* in days; c_{cs} is the daily ship charter rate per TEU carried on vessel *s*; c_{bs}^{us} is the daily bunkerage cost per TEU carried on vessel *s* travelling at a speed of u_s; $t_{i\to j}$ is the sailing time (in days) between port *i* and hub *j*, represented by $\frac{l_s}{u_s}$ in equation (1); n_s is the port call time in days of vessel *s*; $c_{pu(s)}$ is the port access and marine charges levied on vessel *s*; c_{tu} are the cargo dues and container handling rates per TEU handled; x_s is the total number of TEUs loaded onto vessel *s*.

The total generalised cost of shipping a TEU from port *i* to port *c*, with one intermediate stop and transhipment operation at hub *j*, is thus:

$$C(i,c) = C_r + C_s \quad (8)$$

The various cost components were based on real cost data from 2019. The port authority and terminal operators' charges were obtained from the TNPA, TPT, CHCL and the MPA port fees regulation tariff books. For the vessel time charter rates and bunker fuel cost, which tend to fluctuate, the annual average as recorded by Clarksons Research for the calendar year of 2019 applied. As suggested in equation (6), the bunker fuel consumption depends on the speed the vessel is traveling at. The consumption at different speeds was based on earlier work by Notteboom and Cariou (2009) and is captured in Appendix D.

Vessels deployed

For the relay liner network, the analysis considered the generalised cost in relation to an 8850 TEU capacity mainline vessel. The vessel was assumed to be operating at 90% of the nominal capacity, with 50% of the consignment transhipped at the intermediate hub port. The premises of the assumptions are that mainline carriers operating along the same trade lane exchange containers at the intermediate port to reduce port calls in the origin/destination regions. Furthermore, the opportunity to deliver cargo along the lengthy transoceanic connector does not really exist for most of the relay routes considered, and therefore the utilisation rate assumed is reasonable. The two-way container volume carried thus equalled 15 930, and the two-way transhipment volume handled at the respective hubs equalled 7 966 TEU.

For the hub-and-spoke network, the generalised cost of a 6750 TEU mainline vessel applied. This vessel size is considered appropriate for a hub-and-spoke liner network configuration and was also considered in Notteboom's (2010) study in which the author compared hub port configuration to a multiporting configuration for the Southern African container port system. As for the feeder routes, a 1700 TEU vessel applied for the routes from the Southern African ports of Cape Town, Walvis Bay, Maputo and the island port of Toamasina. For the remainder of the feeder routes a 2500 TEU vessel applied. The feeder vessel sizes were based on the currently deployed (Maersk, 2020b; MSC, 2020), and available (Vessel Tracking, 2020) vessels of the container carriers operating in the region.

It could be argued that even smaller feeder vessel sizes ought to apply over shorter sailing distances to relatively minor ports, such as from Cape Town and Maputo to Ngqura (465NM), and Toamasina to Port Louis (476NM). However, the sailing distances associated with transhipping via Ngqura differ substantially from transhipping via Port Louis. Therefore, to simplify the analysis, only two feeder vessel sizes were assumed, and the smaller of the two (1700 TEU) applied to all the Southern African feeder ports, except for the port of Durban. While the port of Durban is less than 400NM from Ngqura, Durban is the premier gateway cargo port and handles over 2.5 million TEUs per annum (TPT, 2020a). Therefore, larger consignments can be expected from the port of Durban.

A 90% vessel utilisation rate applied to all vessels in the hub-and-spoke liner network, of which the full consignment gets transhipped at the hub ports. The two-way container handling volume at the respective hubs is thus 8325 TEU and 7605 TEU respectively. This level of capacity utilisation is practical for a transhipment strategy in which smaller shipments are consolidated into one large shipment. Moreover, neither Ngqura nor Port Louis have large local cargo bases, both ports are focussed on attracting transhipment traffic. Whether the market opportunity exists to substantiate the trade volumes is another question. But with the limited number of origin and destination ports considered in this study, cargo volumes may be split among the economies in close geographical proximity to one another.

The assumptions made and premises of the generalised cost formulation were:

- The total port cost was calculated per TEUs transhipped, the charter cost and bunker cost was calculated per TEU carried.
- The balance of full to empty containers, based on port statistics, and the associated terminal handling rates applied.
- Reefer containers were not considered in the costing model.
- The daily vessel charter rates reflect the capital cost, vessel maintenance and repairs, insurance fees and crew cost.
- Shore charges for container movements in the yard were not considered. Only quay charges applied.
- Discounts offered by the respective hub ports for transhipment consignments were incorporated in the costing model.

3.2 Data Collection Procedure

The study relied on publicly available data sources. MPA, TNPA and TPT publish information on their websites, in annual performance reports and published statistics from which the primary data was sourced. Limitations to primary data accessibility due to the partial nature of the data sets published by port authorities meant that the study also had to also rely on secondary data. The secondary data was collected from the African Development Bank, Clarksons Research, the World Bank, the United Nations Conference on Trade and Development (UNCTAD), Searoutes Distance Calculator, Maersk and the Mediterranean Shipping Company.

3.3 Research Tool

The port to port sea route distances were determined using SeaRoutes - distance calculator (2020). The transit time and generalised cost models were built in Microsoft Excel. The software package offered the required functionality to process the mathematical expressions detailed in Section 3.1.2 and Section 3.1.3.

3.4 Validation and Verification

Research on mathematical modelling of transit time and generalised shipping cost has progressively started attracting the attention of researchers (Du, et al., 2016). The mathematical expressions used in this study is based on previous theoretical work (Álvarez., 2012; Baird, 2006; Notteboom, 2012) and follow the industry norms for transit time and shipping cost calculations.

The predominant trade routes and ports of call were substantiated by examining the routing schedules of the leading maritime carriers operating in the Southern African region (Appendix

A). Searoutes Distance Calculator (2020) is based on Automatic Identification System (AIS) data tracking 50 000 vessels for the past five years and required no further verification. The software was also used to verify the results of the P2P sailing time analysis. Likewise, the individual port performance variables, used to determine the time spent in port, were derived from port AIS data, and required no further verification.

To validate that the appropriateness of the model for evaluating the relative competitiveness of Ngqura and Port Louis, the results of the study were compared to the container market share/shift between the two ports. As noted in the literature review section of this report, the interactions between shippers and carriers and their selection of a transhipment hub results in a higher market share allocation to the selected port. (Veldman and Bückmann, 2003). The transhipment incidence of both ports was observed for the 2019 calendar year; the figures were used to determine the market share of each (based on annual TEU throughput). Although factors other than the ones examined in this study may weigh in on the port market share, in particular the geographic distribution of shipment origins by volume, it would still give a reasonable insight on the current competitive positions of the two ports. A sensitivity analysis was also conducted to determine the impact of the selected input parameters, vessel speed and utilisation degree on the transit time and generalised cost of shipping.

4. DATA

This chapter presents the primary datasets that served as inputs in the models. The first section begins with an overview of the port productivity indicators and explains the relationship between the different port productivity measures. Lastly, the various shipping cost components and charges are explained in greater detail; figures are also cited.

4.1 Port productivity indicators

The individual port productivity indicators are summarised in Table 4-1 below. Only the average pre-berthing delay and average moves/ship working hour are inputs of the transit time model. However, it is essential to explore the other indicators and explain how they influence one another.

Table 4-1: Individual port productivity indicators for 2019. Based on MPA (2020c), TNPA (2020c), TPT (2020b)

Port Productivity Indicator	Transhipment Hub:	
	Ngqura	Port Louis
Berth occupancy (%)	60	75.4
Average pre-berthing delay (hours)	29	5.4
Average moves / gross crane hour	21	22
Average moves / ship working hour	47	37.7
Annual TEU throughput*	718,609	661,196
Transhipment incidence (%)	50	58

**Excluding paid restows*

4.1.1 Berth occupancy

The berth occupancy of both Port Louis and the port of Ngqura decreased from the calendar year of 2018 to 2019 (MPA, 2020c; TNPA, 2020c). Berth occupancy is the ratio of vessel time at berth to the total berth hours available. This is not a quay productivity measure, as it does not account for the loading and unloading rates, but rather a measure of how well port infrastructure is utilised. Port authorities aim to capitalise on the installed terminal capacity and target high berth utilisation rates, but this needs to be balanced with anchorage waiting times. High berth occupancy is an indicator of port congestion (Ports Regulator of South Africa, 2016), which may suggest that insufficient berth slots are available. At an 8% greater TEU throughput in 2019, Ngqura with four available container berths (see Table 2-2) recorded a much lower berth occupancy rate than Port Louis with its three berths, signifying underutilisation of resources.

4.1.2 Average pre-berthing delays

The pre-berthing delay is the time a vessel spends waiting at anchorage to berth. The delay represents the time from its arrival at the port to the time the vessel is berthed. In 2019 vessels spent an average of 29 hours waiting at anchorage outside the port of Ngqura, in contrast to only 5.4 hours at Port Louis. These delays are not always on account of terminal readiness or unavailability of berths; it can also be due to weather conditions (strong winds), delays caused by the vessel, or cargo. Ngqura was adversely affected by bad weather conditions in 2019 (TNPA, 2020c) and therefore, narrowly missed the target performance of 28 hours.

Nevertheless, 28 hours is still a long way off from the 5.4 hours recorded by Port Louis. By implemented a fixed berthing window scheme, Port Louis was able to minimise pre-berthing delays. Carriers generally adhere to their fixed berthing slots as they too operate under tight schedules.

4.1.3 Quay crane productivity

The average moves per Gross Crane Hour (GCH) is the number of containers moved per hour by a single quay crane. It is the industry-standard measure for quay crane productivity in container handling. The global average is around 35 to 40 moves per GCH (Ports Regulator of South Africa, 2016). Figure 4-1 illustrates the quay crane productivity rates achieved by Port Louis and Ngqura from 2015-2019.

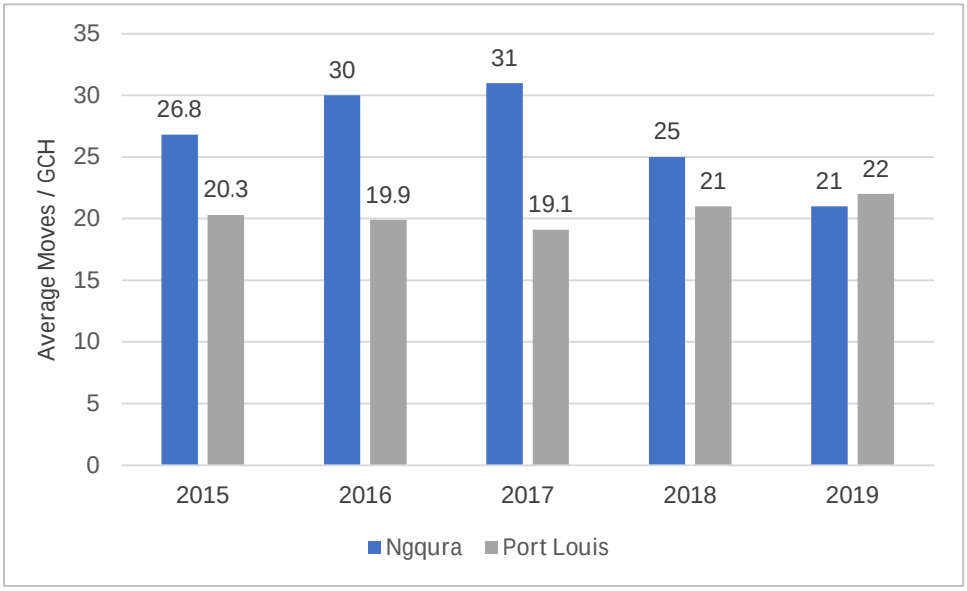


Figure 4-1: Quay crane productivity – Average moves per GCH trend. Based on MPA (2020c) and TPT (2020b).

Ngqura's crane productivity has declined year on year since 2017, and while Port Louis achieved a steady figure of around 20 moves per GCH over the years, neither port is anywhere near the global standard on this measure. Transnet cited inclement weather, poor reliability and availability of equipment and as the main reasons for the decline (TNPA, 2020c).

4.1.4 Berth productivity

Quay crane duty cycles, or moves per GCH, are fixed and have not improved much in recent years (JOC Group, 2014). Once the maximum moves per GCH is achieved, the only way to improve the productivity is by employing more cranes per ship. The average moves per Ship Working Hour (SWH) is the total number of containers moved over the quay divided by the total ship working hours (Ports Regulator of South Africa, 2016). It is a measure of the berth productivity or efficiency. In the transit time model, the ship TAT was calculated by dividing the number of containers handled by the average moves per SWH.

By doing so, the differences in terminal infrastructure between the two ports are accounted for. The greater the number of quay cranes, the higher the potential productivity (assuming all other things equal). Figure 4-2 illustrates the average moves per SWH in relation to the berth occupancy rates of Port Louis and Ngqura from 2015 to 2019.

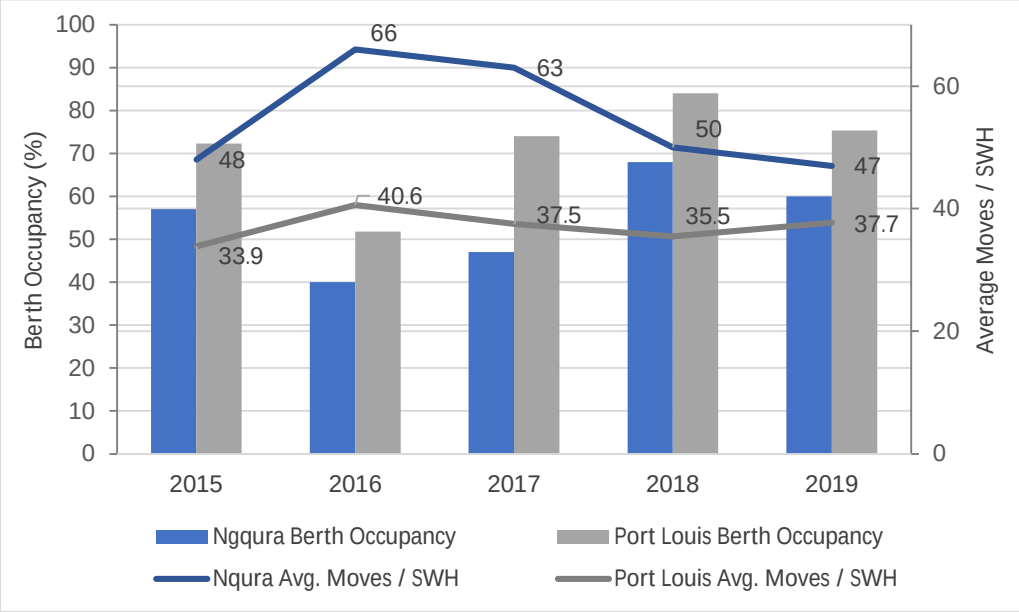


Figure 4-2: Berth productivity – Berth occupancy vs average moves per SWH trends. Based on MPA (2020c) and TPT (2020b).

The average moves per SWH appear to also be positively correlated with the berth occupancy rate. In 2016 when berth occupancies were at their lowest for both ports, the average moves per SWH were at their highest. The relationship is not surprising given that idle cranes from other

berths can be employed to turn-around berthed vessels faster when there are free berths in the port. Ngqura benefitted the most from underutilised infrastructure in 2019 as well as in prior years. Ngqura recorded 47 moves/SWH on average in 2019 while Port Louis averaged 37.7 moves/SWH.

4.2 Cost Components

4.2.1 Port fees and marine charges

The port fees and marine charges are the set of costs levied by the port authority for a single vessel call; and the related nautical services rendered by the port authority. Certain port authorities have special charges distinct to the relevant port, but in general, the standard charges include port dues, berth dues, pilotage services, tug assistance and berthing services. The figures for these charges were obtained from the TNPA tariff book (TNPA, 2019) and the MPA port fees regulation (Ports Fees Regulation, 2008; Ports Fees (Amendment) Regulation, 2017).

MPA's fees are charge per call/service rendered on a sliding scale based on the vessel's gross tonnage. In the case of berth dues, the sliding scale is a variable component of berth occupancy time as well. After the 6th day a vessel is anchored at the berth the charges are increased. Similarly, the marine charges levied by TNPA constitute a basic fixed fee plus a variable component related to the gross tonnage of the vessel. The Port dues and berth dues levied by TNPA comprise a fixed component based on the vessel tonnage (GT), referred to as the basic fee, and an additional variable component related to the berth occupancy time in combination with the gross tonnage. In addition to these standard charges, both MPA and TNPA levy other charges. MPA levies a seamen's welfare due, charged according to the gross tonnage of the vessel, while TNPA introduced a Vessel Traffic Services (VTS) charge, also payable per gross tonnage.

Based on the fee structures of these two ports, the input data for calculating the port fees and marine charges are:

- The registered gross tonnage of the vessels.
- The total port times.

Both ports have variable components related to time, the figures are therefore cited in Chapter 5 of this report. The registered gross tonnages of the allocated vessels were based on the current world fleet and are cited in Table 4-3.

4.2.2 Cargo dues and container handling rates

This group of charges are related to the cargo discharged/loaded overside a berthed vessel. The cargo dues, also known as wharfage, is the fee charged by the port authorities for using the berth to load and unload cargo. For containerized cargo, MPA and TNPA both charge different rates depending on whether it concerns exports, imports, transhipments and whether the container is laden or empty. The rates charged per TEU transhipped are listed in Table 4-2.

Table 4-2: Cargo dues and container handling rates. Based on CHCL (2017), Ports Fees Regulation (2008), Ports Fees (Amendment) Regulation (2017); TNPA (2019) and TPT (2019b)

Cargo dues: Transhipment	Ngqura	Port Louis
Laden TEU per leg inwards or outwards (US$)	$5.90	$27.00
Empty TEU per leg inwards or outwards (US$)	$5.78	$11.00
Terminal handling rates: Transhipment	**Ngqura**	**Port Louis**
Laden TEU per leg inwards or outwards (US$)	$146.33	$52.80
Empty TEU per leg inwards or outwards (US$)	$146.33	$52.80
Balance of full to empty containers	**Ngqura**	**Port Louis**
Laden containers (%)	-	75%
Empty containers (%)	-	25%

The terminal handling charges are the terminal operator fees for the services rendered, i.e. loading or unloading of containers. Handling charges are also referred to as stevedoring charges in some countries. TPT is the terminal operator of all South African ports, while the container terminal at Port Louis is operated by the Cargo Handling Corporation Limited (CHCL). The charges levied by the relevant terminal operators per inwards/outwards container movement are also listed in Table 4-2. Only the quay charges applied to the cost model; shore charges were not considered. The ratio of full to empty containers handled at the port is also of relevance. The figures for Port Louis as recorded in 2019 are cited in Table 4-2. The same figures were obtained for Ngqura, but since the data is confidential, it has been excluded from the table. The average ratio between the two ports applied in the cost model.

