EVALUATION OF NIGERIAN PORTS POST-CONCESSION PERFORMANCE

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Copyright statement

Conference papers

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Abstract

Concession has been acknowledged as a valuable tool for port authorities to retain control of ports and shape the supply side of the terminal market, in the absence of full privatisation. This study empirically examines the influence of transfer of port operational services from the public to the private sector, through concession contracts on operational performance in the context of the Nigerian port industry. It extends the work of Liu (1995) and others on the comparative performance of public and private ports in the UK and other countries, by extending the study to the Nigerian ports concessions.

The Nigerian port reform was borne out of the belief that the transfer of port operations from the public to the private sector will improve the efficiency of the ports, by instigating competition among the various terminal operators. The Nigerian port concession involved the delineation of six Nigerian ports into 25 terminals and awarded to terminal operators. The objectives of the study include, among others; the benchmarking of pre- and post-concession efficiency, to determine sources of efficiency change and to determine factors responsible for the improvement of Nigerian port performance.

A positivist approach is adopted, using quantitative data that involves outputs and inputs related to the port's production function. Theoretical underpinnings of privatisation and performance, as well as empirical evidence from countries, were presented and discussed. The variables of the research were analysed using non-parametric DEA and the Malmquist Productivity Index to determine the efficiency and the sources of productivity change respectively. This study introduced a novel idea, by adopting a concentration index in measuring the level of competitiveness of ports. The conceptualised theoretical model of operational performance was solved using a two-stage multivariate regression, to determine the factors responsible for the improvement of the Nigerian ports' efficiency.

The results of the analysis suggested that the productive performance of the ports under consideration improved after the transfer of terminal operations to the private sector, though not in all the ports. Indicating that the wholesale concession of the ports is not the best after all, some ports would have been better left under public ownership. The driver of the improved efficiency after concession, is scale efficiency (increased throughput levels), rather than technical efficiency. Therefore, the post-concession Nigerian ports performance is influenced by the scale of production and change of ownership. The delineation of the ports into terminals has not ushered in the expected competition among and within the ports.

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List of Abbreviations

ABC	Activity-based costing
ABTL	Apapa bulk terminal
AE	Allocative efficiency
AfDB	African development bank
AICD	African infrastructure country diagnostics
AMS	Associated maritime services limited
ANCLA	Association of Nigerian customs licensed agents
ANOVA	Analysis of variance
APMT	AP Moller Terminal
AREFFN	Association of registered freight forwarders in Nigeria
ASD	Alternative service delivery
ATT	Average turnaround time
BLO	Build-Lease-Operate
BOT	Build-Operate-Transfer
BOST	Build-Rehabilitate-Operate-Transfer
BROT	Build-Operate-Share-Transfer
BPE	Bureau of public enterprises
BUA	BUA ports & terminals
CCTV	Close circuit television
COLS	Corrected ordinary least square regression
CPA	Central port authority
CR	Column Range
CRFFN	Council for the regulation of freight forwarders in Nigeria
CRS	Constant returns to scale
DBC	Dry bulk cargo

DEA	Data envelopment analysis
DEA-BCC	Data envelopment analysis - Banker, Charnes & Cooper model (variable returns to scale model)
DEA-CCR	Data envelopment analysis - Charnes, Cooper & Rhodes model (constant returns to scale model)
DMUs	Decision making units
DP	Dubai port-World
DPP	Direct-profit profitability
DRS	Decreasing returns to scale
DWT	Dead weight tonnage
ECM	Ecomarine
ECOWAS	Economic community of West African states
ED	Executive director
EFFCH	Technical efficiency change
ENL	ENL port, a division of ENL consortium limited
EOI	Expression of interest
EPZ	Export processing zone
FDH	Free disposal Hull
FLT	Federal lighter terminal
FMOT	Federal Ministry of Transport
FOT	Federal ocean terminal
FSL	Five-star logistics
GC	General cargo
GDNL	Greenview Development Nigeria Limited
GHPA	Ghana harbour and ports authority
GJT	Golden jubilee terminal
GM	General manager
GRT	Gross registered tonnage
GTOs	Global Terminal Operators

HHI	Hirschman-Herfindahl Index
IADB	Inter-American Development Bank
ICD	Inland Container Depots
ICRCA	Infrastructure Concession and Regulatory commission Act
ICTSI	International Container Terminal Services Inc.
ILO	International Labour Organisation
IMC	International Maritime Centre
IMO	International Maritime Organisation
INTELS	Integrated Logistics Services
IRS	Increasing Returns to Scale
ISAN	Indigenous Ship-owners Association of Nigeria
ISPS	International Ship and Port Facility Security Code
ITF	International Transport workers Federation
ITOs	International Terminal Operators
JODLIC	Joint Dock Labour Industrial Council
JOSD	Joseph Dam
LPC	Local Port Corporation
LPHA	Lagos Ports and Harbours Authority
MD	Managing Director
MES	Minimum Efficient Scale
MFP	Multi-Factor Productivity
MIC	Maritime industry council
MOT	Ministry of Transport
MPA	Maritime port authority
MPI	Malmquist productivity index
MPS	Meridian port services
MTI	Ministry of Trade and Industry

NAFCON	National fertiliser company of Nigeria
NAGAFF	National association of government approved freight forwarders
NCMDLCA	National council of managing directors of licensed customs agents
NHB	National Harbours Board
NLNG	Nigeria liquefied natural gas
NPA	Nigerian ports authority
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least square regression
PAs	Port Authorities
PCHS	Port & Cargo handling services
PCI	Port competitive index
PECH	Pure efficiency change
PFP	Partial factor productivity
PFSO	Port facility security officer
PH	Port Harcourt
PHPHA	Port Harcourt ports and harbours authority
PPI	Private participation in infrastructure
PPIAF	Public-private infrastructure advisory fund
PPP	Public-private partnership
PRTK	Port reform toolkit
PSA	Port of Singapore Authority
PTML	Port & Terminal multi-services Limited
PTOL	Port & Operations Limited
RORO	Roll-On Roll-Off
SE	Scale efficiency
SECH	Scale efficiency change
SFA	Stochastic frontier analysis
SNFFIEL	Save Nigerian freight forwarders, importers,

	exporters coalition
SOEs	State-owned enterprises
STOAN	Seaport terminal operators association of Nigeria
SUA	Suppression of unlawful acts against cargo, ships, crew and passenger convention
TCIP	Tin Can Island port
TCPC	Technical committee on privatisation and commercialisation
TCT	Tema container terminal
TE	Technical efficiency
TECHCH	Technological change
TEUs	Tonne equivalent units
TFP	Total factor productivity
TICT	Tin Can Island container terminal
TOC	Terminal Operating Companies
TOPA	Terminal Operating Port Authorities
TOSL	Terminal Operating Shipping Lines
TOSS	Terminal Operating Shipping Shippers
TSRC	Transport Sector Reform Committee
UK	United Kingdom
UNCTAD	United Nation's conferences on trade and development
VRS	Variable returns to scale
WACT	West African container terminal
WAFMAX	West African maximum
WBPRTK	World Bank port reform toolkit
WTO	World Trade Organisation

Chapter One: Introduction

1.1 Background to the Research

The last decade has witnessed significant changes in the ports in Sub-Saharan Africa. The 31 countries with ports in the sub-region have either improved legislation or policy oversight, restructured, or embraced private participation in an attempt to reform the ports. The ports in the sub-region are gradually moving away from being publicly operated to engaging the private sector in terminal operations through concession contracts. Most container ports have been a concession, while the specialised ports and terminals are either privately owned or leased. International and local companies participate in the operation of a vast number of ports, even in relatively small ports and in competing terminals at more major ports.

Countries in Sub-Saharan Africa have embraced reforms, as ports play a role in the global trade logistics chain, which impacts heavily on the cost of many exported and imported goods. The belief is that the reforms that improve efficiency will lead to a reduction in total logistics costs. It also impacts positively on the overall competitiveness of economies of reforming countries (Estache, González, & Trujillo, 2001). The most commonly used tool to engage the private sector in the port industry is a concession contract. It is a public–private partnership (PPP) of a contractual nature and has been a favourite means worldwide of instigating port development. It provides new opportunities for injecting private capital, by adopting a market orientation approach. A common feature of reforms is monitoring and evaluation. The focus of ports in post-reform monitoring is partial productivity indicators. The partial indicators, though useful, can be quite misleading, as they do not generate the same ranking for all the ports. As a result, the port authorities have limited information to implement some of the regulatory mechanisms that require consistent estimation of efficiency gains (Trujillo & Nombela, 2000). Hence, the need for a study that reflects the joint effects of all inputs and outputs in the measuring of absolute performance.

Nigeria ports play a significant role in international trade in the sub-region; over 90% of traded goods are carried by sea. The Nigeria economy accounts for over 70% of seaborne trade in the West and Central African sub-region due to its vast population (Fivestar Logistics, 2008). Therefore, assessing the productive efficiency of Nigerian ports after concession is crucial to the implementation of port reforms of other countries in the sub-region.

Port development in Nigeria has a chequered history. However, the history of modern ports administration can be traced to the Port Act 1954. The Act gave impetus to the establishment of the Nigerian Ports Authority (NPA) in April 1955, as a public corporation. It was owned wholly by the Federal Government of Nigeria (FGN) and charged with the responsibility to operate and regulate seaports in Nigeria (Mohammed, 2008). The importance of ports as a catalyst for economic development was recognised in the first national development plan (1962-1968). The plan earmarked Nigerian ports for development; it provided for the expenditure of £45 million for the improvement of facilities at Lagos and Port Harcourt ports (Akinwale & Aremo, 2010). The Nigerian Civil War (1967-1970) constituted a major setback for port development in Nigeria due to the closure of Port Harcourt port to foreign traffic. Lagos port was left to supply port services in Nigeria. As a result, the then military government enacted a decree empowering the NPA to acquire the private ports in the Eastern part: Warri port operated by John Holt transport, Burutu port owned by United African Company (UAC) and Calabar port by five different operators.

After the end of the Civil War, the ports were characterised by a massive influx of imports (construction equipment and cement) for post-war reconstruction. It resulted in unprecedented levels of congestion at the ports. In addition, the road infrastructure was inadequate and could not cope with expeditious evacuation of cargo. The average ship waiting time before berthing was 180 days and approximately 250 days for Lagos port, resulting in the imposition of surcharges. The government embarked on several emergency measures, such as; the construction of a new port in the Lagos area (Tin Can Island port); and the acquisition of new equipment to increase berth productivity and to ameliorate the problem (Shneerson, 1981). The main consequence of port delay is the rise in freight charge. The increase in freight charge impacted on agricultural exports as they could no longer compete in the international market due to the high cost.

The NPA continued with the responsibility of piloting the affairs of the ports as a public corporation with subsidy from the federal government until the economic downturn of the 1980s. The economic recession of the 1980s affected Nigerian ports, as traffic to the ports declined. In response, the government initiated a process of divesting in public corporations, through either commercialisation or privatisation policies. As a result, the NPA was slated for commercialisation. In 1992, the NPA was commercialised and the name was changed to Nigerian Ports Plc, but the ownership was still in the public domain, as the FGN solely owns it. In 1996, four years after commercialisation, the organisation reverted to its former name, the Nigeria Ports Authority (NPA), as a parastatal under the Federal Ministry of Transport (FMOT). However, the revision did not stop the commercialisation efforts, as the corporation continued to operate as a commercial enterprise (NPA Brand Manual, 2005).

The global changes in the port industry, coupled with the economic downturn of the 80s, triggered infrastructure obsolescence and decay. It became evident that the government had no resources, or the managerial ability, to run a modern port successfully (Razak, 2005). In addition, the trend worldwide was that governments were disengaging from port operations and restricting activities to regulation and providing an enabling environment for the private sector to operate, providing the impetus for change. The option of transfering port operations to the private sector through concession contracts then became imperative. The policymakers realised that maintaining the *status quo* would lead to further decay of the ports and losing the competitive edge among ports in the sub-region. Therefore, the introduction of the private sector in port operations in Nigeria was embraced, as it has been acknowledged that private operation of ports will encourage greater flexibility, efficiency and better services to port consumers. It brought to the fore the disengagement of government from the activities that could be more efficiently performed by the private sector.