The charges cited in this section were obtained from the TNPA, TPT, CHCL and the MPA port tariff books (CHCL, 2017; Ports Fees Regulation, 2008; Ports Fees (Amendment) Regulation, 2017; TNPA, 2019; TPT, 2019b). TNPA and TPT tariffs are levied in South African Rand (ZAR) and are subject to Value Added Tax (VAT) of 15%. The exchange rate used to convert the fees to US dollars relates to the situation late in August 2019. A 3% currency conversion fee applies to the transaction, and the VAT was factored in. MPA and CHCL tariffs may be paid in either US dollar or Mauritian rupee; the US dollar fees were used.

4.2.3 Vessel time charter rates and bunker fuel cost

The vessel time charter rates were obtained from Clarksons Research (2019). The rates related to the average price per day recorded in 2019 on a 6-12 months' time-charter. The charter market data presented in Clarksons Research's *Container Intelligence Monthly* report contained a limited number of vessel sizes, thus for the 8850 TEU and 6750 TEU vessels, time charter rates were based on the 9000 TEU and 6800 TEU vessels. Table 4-3 presents the data. The charter rates reflect the capital cost, vessel maintenance and repairs, insurance fees and crew cost. The bunker fuel consumption was obtained from Notteboom and Cariou's (2009) fuel consumption model while the bunker fuel cost/mt relates to the mean price recorded in 2019, as reported by Clarksons Research (2019).

Table 4-3: Vessel time charter rates and bunker fuel cost. Based on Clarksons Research (2019) and Notteboom and Cariou (2009).

Vessel size (TEU nominal)	8850	6750	2500	1700
Gross tonnage	95,400	75,600	26,000	18,300
Vessel type	gearless	gearless	geared	geared
Daily charter rate (US$)	$32,074	$14,935	$9,232	$7,285
Vessel cruising speed (knots)	20	20	18	18
Daily fuel consumption at indicated speed (mt/day)	135	120	50	38
Bunker fuel price (US$/mt – 380 cst)	$421	$421	$421	$421
Daily fuel cost (US$)	$54,674	$42,057	$21,029	$15,982
Total daily ship cost (US$)	$86,748	$56,992	$30,261	$23,267

**The daily vessel charter rates reflect the capital cost, vessel maintenance and repairs, insurance fees and crew cost.*

5. SUB-ANALYSIS RESULTS

This chapter provides the results of the transit distance, transit time, and generalised cost models. Sensitivity analyses were also conducted to determine the impact of the selected inputs, vessel speed and utilisation degree on the transit time and generalised cost models. The results of the analyses are also presented in this chapter. The findings are briefly discussed in each section in order to derive meaning and provide the reader with more context.

5.1 Transit Distance Results

5.1.1 Relay liner network

The relay network transit distance results are presented in Table 5-1 below. The data shows the total sailing distance from the port of origin to the destination port, with one intermediate stop at Ngqura or Port Louis for relay activities. For the South American East Coast services to South East Asia (2) and East Asia (3), both Ngqura and Port Louis are favourably positioned with a difference of less than 1% separating the two hubs. Ngqura is slightly better positioned for trade destined to Jawaharlal Nehru in India. However, when considering the overall transport movement from the South American East Coast to South Asia, the results are comparable.

Table 5-1: Transit distance profiles – relay liner network. Based on Searoutes Distance Calculator (2020).

From (Region)	To (Region)	O/D pair	Distance via (NM)		Opt. hub location:	Diff. (NM):
			Ngqura:	Port Louis:		
1. South Asia	SAEC	Colombo-Santos	7774	7744	Port Louis	-30
		Colombo-Buenos Aires	8044	8004	Port Louis	-40
		Jawaharlal Nehru-Santos	8004	8166	Ngqura	-162
		Jawaharlal Nehru-Buenos Aires	8274	8426	Ngqura	-152
2. South East Asia	SAEC	Singapore-Santos	9040	8987	Port Louis	-53
		Singapore-Buenos Aires	9310	9247	Port Louis	-63
3 East Asia	SAEC	Hong Kong-Santos	10327	10390	Ngqura	-63
		Hong Kong-Buenos Aires	10597	10650	Ngqura	-53
		Shanghai-Santos	10957	11023	Ngqura	-66
		Shanghai-Buenos Aires	11227	11283	Ngqura	-56

Note: SAEC = South American East Coast, O/D = Origin-Destination, Opt. = Optimal, Diff. = Difference

In the relay model a single intermediate hub port call was assumed; whether a multiport or single call strategy emerges after that would depend on trade volumes and the unit cost associated with each strategy. Various network strategies are conceivable. At the time of writing, Maersk's service from Santos to India stops at two ports in the destination region (Maersk, 2020b).

5.1.2 Hub-and-spoke liner network

A transhipment strategy in the context of a hub-and-spoke liner network is the changeover from a multiport to a single call strategy where the partitioning/bundling of containers happens at a hub port. The overall transport movement between the two regions is of greater interest than the results of the individual O/D pairs. The transit distances of the overall transport movement between two regions were obtained by summing the feeder ship and mainline ship sailing distances for the entire service and then dividing it by the number of O/D pairs in the service. The results are summarised in Table 5-2 below and graphically represented in Figure 5-1. The full detailed voyage distance data constituting all the individual O/D pairs, split into feeder and trunk routes, is presented in Appendix B.

Table 5-2: Transit distance profiles – hub-and-spoke liner network. Based on Searoutes Distance Calculator (2020).

	From (Region)	To (Region)	O/D Port Pair	Avg. distance via (NM)		Opt. hub location:	Diff. (NM):
				Ngqura:	Port Louis:		
1	AWC	East Asia	AWC-East Asia	9215	9288	Ngqura	-73
2		SEast Asia	AWC-SEast Asia	7613	7568	Port Louis	-44
3		South Asia	AWC-South Asia	6462	6536	Ngqura	-75
4		Mid. East	AWC-Mid. East	6725	7252	Ngqura	-528
5		AEC	AWC-AEC	3995	5403	Ngqura	-1408
6		SAEC	AWC-SAEC	5665	9322	Ngqura	-3658
7	SA	AEC	SA-AEC	2033	3104	Ngqura	-1071
8		East Asia	SA-East Asia	7253	6990	Port Louis	-264
9		SEast Asia	SA-SEast Asia	5651	5270	Port Louis	-381
10		South Asia	SA-South Asia	4500	4238	Port Louis	-262
11		Mid. East	SA-Mid. East	4763	4954	Ngqura	-191
12		SAEC	SA-SAEC	4380	7701	Ngqura	-3321
13	AEC	East Asia	AEC-East Asia	8012	6025	Port Louis	-1988
14		SEast Asia	AEC-SEast Asia	6410	4305	Port Louis	-2105
15		South Asia	AEC-South Asia	5259	3273	Port Louis	-1986
16		Mid. East	AEC-Mid. East	5522	3989	Port Louis	-1533
17		SAEC	AEC-SAEC	5557	6951	Ngqura	-1394

Note: SAEC = South American East Coast, AWC = African West Coast, AEC = African East Coast, SA = South Africa, SEast Asia = South East Asia, Mid. East = Middle East, O/D = Origin-Destination, Avg. = Average, Opt. = Optimal, Diff. = Difference.

The results show that for the services from AWC to East Asia, South East Asia and South Asia, Ngqura and Port Louis are closely matched. It is also clear that each port has a location advantage depending on the specific trade routes considered. Port Louis is ideally situated the trade flows between the African East Coast and Asia/the Middle East. A 25-38% reduction in transit distances can be realised when cargo is transhipped via Port Louis instead of Ngqura on these services. Conversely, Ngqura's central location between the western feeder routes and eastern trunk routes result in lower overall transit distances on the AWC-Middle East and AWC-AEC services. Furthermore, because Port Louis is distant to the West, the Mauritian port has a significant transit distance disadvantage on the services to the South American East Coast. The transit distance disadvantage amounts to 39% and 43% on the AWC-SAEC and SA-SAEC services, respectively.

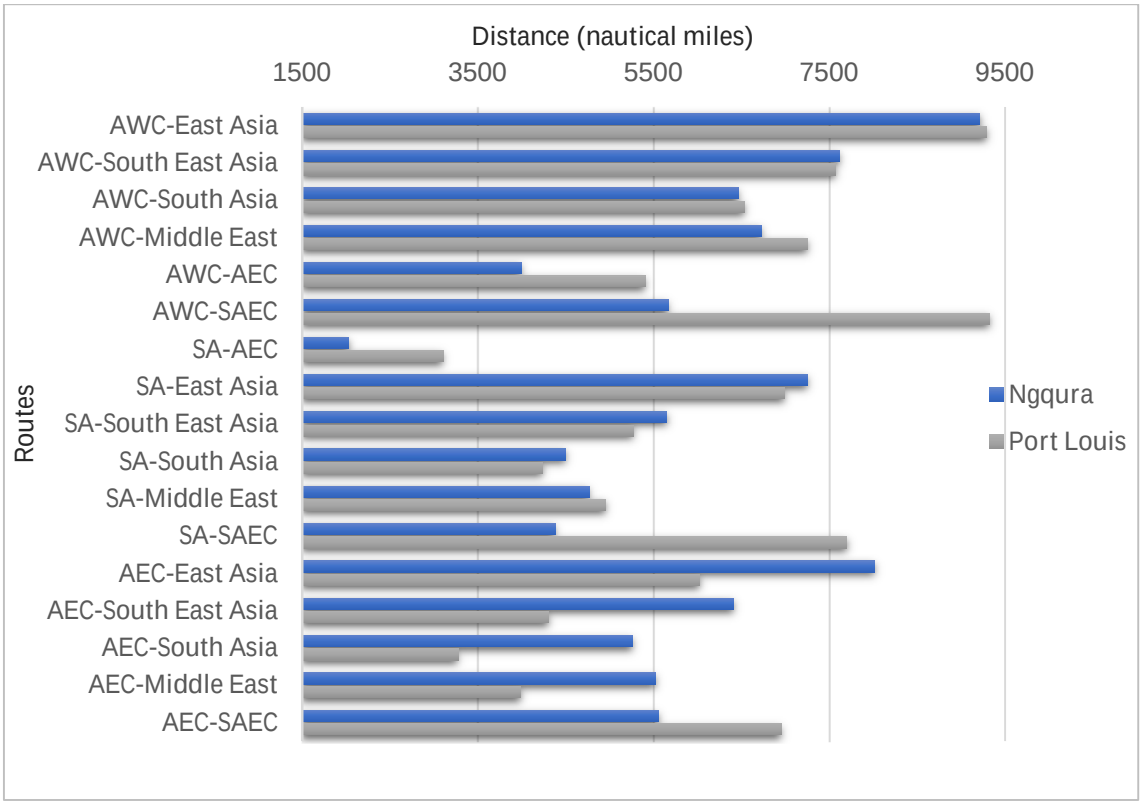


Figure 5-1: Hub-and-spoke liner network transit distance profiles. Own elaboration based on Searoutes Distance Calculator (2020).

Figure 5-2 reveals why there is such a significant transit time disparity between the two routing solutions for services destined to SAEC. Feeder vessels must traverse the entire South African coastline before journeying across the Indian Ocean on route to the Port Louis, only for mainline vessels to traverse the same shipping lane back towards SAEC.

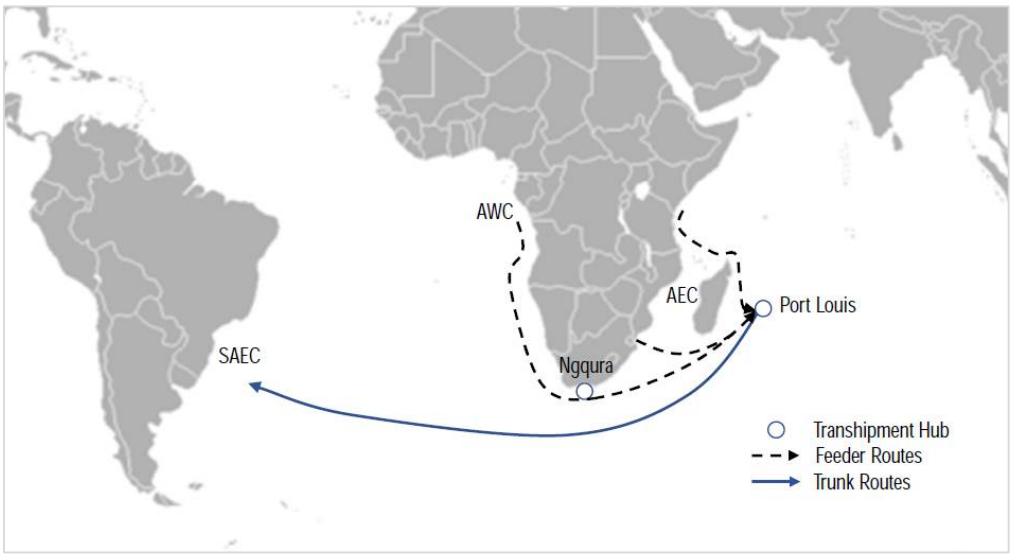


Figure 5-2: Hub-and-spoke liner network – trade with SAEC. Adapted from Free design file (2020)

For the South African feeder market, the transit distance results are mixed. The port of Cape Town is 465NM west of Ngqura, while the Port of Durban is 391NM east of Ngqura. The positioning of these three South African ports relative to one another results in shorter routing distances via Port Louis for trade flows towards the East on the SA-East Asia, SA-South East Asia and SA-South Asia services. Ngqura, conversely, offers shorter sailing distance profiles for trade between the African West Coast and the African East Coast, along with the previously mentioned SA-SAEC service. For SA-Middle East trade, Port Louis has a slightly greater transit distance profile when considering the overall transport movement, but the findings of the O/D pair transit distance analysis are mixed (see Appendix B).

5.2 Transit Time Results

The total transit time from the time of departure at the port of origin to the arrival time at the destination port, with the exclusion of the container dwell time in the yard, is presented in this section. The transit times were calculated at a disaggregate level comprising all aspects of the journey.

5.2.1 Relay liner network

Figure 5-3 depicts the total transit time (in days) associated with each O/D pair under the relay liner network configuration. In the transit distance analysis, the two ports were closely matched, with only a few nautical miles separating them on most of the relay routes. In the transit time analysis, however, a distinction between the two routing solutions comes into view. Ngqura offers the shortest transit time profile with a time difference averaging at 0.83 days over all of the routes considered.

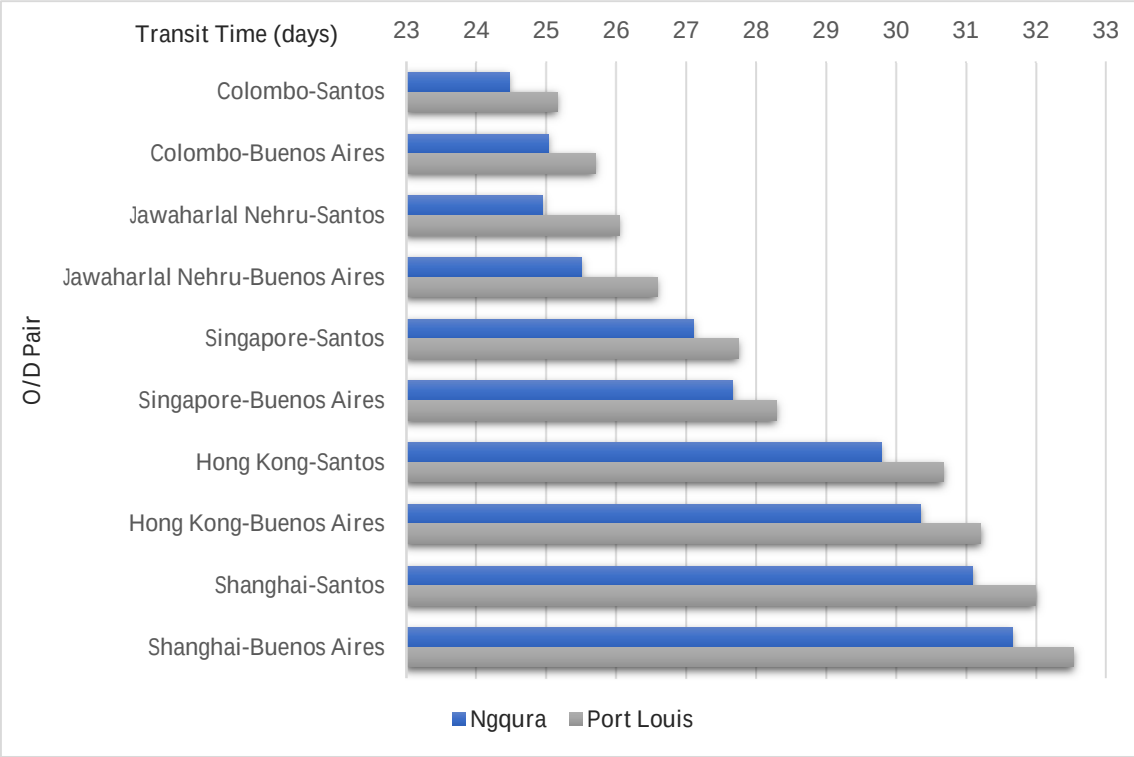


Figure 5-3: Relay liner network transit time results.

Table 5-3 gives a summary of the vessel TAT output variables and anchorage waiting times. The vessel TAT is based on 3 983 TEUs loaded/discharged overside each 8850 TEU vessel, meaning that the two-way container volume handled equals 7 966 TEUs. The sum of the variables constitutes the total port call time over the entire shipping movement. While Port Louis performs well on the measure of pre-berthing delays, the lower berth productivity in relation to the container volume handled gives Ngqura an edge over Port Louis in the relay network assessment.

Table 5-3: Relay liner network total port call time.