1.2 Statement of the Problem

During the 1990s and prior to concession, Nigerian seaports were considered inefficient and unsafe due to massive cargo thefts (wharf rat phenomenon) and among the most expensive ports in the world. Also, the ports in Lagos were notorious for congestion that led to the continuing imposition of congestion surcharges and the high cost of imports, resulting in long turnaround times for ships and increased container dwell times (Leigland & Palsson, 2007). Instead of the international standard of 48 hours ship turnaround time in most Asian and

European ports, as observed by Ducruet and Merk (2012), it took weeks to load and unload ships in Nigeria ports. There were also problems of over bloated workforce, excessive port charges and too many agencies involved in cargo clearing. In addition, the port infrastructure and superstructure had become obsolete and in a state of disrepair and in need of rehabilitation. The government was unwilling to provide the enormous financial outlay required in financing the restoration of port infrastructure due to existing operational inefficiency and corruption, therefore the need for external financing became apparent. In order to mitigate these problems, government decided to introduce the private sector, to bring in expertise in the operation of the ports through concession contracts.

These massive reforms were undertaken in the belief that the reforms that improve operational efficiency of ports are likely to bring down total logistics costs and in turn improve the competitiveness of the Nigerian economy. The most valuable tool for bringing cost-cutting efficiency gains and improvements in the overall performance of the ports is the introduction of some form of competition. Competition can be introduced into the ports through *ex-ante* or *ex-post* approaches (Estache, González, & Trujillo, 2002). *Ex-ante* relies on the auction of rights to operate the port, or in the port while *ex-post* is competition between ports, or between terminals within the port. The Nigerian port concession is articulated to involve these two types of competition.

As a result, the Nigerian government embarked on the most extensive infrastructure port reforms that have taken place worldwide. It culminated in the handing over of port operations, through concession contracts, in 2006 (Ocean Shipping consultants, 2008; Palsson & Leigland, 2007). The primary objective of the Nigerian ports' concession is to attract investment, lower tariffs, improve service delivery to the consumer and in the end improve the overall performance of the ports. However, six years after handing over the operation of Nigerian ports to the private sector, in what is described as the most ambitious port reform that has taken place worldwide, no study has examined the overall impact of the concession to ascertain if the ports are on the path to efficiency. Though there are some studies that have dealt with some aspects of the Nigerian ports' concession such as Akinwale and Aremo (2010), which examined concession as a tool to manage the crisis at Nigerian ports. Oghojafor, Kuye, and Alaneme (2012) studied concession as a strategic instrument for efficiency and Okeudo (2013), looked at the efficiency level of Onne port after the reform. However, all these studies have only employed a piecemeal approach to studying the Nigerian port reform programme and none have evaluated the outcome of the concession programme holistically. That being the case, the research question is: *Has the massive reform that took place during a short period improved the performance of Nigerian ports?* That is what this study investigates and provides a model for future evaluation. To put it succinctly, the study investigated the underpinning questions: "*Does the transfer of the operation of a whole nation's ports from the public to the private sector, through concession contracts, have an influence on the performance of the ports?*

1.3 Research Questions

Focusing on the Nigerian port sector, the study examines the relationship between privatisation through concession contracts and performance. The study focused on 20 concessions for six Nigerian ports (Apapa, Calabar, Onne, PH, TCIP and Warri), which are representative of port infrastructure concessions in 2006. On average, these concessions have been in operation for 6 years.

The research concentrated on investigating these questions:

- Are ports with terminal operations in the hands of the private sector more efficient than those in the public sector?
- Are ports that are under intense intra-port competition more efficient than those that are not?
- What factors influence port operational performance?
- What role does ownership of port institutions play in influencing operational port performance?

1.4 Research Aim and Objectives

The aim of this research is to study the port concession programme and its influence on the efficiency of Nigerian seaports, as well as benchmark the operational efficiency of the ports, to determine which operators are making efficient use, of resources allocated to them. In other words, the research examined in-depth, the post-concession operational performance of Nigerian ports to ascertain whether the ports are on the path to efficiency. The study addressed the aim by focusing on these specific objectives:

i. To measure and examine the efficiency trend of Nigerian seaports;
ii. To evaluate pre- and post-concession Nigerian ports' efficiency;
iii. To examine the overall performance of Nigerian ports from productivity and efficiency change perspectives;
iv. To determine the competitiveness of Nigerian seaports after concession;
v. To determine the factors that influence Nigerian ports' operational performance;
vi. To assess the impact and port users' perspective on the concession programme;

1.5 Significance of the Study

The result of this study is significant and can have some important policy implications. Nigeria is a major force in international trade, with 70% of goods coming to the West, and Central Africa destined to Nigeria. Out of which 80% of the traded goods are transported by sea (UNCTAD, 2009). Therefore, the study of port performance is crucial to the sub-region. The World Bank African infrastructure country diagnostics (2008) assessment of ports in Sub-Saharan Africa ranked Nigeria as the top reformer Vagliasindi and Nellis (2009). The PPI database put the total private sector investment in Sub-Saharan African ports at $1.3 billion, with 62 percent related to the container terminals and 32 percent to multipurpose terminals, with little in the bulk cargo facilities. Nigeria accounts for 55 percent of the total private sector investment in the sub-region and the biggest single deal is the container terminal Apapa in Lagos, Nigeria, which attracted over $300 million. These transactions further attracted $1.7 billion in royalties to governments in the sub-region with over $1billion associated with the Apapa terminal concession (Ocean Shipping consultants, 2008). Also, Nigeria is the only country to concession all her ports in one scoop and the pace of concession (20 concessions within a year) is unprecedented worldwide (Ocean Shipping consultants, 2008). Therefore, it becomes imperative to study the outcome of the programme that attracted such huge investment in the sub-region. The study will also be crucial for governments in the sub-region seeking to embrace port concession, to learn from the successes and mistakes of Nigeria. Globally, the study of the Nigerian ports concession is a good example to demonstrate the effects of national port concessions on port performance.

Although the number of studies measuring ports performance is flourishing, several gaps still exist. For instance, a review of the studies in port economics, policy and management conducted by Pallis, Vitsounis, and De Langen (2010) discovered a total of 395 published journal papers between 1997-2008. A breakdown of the 395 publications by continent revealed that 266 belong to European ports, 99 to North America, 87 to Asia, 20 to Oceania, and 14 to South America, while Africa has only 3. The review indicates that the studies are lopsided in favour of the developed world. It is commonly acknowledged in global network inclusive logic, that "a chain is as strong as the weakest link". As each country's individual port performance will affect the functioning of the chains that make-up the logistic network directly. Therefore, the need to study the outcome of the reform programmes that are targeted to improve the country's performance and overall competitiveness of its ports cannot be overemphasised.

In addition, there are many studies on seaport efficiency measurement, as evident from the surveys of DEA studies by Panayides, Maxoulis, Wang, and Ng (2009); González and Trujillo (2009) and a synthesis by Wang, Song, and Cullinane (2002). The surveys analysed over 26 journal papers on efficiency measurement from 1993-2006. It could be argued that to increase the efficiency of ports, the results of other research can be applied directly. However, as observed by Hall (2002), studies from different countries are hardly comparable, due to the timeframe, entities, the structure of ports, or the countries' social systems differ. However, there are no port efficiency studies devoted solely to productive efficiency, or the effect of privatisation on the operational performance of the Nigerian seaports, despite its strategic position trade-wise, in the sub-region. Hence, the motivation for this study to fill this identified gap. It makes the study crucial to all maritime players.

1.6 An Overview of the Nigerian Economy and Seaports

Nigeria occupies an area of 923,768 sq. KMs and is one of the largest countries in Africa. It is located on the west coast of Africa, bordering Benin, Niger and Cameroon. The country has a rich maritime history and a coastline of 850km which is littered with natural harbours and sandy beaches. Nearly 170m people live in Nigeria, making it the most populous nation in Africa and the 7th largest in the World. It has a GDP per capita of \$3010.3 and a GDP of \$522.6 billion and an annual GDP growth rate of 7.3% in 2013 (World Bank, 2014). The UN forecast that by 2050, the Nigerian population will reach 289 million following only India, China, the USA and Pakistan in global population ranking. Lagos is the second largest city in Africa (after Cairo) with a population of 10.2 million and 60% of Nigeria manufacturing is located in Lagos. The economy is the largest in Sub-Saharan Africa, having just overtaken South Africa; the economy grew by 7.69% and 6.5% in 2011 and 2012 respectively

Nigeria's biggest export is crude oil, and the country's economy is supported by the revenue it generates. Oil accounts for 80% of the country's domestic product. Prior to the discovery of petroleum, agriculture used to be the mainstay of the nation's economy. As the revenue from oil increased, agriculture was neglected. As a result, food production could not keep pace with the expanding population and Nigeria has to import food to supplement local production. Nigeria also imports refined petroleum products despite being the 11th largest oil producer in the world (2,682,000 bbl/day as at 2012). This is due to inefficiency and unreliability of the three big refineries refineries, coupled with economic sabotage in the form of petroleum product vandalisation.

Nigeria is a major advocate of healthy sub-regional ties and trade, after the formation of the Economic Community of West African states (ECOWAS) in 1975. Nigeria maintains non-discriminatory foreign trade relations with all the five continents of the world as a member of the World Trade Organisation (WTO). It has entered into many bilateral trade agreements with various countries. Nigeria's principal trading partners include Belgium, Brazil, France, Germany, Great Britain, Italy, Japan and the USA. There also exists a thriving trade between Nigeria and her neighbouring countries in the west and central African sub-region, while concerted efforts are being made to reach out to southern Africa and the rest of the world.
Nigeria is a member of ECOWAS and with the introduction of a single passport and a single market, subsequently other barriers that limited the flow of goods, services and capital flow between Nigeria and her neighbours, have disappeared. The removal of these barriers, made it impossible for ports in other West African countries previously to load/unload Nigeria cargo by sea, ushered in competition among the ports in the sub-region. This meant the decision and choice variables to use any of these ports Apapa port in Lagos, Cotonou Port in Benin, Lome Port in Togo or Tema Port in Ghana is total cost, speed and reliability of transport. Consequently, Nigerian ports began to lose cargo, because many shippers responded to these scenarios by diverting their containers to other countries for transhipment

to Nigeria in smaller vessels. Nigeria's loss has become its more competitive neighbouring ports' gain.

As the drift of cargo meant for Nigerian ports continued unabated to ports in neighbouring countries, the government came up with a more radical approach to public sector reform in Nigeria. The main thrust of the new approach is a shift from commercialisation to transfer of operational activities of State Owned Enterprises (SOEs), from the public to the private sector, through partial or outright privatisation. For the port industry, the primary goals of this reform were to increase competitiveness and efficiency of national ports. In order to achieve these goals, the government defended an increase of private participation in port management. Nigerian ports moved from a tool port model, where the public sector holds the infrastructure and superstructure, to a landlord port model (Kieran, 2005). In this model, the port authority retains the infrastructure ownership, but private operators provide the services through a licence or concession (Brooks, 2004). The operators are responsible for hiring workers and for investing in equipment and superstructure. The port authority is responsible for the construction and management of infrastructures associated with navigation, such as piers, dams and access channels (Marques & Fonseca, 2010). There are two principal reasons for the adoption of the landlord port model in Nigeria. The first one is related to the need for funding. The Nigerian Port Authority as a public entity was not able to finance the operations alone. The second one concerns the neo-liberal thinking that have characterised the governments in Nigeria since the inception of the present democratic rule (left and right wings), that defend the minimum state intervention.

1.6.1 Nigerian seaports

Figure 1.1 shows the location of the six major Nigerian seaports under study. They are located in the southern part of the country. Two in Lagos State, Apapa and Tin Can and another two in Rivers State, Port Harcourt and Onne, while Warri and Calabar ports are in Delta and Cross River states respectively. Prior to concession, Nigeria had eight ultra-modern ports split into two zones for administrative purposes i.e. Western and Eastern zones under the control of the NPA. The Western zone consists of Apapa port, Container terminal port, Tin Can Island port, and a Roll on-Roll off (RORO) port. The Eastern zone comprises of the Port Harcourt port complex, Delta port complex, Onne port complex, and the Calabar port complex. These eight ports constitute the primary port system, although there are smaller ports and oil terminals that operate under the ports' complexes. After the concession, the ports operate as six complexes: Lagos port complex, Tin Can Island port complex, Rivers port complex, Delta port complex, Onne port complex and Calabar port complex, each complex having ports under its jurisdiction.

Figure 1.1: Map of Nigeria showing location of seaports understudy

Source: Adapted from www.mapsofworld.com (2014)

Lagos Port Complex

The Lagos port complex is located at the Apapa area of Lagos and consists of Apapa port and a container terminal now called APM terminal; it occupies a land area of about 120 hectares. Apapa port has conventional berths that service all cargo types. These include 24 berths for handling dry cargo, two harbour berths for loading and discharging petroleum products. It also houses 13 transit sheds with a total storage space of 78,869 sq.metres and eight warehouses with a total space of 58,042 sq.metres and support facilities for cargo on transit to ECOWAS countries. The container terminal is inside of Apapa wharf and occupies an area of 44 hectares of land. The port terminal has six designated container berths, with a total quay length of 1km and a draught of 11.5m.

There are four terminal concessions carved out of Lagos port complex for four terminal operators; ABTL, ENL and GDNL from the former Apapa port, while the old container terminal is now APMT.

Tin Can Island Port Complex

Tin Can Island port complex is situated north-west of Apapa Wharf Lagos. It is a fusion of Tin Can Island port (TCIP) and the RORO port. The merger was as a result of the terminal concessions in 2006 and the port occupies an area of about 73 hectares of land that complement the RORO port. The TCIP port is comprised of the Kirikiri and Ikorodu lighter terminals and related jetties, in conjunction with a residential estate. The navigable channel has a width of 200m and a depth of 10.5m, with a total quay length of 2189m. It has berths for different cargoes, for example, berths 1 and 1A specialised in handling dry and bulk wheat cargo. The RORO port occupies berths 9 and 10, specially equipped to handle a large number of vehicles, containers and general cargo. The facilities in the RORO port include a car park with capacity for 7987 vehicles. A 435m quay length with a draught of 9.5m, two warehouses of 6800 sq.m each for containers and a stacking area of 22,86 sq.m with a capacity of 6017 tonnes.

There are four terminals and 1BOT terminal carved out of the Tin Can Island Port (TCIP) complex and operated by the following concessionaires; JOSD, FSL, PCHS, TICT and PTML, which is a BOT.

Delta Port Complex

The Delta port complex, in the Eastern zone, comprises of the following ports: Warri, Burutu, Koko and Sapele. It also includes the crude petroleum oil terminals of Escravos, Forcados and Pennington, located in the Delta region of Nigeria. The major port in this zone is the Warri Old and New port. The Warri port comprises of the Old and New Warri port. The Old port began operations in 1969, while the new port started in 1979 as an extension to the Old port. The port facilities available in Warri port include hard quays, jetties and mainstream buoys capable of handling 2.5m tonnes of bulk and break-bulk throughput. There are also 11 privately owned jetties. The depth of the approach channel varies between 6.4m-7m at high tide. The old port has a total quay length of 876m. It comprises of 8 berths, four of which are major berths, 3 are canal berths and one customs jetty, and Ogunu wharf dedicated to Ajaokuta iron and steel industries. The new Warri port comprises of 6 main berths, including one RORO berth, each with a length of 250m. The storage area of the old port consists of six transit sheds, warehouses. It is allocated to oil companies for storing their drilling equipments and warehouses “ A” and “B” have capacities of 14,241 and 5,080 tonnes [1]respectively. The new port has four transit sheds and two warehouses. Both ports have large stacking areas for outdoor cargo storage.

Other ports under the Delta port complex are Sapele, Burutu and Koko ports. The Delta port complex concession comprises of the following operators; Intels, AMS and Julius Berger.

Rivers Port Complex

The Rivers port complex, otherwise known as the Port Harcourt port, is the third largest port complex in Nigeria. The port was built in 1913 during the colonial period, to export coal and other cash crops from the eastern part of Nigeria to Europe. The complex comprises of Port Harcourt port; Okrika refined petroleum oil jetty, Haastrup/Eagle cement Jetty, Kidney Island Jetty, Ibeto Jetty and Macobar and Bitumen Jetties. It is a natural port comprising of eight berths and a quay length of 121kms. The average draught along the quay is 8.97m which can berth vessels of 15,000 tonnes deadweight.

[1] 1Tonne=1000Kilograms throughout this thesis

Port Harcourt port has two concessionaires, namely: Ports and terminal operators' limited (PTOL) and BUA ports and terminal limited (BUA). However, other services such as pilotage, towage, pollution and bathymetric surveys/ dredging of the channels are still the responsibility of the NPA.

Onne port Complex

Onne port started operation in 1982 under a Public-Private Partnership (PPP) arrangement. In other words, it began operation *abinitio* as a landlord port. The Onne port is situated on the Bonny estuary on Ogu creek, which is 25kms from Port Harcourt. It covers a land area of 2,500 hectares. Onne port complex comprises of two main terminal facilities, i.e. Federal Ocean Terminal (FOT) and the Federal Lighter Terminal (FLT). The Port jurisdiction includes the Nigerian liquefied natural gas (NLNG) jetty, NAFCON now known as NOTORE jetty and the midstream discharge at Buoy 9.

In 1986, the Port was designated an oil and gas free zone by the Federal Government via Decree No. 8 of 1986. Presently, over 120 companies operate in the zone, and it is a hub of and oil gas operations and logistics in West and Central Africa. All the major oil companies maintain a presence at Onne port.

The FOT comprises of three berths with a quay length of 750m. The draught alongside the quay is 12m, and the channel is 11.5m, while the turning basin is 530 metres. The FLT has four berths and a total quay length of 1670 metres. Intels and Brawal operate the terminal. In 2010, another container terminal was carved out called West African Container Terminal (WACT) and located in the oil and gas free trade zone; it was concessioned to AP Moller Terminals. It has since commenced operation to cater for the greater Port Harcourt area and eastern Nigeria, including the local lucrative oil industry.

Calabar Port Complex

Calabar port is located 55 nautical miles from the Fairway buoy to the Calabar River, at latitude 4055'N and longitude 8015.3'E. The history of Calabar could be traced to the 15th century, as the pre-medieval merchants entered the eastern part of Nigeria for trade. Different shipping companies, such as M/S Palm Line Agencies limited, Elder Dempster Agencies, UAC and John Holts operated the port. The Federal Government of Nigeria took over the operations of the port in 1969 and handed it over to the Nigerian ports authority, due to the inability of the private companies to provide adequate facilities for the functioning of the port. Thereafter the modernization of the port of Calabar was included in the 3rd national development plan of 1975-1980, to provide port facilities that will cope with the increasing demand of the domestic economy. The new Calabar port was commissioned in 1979.

The port comprises a land area of 38 hectares, with four quays measuring 215m long and 40m wide, and the channel width is 150m. The port has six operational berths, two warehouses measuring 150m x 40m and 175m x 40m. The operational area has been delineated into two terminals, A & B. Terminal A (2 berths) is allocated to Intels Nigeria Limited (Intels) and terminal B (4 berths) to Ecomarine terminals limited (ECM) and the Old port is a concession to Addax Nig. Limited.

1.7 Yearly Traffic Pattern and Trends of Nigerian Seaports

Table 1.1 shows the traffic growth pattern of Nigerian seaports for the period under study. The highest growth rate of 34.05% and 24.53% were observed between 2006 and 2007 for GRT and throughput respectively in the year terminal operations were transferred to the private operators. It is followed by a growth of rate of 26.27% and 24.22% for GRT and throughput respectively, achieved between 2000 and 2001. The period is both economically and politically remarkable in the annals of the country. It is the time that democratic rule returned to the country after a prolonged rule by the military, which restored confidence in the country by the international community. The new democratic administration increased wages by over 500%, which increased the purchasing power of many Nigerians. Nigeria being an import dependent country, this boosted trade and the flow of all types of imports to Nigeria. Almost all the imports pass through the ports; therefore, this increases traffic flow and the volume of cargo that passes through the ports.

Table 1.1 Gross registered tonnage (GRT) of vessels and throughput

Year	GRT (tonnes)	Annual percentage change in GRT	Throughput (tonnes)	Annual percentage change in throughput	Number of vessels	Annual percentage change in No. of vessels
2000	44,432,370		28,932,880		4087	
2001	56,106,345	26.27	35,940,692	24.22	4473	9.44
2002	53,267,921	-5.06	36,987,241	2.91	4143	−7.37
2003	60,622,666	13.81	39,765,945	7.51	4315	4.15
2004	61,384,221	1.26	40,816,947	2.64	4553	5.51
2005	60,541,810	-1.37	44,952,078	10.13	4586	0.72
2006	63,267,047	4.50	46,150,518	2.67	4800	4.67
2007	84,806,792	34.05	57,473,350	24.53	4849	1.02
2008	89,505,702	5.54	64,372,749	12.00	4623	-4.66
2009	90,603,611	1.23	65,775,509	2.18	4721	2.12
2010	108,621,872	19.89	76,774,727	16.72	4881	3.39
2011	122,614,716	12.88	83,461,697	8.71	5232	7.19

The small percentage increase observed between 2008 and 2009 is due to the high level of congestion experienced at the Lagos ports. As terminal operators increased their capacity without a commensurate improvement in other related transport infrastructure, this gave rise to cargo build up at Apapa and TCIP. The congestion was so intense that the then NPA managing director, Oman Suleiman, suspended ship entrance into the Lagos ports from February to April 2009, to remove what was described as an "alarming backlog". This affected the growth of traffic for the period. However, the increase in the number of ships that call at Nigeria is below 10 percent for the period. Although that throughput grew by 12% between 2007 and 2008, the number of ships that called at Nigerian ports decreased by -4.66%. A cursory look at the GRT and the number of vessels shows a progressive increase in the size of ships that call at the ports from 2008-2011. For example, bigger container ships of 4,500 TEUs (WAFMAX) have started calling at Nigerian ports with the dredging of the Apapa channel and Bonny channel to a depth of 11.5metres. The structure of the remaining parts of the thesis is as follows:

1.8 Organisation of Thesis

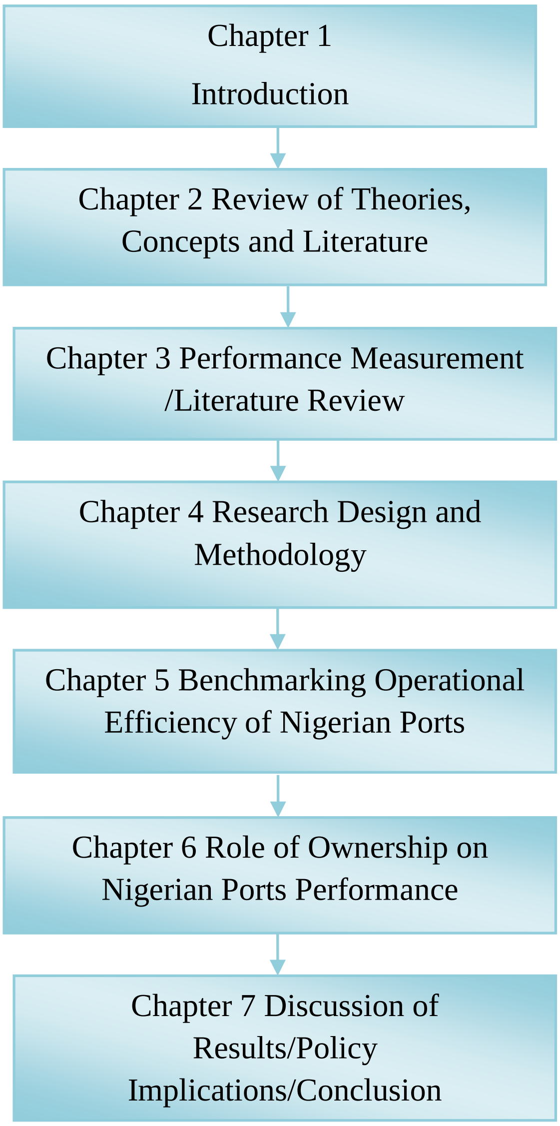


Figure 1.2: Thesis structure

Chapter 2 examines the theoretical underpinnings surrounding privatisation, competition, regulation and their relationship to efficiency, with particular emphasis on the port industry. The literature on studies dealing with the outcome of privatisation as it relates to the port industry is explored, and the gap in the literature will be revealed in order to situate this research.