Transit time input and output variables	Routing solution	
	Ngqura:	Port Louis:
Pre-berthing delays: vessel r (days)	1.21	0.23
Time in port: vessel r TAT (days)	3.53	4.40
Time in port: vessel s TAT (days)	3.53	4.40
Total port call time (days):	8.27	9.03

Figure 5-4 illustrates the two routing solutions' total transit time at a disaggregated level for the Jawaharlal Nehru-Santos O/D pair. In the transit time model, port calls amount to 33% of the total transit time for Ngqura on the Jawaharlal Nehru -Santos service and 35% for Port Louis. The bulk of the time relates to the ship TAT, calculated at 3.53 days per vessel at the port of Ngqura and 4.40 days per vessel at Port Louis, thus totalling 7.06 days and 8.80 days respectively when considering both vessels in the relay transport movement.

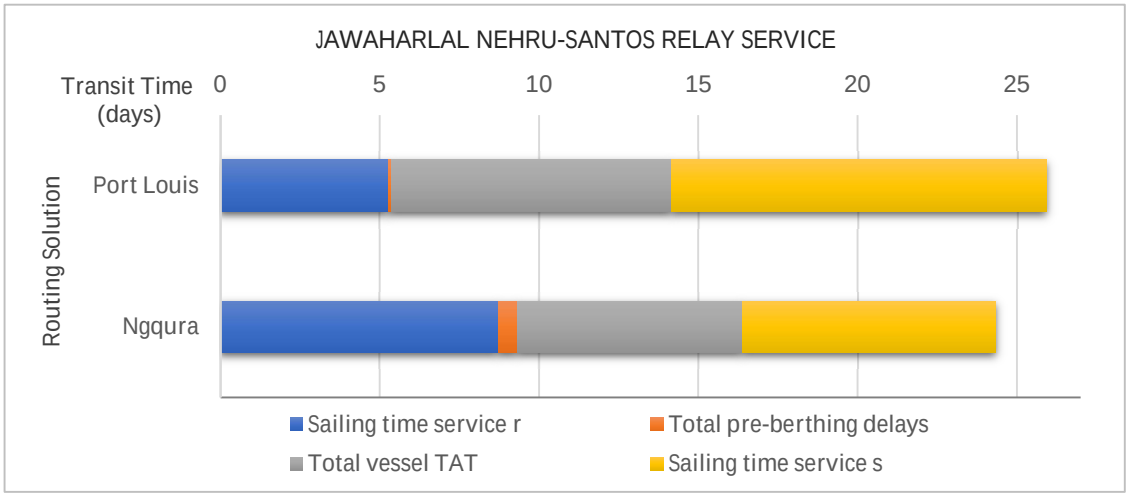


Figure 5-4: Relay liner network - Jawaharlal Nehru-Santos total transit time.

It is worth noting that the ship TAT was based on the average moves/SWH as recorded by each port (in 2019) in relation to the number of containers lifted. However, as stated under the berth productivity indicator in Section 4.1.4, the average moves/SWH is, among other things, influenced by the average crane density per vessel. The number of STS cranes to employ on any given vessel depends on the container volume exchanged per call and the gross berth time allowed or desired. The average container vessel arrival at Mauritius ports by size was 4457 TEU (UNCTAD, 2020). Port Louis is the primary maritime gateway and handles 99.5% of the country's total trade volume. The average vessel arrival by size at South African ports was 5068 TEU (UNCTAD, 2020). The figure was recorded for the entire South African container port system, constituting five container ports.

Assuming that the figure is indicative of the vessels handled at Ngqura, then the average berth productivity figures relate to post-panamax vessels for both ports. The average crane density for a 4500 TEU vessel is typically in the range of 2-2.3 (Notteboom, 2010). In general, upwards of four cranes are desirable for working an 8850 TEU vessel. If more STS cranes were allocated to each vessel, then the container consignment could be exchanged in a shorter time frame. Nonetheless, the purpose of this study is not to determine the operational efficiency theoretically achievable for each port. Modelling the simultaneous berth- and quay crane allocation problem to determine what is achievable falls outside this analysis scope

5.2.2 Hub-and-spoke network

As with the hub-and-spoke transit distance analysis, the overall transport movement between two regions (i.e. service), was assessed in hub-and-spoke transit time analysis. The average transit times associated with each of the two routing solutions was obtained by summing the transit times of the individual O/D pairs and dividing it by the number of O/D pairs in that service. Figure 5-5 presents the transit time results while Table 5-4 summarises the vessel TATs at each port. The typical total port call time shown in Table 5-4 represents the scenario of a 2500 TEU vessel on voyage *R* and a 6700 TEU vessel on voyage *S*. Similar to the relay liner network transit times, Ngqura outpaces Port Louis on the total port call times. Though the slower vessel TAT is offset by the reduced pre-berthing delay at Port Louis, the pre-berthing delay only applies to the first vessel in the transportation movement from port *i* to port *c*, namely vessel *r*.

Table 5-4: Transit time analysis – hub-and-spoke liner network total port call time.

Transit time input and output variables	Routing solution	
	Ngqura:	Port Louis:
Pre-berthing delays: vessel r (days)	1.21	0.23
Time in port: vessel TAT (days):		
6700 TEU mainline vessel	5.39	6.71
2500 TEU feeder vessel	1.99	2.49
1700 TEU feeder vessel	1.36	1.69
Typical total port call time (days):	8.59	9.43

The typical total port call time represents the scenario with a 2500 TEU vessel on voyage R and a 6700 TEU vessel on voyage S.

Consequently, routing via Ngqura takes less time than routing via Port Louis on most of the services, as shown in Figure 5-5. For the services where the transit distance profiles of the two routing solutions were closely matched, Ngqura offers a reduced transit time profile. The aforementioned situation is demonstrated on the AWC-East Asia, AWC-South East Asia, AWC-South Asia, AWC-Middle East, SA-East Asia, SA-South East Asia and SA-South Asia services.

The transit time results on the remainder of the services are comparable with the transit distance results presented in Figure 5-5.

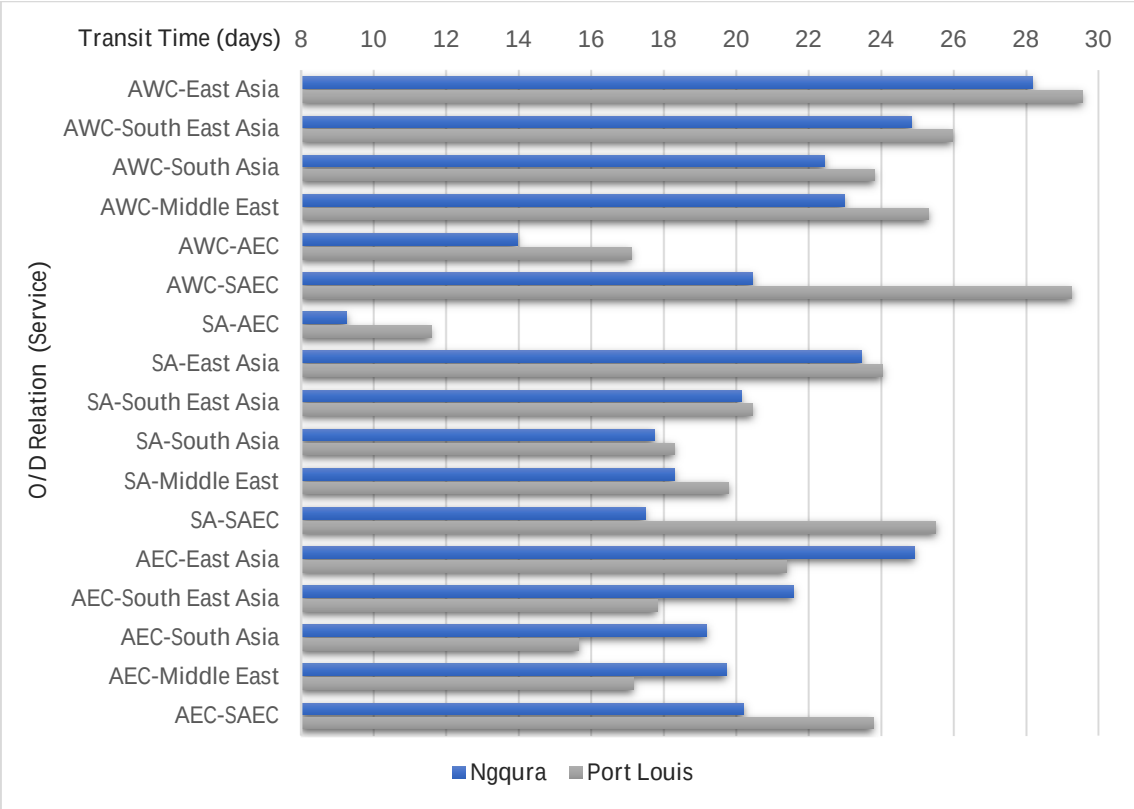


Figure 5-5: Hub-and-Spoke liner network transit time results.

5.2.3 Sensitivity analysis: transit time model

A sensitivity analysis was conducted to determine the sensitivity of the transit time model to both vessel speed and utilisation degree. As stipulated in Section 3.1.2 - 3.1.3 of this report, the vessel speeds and utilisation degree were fixed inputs. The vessel speeds were selected based on the argument in favour of slow steaming, while the vessel utilisation rates formed part of the liner network designs. The premises and assumptions of this report may however differ from the prevailing and/or future liner network strategies. It is therefore necessary to assess the impact of the two selected inputs on the transit time results. Figure 5-6 presents the impact of vessel speed variations on the transit times of the Jawaharlal Nehru-Santos relay route. The graph shows that a change in vessel speed from 20 knots to 25 knots has little impact on the disparity in transit times between the two routing solutions.

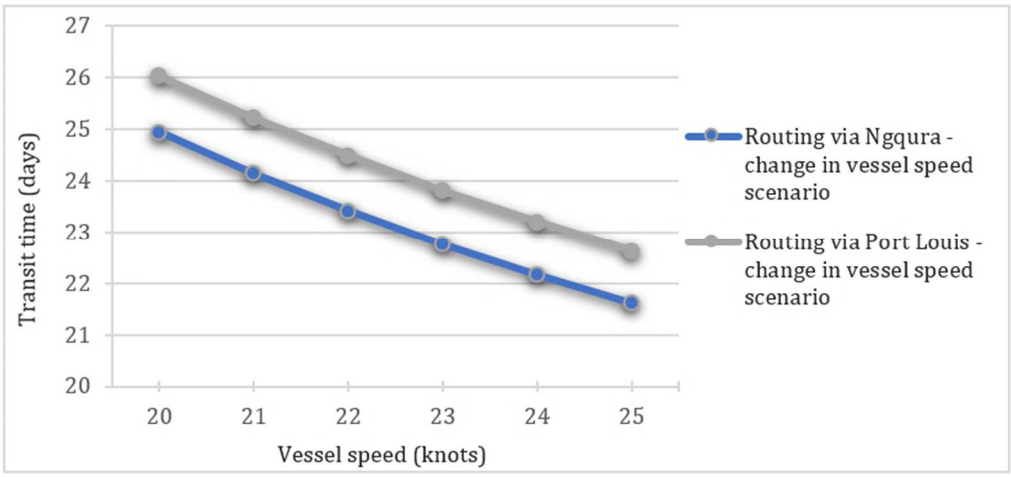


Figure 5-6: Jawaharlal Nehru relay route - impact of vessel speed on transit times.

Figure 5-7 shows the impact of a decrease in vessel utilisation degree on the transit time disparity between Ngqura and Port Louis for the same relay route. Because the percentage of transhipment containers is expressed in relation to the vessel utilisation rate, the number of containers handled at the intermediate hub changes when the vessel utilisation rate changes; the ship TAT varies accordingly. The results show that a change in the utilisation rate has a notable impact on the gap in transit times between the two routing solutions. Though the rival seaports' sailing distance profiles are similar, the transit time results showed that the calculated port times are not alike. The different pre-berthing delays and berth productivity rates recorded by each port in 2019 means that the degree to which the transit times change is dissimilar between the routing solutions. When the ship TATs decrease, the effects of the pre-berthing delays recorded at Ngqura are more profound on the overall transit time. Port Louis on the other hand performed well in terms of pre-berthing delays. Therefore, a decrease in vessel utilisation rate from 90% to 50% (on the relay routes) reduces the transit time gaps between the two routing solutions.

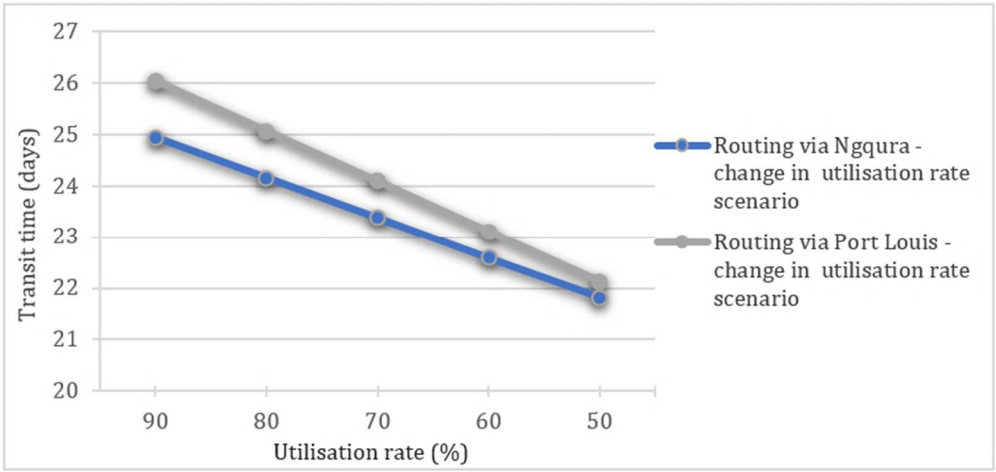


Figure 5-7: Jawaharlal Nehru relay route - impact of vessel utilisation rate on transit times

For the hub-and-spoke liner network, the results of the sensitivity analysis are somewhat mixed. The newer generation feeder vessels have lower maximum speeds than mainline carriers. The maximum speed of modern-day feeder vessels is 18-19 knots for a 1700 TEU vessel (Mandarinshipping, 2016) and 19-20 knots for a 2500 TEU vessel (Mandieselturbo, 2013). Bearing this in mind, feeder vessel speed increases of 1-2 knots is possible, but no more. Mainline vessels do not have the same maximum speed constraint and can easily increase their cruising speed to 25 knots. Hence services with greater trunk route than feeder ship sailing distances stand to benefit the most on the overall transit time reduction associated with vessel speed increases. Table 5-5 summarised the feeder and trunk route distances averaged over the 96 O/D port pairs. The data shows that Ngqura would benefit the most from mainline vessel speed increases, though the outcome would depend on the specific service.

Table 5-5: Average feeder and trunk route sailing distances.

Routing:	via Ngqura	via Port Louis
Average feeder route distance (NM)	1589	4034
Average trunk route distance (NM)	2845	3269

Figure 5-8 presents the results of a change in vessel utilisation degree on the hub-and-spoke services' transit times. Two services were considered: AWC-Middle East and AEC-Middle East. Figure 5-8 shows that the change has a marginal impact on the transit time gap between the two routing solutions. In the instance where routing via Ngqura is the quickest at a 90% vessel utilisation rate (AWC-Middle East service), the transit time gap between the two hub options decreases as vessel utilisation rates decline. The opposite is true for services where routing via Port Louis is quicker, i.e. the transit time gap increases (AEC-Middle East service). The disparity is due to the difference in port productivity measures recorded by the ports, as explained earlier.

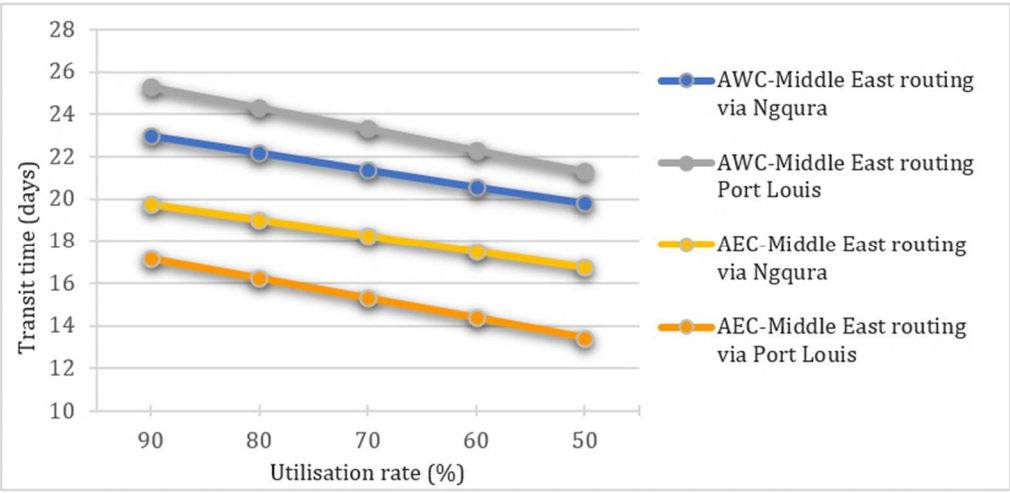


Figure 5-8: Hub-and-spoke liner network - impact of vessel utilisation rate on transit times.

5.3 Generalised Cost Results

The generalised shipping cost incurred from the time the vessel departs at the originating port to the arrival time at the destination port, with one port call at the transhipment hub port, is presented in this section. The total charges are given at a disaggregated level signifying the various cost groups discussed in Section 4.2. After determining the total system cost, the figure was converted to a cost per TEU slot. Four different cost scenarios were encountered based on the deployed vessel size. These scenarios are:

8850 TEU vessel inwards/outwards (90% utilised; 50% thereof transhipped).

6750 TEU vessel inwards/outwards (90% utilised and transhipped).

2500 TEU vessel inwards/outwards (90% utilised and transhipped).

1700 TEU vessel inwards/outwards (90% utilised and transhipped).

While there was only one combination under the relay liner network, i.e. 8850 TEU vessel inwards and 8850 TEU vessel outwards, various combinations were encountered in the hub-and-spoke liner network configuration, depending on the O/D port pair. Table 5-6 zooms in on the charges related to each hub port of call and vessel size under the different cost groups. For the sake of comparison, a fixed sailing distance was specified for each leg of the journey. The sailing distances were based on the typical mainline and feeder ship sailing distances. Time differences at anchorage and ship TAT were also considered. Some interesting observations are made from Table 5-6. The two port authorities' fee structures are similar in respect of the total port tariffs, i.e. port dues and marine charges. The only notable difference is in the marine service charges levied on smaller feeder vessels, where MPA's marine service charges are substantially less than TNPA's.