Chapter 3 aims to review the literature on performance measurements, with a focus on efficiency and productivity evaluation techniques. The chapter also evaluates the different efficiency and benchmarking approaches available in the port industry with particular emphasis on Data Envelopment Analysis (DEA) and the Malmquist Productivity Index

(MPI). These will be the two methods employed in the analysis of the efficiency and productivity of Nigerian seaports.

Chapter 4 will describe the research design and strategy used to explore the influence of concession on the port industry in Nigeria. A number of analytical techniques, such as DEA and MPI, will be used in variable operationalisation. The survey design and analysis used to test the specific hypotheses will be explained. It elucidates the data collection methods and the criteria employed in this study.

Chapter 5 will utilise DEA variants of Inter-temporal, Contemporaneous and Window to analyse the efficiency of the ports for the 12 years under study and report on the results obtained. Also, the DEA-CCR (Variable returns to scale) with sets of panel data of six years (2000-2005 and 2006-2011) will be used to analyse the pre- and post-concession efficiency of the Nigerian seaports. The results obtained in the two analyses will be used to test the hypothesis. Equally, the chapter will explore the productivity change in the ports over the two periods by underpinning the sources of inefficiency.

Chapter 6 synthesises the findings of chapter 5 with competition and other exogenous factors to determine the role each plays in determining port operational performance. It is to assess the influence of ownership on efficiency and to model the performance of Nigerian seaports.

Finally, Chapter 7 discusses the summary of the key findings and draws conclusions based on the results obtained from the various analyses. It also highlights the policy and managerial implications of the study, based on the findings. In addition, recommendations will be proffered based on the outcomes of the research. This chapter brings out the limitations of the study and the areas of focus for future research.

Chapter Two: Review of Theories, Concepts and Literature

2.1 Introduction

This chapter reviews the various theories and concepts that underpin this research focusing on port privatisation and ownership. It also discusses economic attributes of ports and compares different port ownership and administrative models. It Considers that different management structures exist, and the quality of governance varies across countries. Additionally, for the fact that ports exhibit both public and private goods characteristics, the chapter argues for the need to adopt an appropriate ownership and regulatory framework which is country specific. It also discusses the different privatisation options and the trend in selected countries and Africa in particular, within the context of port management models presented previously. Equally it explores the relationship between privatisation, competitiveness, regulation and economic efficiency, theoretically. The final section of the chapter examines the empirical evidence of this relationship from previous studies.

2.2 The Concept of Port Services

In broad terms, a port can be defined as an entity (organisation) that provides services and facilities for ship turnaround (Trujillo & Nombela, 1999). In short, it provides facilities for loading and offloading cargo from vessels. Although this pedestrian view of ports may not be an up-to-date view of the contemporary port today, it captures the critical role of a port that has not been undervalued. The significant interest in ports and the services they provide revolves around efficient loading and unloading of cargo. However, the role of modern ports as of today is captured in the United Nations conferences on trade and development's (UNCTAD) definition;

"Seaports are interfaces between several modes of transport, and thus they are centres for combined transport. Furthermore, they are multi-functional markets and industrial areas where goods are not only in transit, but they are also sorted, manufactured and distributed. As a matter of fact, seaports are multi-dimensional systems, which must be integrated within logistic chains to fulfil properly their functions. An efficient seaport requires, besides infrastructure, superstructure and equipment, adequate connections to other transport modes, a motivated management, and sufficiently qualified employees" (Trujillo & Nombela, 1999, p. 4).

Furthermore, other definitions by authors such as Notteboom and Winkelmans (2001b) focused on the role of logistic networks while De Langen (2002) added the role of ports in industrial networks to the definition.

The later definitions show that the functions of modern ports have become complex and diversified, i.e. they have become centres of agglomeration of economic activities. Nevertheless, the primary role of seaports remains “loading and unloading” cargo; the other activities are regarded as value-adding, as they are not the main activities. Therefore, the importance of seaports to the economy hinges on the ability to facilitate international trade flows as the bulk of domestic and international trade is carried by sea. Seaborne trade depends on ports for its operations, as it acts as maritime/land transport (railways, road or inland navigation) interface. It implies that for efficient maritime transports, ports need to perform the core role of “lifting up” and “putting down” of cargo efficiently. Despite the complex and diversified nature of modern ports, they render the following services: cargo services, vessel services, infrastructure, marketing, management and security. Table 2.1 shows the different services and the activities involved in each category.

Table 2.1: Port functions

Service	Activities
Cargo services	Stevedoring, Long shoring, Equipment operations, Transit storage; Receiving and delivery, Cargo tracking, Assembly and processing (consolidation, bagging, packing, mixing); Storage and warehousing; Transfer to land transport.
Vessel services	Navigational aids, Pilotage, Towage, Mooring, and Bunkering, Utilities, Reception facility (garbage removal), Stowage, Anchorage, Buoys, Launch services and Vessel repair.
Infrastructure	Hydrographical surveys, Dredging, Repair and maintenance, Engineering design, Port construction, Equipment procurement.
Marketing	Market research, Promotion and sales
Management	Billing accounting, Data processing, Staffing
Security	Security forces, Fire and rescue, Pollution control

Source: Adapted from Cheon (2007b).

The functions reveal that multiple services are provided within the port area. More often, these services can be provided by independent firms working in the port and the services can also be provided by a single firm in the case of small ports. The space limitation reduces the number of feasible operators within a port area. Sometimes, only a single operator can be accommodated in the case of small ports in remote locations (Trujillo & Nombela, 1999). The agency that normally coordinates the activities and ensures the proper use of common facilities takes care of safety and general design of port facilities is called the port authority. The next section discusses the role that port authorities play in the port industry.

2.2.1 Port authorities

The governing body in-charge of ports is often referred to as a port authority, port management or port administration. The administration or governance of ports is of crucial importance for the organisation, coordination and control of port activities (Cullinane & Song, 2002). A commission of the European communities, 2001, defined a port authority as *"the entity, which whether or not in conjunction with other activities, has its objective under national law or regulation, the administration and management of port infrastructures, and the coordination and control of the activities of the different operations present in the port"*. De Monie (2004), observed that the term port authority connotes a public form of port management. However, it is used as a generic term to describe the body with the statutory responsibility of managing a port's water and landside domain. While Verhoeven (2010) argued that, irrespective of the ownership and management entities to which port authorities belong, they are hybrid entities that contain some elements of both public and private law. Therefore, they are conferred with an exclusive right of administrative action and in some cases even criminal law competence and at the same time they are undertakings that compete (Verhoeven, 2010). These far-reaching attribute flow from the fact that seaports possess both public utilities and private enterprise characteristics (Meersman & Van de Voorde, 2002).

Port authorities can exist at all tiers of government, be it national, regional, provincial or local. Although the most prominent is the local port authority, that is an authority that exercises jurisdiction over the port area. National port authorities exist in countries such as Aruba, Nigeria, Sri Lanka and Tanzania (World Bank, 2007b). The traditional roles or functions of port authorities are classified into three categories; landlord, regulator and operator (Baird, 1995; Baltazar & Brooks, 2001). These three broad classifications are in tandem with the legal status of port authorities (Van Hooydonk, 2002). Other classifications do exist, but they are still linked to the three major broad categories. Regardless of whether the port authority owns the land, or manages it on behalf of the national or local government, the functions of ports outlined previously in Table 2.1 are carried out or coordinated by the port authorities. For instance, the landlord port authority performs the duties of the landlord of the port. As the administrative responsibility of the Landlord port is vested with the Landlord port authority (Baird, 2000; Baltazar & Brooks, 2001; Van Hooydonk, 2002). Likewise the operational and regulatory roles of ports, although the landlord function is regarded as the most important function of a modern-day port authority from the value chain perspective (Dooms & Verbeke, 2007).

The statutory roles of national port authorities, as listed in the United Nations Conference on Trade and Development (UNCTAD) Handbook for Port Planners in Developing Countries UNCTAD (1985) are as follows: (a) the approval of a port investment plan in line with the national plan maintained by the authority; (b) setting of the port’s financial policy which will bring a return on investment; (c) infrastructural funding and to advise government on funding alternatives; (d) regulation of rates and charges by setting a tariff policy that will protect the public interest; (e) set the labour policy, which is impartial, to minimise friction between labour unions and management; (f) licensing of third parties to provide certain services to the port; (g) collect, collate, analyse and disseminate information on port activities and sponsor port research when necessary and (h) provide legal advice to local port authorities.

The changing role of the port environment, due to privatisation, has altered the traditional role of port authorities. It has been so much, that Goss (1990a) has questioned the need for port authorities, recommending repositioning and development of new strategies. Notwithstanding the necessity of establishing public ports’ authorities have been called into question. The prevailing situation globally favours having one, either at a local or national level, depending on the size of the country (Juhel, 2001). It is necessary to have a clearly identifiable public partner that represents the public interest, to act as a partner to the private sector in negotiating and implementing new operational strategies for the port industry. The absence of such authority, that can be accessible locally, could be an obstacle to the development of a viable public-private partnership. Moreover, the new envisaged roles apply mainly to port authorities in developed countries, as the developing countries are still struggling to fulfil the traditional roles.

2.2.2 Port operators

As there are roles for central governments and port authorities, so also port concessionaries (such as stevedoring firms, cargo handling companies, and terminal operators) play key roles in the port communities. Terminal concessions are granted to companies with different backgrounds. The award of the concession to private entities expands their activities to terminal operations, so they become terminal operators. The private entities form an important strand in the concession process, as its success, or otherwise, depends on the experience, behaviour and the performance of the private parties (Theys, Notteboom, Pallis, & De Langen, 2010). There are many classifications of terminal operators in the literature; the most recent is Farrell (2012), which identified 11 groups based on the geographical reach and activities of the entities involved in concessions. They include: Global terminal operators (GTO), Regional terminal operator (RTO), Stevedores (STE), Shipping lines (SL), Freight transport companies (FT), Construction companies (CC), Equipment manufacturers (EM), Property developers (PD), Industrial conglomerates (IC), Public authorities (PA) and Financial institutions (FI).

There is another proposed classification of terminal operating companies by Bichou and Bell (2007), namely: terminal operating shipping shippers (TOS). This group engage mainly in bulk cargo operations, examples include oil companies such as Shell, or cement companies such as Dangote. Another group is the terminal operating shipping lines (TOSL) that operate port facilities by acquiring long-term concessions or leases. An example of this is APM terminals, where the parent company is the Maersk shipping line. There are also terminal operating port authorities (TOPA), which have expanded their activities by operating ports or terminals in other countries as their base. Lastly in this classification, is the terminal operating companies (TOC). This group are made up of companies that undertake activities in logistics, property development, or related business ventures and have extended to international port operations and management. Companies in this group include HPH, ICTSI and SSA Marine. The TOCs are also regarded as transnational terminal operating companies (TTOs) by Slack and Frémont (2005). Parola and Musso (2007) categorised terminal operating companies into three broad groups, the pure stevedores, integrated carriers and hybrid terminal operators.