In a bid to make transhipment at Port Louis attractive, MPA offers discounted rates of up to 40% for vessels calling at Port Louis for transhipment. The discount figure depends on the volume of containers exchanged; vessels unloading 100 – 150 transhipment TEUs get a discount rate of 30%, and for vessels unloading over 150 transhipment TEUs, a 40% discount applies (Port Fees Regulation, 2008). It is understood that the same discount applies to the next vessel calling to load the containers, provided that it is reshipped within 28 days of completing the initial discharge.

Table 5-6: Generalised shipping cost over a fixed sailing distance. Based on CHCL (2017), Clarksons Research (2019), Port Fees Regulation (2017), Ports Fees (Amendment) Regulation (2017), TNPA (2019) and TPT (2019b).

Vessel size (TEU nominal):	8850		6750		2500		1700	
Transhipment hub:	Ngqura	Port Louis	Ngqura	Port Louis	Ngqura	Port Louis	Ngqura	Port Louis
Port dues and marine charges:								
Time in port (days)	3.53	4.40	5.39	6.71	1.99	2.49	1.36	1.69
Time at anchorage (days)	1.21	0.23	0.00	0.00	1.21	0.23	1.21	0.23
Port & berth dues (US$)	$21,122	$14,721	$21,083	$19,036	$4,428	$3,952	$2,766	$2,050
Marine services charges (US$)	$12,966	$13,135	$12,031	$11,579	$9,512	$5,850	$7,449	$4,118
Additional charges (US$)	$2,852	$4,110	$2,260	$3,615	$777	$1,820	$547	$1,281
Total (US$)	$36,945	$31,971	$35,380	$34,237	$14,721	$11,625	$10,765	$7,450
Cargo dues and container handling charges:								
Volume of TEU's transhipped	3983	3983	6075	6075	2250	2250	1530	1530
Transhipment cost	$585,545	$301,806	$893,092	$460,325	$330,775	$170,491	$224,927	$115,934
Ship cost/day:								
Charter rate/day (US$)	$32,074		$14,935		$9,232		$7,285	
Fuel cost/sailing day (US$)	$54,674		$42,057		$21,029		$15,982	
Total daily ship cost (US$)	$86,748		$56,992		$30,261		$23,267	
Ship cost/route:								
Vessel speed (knots)	20		20		18		18	
Shipping cost/NM @ indicated speed (US$)	$181		$119		$63		$48	
Typical sailing distance (NM)	6000		5000		2500		2500	
Typical sailing time (days)	12.5		10.42		5.79		0.58	
Fuel cost/non sailing day (US$)	$2,734		$2,103		$1,051		$799	
Shipping cost/typical route (US$)	$848,453	$844,661	$529,858	$552,490	$208,073	$149,630	$113,233	$108,015
Total cost per TEU transported (US$)*	*$369.31*	*$295.87*	*$240.05*	*$172.35*	*$246.03*	*$147.44*	*$228.06*	*$151.24*

** The fuel consumption while at anchorage is 5% of the consumption at sea.*

TNPA, on the other hand, has a marine services incentive that applies to service charges such as pilotage, berthing services and vessel assistance. The threshold number of vessel-calls at South African ports is 500 before TNPA's discount applies. After that, a 1% discount applies for every 50 calls above the threshold, with a discount ceiling of 20% (TNPA, 2019). The incentive applies per shipping line on a national basis. Given that the frequency of vessel calls per shipping line at Transnet ports is unknown, the discount was not applied to the model. Regardless though, the port call charges are relatively small compared to the container handling charges on large container consignments. This will be demonstrated later.

Apart from the marine services incentive, TNPA also has a special cargo due dispensation to support transhipment at Ngqura. However, the low cargo dues do not compensate for the high terminal handling fees levied by the terminal operator, TPT. The handling fee on a single transhipment TEU inwards and outwards is equivalent to the standard fee charged for both import and export TEUs, with no differentiation between laden or empty boxes. The difference in terminal handling rates between the two ports is summarised in Table 4-2 (page 42). Port Louis' terminal operator, CHCL, charges rates well below the TPT rates at Ngqura. CHCL's transhipment container handling fee is equivalent to the standard rate charged on an empty import/export TEU, which is nearly 50% cheaper than the rate charged on a laden container. On account of this, the sum of Port Louis' cargo dues and handling charges is nearly half the total charge levied by Transnet at the Ngqura container terminal (see Table 5-6). This has a significant impact on the overall system cost and the potential economies of scale that can be realised.

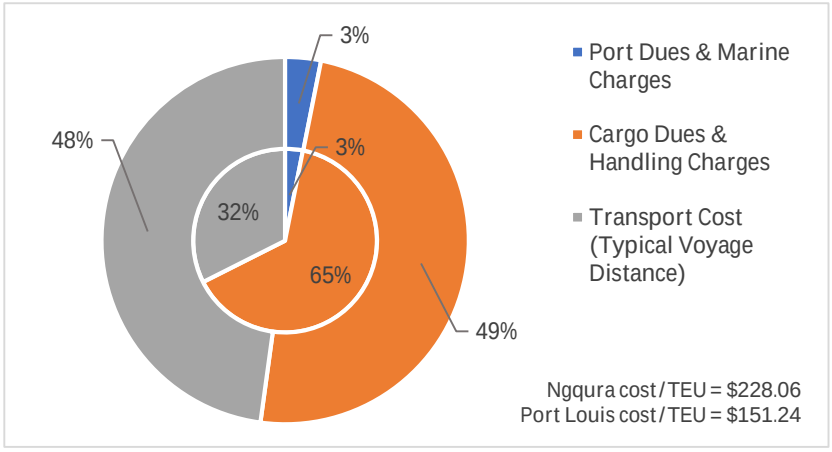


Figure 5-9: Cost breakdown of a 1700 TEU vessel.

Figure 5-9 shows the cost breakdown on a 1700 TEU capacity vessel sailing 2500 NM and transporting and unloading 1530 TEUs. The designated mainline vessel speed of 18 knots applies. The inner circle represents the scenario of routing via Ngqura, while the outer circle represents routing via Port Louis. Routing via Ngqura, the port costs amount to 68% of the total system cost,

with port fees representing 3% only, while the vessel operating cost accounts for the remaining 32%. Because of the lower terminal handling charges at Port Louis, the port costs averages 52% of the total system cost compared to Ngqura's 68%, with 3% accounting for port fees. Most notably, the cost breakdown shows the significance of terminal handling fees on the overall transportation cost.

5.3.1 Relay liner network

Table 5-7 gives the total cost/TEU (transhipped) on a port-to-port basis for the relay liner network. The results show that Ngqura's container terminal is more expensive on all the relay routes considered in this study by a substantial margin. The full breakdown per cost group is provided in Appendix C.

Table 5-7: Relay liner network generalised cost analysis – cost per TEU.

	Total Cost/TEU (US$)	
Relay route:	via Ngqura:	via Port Louis:
Colombo-Santos	$525.25	$382.93
Colombo-Buenos Aires	$531.52	$389.06
Jawaharlal Nehru-Santos	$530.55	$392.58
Jawaharlal Nehru-Buenos Aires	$536.82	$398.32
Singapore-Santos	$554.22	$411.17
Singapore-Buenos Aires	$560.09	$416.90
Hong Kong-Santos	$583.09	$442.91
Hong Kong-Buenos Aires	$589.37	$449.04
Shanghai-Santos	$597.33	$457.19
Shanghai-Buenos Aires	$603.61	$463.33

5.3.2 Hub-and-spoke network

Table 5-8 summarises the total cost/TEU of the full transportation movements between two regions for the hub-and-spoke liner network configuration. Despite the shorter sailing distances and total transit time on most of the services, Ngqura is only competitive on the trade flows between the African West Coast and South Africa and-SAEC in terms of cost. Still, MPA's and CHCL's competitive pricing strategies are enough to ensure that Port Louis is the lowest cost option on all the O/D relations analysed. Appendix C once again provides the full breakdown of the various cost groups.

Table 5-8: Hub-and-spoke liner network generalised cost analysis – cost per TEU.

Services:	Total Cost/TEU (US$) via Ngqura:	via Port Louis:
African West Coast-East Asia	$545.26	$426.92
African West Coast -South East Asia	$513.22	$393.15
African West Coast -South Asia	$491.54	$372.99
African West Coast -Middle East	$496.57	$387.00
African West Coast - African East Coast	$462.15	$356.24
African West Coast -SAEC	$469.17	$422.15
South Africa-African East Coast	$405.11	$286.68
South Africa -East Asia	$483.92	$356.45
South Africa -South East Asia	$451.82	$322.68
South Africa -South Asia	$430.21	$302.52
South Africa -Middle East	$435.23	$316.53
South Africa - SAEC	$427.86	$370.28
African East Coast -East Asia	$510.99	$324.30
African East Coast -South East Asia	$479.66	$290.53
African East Coast -South Asia	$457.28	$270.36
African East Coast -Middle East	$462.31	$284.38
African East Coast - SAEC	$465.87	$344.15

5.3.3 Sensitivity analysis: cost model

As with the transit time analysis model, the impacts of vessel speed and utilisation rate on the cost of transportation were also investigated. Figure 5-10 presents the results for both scenarios on the Jawaharlal Nehru-Santos relay route. As shown, the vessel speed and utilisation rate both have little impact on the transportation unit cost differentiation between the two hub ports. As expected, the cost of moving a single container rises with an increase in vessel speed due to the increased fuel consumption. Similarly, the cost unit cost of transportation increases with a decrease in vessel utilisation rate.

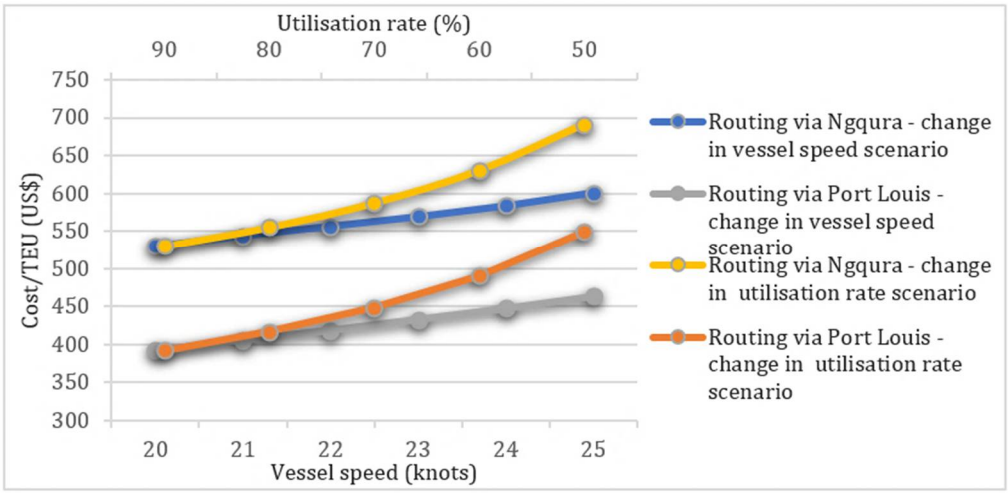


Figure 5-10: Jawaharlal Nehru relay route - impact of vessel speed and utilisation rate on the cost/TEU.

For the hub-and-spoke liner network the impact was once again assessed on the AWC-Middle East and AEC-Middle East services, as shown Figure 5-11. The findings are similar to the outcomes described for the Jawaharlal Nehru-Santos relay route regarding vessel speed variability; i.e. the vessel speed has no significant impact on the cost disparity between the two routing solutions.

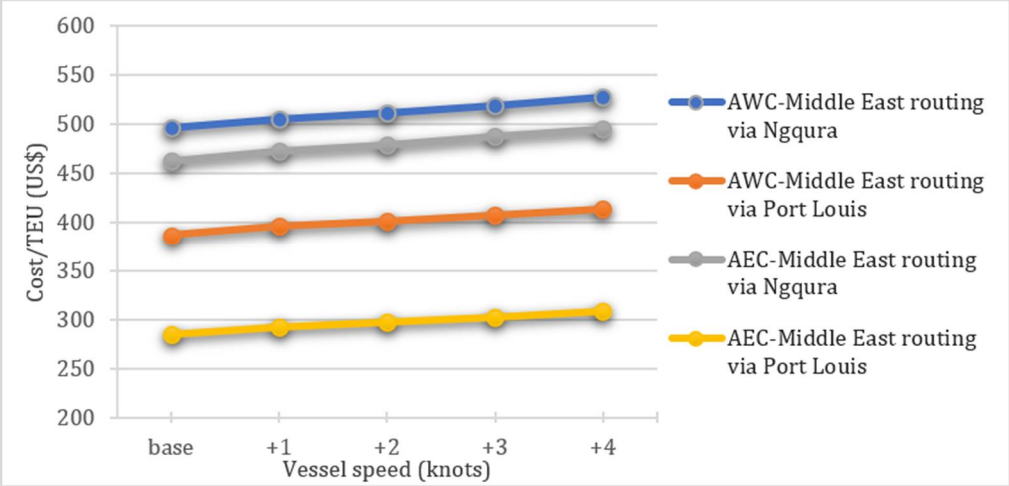


Figure 5-11: Hub-and-spoke liner network - impact of vessel speed on the cost/TEU.

On the other hand, Figure 5-12 shows that the vessel utilisation rate has a marginal impact on the generalised cost difference between the two routing alternatives, depending on the sailing distance profiles of the particular services. As to be expected, the cost of moving a single TEU increases with a drop in the vessel utilisation rate. However, the impact is more profound for smaller feeder vessels than on larger container carriers since the container slot cost per day is higher on smaller vessels. Therefore, on O/D trade pairs with similar feeder vessel sailing distance profiles, the cost impact is more or less the same (with a change in utilisation rate). This observation is noted when considering the AEC-Middle East services for which the feeder vessel sailing distance is 1187NM for routing via Ngqura, and 962NM for routing via Port Louis. The feeder vessel sailing distances are comparable, as such the transportation cost increases at the same rate for both routing solutions.

Conversely, the feeder route distance on the AWC-Middle East service is 2389.5NM for routing via Ngqura, compared to 4225NM for routing via Port Louis. Feeder vessels must sail almost 2000NM further when routing via Port Louis. Consequently, the additional sailing distance

adversely impacts the unit cost of transportation on the service. As a result, the cost differentiation between the two routing solutions narrows slightly with a decrease in vessel utilisation rate.

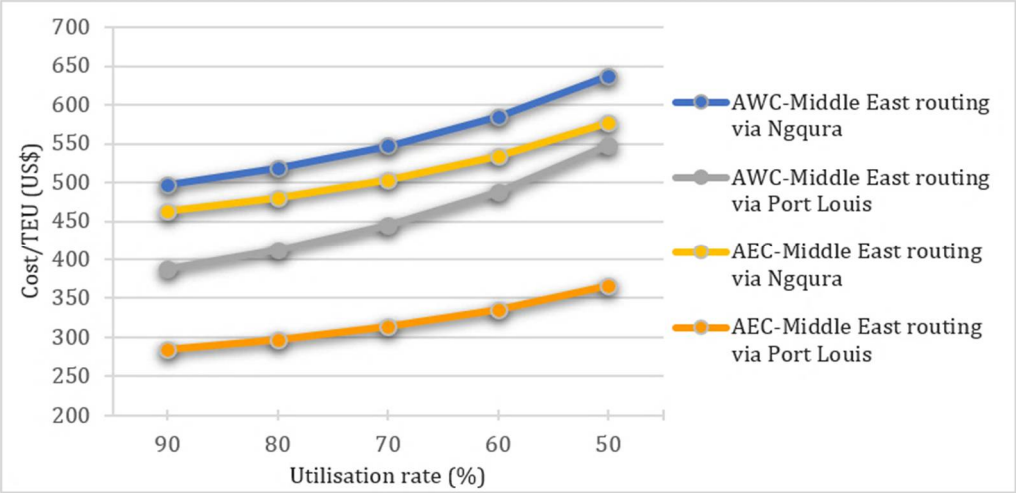


Figure 5-12: Hub-and-spoke liner network - impact of vessel utilisation rate on the cost/TEU.

6. RESULTS AND ANALYSIS

In this chapter, the relative competitiveness of the two transhipment hub ports is analysed. The first section presents the results for the two liner network configurations, relay and hub-and-spoke. The model validation exercise is presented in the second section. Lastly, this chapter is concluded with an analysis to determine the optimal transhipment hub port in the Southern African container port system.

6.1 Port Competition Results

6.1.1 Relay liner network

The competitive dynamics between Ngqura and Port Louis on a port-to-port basis, are presented in Figure 6-1 for the relay liner network. The results for all of the 10 O/D pairs are presented. The x-axis represents the unit cost difference between the two routing solutions, expressed as a percentage. The y-axis shows the transit time difference between relaying via Ngqura vs relaying via Port Louis in days. Routing via Ngqura was taken as the base scenario in the comparison, therefore a negative value on the transit time x-axis means that routing via Ngqura is cheaper. Conversely, a negative value on the x-axis means routing via Ngqura takes less time. Based on these parameters there were four potential outcomes:

- Routing via Ngqura is less costly and takes less time.
- Routing via Ngqura is more costly but takes less time.
- Routing via Ngqura is less costly but takes more time.
- Routing via Ngqura is more costly and takes more time.

Figure 6-1 shows that the relay network analysis results are concentrated in one quadrant of the graph: i.e. routing via Ngqura is more costly but takes less time. Ngqura thus outperforms Port Louis on the transit time measure; however, routing via Port Louis is more cost-effective than routing via Ngqura. The results aptly demonstrate the bearing of MPA's competitive pricing strategy; Port Louis is on average 25.16% less costly than Ngqura. The most significant cost difference is noted on the Santos-Colombo relay route, for which Port Louis is 27.10% cheaper than Ngqura. The considerable cost difference between the two routing solutions is problematic for Ngqura's overall appeal. Especially given that the Port Louis is less than a day's travel time off the pace of routing via Ngqura.

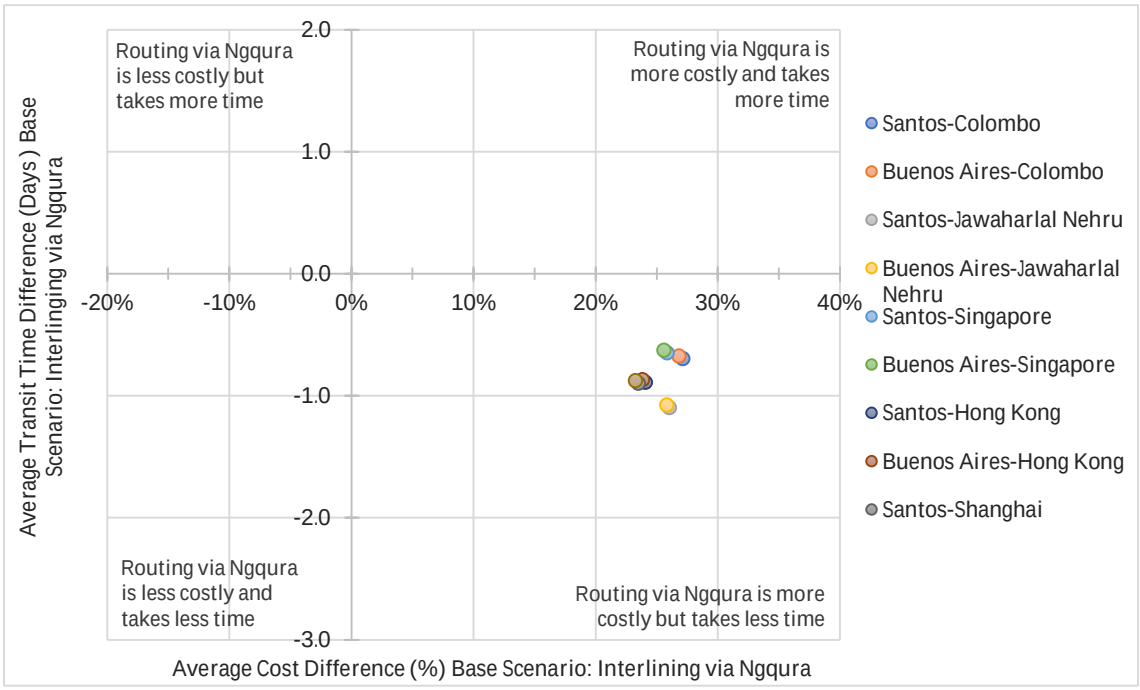


Figure 6-1: Competition between Ngqura and Port Louis – relay liner network. Adapted from Notteboom (2012, p.172).

6.1.2 Hub-and-spoke liner network

For a hub-and-spoke relay liner network configuration, the transit times and generalised cost results were averaged over the 17 regional O/D relations. The focus is predominantly on the overall transport movement between regions, due to the nature of a hub operation. Figure 6-2 presents the competitive dynamics between the two ports are for the 17 services. As before, the x-axis represents the cost difference between the two routing solutions, expressed as a percentage, and the y-axis shows the transit time difference in days. Routing via Ngqura was once again taken as the base scenario in the comparison.

Figure 6-2 shows that though transit times were very favourable for routing via Ngqura, the high port charges lessens the port's favourability. The results are spread out across two quadrants of the graph: i.e. routing via Ngqura is more costly but takes less time, and routing via Ngqura is more costly and takes less time. There are only two services for which Ngqura shows favourability; AWC-SAEC and SA-SAEC. The transit time advantage while routing via Ngqura on the aforementioned services is 8.80-days and 8.03-days, respectively. Though on generalised cost Port Louis comes out on top for these two services, the considerable transit time gap negates the cost-saving benefits. On the contrary, Port Louis definitively outperforms Ngqura on the O/D relations of AEC-East Asia, AEC-South East Asia, AEC-South Asia and AEC-Middle East.

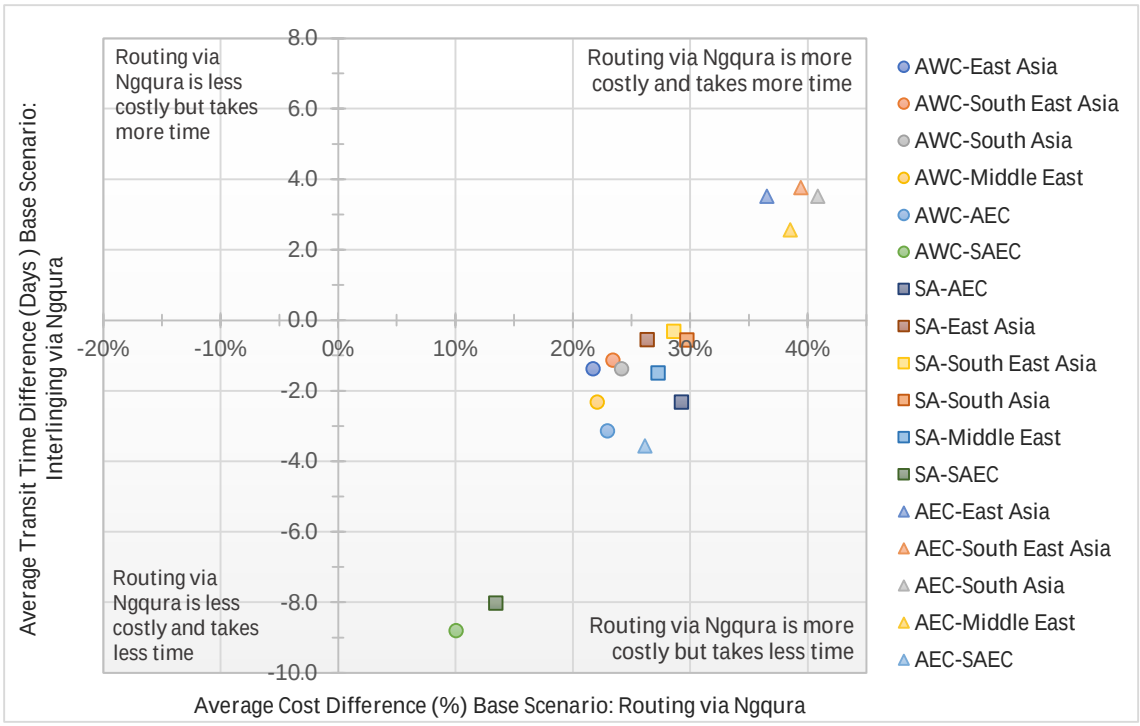


Figure 6-2: Competition between Ngqura and Port Louis – hub-and-spoke liner network. Adapted from Notteboom (2012, p.172).

The two ports exhibit the strongest competition on the remaining 11 O/D relations. The calculated transit time gaps and cost differences on the *closest competition services* are:

- AWC-East Asia: 1.38-day transit time advantage, 21.70% cost disadvantage via Ngqura.
- AWC-South East Asia: 1.13-day transit time advantage, 23.39% cost disadvantage via Ngqura.
- AWC-South Asia: 1.38-day transit time advantage, 24.12% cost disadvantage via Ngqura.
- AWC-Middle East: 2.32-day transit time advantage, 22.07% cost disadvantage via Ngqura.
- AWC-AEC: 3.14-day transit time advantage, 22.92% cost disadvantage via Ngqura.
- SA-AEC: 2.32-day transit time advantage, 29.23% cost disadvantage via Ngqura.
- SA-East Asia: 0.56-day transit time advantage, 26.34% cost disadvantage via Ngqura.
- SA-South East Asia: 0.31-day transit time advantage, 28.58% cost disadvantage via Ngqura.
- SA-South Asia: 0.56-day transit time advantage, 29.68% cost disadvantage via Ngqura.
- SA-Middle East: 1.50-day transit time advantage, 27.27% cost disadvantage via Ngqura.
- AEC-SAEC: 3.56-day transit time advantage, 26.13% cost disadvantage via Ngqura.

Whether Ngqura or Port Louis secures the market share on these services would depend on what is valued more by the stakeholders; transit time or transport cost.

6.2 Model Validation

To validate that the model is appropriate for evaluating Ngqura and Port Louis's relative competitiveness, the study results were compared with the transhipment container market share between the two ports. As noted in the literature review section of this report, the interactions between shippers and carriers and their selection of a transhipment hub result in a higher market share allocation to the selected port. (Veldman and Bückmann, 2003). The market share between the two rival hub ports, as recorded in 2019, is presented in Figure 6-3 below. The inner-circle represents the transhipment TEU market share, and the outer circle represents the total TEU throughput for the 2019 calendar year. Ngqura had a greater annual TEU throughput than Port Louis (718 609 vs 661 196), but Port Louis attracted more of the transhipment market share.

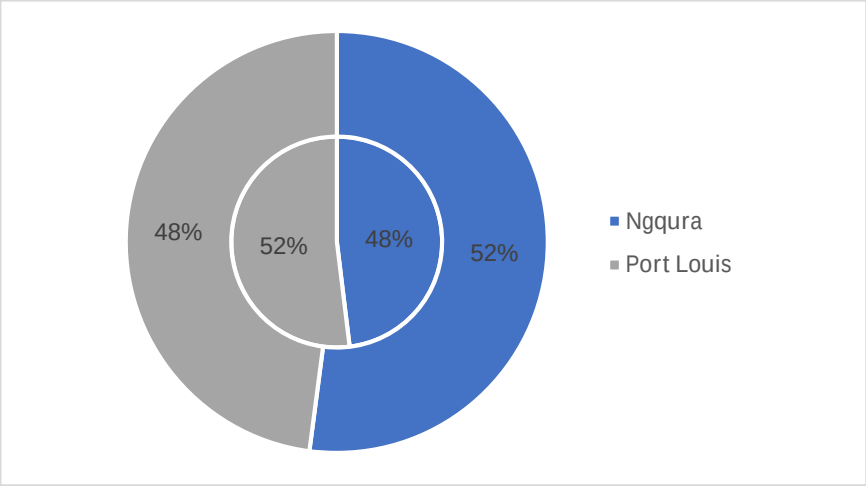


Figure 6-3: 2019 Container market share between Port Louis and the Port of Ngqura. Based on MPA (2020) and TPT (2020b).

Based on the TEU throughput volumes and transhipment incidences, neither port currently serves as a major transhipment hub. Instead, the leading container carriers operating around the African continent tend to favour multiport itineraries. With multiport itineraries, a vessel sailing along a particular route will call at numerous ports along the way with direct calls. Import containers are delivered straight to the destination, and export containers are collected. The berthing schedules of Port Louis and the Port of Ngqura were observed over a three-month period to derive the typical vessel calls and shipment sizes. Copies of the typical berthing schedules are presented in Appendix E.

The schedules provide the vessel name, estimate time of arrival, allocated berth, number of containers to discharge, and containers to load. Based on the details provided, the TEU carrying capacity of each vessel could be determined. However, no distinction is made between import,

export, and transhipment containers. The assumption was made that larger container exchanges in relation to the vessel size are transhipment consignments. The main observations made from the berthing schedules of the two ports are:

- Ngqura regularly serves larger mainline vessels of 8000 – 12 000 TEU carrying capacities.
- Port Louis regularly serves small to medium-sized feeder vessels (1850 TEU – 3100 TEU). 8000-12 000 TEU vessels call at the port less frequently.
- For the vessels of 8000 TEU and upwards, the typical one-way container volume transferred over the quay (unloading or loading) at both terminals is less than 20% of the vessel's overall carrying capacity.
- For small to medium-sized feeder vessels (1850 TEU – 3100 TEU), the typical one-way container volume transferred over the quay (unloading or loading) is between 25 -75% of the vessels' overall carrying capacities. Larger consignments (in relation to the vessel sizes) are more consistently exchanged at Port Louis than at the Port of Ngqura.
- Fewer 4000 - 6750 TEU vessels called at either port during the observation period compared to the number of 8000-12 000 TEU vessels.

It is difficult to deduce from the berthing schedule whether the larger container vessel calls (8000 -12 000 TEU vessels) relate to direct call or transhipment operations. However, the more frequent calls at Ngqura for vessels of these sizes are in line with the results of the relay liner network analysis. Kavirathna, et al. (2018) also suggested that transit time is more critical than monetary factors in cargo relay operations. However, the cost difference between the two routing solutions on relay operations is substantial, whereas the transit time difference is marginal. Because of the limited data available, no conclusion can be drawn on the model's accuracy for determining the optimal transhipment hub in a relay network configuration.

Concerning the hub-and-spoke liner network, the greater number of feeder vessels calls at Port Louis, coupled with the larger container exchanges, suggests that more carriers prefer Port Louis as a transhipment hub. This observation correlates with whereby Port Louis experienced a greater transhipment market share. In order to compare the transhipment market share between the two ports with the results of the hub-and-spoke liner network analysis, the utilisation degree must first be adjusted to reflect the 2019 situation at the two hubs. As shown in the sensitivity analyses, both the transit time and generalised cost models are sensitive to variations in the vessel utilisation degree. The typical container volumes exchanged at each port in 2019 were below the 90% vessel utilisation rate assumed in the analysis. Based on the observations made from the berthing schedules, a 50% utilisation degree is more appropriate.

Figure 6-4 depicts the shift if the vessel utilisation degree is adjusted to 50% of the overall vessel capacity for the hub-and-spoke liner network. Section 5.3.3 revealed that the generalised cost gap between the two routing solutions does not change drastically for services with similar feeder route distance profiles. The change is most profound on services with different feeder route distance profiles. As a result, the cost differentiation between the two routing solutions remains approximately the same for the five services emanating from the African East Coast with the adjusted vessel utilisation rate. On all of the remaining services, Ngqura has a shorter feeder route distance profile, and therefore the unit cost of transportation decreases in relation to routing via Port Louis.

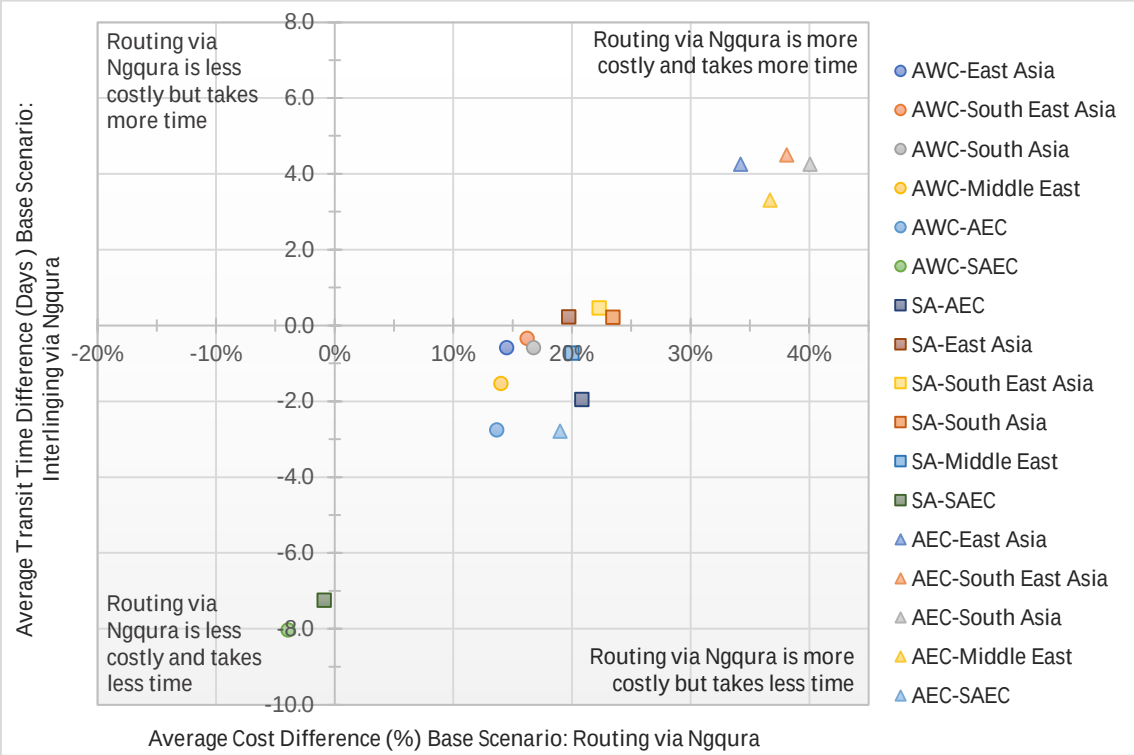


Figure 6-4: Model Validation.

In terms of transit time, Port Louis benefits the most from a reduction in vessel utilisation rate (refer to Section 5.3.3). The change's effects are best witnessed on the 11 O/D relations identified as *close competition services* in the hub-and-spoke liner network analysis. At a 50% vessel utilisation rate, Port Louis shows clear favourability for seven of the services instead of four at a 90% utilisation rate. At the same time, the transit time gap is reduced to less than 1-day on the AWC-East Asia, AWC-South East Asia, AWC-South Asia and SA-Middle East services. Port Louis is also between 14%-20% cheaper on these services.

In conclusion, it is challenging to validate the model based on the market share alone. The prevailing container carrier itineraries favour a direct call approach, and vessel sizes deployed vary considerably. Furthermore, a weighted average cannot be computed without the geographic distribution of shipment origins by volume, hence the relative importance of specific trade routes/services could not be determined. Nonetheless, the model validation exercise gives valuable insight into the two ports' current competitive positions. The findings from Figure 6-4 appear to correlate well with the transhipment market share between the two hubs as depicted in Figure 6-3. Port Louis has a slight advantage over Ngqura, particularly on pricing, but the two hubs are closely matched on transit times for several services.

6.3 Analysis

The prospects of either port developing into the main transhipment hub port in the Southern African region will depend on the interplay of forces affecting the decision. While the advantages of each port were adequately demonstrated, the research question remains unanswered. model validation exercise in Chapter 6 demonstrated the model's capability to capture the two hub ports' competitive positions on the hub-and-spoke liner network. Port Louis and Ngqura each performed favourably on some routes/services. Though the port choice decision is less straightforward when considering the competitive range of routes/services and the logistical planning involved in consolidating shipments from various regions.