Nevertheless, the two most outstanding concession participants are the GTOs and the shipping lines involved in concessions. The role of GTOs is critical to port operation as literature has revealed that international terminal operators are the dominant players in the cargo handling industry, especially of containers. The top ten terminal operators handle 64.4% of total world cargo (Notteboom & Rodrigue, 2012). The GTOs successful inroad into port operations can be attributed to the strategic importance of seaports and the need to secure reliable supply chains (Farrell, 2012). Also, Farrell (2012) was of the view that due to size, reputation and independence, the international terminal operators are better placed to attract business to ports. The presence of GTOs in many ports provides the ease of switching equipment and management resources around the world, hence the flexibility to respond to market changes. In addition, Notteboom and Rodrigue (2012), described GTOs as market seekers that pay particular attention in selecting their locations.

Furthermore, the market segment for single-user terminals operated by global container carriers is expanding rapidly (Wiegmans, Hoest, & Notteboom, 2008). The growth is possible because shipping lines strive to secure terminal capacity at major locations globally through vertical integration of shipping lines into port operations. It provides the shipping lines the control of their global door-to-door services. The assumption is that the operation of terminals by shipping lines will result in efficiency gains, delivery of better service and reduction in port charges (Slack & Frémont, 2005). Another advantage derivable from shipping lines operating port services is throughput guarantee, resulting from the vertical integration in the supply chain. According to Farrell (2012), although many new companies have entered the terminal operation market, only very few outside the shipping companies are successful. That notwithstanding, shipping lines are keener on locations with the potential for high-value additions in the overall supply chain (Notteboom & Rodrigue, 2012).

Typically, most port operators are private firms that pursue conventional microeconomic objectives, such as profit maximisation, growth and additional market share. The creation of an enabling environment for port operators to freely pursue such objectives ensures the achievement of benefits of a market-orientation in ports. The nature of a port service confers it with unique economic characteristics, explained in the following section.

2.2.3 Economic characteristics of port service

2.2.3.1 Public versus private goods characteristics

Sloman (1997, p. 349) defined public good as: *"a good or service which has the features of non-rivalry and non-excludability and, as a result, would not be provided by the free market"* According to Coase (2005), it is impossible for suppliers to exclude potential consumers in public goods. While Goss (1990a, p. 265) views public goods as; "those which are unlikely to be provided sufficiently, satisfactorily, or at all, by competitive industries". Thus, public goods should be provided where there is some market failure. However, a good or service is regarded as a public good if it fulfils the following conditions: joint or non-rivalrous consumption; inability to exclude those who refuse to pay and non-rejectability of consumption (Goss, 1990a). The basis of classifying public goods by modern economists is "the practical impossibility to charge for the use of the goods" and "the indivisibility of the cost of the goods, so the marginal cost is zero" (Baird, 2004).

In terms of ports, the economic characteristics of non-divisibility and the high cost of providing port infrastructure is the impetus for traditionally regarding ports as public goods, although some port services can also be provided privately. Ports are regarded as public goods due to the significant role they play in facilitating trade growth and associated economic developments. These economic multiplier effects have been used to justify direct public sector investment in ports, as the narrow, non-rivalry and excludability theory of economics has been rendered ineffective as a result of advancements in technology (Baird, 2004; Song, Cullinane, & Roe, 2001). In support, Abbes (2007) argued that the model of regarding ports as public goods is fast disappearing. Due to institutional reforms in the port sector, it is gradually being replaced by the model that allows the sharing of the functions in the port between the public and the private sector.

Another argument for government engagement in the provision of port services directly, is that port services are considered as merit goods. Rosen and Gayer (2008) described merit goods as services that are required to be supplied even if the public do not demand them directly. Another reason adduced by governments for engaging in the provision of port services publicly is externalities associated with the production of the service. Carlton and Perloff (2005) are of the view that externalities occur when the user of the service does not incur the full cost of the harm their actions do to others. Alternatively, they enjoy the full benefits the goods have brought to others. It means that externalities can be negative or positive depending on its effects on others. For instance, the negative impact of pollution caused by shipping is being borne by individuals who did not participate in creating the pollution.

Carlton and Perloff (2005) define private goods as those that if consumed by one, cannot be consumed by another. Ports can also be viewed as private goods because of the direct economic benefits generated from their operations. Market transactions between private parties exert influence on the value of the majority of private goods. On the contrary, a considerable value of public services is not obtained from a transaction, because the buyers and sellers act independently and have no direct relationships. Therefore, private firms have no motivation to produce them. The positive externalities and social benefits generated by public goods are in excess of the price the private sector can charge for them. Therefore, some public intervention is necessary to ensure the adequacy of production. Sechrest (2003), provided examples of private provision of public goods in the maritime industry, as cargo handling, towing and mooring.

In summary, it can be argued that although some port facilities have been viewed as public goods, seaports considered as a whole do not exhibit public goods' characteristics. It is not possible to exclude users and it is not feasible to produce the same quantity of services to more users without increasing costs. Therefore, seaports from an economic perspective do not necessarily have to be in the public domain, as it is possible to operate them as commercial organisations. However, considering the strategic importance of seaports to the overall national economy, the objective of governments should be geared towards ensuring that efficiency gains are achieved through private participation. It is these configurations and how to balance public and privates interests that make port ownership and administration cumbersome.

2.2.3.2 Perfect competition and natural monopoly

The classic and common argument for classifying all ports as natural monopolies is fast fading, as ports possess both public and private goods characteristics. In support, Perez-Labajos and Blanco (2004) argued that the separation of infrastructure and superstructure (vertical disintegration) and segregation of services (horizontal disintegration of activities), shows the extent that competitiveness can be introduced. According to Perez-Labajos and Blanco (2004), the only reason to justify the separation of port activities, and the introduction of competition, is the perceived efficiency gain. However, it is not clear whether the production and provision of a private good publicly will lead to a more efficient service. Although economic theory suggests that assuming perfectly competitive market conditions, the marginal cost will equal marginal revenue, and the perfectly competitive quantity of goods will be supplied and purchased (Shepherd & Shepherd, 2003).

Figure 2.1 shows a perfectly competitive market condition for a privatised firm; here the market equilibrium would be at a price of 100GBP for a quantity of 20,000 seats per year. The assumption is that in a perfectly competitive market, the buyers and suppliers face the same price. At that point ("a" in our case), marginal revenue (benefit) is equal to marginal cost. The market is considered economically efficient at that point, as all participants in the market act selfishly and independently without any government intervention. The above scenario is based on the assumption that firms supply the same product, using the same resource and compete only on price. In essence, the profit-maximising Pareto equilibrium then does not promote competition, which is highly unrealistic.

Therefore, if the natural monopoly argument is upheld and the public operates seaports, the SOEs (PAs) may with time be confronted with increasing competition, arising from the introduction of new products and processes. The situation may arise due to either delayed investment by the public port authorities or alternatively, the private entities find alternative ways of funding capital investments (Baird, 2004; Haralambides, Cariou, & Benacchio, 2002;

Shepherd & Shepherd, 2003). Ports in the public domain are less proactive in embracing new technology compared with their counterparts in the private sector (Notteboom & Winkelmans, 2001b; Shepherd & Shepherd, 2003).

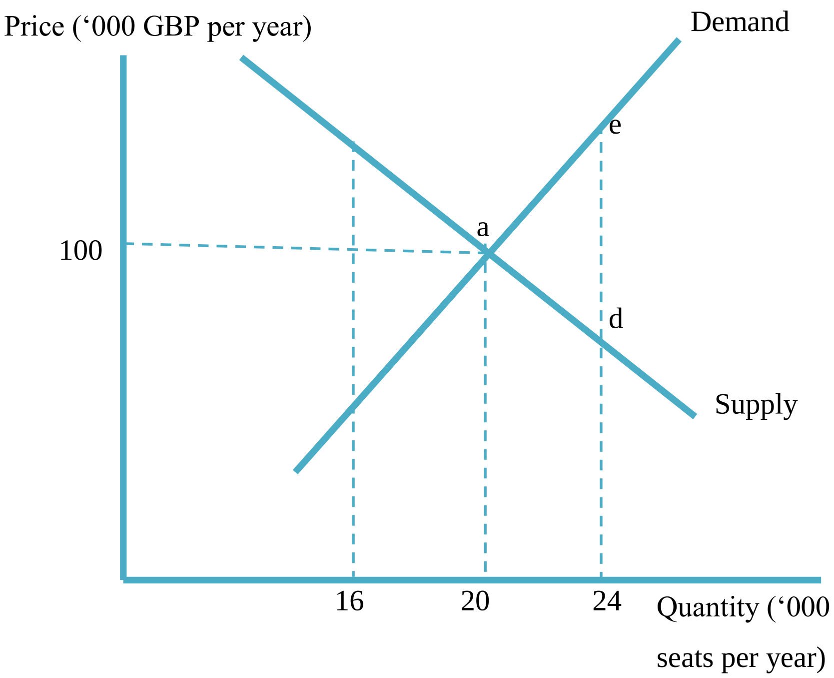


Figure 2.1: Perfectly competitive market

Source: Newman (2013)

Taking into account that ports are private services (goods) that can be provided publicly, there have been suggestions as to why ports exhibit monopolistic behaviour. Newman (2013) argued that the provision of port services requires massive investments in developing infrastructures, such as construction of quay walls and berths; provision of hinterland linkages e.g. rail and road and continuous dredging. Thereby constituting a significant barrier to entry, as well as limiting the number of viable locations for establishment of a port. However, Fischer (2007) and Engel, Fischer, and Galetovic (2013) give an interesting description of natural monopolies as being existent in the presence of increasing returns to scale. In the provision of services such as electricity, water and mass transit, over time, average cost diminishes at a rate that only a single provider can be sustained at a certain point in time. At this point, positive profits are no longer feasible because price equals marginal cost (Engel et al., 2013). Hence, the provision of port services could be regarded as having increasing returns to scale due to the massive capital investment required.

Therefore, the provision of port services may be seen as a natural monopoly. However, that does not mean the state should provide it, neither does the presence of increasing returns to scale mean that a government monopoly should exist. There are three options open to government as suggested by Fischer (2007), to handle natural monopolies: firstly sale of the monopoly rights to a private entity, while the government regulates taxes payable by the private monopolist. Secondly, government could provide the initial capital outlay for infrastructure investment. Then, the provision of port services is open to competitive bidding for many suppliers to undertake the production of port services so as to improve the quality of service to the consumer. Finally, in the case of a natural monopoly, the state should either opt to set prices or regulate the profits of the private operator in order to protect consumer (Ferguson & Ferguson, 1994)**.**

Nowadays, the model of regarding ports as natural monopolies is only relevant where inter-port competition is imperfect, observed, mostly with ports that serve captive hinterlands. Even then, monopolies tend to disappear with the introduction of intra-port competition through privatisation. For ports with contestable hinterlands, inter-port competition reduces economic rents for competing ports. As a result, the trend these days is towards the sharing of responsibility between the public and private sectors by granting operational rights through concession agreements. Then the role of government should be to ensure that the consumers of the service are not unduly exploited. This could be achieved by putting in place a robust regulatory framework in the form of price setting or profit regulation (Farrell, 2002; Lambertides & Louca, 2008; Notteboom, 2006, 2007b; Theys et al., 2010). Therefore, the economic characteristics of ports give rise to different port ownership models, as discussed in the next section.