The two ports exhibited strong competition on several services, particularly in the hub-and-spoke liner network configuration. Consequently, the market share allocation will largely depend on what stakeholders' value more, transit time or transit cost. The sensitivity analyses and model validation exercise showed that Port Louis would benefit the most from a decreased vessel utilisation degree. Which would in turn enable the port to close the transit time gap to Ngqura on numerous services/routes. However, carriers aim to maximize the available container slots on a vessel to reduce cost and increase revenue. Therefore, reduced vessel utilisation rates are not a compelling argument in favour of Port Louis. Furthermore, because the cost of delays is not merely equal to the daily ship charter rate/s (Baird, 2006), it is also not easy to quantify the cost of transit time differences in terms of actual cost and opportunity cost. However, it is relatively simple to determine the cost associated with vessel speed increases. At the current low bunker fuel rates, it is feasible for vessels routing via Port Louis to increase their cruising speed in order to close the transit time gap to Ngqura.

Carriers reduce vessel speeds not only on account of carbon emission reductions, but more so to reduce the cost of shipping (JOC Group, 2021). High bunker fuel prices give shipping lines

incentive to slow steam (Notteboom, 2012). Still, if the associated cost saving is less than the saving in fees that could be realised from changing the vessel calling pattern (which includes the intermediate port of call), the profitability is eroded. The normal cruising speed for mainline containerships is between 20 and 25 knots compared to slow steaming speeds of between 18 and 20 knots (Rodrigue, 2020). In this section, the implications of vessel speed increases to normal cruising speeds for routing via Port Louis is explored.

6.3.1 Vessel speed increases: Relay liner network

Figure 6-1 showed the results of the hub port competition analysis for a relay liner network configuration. The transit time differences between the two routing solutions are relatively small when compared with the overall voyage times. Port Louis was less than a day's travel time off the pace of routing via Ngqura. In Figure 6-5 below the effects of a mainline vessel speed increase from 20 knots to 22 knots (routing via Port Louis only) is illustrated.

As expected, the estimated bunker fuel consumption increases, thereby increasing the total voyage cost of both vessels in the service. The estimated bunker fuel consumption at varying cruising speeds is presented in Appendix D. For an 8850 TEU vessel, the bunker fuel consumption is projected to increase from 130 mt/day (cruising at 20 knots) to 181 mt/day (cruising at 22 knots). With the vessel speed increase on only one of the routing solutions, the gap in transit times between the two routing solutions is closed out on all the routes analysed. Routing via Port Louis is on average 20% less costly than routing via Ngqura for the presented scenario.

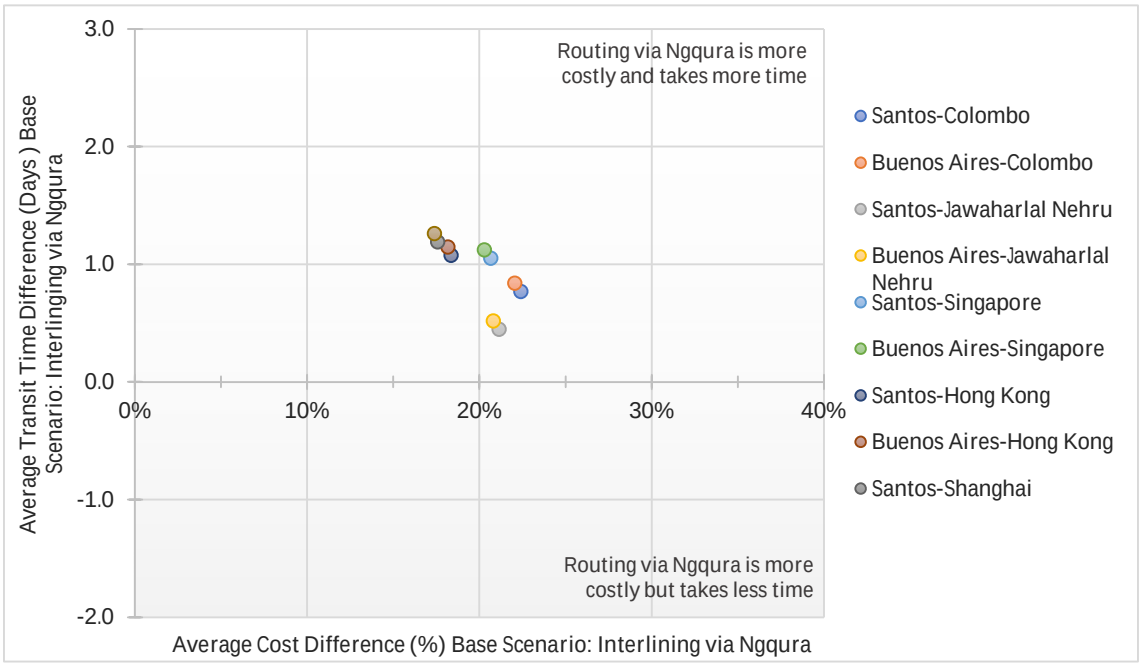


Figure 6-5: Scenario analysis – relay liner network.

6.3.2 Vessel speed increases: Hub-and-spoke liner network

The transit times and generalised cost results of the hub-and-spoke liner network, averaged over the 17 regional O/D relations, were discussed in Section 6.1.2. The results showed that though transit times were very favourable for routing via Ngqura, the high port charges lessen the port's favourability. The two ports exhibited strong competition on 11 of the 17 O/D relations analysed (refer to Figure 6-2). On some of the regional O/D pairs, only marginal vessel speed increases are required for Port Louis to become a time effective routing solution. For instance, on the SA -East Asia, SA-South East Asia and SA-South Asia services, mainline and feeder vessels routing via Port Louis only have to increase their speed by 1 knot to 21 knots and 19 knots to close the transit time gap to Ngqura. These speed increases are marginal and still within range of slow steaming

The results of a mainline vessel speed increase to 25 knots, and a feeder vessel speed increase to 19 knots (routing via Port Louis), are shown in Figure 6-6. With the suggested normal cruising speeds, the transit time gap to Ngqura could be closed out on some of the more distant African West Coast services. The change in vessel speeds would allow routing via Port Louis to be more time- and cost-effective on the AWC-East Asia, AWC-South East Asia, AWC South Asia, SA-East Asia, SA-South East Asia, SA-South Asia and SA-Middle East services. As stated earlier, only marginal vessel speed increases are required on the latter three services.

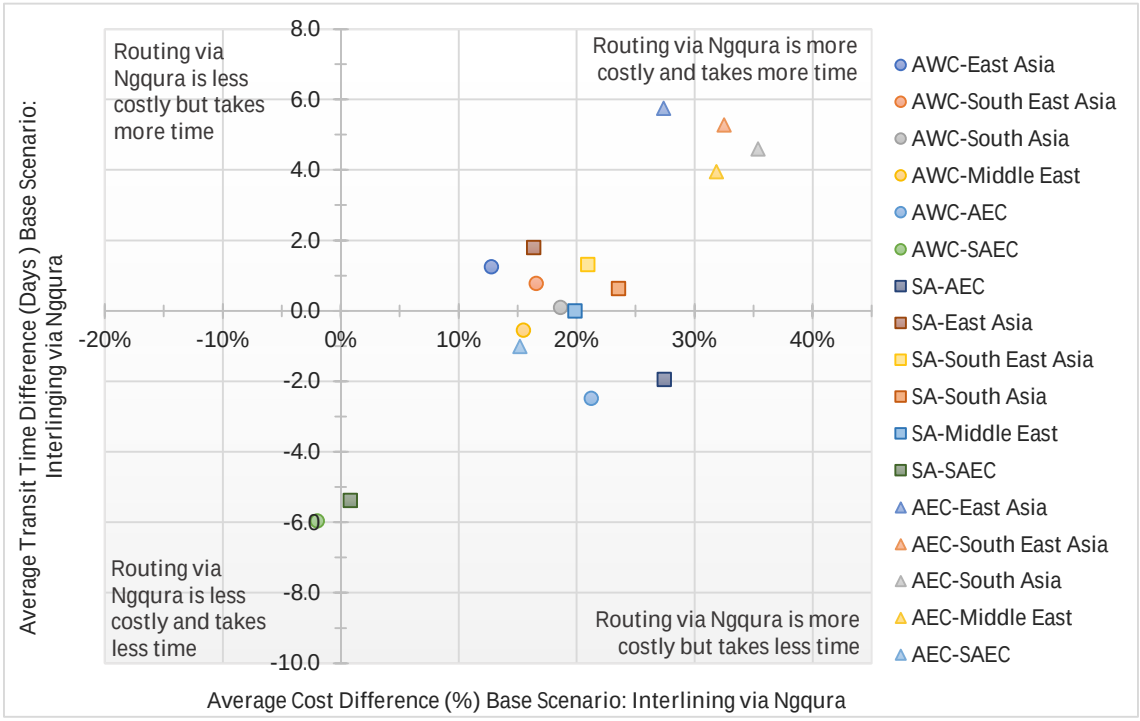


Figure 6-6: Scenario analysis – hub-and-spoke liner network.

Ngqura, conversely, would remain the quickest routing solution on the AWC-AEC, SA-AEC, AWC-Middle East and AEC-SAEC services, though the transit time gap between the two routing solutions reduces considerably. Given the cost savings that could be realised, it may be more economical to route these shipments via Port Louis and allow for extra transit time. The prospect thereof would depend on the logistical changes required to combine cargo flows and the total system cost. As for the SA-SAEC and AWC-SAEC services, the constituent O/D pairs had highly unfavourable transit distance profiles when transhipping via Port Louis. Any potential cost saving benefits are negated in the attempt to close out the transit time gap to Ngqura.

7. DISCUSSION

The purpose of this study was to further the research work of Notteboom (2012) by investigating the individual competitiveness of the main transhipment hub port rivals situated along the Cape passage, Ngqura and Port Louis, for hub-and-spoke and relay liner network structures. Three key objectives differentiated the problem. This study's first objective was to explore and identify the critical criteria for optimal transhipment hub port selection. After determining the critical criteria, the objective was to develop a model to compare and evaluate Ngqura and Port Louis's relative competitiveness and determine the optimum transhipment hub port in the Southern African region for both relay and hub-and-spoke liner networks.

The literature reviewed revealed that the most important factors influencing the choice of transhipment hub port are monetary and transit time-related factors. Operational efficiency and adequate infrastructure were identified as the third most important criterion, followed by frequency of feeder services/liner connectivity. Based on the literature review findings, the concept of market position was subsequently investigated through weighting up decision's economic aspects, similar to the approaches by Baird (2006) and Notteboom (2012). Total transit time and generalised cost models were developed to compare the two hub ports over ten relay and 96 hub-and-spoke origin-destination pairs. The method was adapted to include operational efficiency measures in the transit time model.

Though there are many ways to measure port performance and operational efficiency (Ducruet et al., 2014), carriers and shippers are primarily concerned with the ship turnaround times (TAT) at the ports. Therefore, the typical ship TAT was calculated based on the actual recorded pre-berthing delays and berth productivity rates of each port (as recorded in 2019). By doing so, the two ports were not only contrasted on their operational performance, but they were also compared on the same parameters and definition of ship TAT. The definition of ship TAT often varies from port to port as port statistics are not always clear on the measure of vessel TAT (Ducruet, et al., 2014). An accurate transit time comparison of the two routing solutions could not be achieved without considering the metrics.

Port Louis performed well on pre-berthing delays but lagged behind Ngqura on quay productivity rates. The port infrastructure comparison revealed that both Ngqura and Port Louis meet the modern-day infrastructure requirements for mega-ships. However, the difference in terminal infrastructure between the two ports proved to impact the port's operational efficiency and ability to turn around vessels quicker. Ngqura achieved higher berth productivity rates in 2019, partly

due to lower berth occupancy rates. With lower berth occupancy rates, idle cranes from other berths can be employed to turnaround berthed vessels faster. Ngqura also benefits from higher capacity STS cranes and the advantage of an additional crane. However, Port Louis was able to compensate for the infrastructure shortcomings with better service reliability. Port authorities generally aim to capitalise on the installed terminal capacity and target high berth utilisation rates, but this needs to be balanced with anchorage waiting times.

Increased time at anchorage is associated with port congestion Ports Regulator of South Africa, 2016), yet Ngqura was troubled with higher pre-berthing delays despite the lower berth occupancy rates recorded in 2019. TPT attributed the unsatisfactory operational performance to adverse weather conditions. The terminal operator reported that they are working towards implementing wind mitigation measures, such as anti-sway technology on cranes and hydraulic mooring tension system solutions (TPT, 2019a, 2020b). The relay and hub-and-spoke liner networks' findings will be interpreted and discussed in greater detail in the next section.

7.1 Relay Liner Network

The sub-analysis results revealed that the two ports are closely matched on sailing distances over the ten relay routes assessed. Though Ngqura proved to be the more time-effective routing solution in the transit time analysis, Port Louis managed to stay within a competitive range of Ngqura by keeping pre-berthing delays to a minimum. The results of the generalised cost analysis, however, proved to be problematic for Ngqura's seemingly attractive intermediate location. Port Louis has a highly competitive pricing strategy and is considerably less costly than Ngqura.

Shipping lines are less concerned about nautical accessibility when bunker fuel prices are low (Notteboom, 2012), and greater cost savings can be realised on port charges. Given that the bunker fuel rates recorded in 2019 are lower than the high rates recorded in the previous decade (UNCTAD, 2010; World Bank Group, 2015, 2018), carriers have greater routing flexibility. Figure 6-5 shows that the additional bunker fuel cost with a 2-knot sailing speed increase (for routing via Port Louis) is not significant in terms of the overall transportation cost. Port Louis would remain the most cost-effective routing solution, despite the increased vessel sailing speed and the associated rise in bunker fuel cost. The findings, therefore, demonstrate the favourability of Port Louis in the short term for a cargo relay operation along the Cape passage.

These findings contradict the observations made from the two ports' berthing schedules (see Section 6.2, whereby Ngqura serviced larger container vessels (8000-12 000 TEU) more frequently. As stated in Section 6.2, it is unclear whether the vessel calls relate to multiport or

relay operations. The assumptions made in the relay liner network configuration may not reflect Ngqura or Port Louis's prevailing operations. The vessel sizes were based on the itineraries of the MSC and Maersk (Maersk, 2020b; MSC, 2020), but the carriers did not specify the volume and type of cargo (gateway/transhipment) handled at the two ports. A 50% vessel utilisation rate was assumed in the relay liner configuration, totalling a container exchange of 7 966 TEU for the two vessels in the service. The transit time calculations showed that it would take Ngqura 7.06 days to turn around the two vessels and 8.80 days at Port Louis.

Yet Port Louis and Ngqura are not only competing for pure relay traffic. The central port region for intercontinental relay is along the equatorial beltway. (Notteboom, 2012). Therefore, even though the results show that Port Louis is less costly than Ngqura and can compete on transit times, relay operations at the port are not guaranteed. Based on the prevailing multiport itineraries of the leading container carriers (Maersk, 2020b, 2020c; MSC, 2020), the Suez passage is the predominant trade route for intercontinental relay operations. Shipments are typically routed via world-class container terminals, such as Algeciras and Singapore. Shipping lines want ever shorter port stays to make the economies of scale work (Cullinane and Khanna, 2000). The leading global transhipment hubs are capable of moving over 100 containers per ship working hour (Ports Regulator of South Africa, 2016). Both Ngqura and Port Louis underperform against the global standard (47 and 37.7 moves/SWH, respectively), and so greater operational efficiency is necessary for these ports to become globally competitive.

7.2 Hub-and-Spoke Liner Network

In the sub-analysis of the hub-and-spoke liner network, the transit distance assessment demonstrated the impact of port location on nautical accessibility. Port Louis is well-positioned for trade flows from the African East Coast to the Middle East and far East, but the port is distant to the West and cannot compete with Ngqura on the western trade flows. The transit distance and transit time analyses revealed strong competition between the two ports for the services emanating from the South African container port system. Though Ngqura outpaced Port Louis slightly when considering the overall transportation movement, the results were mixed for the individual O/D pairs. It would be sensible to bundle some of the South African container consignments with traffic from the African West Coast destined to the East, and vice versa. Reducing unnecessary transport movements will not only cut the transit time and unit cost of shipping, but it is another critical step towards reducing maritime generated carbon emissions (Baird, 2006). However, the exact configuration would largely depend on which of the two hub ports the service is configured around.

Interestingly, the services emanating from Transnet ports in South Africa are considerably less costly to route via Port Louis than the Transnet owned and operated port of Ngqura. According to the TNPA and TPT tariff books (TNPA, 2019; TPT, 2019b), Transnet does not offer discounts on coastwise cargo. Though numerous studies have emphasised high tariffs at Transnet ports (Notteboom, 2010; Meyiwa and Chasomeris, 2020; TNPA, 2012), TNPA's pricing strategy still works on the revenue requirement methodology. Considering the close competition on the SA services discussed in the previous paragraph, only marginal vessel speed increases are required for routing to close the transit time gap to Ngqura. As stipulated in the relay liner network discussion, carriers have greater routing flexibility when bunker fuel prices are low compared to the overall transportation cost. Therefore, vessel speed increases are not only possible but also likely to occur.

Figure 6-6 shows that the transit time difference between Ngqura and Port Louis could be decreased and even diminished if vessels routing via Port Louis opted to cruise at normal sailing speeds instead of slow steaming. MPA's competitive pricing strategy would negate the increase in voyage cost, and thus, Port Louis would remain the most cost-effective routing solution. Consequently, Port Louis performs better in terms of transit time and cost on 10 of the 17 services investigated. Moreover, Port Louis is also within close range of Ngqura regarding transit times on the AWC-Middle East and AEC-SAEC services. Based on these findings, Port Louis is the optimal port for a hub-and-spoke operation within the Southern African region, at least in the short term. These findings correlate with the 2019 transhipment market share between the two ports, whereby Port Louis is already the favoured transhipment hub port.

This is not to say that Ngqura will not attract any transhipment cargo; the port is favourably positioned for westbound trade flows and offers the shortest transit time on the accompanying trade flows. It is also worth noting that the prospects of either port developing into the preferred regional transhipment hub may depend on factors other than those addressed in this study. Changes in cost factors or maritime regulations in the medium to long term can significantly impact the outcome. The IMO's plan to reduce CO2 emissions by 40% or more remarkable by 2030 (IMO, 2021) is highly ambitious. To stay ahead of the trajectory presented in Figure 1-1, the IMO may have to mandate some of the guidelines proposed in the SEEMP. It is therefore conceivable that slow steaming practices may become mandatory in the future.