2.3 Conceptual Framework for Classifying Port Ownership and Administrative Models

Th**e** economic characteristics of ports discussed above show that there are many activities performed concurrently within the limited space of the port area. The agency that normally coordinates the activities and ensures the proper use of common facilities takes care of safety, and the general design of port facilities, is called the port authority. The configuration of most port authorities is public, but there are instances of purely private authorities. However, depending on the role assumed by port authorities, different models of organising ports do exist. In other words, different port ownership and administrative structures arise as a result of the distribution of property rights of infrastructure, superstructure and services. Alderton (2005) provided a traditional classification of port ownership as; state ports, autonomous ports, municipal ports and private ports. Goss (1990b), Heaver (1995) and De Monie (1996), identified three types depending on the role played by the port authority. The World Bank Port Reform ToolKit (WBPRTK), World Bank (2007a) outlined four administration models. The four WBPRTK administration models are the Service port, the Tool port, the Landlord port and the Private Service port. The models differ in terms of whether services are provided by the public sector, the private sector or mixed ownership providers, their orientation (local, regional or global), the ownership of superstructure and who provides dock labour and management. However, it is not unusual to find hybrid models that combine the features of a number of other types (Bichou & Gray, 2005).

Mangan and Cunningham (2000), provided four models. Likewise, Baird (1995) and Baird (1997) identified four models as an alternative framework for analysing port administration and ownership, which are referred to as "Port Function Matrix" (Table 2.2). The conceptual framework of the two approaches is the assumption that a port, whether in private or public hands, provides three essential functions within the port area, namely; the regulatory function, the landowner function and the operator function. Regulation clearly describes the control of port land areas and the responsibility to manage the port estate. As well as the planning, implementation of policies and strategies for the port's physical development of superstructure and infrastructure and management of other stakeholders operating at the port. It can be regarded as the primary role of port authorities, as they are mainly statutory powers granted to the public or private ports' management (Nagorski, 1972). The operator function involves physical handling of cargo and passenger tasks between sea and land. Mangan and Cunningham (2000), described the operator function as a cargo handling function which entails loading and unloading of vessels, cargo storage and provision of value-adding services. The landowner function concerns the management and maintenance of physical assets, such as quay walls, berths, terminals and parking areas.

Table 2.2: Port function matrix

Port Functions			
PORT MODELS	**Regulator**	**Landowner**	**Operator**
PUBLIC	Public	Public	Public
PUBLIC/private	Public	Public	Private
PRIVATE/public	Public	Private	Private
PRIVATE	Private	Private	Private

Sources: Baird (1995) and Baird (1997)

The arrangement of the basic functions of the port by the matrix makes it possible to ascertain the level of influence exerted by the public or private sector in a given port. Depending on which of the functions is the responsibility of public or private organisations. The Baird's port function matrix and the WBPRTK (World Bank, 2007) classification are the same, the difference being in the nomenclature. In the PUBLIC model, the three functions are undertaken by the public port authority, or under the control of any agency appointed by the government. It is synonymous with a comprehensive port service model in the World Bank classification. The challenge with this model is that it could lead to inefficiencies in service provision, as the port regulates itself in the provision of services. The PUBLIC/private port depicts the model in which the operator function is the responsibility of the private sector, and the government controls the regulatory and landowner function. It is the Landlord port or model, according to the WBPRTK. This model allows the government to retain control over land, infrastructure and regulation so as to safeguard public interest, while the expertise of the private sector is brought to bear on the operations. Baird (2002) study of ownership of the top 100 World container terminals demonstrated that this model could lead to improved efficiency. The PRIVATE/public port is a variant of the Tool port model in the World Bank classification. Here both the operator and landowner function is in the hands of the private sector, while the regulatory function is under the public domain. This model could ensure a good return on investment for operators who assumed all the risks involved in investing in an unpredictable port environment. On the contrary, the ownership of land and operation of all services by the private sector may result in the transfer of a public monopoly to a private monopoly. Last but not the least; the PRIVATE port is a port in which the three primary functions of the port are controlled by the private sector. The concern with this model is that it may create a monopoly and lead to market failure, as the private is left to provide all services without oversight.

Although traditionally ports were publicly owned, the global trend nowadays is to move from purely public ports towards a port with greater private sector participation. Thus, making the public/private the most widely preferred model (Baird, 1995, 1999). Other authors, such as Saundry and Turnbull (1997), Notteboom, Pallis, and Farrell (2012) were also of the view that the landlord model is the most widely applied. Although the method of application differs within or between countries, even Europe with strong central administrative bodies for ports, differences exists between Latin and Anglo-Saxon countries. Additionally, Van Reeven (2010), is of the view that the Landlord port model is the dominant model in large and medium-sized ports. This is due to the unique attribute of vertical separation of port authority and service provision, which allows competition between different service providers in a port. Another factor that make the Landlord model the natural choice for most port privatisation programmes, is the long-term nature of concession contracts (Baird, 2002; Kent & Ashar, 2001; World Bank, 2007a). This makes it relatively easy to attract investment to the port. In addition, there is rapid response to market fluctuations, as the private sector is in charge of cargo handling operations and at the same time owns, operates and maintains all the equipment used in cargo handling.

On the other hand, Brooks (2004) warned that the Landlord model despite the enthusiasm for it, could lead to over-capacity and duplication of marketing efforts, as operators try to expand. Additionally, there is an inherent risk of underestimating the time for additional capacity. Tull and Reveley (2001) argued that the broad acceptance of the model should not shield it from the fact that within the port utility function, the private sector may or may not be investing in port superstructure. As the model allows for private investment in superstructure. Baird (2004) admonished that, although the matrix provides a theoretical understanding of different types of port ownership models, the degree of public involvement should naturally be dependent upon national ideology. In support, Cass (1996) and Heikkila (1990) cited the example of the United States, where the municipal authority plays a significant part in the operation of the port. Thi is in contrast to Taiwan, where administration of ports is centralised.

2.4 Port Privatisation

2.4.1 Definition

The diversity of privatisation is not unique to the port sector. The structures and policies vary not only in developed economies, but also within developing economies. The term port reform has become analogous to privatisation, whereas it is an aspect of port reform. Likewise, other terms, such as Devolution, Corporatisation, Commercialisation and Deregulation have frequently been used in literature in place of privatisation since the popularisation of the term by Thatcher's government in the early 1980s (Baird, 1997; Cullinane, Ji, & Wang, 2005a; Ircha, 2001). Many authors have described the difficulty in defining port privatisation. Ircha (2001) defines port privatisation as all manner of steps taken to enhance the commercial orientation of port operation. While Cass (1996) defines it as the actual transfer of ownership of port properties from the public to the private sector, *or* as the application of private capital to fund investment in port development and maintenance, as well as in certain port activities. However, a more apt, precise and encompassing definition is captured in the guideline for port authorities on privatisation of port facilities as; "the transfer of ownership of assets from the public to the private sector or the application of private capital to fund investments in port facilities, equipments and systems" (UNCTAD, 1998, p. 1). In economics parlance, without actual private ownership or the private funding of port assets or services, there can be no privatisation.

This definition captures the essence of port privatisation, because the increased participation of the private sector in the provision of port services, without corresponding private investment, can only be viewed as port devolution, not privatisation. This distinction is necessary because seaports, due to their size and strategic importance in the global trade supply chain, have been the target of neo-liberal reforms. The 1980s witnessed many countries, especially in the Western World, adopting various economic concepts, such as commercialisation, corporatisation and privatisation, in reforming their port authorities. However, many of these approaches overlap, for instance in terms of privatisation there is an array of techniques, or combination of techniques, that the concept embodies. Although the three different concepts may seem the same, as they involve ways of injecting private sector principles into the public port authorities, they are different in economic terms. For instance, commercialisation means making public port authorities aware of the needs of its public and private clients, by making them more accountable for their decisions, operational performance and financial results. It also presupposes non-interference of government, or other public institutions in the activities of the port authority (Tull & Reveley, 2002; UNCTAD, 1998). In West Africa, commercialisation ranges from the reforms to improve efficiency and profitability, to financial independence from the state (Iheduru, 1993). On the other hand, corporatisation entails given public organisation the legal status of a private corporation or company while government still owns the shares of the company. Despite that, the land and other assets are legally transferred to the newly formed company but the port remains in the public domain. The establishment of a clear-cut accountability process and competitive neutrality i.e. a situation where the public company faces the same market forces as the private counterpart is an essential requirement of corporatisation (Tull & Reveley, 2002; UNCTAD, 1998).

Another term used in literature to describe privatisation is deregulation which represents the elimination or liberalisation of rules and regulations that inhibit a free market and which can have negative and positive consequences (UNCTAD, 1998). Although the elimination of restrictive port rules and regulations in order to usher in a free market and promote efficiency is a welcome development, there is a need for at least a minimum level of regulation to ensure that the management and operation of ports respect international codes, rules and regulations about safety, environment, security and employment.

Nevertheless, UNCTAD (1998) refer to privatisation, commercialisation, corporatisation and deregulation, as concepts as they involve the process of assigning a greater role to the private sector in the management of economic activities, or granting greater freedom for the private sector to operate. Coltof (1999), called them strategies of port reform. In order to realise these concepts, various instruments are employed to ensure implementation. Trujillo and Nombela (1999) and Guasch (2004) identified 7 different instruments that can be used to engage the private sector in the port industry as: full privatisation (outright sale); Build operate and own (BOO); concession contracts (Build/Rehabilitate, operate and transfer, BOT/ROT); Joint venture, Leasing, Licensing and Management contracts (Figure 2.2). However, it is the type of privatisation that is adopted that determines the instrument to be used. The primary objective of port privatisation is to improve the efficiency and flexibility of doing port business. In any case, no matter the type of privatisation, the primary objective should be to substitute the less efficient, bureaucratic and often politicised operations in the public sector with more efficient port operations.

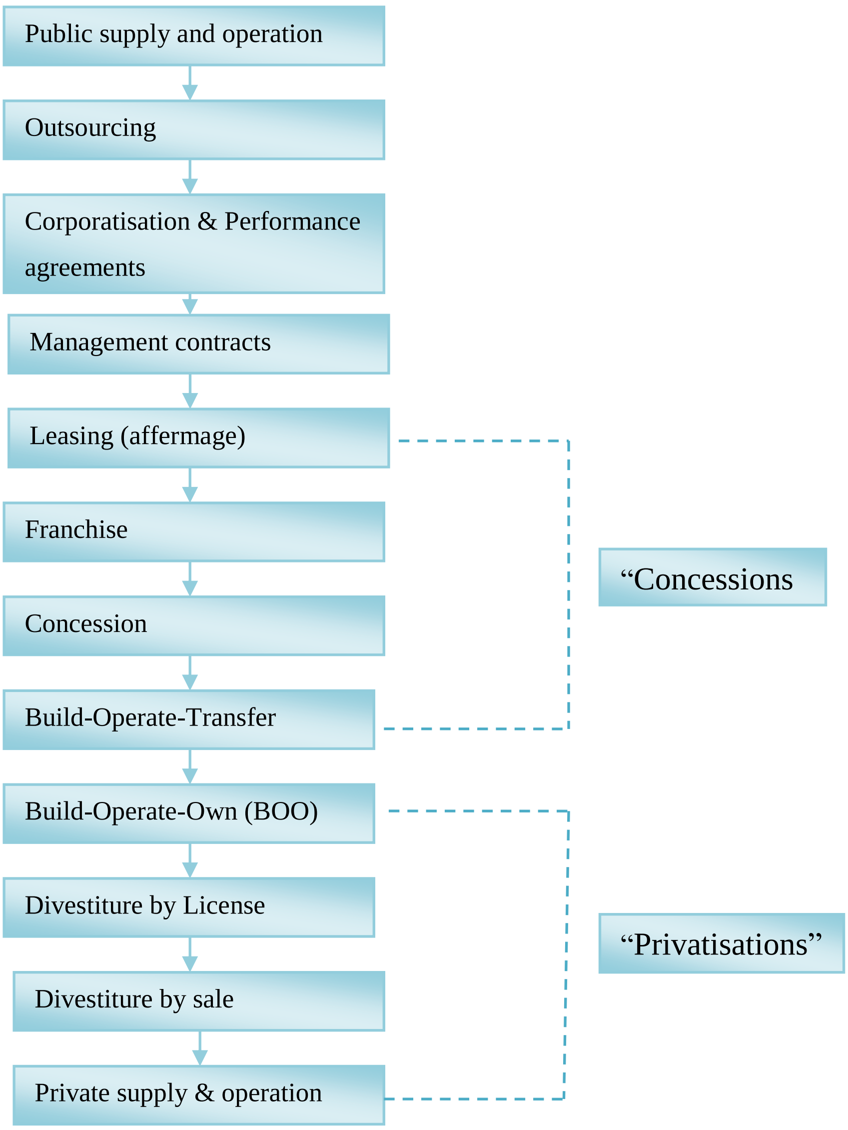


Figure 2.2: Array of Privatisation Options in the Port Industry

Source: Adapted from Guasch (2004)