8. CONCLUSION AND FUTURE WORK

8.1 Conclusion

Transhipment hubs naturally develop around strategic passages or locations with low deviation distances from the main shipping trade lanes. The purpose of this study was to evaluate and compare the competing Southern African transhipment hub ports, Ngqura and Port Louis, to determine the optimum transhipment hub port along the Cape maritime passage. These ports are ideally situated along the major south-south trade routes. The competitive dynamics between the two ports are of particular interest, given that the Cape passage's significance in the global maritime network is expected to rise (Fraser and Notteboom, 2012; Notteboom, 2012).

The maritime industry is cost-driven; the optimal transhipment hub port must be less expensive than its competitors while offering reduced sailing times. Based on these two measures, this study's findings demonstrate that the current optimal Southern African transhipment hub to serve both relay and hub-and-spoke liner network operations around the Cape passage is Port Louis. The port offers high service reliability whilst also offering the most competitive pricing strategy. Relay operations rely on high reliability, which can even outweigh transit times (Notteboom, 2012). Despite the fact that the findings showed Port Louis performed well on the reliability measure, neither port is really in strong contention for intercontinental relay operations. Greater operational efficiency is required of both transhipment hubs to compete with the world-class global transhipment hubs.

It was also noted that Port Louis has less terminal area and available berthing slots than Ngqura. Though the assessment of yard capacity constraints fell outside the scope of this study, it is conceivable that capacity constraints may potentially hamper the transhipment market share captured by Port Louis in the near future. The port authority has reportedly embarked on a number of projects to create capacity ahead of demand (MPA, 2020a). The timing and successful executing of the expansion projects will be vital to Port Louis' success.

The study also demonstrated the prospects of Ngqura developing into the optimal transhipment hub provided that terminal charges are reduced. Ngqura is ideally situated to serve both relay liner networks with better nautical accessibility than Port Louis on most of the trade routes assessed. The Transnet port is also better equipped for largescale relay operations, with a greater number of berths that can accommodate 9000 TEU capacity vessels and higher capacity STS cranes. Furthermore, because Transnet operates all the commercial ports in South Africa, the state-owned

company has the flexibility of moving quayside and yard equipment from one port to another if inter-range container volumes shift.

Consequently, the hub operation at Ngqura could be strongly supported if Transnet lowered tariffs and offered special rates for feeder vessels calling at other Transnet ports (coastwise cargo vessels). Without any tariff reductions, the attractiveness of Ngqura will depend on the market dynamics that unfold. The port delivered poor operational performance; consequently, it is unlikely that port performance will strengthen Ngqura's bid on transhipment cargo. Rising bunker fuel prices or the implementation of mandatory slow steaming practices by the IMO may result in a future shift in the favourability from Port Louis to Ngqura. However, Transnet would ideally want to make tariff changes now in the short term to secure regular, fixed call services to Ngqura for the future. Ports would face greater difficulty attaining similar liner shipping connectivity indexes of early adopters (Notteboom, 2010).

In conclusion, this study provides an empirical assessment of the competitive positions of the two transhipment hub ports. Though the results of this study demonstrated that Port Louis is the optimal port to serve as a transhipment hub along the Cape passage in the short term, the debate is still far from being closed. Both ports are in the early development phases, and there is still room for improvements and developments to strengthen their competitive positions. Also, as noted previously, changes in cost factors or maritime regulations is likely to have a substantial impact on the market potential of the two ports in the medium and long term. As its main contribution, this study should enable the relevant port authorities and terminal operators to identify deficits that need improvement to stay ahead of the competition. Further research is required to determine the volume of transhipment containers that the Southern African container port system could capture to determine potential yard capacity constraints at either port**.**

8.2 Study Limitations

The study had the main limitation of available and comparable open data. Most of the primary and secondary data obtained are typically averaged over the study year, and it was therefore difficult to derive accurate conclusions. The lack of comparable container dwell time data also meant that the ports could not be compared on full D2D transit times. Shippers are mostly concerned with the full D2D transit times. Transhipment container dwell times ranged from 5.4 to 7.0 days at Transnet operated ports (TPT, 2020b). A 5-7-day dwell time could have a considerable impact on the overall D2D transportation times.

The validation process also had its limitations owing to data accessibility. With the lack of data on the geographic distribution of shipment origins by volume and the shipments' status (import/export/transhipment), it was not possible to determine the extent of relay and hub-and-spoke operations at the two intermediate ports. Nor could the transhipment volumes exchanged by each vessel be verified. As such, the relative importance of specific trade routes and services in the port choice decision could not be determined. Lastly, the study did not consider yard capacity constraints or non-quantitative measures in the comparison.

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10. APPENDICES

APPENDIX A

Calling Patterns of the Main Container Carriers at Southern African Ports

This section gives the breakdown of the container traffic by shipping lines in the Southern African region.

Table 10-1: Calling patterns of the main container carriers at Southern African Ports. Own elaboration based on published merchant haulage schedules and MPA (2020c)

Main shipping liners operating in Southern African region	Calling at:							
	Port Louis	Market share (%)	Ngqura	Market share (%)	Durban	Market share (%)	Cape Town	Market share (%)
MSC	✓	50.40	✓	unknown	✓	unknown	✓	unknown
Maersk	✓	31.60	✓	unknown	✓	unknown	✓	unknown
CMA-CGM	✓	12.20	✓	unknown	✓	unknown	✓	unknown
Hapag-Lloyd	✓	<0.4%	✓	unknown	✓	unknown	✓	unknown
Pacific International Line	✓	3.00	×	N/A	✓	unknown	✓	unknown
Safmarine	✓	unknown	✓	unknown	✓	unknown	✓	unknown

Note: Transnet does not publish the breakdown of container traffic by shipping lines.

APPENDIX B

Hub-and-Spoke Transit Distance Analysis Full Results

This section presents the full data set on the hub-and-spoke network transit distance analysis. Table 10-2 covers the trade routes originating from/to the African West Coast ports, Table 10-3 covers the trade routes from/to the South African ports and Table 10-4 the trade routes from/to the African East Coast ports. Trade flows are merely presented in one direction for ease of reference, the origin-destination pairs as presented here may also be reversed.

Table 10-2: Hub-and-spoke network - Full transit distance analysis for cargo originating from the African West Coast. Based on Searoutes Distance Calculator (2020).

O/D pair no:	From (Region)	To (Region)	O/D Pair	Feeder distance (NM)		Trunk route distance (NM)		Total distance (NM):		Opt. hub location:	Diff. (NM):
				Ngqura:	Port Louis:	Ngqura:	Port Louis:	Ngqura:	Port Louis:		
1	African West Coast	East Asia	Abidjan-Shanghai	3118	4954	7140	5379	10258	10333	Ngqura	-75
2			Abidjan-Hong Kong	3118	4954	6510	4746	9628	9700	Ngqura	-72
3			Tincan Island -Shanghai	3015	4851	7140	5379	10155	10230	Ngqura	-75
4			Tincan Island -Hong Kong	3015	4851	6510	4746	9525	9597	Ngqura	-72
5			Pointe Noire-Shanghai	2265	4101	7140	5379	9405	9480	Ngqura	-75
6			Pointe Noire-Hong Kong	2265	4101	6510	4746	8775	8847	Ngqura	-72
7			Walvis Bay-Shanghai	1160	2995	7140	5379	8300	8374	Ngqura	-74
8			Walvis Bay-Hong Kong	1160	2995	6510	4746	7670	7741	Ngqura	-71
9		South East Asia	Abidjan-Singapore	3118	4954	5223	3343	8341	8297	Port Louis	-44
10			Tincan Island -Singapore	3015	4851	5223	3343	8238	8194	Port Louis	-44
11			Pointe Noire-Singapore	2265	4101	5223	3343	7488	7444	Port Louis	-44
12			Walvis Bay-Singapore	1160	2995	5223	3343	6383	6338	Port Louis	-45
13			Abidjan-Jawaharlal Nehru	3118	4954	4187	2522	7305	7476	Ngqura	-171
14			Abidjan-Colombo	3118	4954	3957	2100	7075	7054	Port Louis	-21
15			Tincan Island -Jawaharlal Nehru	3015	4851	4187	2522	7202	7373	Ngqura	-171

16	African West Coast	South Asia	Tincan Island -Colombo	3015	4851	3957	2100	6972	6951	Port Louis	-21
17			Pointe Noire-Jawaharlal Nehru	2265	4101	4187	2522	6452	6623	Ngqura	-171
18			Pointe Noire-Colombo	2265	4101	3957	2100	6222	6201	Port Louis	-21
19			Walvis Bay-Jawaharlal Nehru	1160	2995	4187	2522	5347	5517	Ngqura	-170
20			Walvis Bay-Colombo	1160	2995	3957	2100	5117	5095	Port Louis	-22
21		Middle East	Abidjan-Jebel Ali	3118	4954	4410	3000	7528	7954	Ngqura	-426
22			Abidjan-Jeddah	3118	4954	4260	3054	7378	8008	Ngqura	-630
23			Tincan Island -Jebel Ali	3015	4851	4410	3000	7425	7851	Ngqura	-426
24			Tincan Island -Jeddah	3015	4851	4260	3054	7275	7905	Ngqura	-630
25			Pointe Noire-Jebel Ali	2265	4101	4410	3000	6675	7101	Ngqura	-426
26			Pointe Noire-Jeddah	2265	4101	4260	3054	6525	7155	Ngqura	-630
27			Walvis Bay-Jebel Ali	1160	2995	4410	3000	5570	5995	Ngqura	-425
28			Walvis Bay-Jeddah	1160	2995	4260	3054	5420	6049	Ngqura	-629
29		African East Coast	Abidjan-Mombasa	3118	4954	2094*	1427*	5212	6381	Ngqura	-1169
30			Abidjan-Dar Es Salaam	3118	4954	1952*	1358*	5070	6312	Ngqura	-1242
31			Abidjan-Toamasina	3118	4954	1688*	476*	4806	5430	Ngqura	-624
32			Abidjan-Maputo	3118	4954	686*	1448*	3804	6402	Ngqura	-2598
33			Tincan Island -Mombasa	3015	4851	2094*	1427*	5109	6278	Ngqura	-1169
34			Tincan Island -Dar Es Salaam	3015	4851	1952*	1358*	4967	6209	Ngqura	-1242
35			Tincan Island -Toamasina	3015	4851	1688*	476*	4703	5327	Ngqura	-624
36			Tincan Island -Maputo	3015	4851	686*	1448*	3701	6299	Ngqura	-2598
37			Pointe Noire-Mombasa	2265	4101	2094*	1427*	4359	5528	Ngqura	-1169
38			Pointe Noire-Dar Es Salaam	2265	4101	1952*	1358*	4217	5459	Ngqura	-1242
39			Pointe Noire-Toamasina	2265	4101	1688*	476*	3953	4577	Ngqura	-624
40			Pointe Noire-Maputo	2265	4101	686*	1448*	2951	5549	Ngqura	-2598
41			Walvis Bay-Mombasa	1160	2995	2094*	1427*	3254	4422	Ngqura	-1168
42			Walvis Bay-Dar Es Salaam	1160	2995	1952*	1358*	3112	4353	Ngqura	-1241

43	African West Coast	African East Coast	Walvis Bay-Toamasina	1160	2995	1688*	476*	2848	3471	Ngqura	-623
44			Walvis Bay-Maputo	1160	2995	686*	1448*	1846	4443	Ngqura	-2597
45		SAEC	Pointe Noire-Santos	2265	4101	3817	5644	6082	9745	Ngqura	-3663
46			Pointe Noire-Buenos Aires	2265	4101	4087	5904	6352	10005	Ngqura	-3653
47			Walvis Bay-Santos	1160	2995	3817	5644	4977	8639	Ngqura	-3662
48			Walvis Bay-Buenos Aires	1160	2995	4087	5904	5247	8899	Ngqura	-3652

Table 10-3: Hub-and-spoke network - Full transit distance analysis for cargo originating from South Africa. Based on Searoutes Distance Calculator (2020).

O/D pair no:	From (Region)	To (Region)	O/D Pair	Distance via (NM)		Trunk route distance (NM)		Total distance (NM):		Opt. hub location:	Diff. (NM):
				Ngqura:	Port Louis:	Ngqura:	Port Louis:	Ngqura:	Port Louis:		
49	South Africa	African East Coast	Durban-Mombasa	391	1553	2094*	1427*	2485	2980	Ngqura	-495
50			Durban-Dar Es Salaam	391	1553	1952*	1358*	2343	2911	Ngqura	-568
51			Durban-Toamasina	391	1553	1688*	476*	2079	2029	Port Louis	-50
52			Durban-Maputo	391	1553	686*	1448*	1077	3001	Ngqura	-1924
53			Cape Town-Mombasa	465	2301	2094*	1427*	2559	3728	Ngqura	-1169
54			Cape Town-Dar Es Salaam	465	2301	1952*	1358*	2417	3659	Ngqura	-1242
55			Cape Town-Toamasina	465	2301	1688*	476*	2153	2777	Ngqura	-624
56			Cape Town-Maputo	465	2301	686*	1448*	1151	3749	Ngqura	-2598
57		East Asia	Durban-Shanghai	391	1553	7140	5379	7531	6932	Port Louis	-599
58			Durban-Hong Kong	391	1553	6510	4746	6901	6299	Port Louis	-602
59			Cape Town-Shanghai	465	2301	7140	5379	7605	7680	Ngqura	-75
60			Cape Town-Hong Kong	465	2301	6510	4746	6975	7047	Ngqura	-72
61		South East Asia	Durban-Singapore	391	1553	5223	3343	5614	4896	Port Louis	-718
62			Cape Town-Singapore	465	2301	5223	3343	5688	5644	Port Louis	-44

63	South Africa	South Asia	Durban-Jawaharlal Nehru	391	1553	4187	2522	4578	4075	Port Louis	-503
64			Durban-Colombo	391	1553	3957	2100	4348	3653	Port Louis	-695
65			Cape Town-Jawaharlal Nehru	465	2301	4187	2522	4652	4823	Ngqura	-171
66			Cape Town-Colombo	465	2301	3957	2100	4422	4401	Port Louis	-21
67		Middle East	Durban-Jebel Ali	391	1553	4410	3000	4801	4553	Port Louis	-248
68			Durban-Jeddah	391	1553	4260	3054	4651	4607	Port Louis	-44
69			Cape Town-Jebel Ali	465	2301	4410	3000	4875	5301	Ngqura	-426
70			Cape Town-Jeddah	465	2301	4260	3054	4725	5355	Ngqura	-630
71		SAEC	Durban-Santos	391	1553	3817	5644	4208	7197	Ngqura	-2989
72			Durban-Buenos Aires	391	1553	4087	5904	4478	7457	Ngqura	-2979
73			Cape Town-Santos	465	2301	3817	5644	4282	7945	Ngqura	-3663
74			Cape Town-Buenos Aires	465	2301	4087	5904	4552	8205	Ngqura	-3653

Table 10-4: Hub-and-spoke network - Full transit distance analysis for cargo originating from the African East Coast. Based on Searoutes Distance Calculator (2020).

O/D pair no:	From (Region)	To (Region)	O/D Pair	Distance via (NM)		Trunk route distance (NM)		Total distance (NM):		Opt. hub location:	Diff. (NM):
				Ngqura:	Port Louis:	Ngqura:	Port Louis:	Ngqura:	Port Louis:		
75	African East Coast	East Asia	Toamasina-Shanghai	1688	476	7140	5379	8828	5855	Port Louis	-2973
76			Toamasina-Hong Kong	1688	476	6510	4746	8198	5222	Port Louis	-2976
77			Maputo-Shanghai	686	1448	7140	5379	7826	6827	Port Louis	-999
78			Maputo-Hong Kong	686	1448	6510	4746	7196	6194	Port Louis	-1002
79		South East Asia	Toamasina-Singapore	1688	476	5223	3343	6911	3819	Port Louis	-3092
80			Maputo-Singapore	686	1448	5223	3343	5909	4791	Port Louis	-1118
81		South Asia	Toamasina-Jawaharlal Nehru	1688	476	4187	2522	5875	2998	Port Louis	-2877
82			Toamasina-Colombo	1688	476	3957	2100	5645	2576	Port Louis	-3069
83			Maputo-Jawaharlal Nehru	686	1448	4187	2522	4873	3970	Port Louis	-903
84			Maputo-Colombo	686	1448	3957	2100	4643	3548	Port Louis	-1095
85		Middle East	Toamasina-Jebel Ali	1688	476	4410	3000	6098	3476	Port Louis	-2622
86			Toamasina-Jeddah	1688	476	4260	3054	5948	3530	Port Louis	-2418
87			Maputo-Jebel Ali	686	1448	4410	3000	5096	4448	Port Louis	-648
88			Maputo-Jeddah	686	1448	4260	3054	4946	4502	Port Louis	-444
89		SAEC	Toamasina-Santos	1688	476	3817	5644	5505	6120	Ngqura	-615
90			Toamasina-Buenos Aires	1688	476	4087	5904	5775	6380	Ngqura	-605
91			Maputo-Santos	686	1448	3817	5644	4503	7092	Ngqura	-2589
92			Maputo-Buenos Aires	686	1448	4087	5904	4773	7352	Ngqura	-2579
93			Mombasa-Santos	2094	1427	3817	5644	5911	7071	Ngqura	-1160
94			Mombasa-Buenos Aires	2094	1427	4087	5904	6181	7331	Ngqura	-1150
95			Dar Es Salaam-Santos	1952	1358	3817	5644	5769	7002	Ngqura	-1233
96			Dar Es Salaam-Buenos Aires	1952	1358	4087	5904	6039	7262	Ngqura	-1223

APPENDIX C

Generalised Cost Analysis: Cost Breakdown

This section presents the cost breakdown per cost group on the relay- and hub-and-spoke liner network configurations. The three distinct costs groups are the vessel charter cost, bunker fuel cost and port cost. The port costs are within the control of the port authorities and terminal operators, while the former two cost groups' rates are dependent on the market situation. The vessel time charter rates are influenced by the carrier's vessel demand of a specific size and the available ship supply. Similarly, bunker fuel rates fluctuate when the supply and demand for oil changes. However, it affects vessels of all sizes as opposed to the charter rates, which may at any given time, be stable for one vessel type and size but rising or falling for another. The split between the port fees charged per vessel call and the cargo dues plus handling fees levied on the container consignment was already discussed and depicted in Section 0 and therefore, these sets of costs are grouped.