2.4.2 Concession agreement as an instrument of port privatisation

A concession from an economic perspective is in the form of a public-private partnership arrangement, used to engage the private sector in the port business. Brooks and Pallis (2008) describe a concession contract as a legal instrument used to assign roles and responsibilities between the private and the public. Concession can be described as;

"*An arrangement whereby a private party – the concessionaire – leases assets from a public authority for a given, usually extended, period and has responsibility for new fixed investments during the period and for providing services associated with the assets. In return, the concessionaire receives specified revenues from the operation of the assets. At the end of the contracted period, the assets revert to the public sector or a new concession is awarded*" (Aronietis, Monteiro, Van de Voorde, & Vanelslander, 2010, p. 3).

In broad terms, a concession contract is a legal agreement in which the government grants a firm the right to provide services with significant market power. It allows the government to retain the ownership of portland and at the same time license operators, engage in construction activities and ensure that public interests are protected. It also frees government from operational risks and financial burden Farrell (2012). It equally allows for competition between different operators within the port, for ports with considerable size. However, for small sized ports, concession as a means of introducing competition for the market in the absence of competition in the market may not be feasible. It is a widely used tool by port authorities to improve the fortunes of ports through the award of port services to private international terminal operators (ITOs) (Notteboom, 2007a; Pallis, Notteboom, & De Langen, 2008). The attraction of the policy is that, through the contract award procedure, the port authorities can in principle retain some control over the organisation of the port and the structure of the supply side of the terminal market. At the same time, making sure that the portland resource is put to optimal use (Notteboom, Verhoeven, & Fontanet, 2010).

Concessions are extensively used in the port sector and may include the rehabilitation or construction of infrastructure by the concessionaire. For example, the World Bank private participation infrastructural database published in WBPRTK, (2007), shows 299 port projects for the period 1990-2006. A breakdown of the number indicates that 151 were direct concessions, 107 greenfield projects mostly land concessions, 23 management and lease contracts and 18 divestiture projects. In 2006 alone, there are 59 seaport projects, 40 of which were concessions.

According to Notteboom (2006) and UNCTAD (1995a), concession contracts can be in the form of Build-Lease-Operate (BLO); Build-Operate-Transfer (BOT); Rehabilitate-Operate-Transfer (ROT); Build-Rehabilitate-Operate-Transfer (BROT) and Build-Operate-Share-Transfer (BOST). Although long-term leases and operating licenses are most often regarded as a concession they are not the focus of this study. The different concessions can be classified into two categories, Brownfield and Greenfield projects (Farrell, 2012). Greenfield concession contracts refer to agreements for newly built facilities, or port development at new locations. Brownfield project concessions involve either the rehabilitating of facilities already in operation, or the granting of expansion rights. However, most national port concession programmes involve mixed structures i.e. the transfer of an existing operational terminal along with a commitment for building of a new Greenfield terminal by the operator. Mixed concessions can be found in the Frihamnen/Norvikudden terminals at Stockholm, the Rajiv Ghandi/Vallapadam terminals at Kochi, the Dakar/Port du Futur in Senegal, the Djibouti/Doraleh and the Tincan Island/Nigeria. Invariably, concession is not only the most applied privatisation instrument in the port industry; it is also the most capable of maximising the operational efficiency of ports with less friction between the PAs and the terminal operators.

2.4.3 Justification for port privatisation

Ports are complex organisations with responsibilities devolved to the port authority, government and the private sector. Arguments for public ownership of ports revolve around the natural monopoly attribute of ports. Hence, it is theoretically assumed that public ownership will deter ports from exploiting monopoly rents. Although there have been other motives adduced for public ownership of ports, such as: the inability of the private sector to undertake costly investments of a long term nature, the desire to prevent or perhaps create preferential treatment between different port users (for example, cheaper charges for exports), the need to put the activities of the ports in cycle with those of hinterlands; and national security and regional economic developments, are typically some of the arguments against privatisation (Haarmeyer & Yorke, 1993; Tull & Reveley, 2002). However, there is no compelling empirical evidence to prove that efficiently run private ports will endanger these concerns.

On the other hand, the privatisation of ports is implemented based on the objectives of the programme, and it is the potential for achieving the goals that provides the justification for the exercise. UNCTAD (1995a) outlined the general objectives of privatisation as: encouraging efficient port services, branching out port services and improving competition, minimising cost of port services streamlining processes and organisation, reduction of government financial and administrative burden and minimising of bureaucratic/political interference. The argument for port privatisation hinges on the perceived benefits that accrue to stakeholders (government, transport and terminal operators, shippers, exporters, importers and consumers) from the implementation of these objectives. It is derived from the widely held belief that the private sector is inherently more efficient than the public sector (Eyre, 1990).

Governments at national or state level embrace port privatisation, due to the perceived macroeconomic benefits: improvement in external trade competitiveness by reducing the cost of port services that impacts on overall transport cost. Reductions in the financial burden of governments (budgets) as part of port investment and the operating costs, are transferred to the private sector, thus raising revenue for the government through sale of port assets (asset divestiture). At the microeconomic level, the belief is that the discipline of the private sector will be brought to bear on the ports, culminating in improved operational efficiency (Haarmeyer & Yorke, 1993).

From the transport and terminal operators' perspective the argument is that privatisation benefits them, as it leads to more cost-efficient port operation and services, resulting in effective use of transport assets and greater business opportunities. The shippers, exporters and importers benefit from privatisation through reduced costs that imply a lower cost of imported goods and intermediate products and enhanced competitiveness of exports. Moreover, for the consumers, privatisation means lower prices for goods and a broad access to a broad range of products from the improved access and increased competition between suppliers (WBPRTK, 2001).

It is in line with these benefits associated with privatisation that Tongzon and Heng (2005) suggested that, privatisation, even without a change in competition, leads to improved efficiency. As a result, many ports worldwide in the last three decades have reformed their ports through privatisation.

2.5 Survey of Global Port Ownership, Privatisation and Administrative Structure

United Kingdom

There are three different types of ownership models in the UK port system. Some ports are either under private ownership or under municipal control, while others are managed by a trust. All of them are autonomous, self-financing, open to market forces and do not rely on government support or subsidy. There is no governmental or regulatory control over tariff policies and commercial strategies, although aggrieved users may appeal on policies that affect them adversely. The Government of the United Kingdom do not grant subsidies to ports, in contrast to other European ports. Ports are expected to set their charges to cover operational costs and also charge lump costs to include investment and maintenance. The UK pursues a hands-off, or non-interference policy, in terms of economic regulation (Baird & Valentine, 2006). The United Kingdom experience is the most advanced form of port sector privatisation worldwide.

Several studies of the model criticised the model as falling below a market ideal (Baird, 1995; Saundry & Turnbull, 1997; Thomas, 1994). According to Baird (2000), the approach employed in devolving British ports posed a unique challenge, because prior to the sale of the ports, no market existed for the sale of portland. As a result, the author maintained that the base values used by the government to calculate the selling prices of the land were inadequate and suggested a regulator to prevent monopolistic tendencies by operators. On the other hand, Gilman (2003) argued that the new model shows that the UK government does not want to be involved in port management. Therefore in the UK, port regulation as distinct from port management, is almost non-existent. This experiment has been working well in Britain, though no other country has embraced the UK, or "Anglo-Saxon" model of port management, as called by Suykens and Van de Voorde (1998).

Baird and Valentine (2006) were of the view that the privatisation model adopted by the UK has only improved total throughput by only 75%, as at 2003. Although some cargo segments have witnessed astronomical growth in throughput, for example containers, and RORO cargo have increased by fivefold after privatisation. In the same vein, the study of the performance of British ports by Liu (1995) shows that the privatisation of British ports did not improve the performance of the ports. It shows that the high degree of privatisation does not imply a high level of efficiency. This observation is supported by Tongzon and Heng (2005), that the relationship between privatisation and efficiency is not linear, rather it is a U-shaped relationship.

United States of America

The history of the evolution of the USA ports, as traced by Ircha (1995), started from the private sector (as railroad ports) to the current status as public enterprises managed by local and regional administrative structures. The administrative framework consists of both public and private organisations involved in port management at national, regional and local levels, each with differing priorities, requirements and procedures (Newman & Walder, 2003). Olson (1992) identified 10 different forms of ownership system used in the USA ports and concluded that this approach has led to intense competition among the USA ports. Ircha (2001), agreed, by asserting that the decentralised system has proven effective in promoting local economic interest. Ircha (2001) concluded that the introduction of port reform and privatisation in North America has improved the performance of the port industry. However, Brooks (2006) and Helling and Poister (2000) criticised the system for allowing unfair subsidies and creating an uneven playing field between ports, both locally and internationally. Furthermore, Helmick, Wakeman III, and Stewart (1996) concluded: "subsidised competition may have created excess port capacity in the US. The US port system does not suffer from the 'Bandwagon effect' . As it adopts methods that suit the constitution, because there is no universal system of port governance, each country should be allowed to develop a system appropriate for their environment.

However, unlike many countries, there is no national port authority, rather authority is diffused throughout three levels of government; federal, state and local. It stems from the federal character of the US constitution, that reserves powers for the national, and others strictly for the states (Sherman, 2000). Nowadays, several USA ports, especially the Anglo-Saxon are applying the concession system. For example, Tacoma port in 2008, where concessions represent 75 percent of the total port revenue (Aronietis et al., 2010). The lack of a central port authority implies that in the USA unlike in other countries, the decision to privatise ports is not a national issue; rather it rests with the different authorities responsible for port administration. As a result, privatisation of ports has not taken root in the country. This portends negative consequences for the future competitiveness of the USA port industry. However, Khan (2013) is of the view that those ports that have embraced privatisation have shown significant improvement in performance. In the same vein, the study of the relative efficiency between privatised and publicly operated USA ports by Goulding (2005), revealed that the involvement of the private sector impacted positively on the efficiency and financial performance of USA ports.

Hong Kong

Port management in Hong Kong operates as a three-tiered hierarchy, (Cullinane & Song, 2001, 2002; Song & Cullinane, 2006). At the top is the government of the Hong Kong Special Administration Region (HKSAR), which leases land to the terminal operators. The second tier is the Marine Department, which acts as a port authority and performs regulatory functions and strategic planning. To assist these two tiers is the Hong Kong Maritime Industry Council (MIC) and the Hong Kong Port Development Council (PDC). The two departments are created from the Port and Maritime Board and charged with the responsibility of promoting the territory’s maritime and port industries. While the third tier consists of the four privately owned companies that own and operate all the container terminal facilities and perform all activities associated with the cargo handling. Hong Kong’s public-private arrangement is being used as a model of private sector participation. Despite the fact that Hong Kong ports have a relatively small land mass compared to the volume of cargo it handles, Hong Kong is one of the world’s biggest ports (Brooks, 2004). Though it is apparent from the Hong Kong example that private sector competition is associated with better asset utilisation, it does not confirm that the model is appropriate for all situations.