Table 10-5: Relay liner network routes - cost group breakdown (cost per TEU). Authors own elaboration based on CHCL (2017), Ports Fees Regulation (2008), Ports Fees (Amendment) Regulation (2017); TNPA (2019) and TPT (2019b).

	Charter Cost/TEU (US$)		Bunker Cost/TEU (US$)		Port Cost/TEU (US$)		Total Cost/TEU (US$)	
Relay route:	via Ngqura:	via Port Louis:	via Ngqura:	via Port Louis:	via Ngqura:	via Port Louis:	via Ngqura:	via Port Louis:
Colombo-Santos	$98.74	$101.56	$113.94	$113.77	$312.57	$167.60	$525.25	$382.93
Colombo-Buenos Aires	$101.15	$103.97	$117.80	$117.49	$312.57	$167.60	$531.52	$389.06
Jawaharlal Nehru-Santos	$100.75	$105.18	$117.23	$119.80	$312.57	$167.60	$530.55	$392.58
Jawaharlal Nehru-Buenos Aires	$103.17	$107.20	$121.09	$123.52	$312.57	$167.60	$536.82	$398.32
Singapore-Santos	$109.62	$112.03	$132.03	$131.54	$312.57	$167.60	$554.22	$411.17
Singapore-Buenos Aires	$111.63	$114.05	$135.89	$135.25	$312.57	$167.60	$560.09	$416.90
Hong Kong-Santos	$120.09	$123.72	$150.43	$151.59	$312.57	$167.60	$583.09	$442.91
Hong Kong-Buenos Aires	$122.51	$126.14	$154.29	$155.30	$312.57	$167.60	$589.37	$449.04
Shanghai-Santos	$125.33	$128.96	$159.43	$160.63	$312.57	$167.60	$597.33	$457.19
Shanghai-Buenos Aires	$127.75	$131.38	$163.29	$164.35	$312.57	$167.60	$603.61	$463.33

Table 10-6: Hub-and-spoke liner network services - cost group breakdown (cost per TEU). Authors own elaboration based on CHCL (2017), Ports Fees Regulation (2008), Ports Fees (Amendment) Regulation (2017); TNPA (2019) and TPT (2019b).

	Charter Cost/TEU (US$)		Bunker Cost/TEU (US$)		Port Cost/TEU (US$)		Charter Cost/TEU (US$)	
Services:	via Ngqura:	via Port Louis:	via Ngqura:	via Port Louis:	via Ngqura:	via Port Louis:	via Ngqura:	via Port Louis:
AWC-East Asia	$84.58	$94.78	$154.17	$169.86	$306.51	$162.27	$545.26	$426.92
AWC-South East Asia	$76.34	$85.81	$130.38	$145.07	$306.51	$162.27	$513.22	$393.15
AWC-South Asia	$70.55	$80.52	$114.48	$130.20	$306.51	$162.27	$491.54	$372.99
AWC-Middle East	$71.78	$84.21	$118.27	$140.52	$306.51	$162.27	$496.57	$387.00
AWC-AEC	$62.99	$73.05	$91.69	$121.50	$307.47	$161.69	$462.15	$356.24
AWC-SAEC	$63.74	$92.65	$98.80	$167.30	$306.63	$162.20	$469.17	$422.15
SA-AEC	$47.66	$52.19	$49.85	$72.92	$307.60	$161.58	$405.11	$286.68
SA-East Asia	$65.76	$73.18	$111.53	$121.08	$306.63	$162.20	$483.92	$356.45
SA-South East Asia	$57.51	$64.20	$87.92	$96.29	$306.39	$162.20	$451.82	$322.68
SA-South Asia	$51.73	$58.91	$71.84	$81.41	$306.63	$162.20	$430.21	$302.52
SA-Middle East	$52.96	$62.60	$75.63	$91.73	$306.63	$162.20	$435.23	$316.53
SA-SAEC	$51.12	$76.74	$70.11	$131.34	$306.63	$162.20	$427.86	$370.28
AEC-East Asia	$73.81	$62.67	$130.31	$99.58	$306.88	$162.05	$510.99	$324.30
AEC-South East Asia	$65.56	$53.69	$107.22	$74.79	$306.88	$162.05	$479.66	$290.53
AEC-South Asia	$59.78	$48.41	$90.62	$59.91	$306.88	$162.05	$457.28	$270.36
AEC-Middle East	$61.01	$52.10	$94.41	$70.23	$306.88	$162.05	$462.31	$284.38
AEC-SAEC	$62.73	$68.54	$96.51	$113.40	$306.63	$162.20	$465.87	$344.15

Note: SAEC = South American East Coast, AWC = African West Coast, AEC = African East Coast, SA = South Africa.

APPENDIX D

Vessel Fuel Consumption

This section presents the vessel fuel consumption at different speeds for the four different vessel sizes considered in this study.

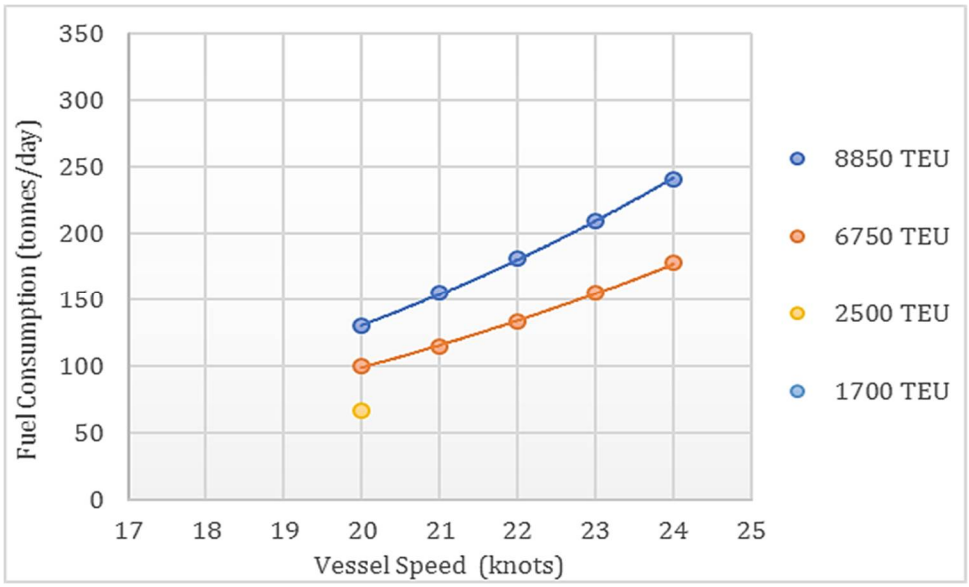


Figure 10-1: Fuel consumption by container ship size and speed. Own elaboration based on Notteboom, and Cariou (2009); Mandarin shipping (2016).

APPENDIX E

Berthing Schedules: The Port of Ngqura and Port Louis

In this section the typical berthing schedules of the two transhipment hubs, as observed from October 2020 to January 2021, are displayed.

Table 10-7: MPA – Daily port situation 16/10/2020. MPA (2020b).

Serial No. 290/2020 FRIDAY 16th OCTOBER 2020		MAURITIUS PORTS AUTHORITY DAILY PORT SITUATION http://www.mauport.com/downloads/portsituation/PORTSITUATION.pdf					
		VESSELS DISCHARGING / LOADING OPERATIONS					
			DATE			BALANCE of CARGO	
BERTH	BOLLARD	CARGO VESSELS	ARR.	START	ETD	DISCHARGING	LOADING
Q4	(18 22)	BLACK RHINO 101mt	16.10	16.10	20.10	178 Containers +8 C.Pens+9 B.Fowl+59 Cattles	
Q2	DOL 09	SEBRING EXPRESS (PCC) 180 + 35mts	16.10	16.10	16.10	337 Vehicles(25 Drivers)	
BERTH		BULK VESSELS	ARR.	START	ETD	DISCHARGING & LOADING	
OH		MAERSK ADRIATIC 184mt	13.10	14.10	20.10	Dis 11,925MT B/Fuel Oil(STS Hakkassan)	
BERTH	BOLLARD	CRUISE VESSELS	ARR.	DEP	TIME		
BERTH	BOLLARD	NAVAL & RESEARCH VESSELS	ARR.	DEP	TIME		
OH-CNOI		LE MALIN 54mts	15.09				
BERTH	BOLLARD	VESSELS AT CONTAINER TERMINAL	ARR.	START	ETD	DISCHARGING	LOADING
MCT 1		SAN CHRISTOBAL 300mt	15.10	16.10	16.10	5 Containers	363 Containers
OH-MCT 1		CMA CGM KAILAS 197mts	16.10	16.10	17.10	134 Containers	389 Containers
	BOLLARD	VESSELS AT CONTAINER TERMINAL	ARR.	START	ETD	DISCHARGING	LOADING
MCT 2	STB 13 22	MSC DENISSE 199mt	14.10	14.10	16.10	37 Containers	411 Containers
OH-MCT 2		CAP CARMEL 213mts	16.10	17.10	18.10	343 Containers	272 Containers
	BOLLARD	VESSELS AT CONTAINER TERMINAL	ARR.	START	ETD	DISCHARGING	LOADING
MCT 3	STB 27 35	MSC LUCIA 190mt	15.10	15.10	18.10	216 Containers	954 Containers
BERTH	BOLLARD	Name of Fishing Vessel	ARR.	START	ETD	CONTAINERS TO BE STUFFED & BUNKER/BAITS/PROVISIO	
MFD							
FDM1/2		AFFINIS	10.10	12.10		Dis 4,453ts F/Fish	
FDM3		LU WEI YUAN YU 288	15.10	15.10		Dis ts F/Fish	
FDM4							
FDM5		LU RU YUAN YU No.188	7.10			Dis ts F/Fish	
FDM6							
FDM7							
QA	(01 03)	HSIN MING SHENG 28/HSIN MING SHENG 18	24.09			Ld Provisions	
QD	(20 24)	DONG WON 637 /DONG WON 639	28.09	14.10		Dis ts F/Fish	
Q3	(10 13)	LONG XING 636(13.07)	13.07			Ld Bunker	
TFF/F1		MAUSTRAL/SPHYRNA II/INVESTIGATOR II/SEA TREASURE/SEA BREEZE/MAKAIRA/MAHI MAHI					
TFF/F2		MARIAM 1(10.10)/DAI FAH 6					
TFF/F3		PUTRA JAYA 33 / IGRECK					
TFF/F4		WESTFIELD 1/DJASAZEE 1/GANGA/ROYAL PHOENIX II/FEROIQ/SSALACIA 1/KEOLI					
TFF/F5		DIEGO STAR 2/ROSHAN/DIEGO STAR 6					
TFF/F6		SHANDRANI 2/SHANDRANI					
TFF/F7							
BERTH		CONTAINER VESSELS (Waiting)	ARR.	Time	Cargo for Discharging & Loading		REMARKS
OH		CMA CGM KAILAS 197mts	16.10	6.40	Dis 134 & Ld 389 Conts		
OH		CAP CARMEL 213mts	16.10	11.40	Dis 343 & Ld 272 Conts		

Table 10-8: MPA – Daily port situation 06/01/2020. MPA (2020b).

Serial No. 06/2021 WEDNESDAY 06th JANUARY 2021				MAURITIUS PORTS AUTHORITY DAILY PORT SITUATION http://www.mauport.com/downloads/portsituation/PORTSITUATION.pdf				
VESSELS DISCHARGING / LOADING OPERATIONS								
				DATE			BALANCE of CARGO	
BERTH	BOLLARD	CARGO VESSELS		ARR.	START	ETD	DISCHARGING	LOADING
QE	(25 32)	MAURITIUS TROCHETIA (idle)	110mts	31.12	31.12	15.01		
Q3	(08 13)	LANGEOOG	110mts	5.01	6.01	8.01	Dis 151 Conts + Ld 24 Conts	
Q4	(13 19)	BLACK RHINO	101mts	6.01	6.01	9.01	Dis 152Conts+ 1veh	
BERTH		BULK VESSELS		ARR.	START	ETD	DISCHARGING & LOADING	
Q3	(04 13)	IVS GLENEAGLES	190mts	30.12	30.12	6.01		
MST		MT MELODY	183mts	2.01	2.01	6.01	Dis 11,348ts B/Fuel Oil (MST)	
Q1-OIL JETTY	(01 Dol)	AVANTI	180mts	4.01	4.01	6.01	Dis 3860ts Q1 -MGO (13,663ts B/White Oil(Oil Jetty)	
OIL JETTY-OH-Q1		EUPEN	180mts	4.01	4.01	6.01	Ld Bunker O/H	
BERTH	BOLLARD	CRUISE VESSELS		ARR.	DEP	TIME		
BERTH	BOLLARD	NAVAL & RESEARCH VESSELS		ARR.	DEP	TIME		
BERTH	BOLLARD	VESSELS AT CONTAINER TERMINAL		ARR.	START	ETD	DISCHARGING	LOADING
MCT 1		CMA CGM KAILAS	197mts	21.12	22.12	7.01		425 Containers
MCT 2		MSC DENISSE	199mts	5.01	6.01	8.01	933 Containers	1321 Containers
MCT 3		GH ZEPHYR	212mts	6.01	6.01	6.01	276 Containers	217 Containers
BERTH	BOLLARD	Name of Vessel		ARR.	START	ETD	CONTAINERS TO BE STUFFED & BUNKER/BAITS/PROVISION	
MFD		KHAYANG 333		3.01	5.01		Dis 161 ts F. Fish	
FDM1/2		AFFINIS		28.12	4.01		Dis 4,433ts F. Fish	
FDM3								
FDM4								
FDM5/6		CHEN YU 7		29.12	4.01	6.01	Dis 144ts F. Fish	
FDM7								
QA-1WEST	(01 03)	CHU HUAI 268		4.01	4.01		Dis Fish	
QA-1WEST	(14 16)	SHIN LIAN FA 338		2.01	2.01		Ld Bunker	
Q4	(19 22)	TOMI MARU 58		4.01	4.01		Ld 250MT MGO/Dis ts Fish	
TFF/F1		MAUSTRAL/SPHYRNA II/INVESTIGATOR II						
TFF/F1		SEA TIGER/SEA TREASURE/SEA GRACE/MAKAIRA/SEAMASTER/SEA BREEZE/SNAPPER/MAHI MAHI						
TFF/F2		SEAFARER FISHING/GANGA/ RENAISSANCE/SERENITY/YEYE						
TFF/F3		DAI FAH 1/DAI FAH 2/DAI FAH 6/DAI FAH8						
BERTH		CONTAINER VESSELS	(Waiting)	ARR.	Time	Cargo for Discharging& Loading		REMARKS
O/H -Q3 (08 13)		LANGEOOG	110mts	5.01	23.05	Dis 151 & Ld 24 Conts		

Table 10-9: Ngqura container terminal – Vessel berthing schedule 19/10/20. TNPA (2020a).

NGQURA CONTAINER TERMINAL : VESSEL BERTHING						
DATE AND TIME LAST UPDATED: 19/10/2020 14:23						
NAME OF VESSEL	ESTIMATED DATE OF BERTHING	ESTIMATED TIME OF BERTHING	NO. OF CONTAINERS TO DISCHARGE	NO. OF CONTAINERS TO LOAD	BERTHING SHED	COMMENTS
MOL PROFICIENCY	20.10.20	20:00	900	130	102	
MSC AMALFI	21.10.20	14:00	750	620	100	
SEASPAN OSPREY	22.10.20	01:00	250	600	102	
BOUNDARY	22.10.20	01:00	300	300	101	
MAERSK AMAZON	23.10.20	16:00	452	1252	100	
MSC PHOENIX	26.10.20	16:00	562	1000	100	
LORI	27.10.20	08:00	1500	700	102	
BORDER	27.10.20	20:00	300	300	101	
SANTA CLARA	28.10.20	09:00	653	228	100	
CHALLENGER	28.10.20	09:00	0	7	102	LOADING ONLY
PARANAGUA EXPRESS	28.10.20	22:00	290	350	101	
MSC BEATRICE	29.10.20	14:00	1300	1600	102	
MAERSK SHIVLING	29.10.20	20:00	366	3524	101	
MSC CAPRI	01.11.20	12:00	600	600	102	
CITY OF HONG KONG	01.11.20	23:00	400	100	101	
MSC PEGASUS	02.11.20	17:00	1000	1000	100	
MP THE BROWN	02.11.20	19:00	1000	1000	102	
MSC ELMA						NO LONGER LISTED
MAERSK SAIGON						NO LONGER LISTED

Table 10-10: Ngqura container terminal - Vessel berthing schedule 06/01/20. TNPA (2020a).

NGQURA CONTAINER TERMINAL : VESSEL BERTHING						
DATE AND TIME LAST UPDATED: 06/01/2021 12:28						
NAME OF VESSEL	ESTIMATED DATE OF BERTHING	ESTIMATED TIME OF BERTHING	NO. OF CONTAINERS TO DISCHARGE	NO. OF CONTAINERS TO LOAD	BERTHING SHED	COMMENTS
MSC JEANNE	05.01.21	03:00	142	100	102	
MP THE LAW	05.01.21	09:00	1821	910	102	
MAIRA XL	06.01.21	01:00	700	400	101	
MAERSK TANJONG	07.01.21	11:00	319	1650	100	
HORIZON	07.01.21	14:00	250	0	101	DISCHARGING ONLY
SANTA VANESSA	08.01.21	01:00	400	2000	100	
LYME BAY	08.01.21	16:00	50	250	101	
LORI	09.01.21	02:00	400	600	100	
MONTEVIDEO EXPRESS	09.01.21	12:00	290	350	101	
BORDER	10.01.21	09:00	600	250	102	
MSC PEGASUS	10.01.21	21:00	550	1200	100	
CITY OF HONG KONG	11.01.21	08:00	153	100	102	
BOUNDARY	12.01.21	20:00	600	250	102	
MAERSK TAIKUNG	13.01.21	01:00	262	1650	101	
SANTA RITA	13.01.21	04:00	804	400	101	
MSC CAPRI	14.01.21	08:00	380	250	102	
MSC AVNI	14.01.21	09:00	300	600	101	
ATHENS GLORY	15.01.21	01:00	510	250	102	
CMA CGM JAMAICA	15.01.21	11:00	50	250	100	
PANTHER	16.01.21	06:00	1114	0	101	
MSC FLAMINIA	16.01.21	08:00	750	150	100	
MP THE BROWN	17.01.21	08:00	900	900	100	
MSC RITA	18.01.21	08:00	1000	1500	100	