Singapore

Prior to 1997 the Port of Singapore Authority (PSA), was a public port authority under the government of Singapore, which owned facilities and operated the container terminal. On 1st. October, 1997 the PSA was corporatised. The corporatisation involved the transformation of the PSA from a government body, to one where government plays no role. It has a commercial objective and takes decisions on a commercial basis, like a private sector company. At the same time, it is an entirely owned government entity, because the government owned subsidiary Temasek Holdings (private) Ltd, holds 100% of the shares of the PSA corporation (Song & Cullinane, 2001). The corporatisation marks the separation of terminal operations from the functions of the port authority. The PSA Corporation is entrusted with terminal operations, while the Maritime and Port Authority (MPA) performs the statutory roles of the port authority. These changes in the administrative structure are necessitated by the need to enhance the commercial flexibility of the PSA Corporation to operate and invest more efficiently in the competitive environment of the emerging regional port market. In other words, it is the PSA strategy of going global (Juhel, 2001).

In December 2003, the PSA Corporation was restructured again to operate only on Singapore's domestic container terminal. At the same time, this newly downsized entity became a 100% subsidiary of a new holding company, PSA International. It is still a government entity because Temasek Holdings owns 100% equity of the company (PSA International, 2003c). Earlier in 2003, the PSA Corporation's other business interests transferred to Hazeltree Holdings Pte Ltd, still a subsidiary of Temasek Holdings to allow PSA International to focus on its core competence of port development and terminal operations. Since then, PSA International operates over 17 terminals in 11 countries, including Singapore port. The Port of Singapore is a success story having maintained the number one position in global port rankings until 2011, when it was overtaking by the port of Shanghai, China and has remained in second place to date. Thus, a corporation turned around the fortunes of PSA, from a national port authority to an international company and a global player in the container market. It shows that corporatisation as a way of injecting private sector ideas into the port industry, can improve performance if well managed.

Australia

Everett and Robinson (1998) were of the view that port reform commenced in Australia in the 1980s and prior to this period, ports were administered as state statutory authorities. Dick and Robinson (1992) claimed that the port reforms did not get it right, because the government failed to alter the fundamental structure of port authorities, which discouraged innovation and initiative. The ports ownership approach in Australia is a mixed one, depending on the locale. While most opted for a corporate structure, the State of Victoria ports of Geelong and Portland were privatised, and the government of Western Australia opted for a commercial model (Everett, 2003).

Everett (2003) observed that there was confusion in implementing Australia's corporatised model. While the ports are expected to perform as a private sector, the law allowed the Minister of transport to interfere in the day-to-day decision making. The ministerial intervention may lead to sub-optimal performance, or the non-realisation of commercial objectives, as a result of conflict between corporation laws and statutes establishing the entity. Thus, government ministers can exercise power over the activities of the corporation, whether or not they are in consonance with the goals and objectives of the organisation as suggested by the Matching Framework and the concept of fit (Brooks, 2004). In conclusion, Everett (2003) called for a legislative framework compatible with the port's appropriate corporate structure, for optimal performance.

Everett and Robinson (1998) further observed that the Australian port reforms have challenges, such as: the government inability to remove non-core assets from ports, fund public service obligations outside of port budgets and control staffing. Staff strength is always in excess of that necessary for core port activities. In these cases, they argued, the ownership of the port is not relevant to the performance outcome. Everett and Robinson, (1998) too noted that governments are not just seeking port efficiency, but also national competitiveness that has not materialised due to the confusion of practising different ownership models at the same time.

Argentina

In Latin America, port reform was synonymous with the introduction of the private sector and the change of port operational structure from Service or Tool port model to the landlord model (Baird, 2002; Hoffmann, 2001). Argentina was among the first in this region to embrace private sector participation in its port system, through concessions (Serebrisky & Trujillo, 2005). These involved the liberation of all contractual arrangement with stevedoring companies, deregulation of pilotage and towage services and freedom to establish tariffs. As well as the abolition of the previous labour agreement and all other practices that discourage port productivity, by decree 817 of 1992, it set the tune for port reform in Argentina. The end of restrictions to entry into the sector increased competition, because it allowed operators to manage and operate ports in public or private sectors for commercial, industrial or recreational usages. The only condition attached was compliance with the standard supporting services requirements, such as customs, safety and environmental regulation (Ibid).

The deregulation of port services was done in phases; firstly, antitrust laws were enacted to protect users against anti-competitive behaviour. Secondly, decentralisation; transfer of small ports to provinces with freedom of operation, concession or closing. Thirdly, the major ports (Santa Fe, Rosario, Buenos Aires, Quequen and Bahia Blanca), excluding Puerto Nuevo of Buenos Aires, were created. Also, an independent, autonomous company '*Sociedades de Administacion Portuaria (SAP)'* was established, for the maintenance of port's infrastructure and common user areas, including waterways and access area.

The port of Buenos Aires was divided into two areas, with different functions and administrations. The area called *Puerto Nuevo,* located in the capital city Buenos Aires is under the national jurisdiction; the port was divided into six container terminals and concessioned to private operators to promote inter-terminal competition. While the area called Dock Sud was transferred to the province of Buenos Aires as a specialised port for liquid bulk (petrochemical). The concession of Puerto Nuevo was followed by the construction of a new container terminal in the zone in 1995. The proximity of Dock Sud (only 50kms from Puerto Nuevo) created intra-port competition.The Dock Sud concession was granted by Buenos Aires province without competitive bidding for 30years (Estache & Carbajo, 1996; Serebrisky & Trujillo, 2005).

According to Estache and Carbajo (1996), the Argentine port reforms led to improved labour productivity involving reductions in port charges and other ship charges, of between 30 to 70 percent for containers and 10 percent for other bulk cargo, in less than two years. The study of the impact of Argentina's port reforms which focused on Puerto Nuevo of Buenos Aires by Serebrisky and Trujillo (2005), using standard partial indicators (labour productivity, capacity utilisation and quality of service), revealed steady improvement. On the other hand, the employment figures have significantly dropped, though there was a change in labour relations and decentralisation of workers' unions from the national level to the port level. Furthermore, it reduced government fiscal burden and eliminated all cross subsidies. In summary, although the performance of post-reform ports in Argentina has been very impressive, more needs to be done in the areas of institutional reforms. For example, sixteen years into the reforms the port of Puerto Nuevo still does not have an independent regulator (SAP) which impacts on monitoring port activities.

2.5.1 Port ownership and administrative models in Africa

2.5.1.1 Administrative models

Most African ports lack autonomy, as administration is centralised with the direct involvement of the Ministry of Transport in the supervision of port services. Table 2.3 shows the near absence of a robust regulatory framework. The majority of the ports in this region are still regulated at the Ministry of Transport level and in one or two countries by the port authorities, except South Africa, which has an independent regulator. The issue is how a port authority can be an unbiased umpire, in a conflict in which it is one of the parties. The Landlord port model is dependent on broad institutional reforms and may function better in the presence of an independent regulator (Cullinane & Song, 2002; Trujillo & Nombela, 1999). Furthermore, the concession of container terminals to the private sector, or independent terminal operators, is a partial step towards adopting the Landlord model. However, more needs to be done in the area of governance, if ports in the sub-region are to deliver efficient services of the type found in the developed world.

Table 2.3: Port management models and regulatory agencies in selected African countries

Country	Management Model	Agency Responsible for Regulation
Djibouti	Management Concession	Ministry of Transport
Sudan	Service port	Sudan Seaport Corp.
Kenya	Service port	Ministry of Information, Transport and Communication
Tanzania	Part landlord, part service port	Tanzania ports authority
Madagascar	Part landlord, part service port	NA
Namibia	Service port	Namibian ports authority
South Africa	Service port	Independent Regulator
Angola	Part landlord, part service port	Ministry of Transport, Merchant Marine and Ports Division
DR Congo	Service port	NA
Congo Brazzaville	Service port	Port Autonome de Pointe Noire
Cameroon	Part landlord, part service port	National ports authority
Nigeria	Landlord port	Nigerian ports authority
Benin	Service port	Ports Autonome de Cotonou
Ghana	Landlord port	Ghana ports and harbour authority
Cote d'Ivoire	Part landlord, part service port	The Autonomous Port of Abidjan
Senegal	Part landlord, part service port	Director of Ports and the Interior Maritime Transport
Cape Verde	Service port	NA

Source: Cameron (2008)

2.5.1.2 Ownership Models

African countries have been slow in embracing port privatisation compared to other regions of the World (AfDB, 2010). The prevalent model of port ownership is the service port (Comprehensive) model. Although Table 2.3 shows that most ports in Africa are tilting towards the Landlord model, like other parts of the world, the level of implementation is still in the infancy stage. In the majority of the countries, only container terminal activities have been concessioned. The other terminals are being operated by the port authorities, except

Nigeria, which, has achieved full concession (Trujillo, González, & Jiménez, 2013). The practice of public ownership is considerable in a number of African ports, whereby port infrastructure and superstructure, as well as operation, are still in the public domain. In terms of institutional reforms for port organisations, the globally preferred model is the Landlord model, but this is not the case in Sub-Saharan Africa (Figure 2.3). The retaining of the Service model by most countries in Sub-Saharan Africa implies that the public sector, with its attendant inefficiencies, is the manager and operator of ports in the region.

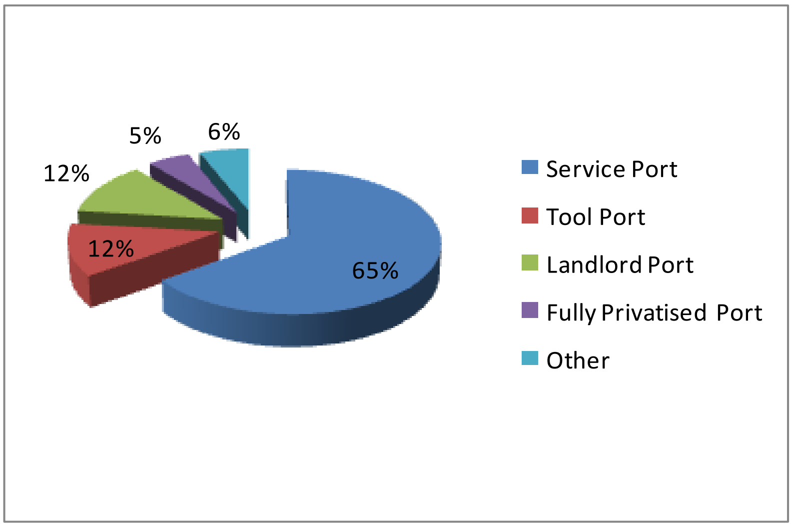


Figure 2.3: Different port Management Models in African Ports

Source: Adapted from Ocean Shipping Consultants (2009)

The African Development Bank (AfDB) report outlined several factors that have contributed to the smaller involvement of the private sector in African seaports. First, the small size of a vast number of the ports makes them commercially unattractive to investors. It is evident in the list of Top 50 World container ports in 2012, that Durban port in South Africa is the only African port in the list. It is ranked 50 on the list and handled 2.59 million TEUs (World Shipping Council, 2013). The second factor that deters private investment is the chaotic and volatile nature of the institutional and political environments pervading several African countries, which lead to commercial and political uncertainties. Thirdly, many ports operate in a monopolistic environment due to cumbersome cross-border procedures, which limit inter-port competition between neighbouring countries. For instance, most traders in Tanzania use Dar es Salaam port and shippers from Kenya use Mombasa only. It is different to what is obtainable in Europe. Some of the cargoes meant for Germany, use Rotterdam in the Netherlands. Likewise much of the Norwegian cargo use Gothenburg in Sweden and Polish cargo transits mainly through Hamburg in Germany. In addition, there is stiff opposition to reform from trade unions and vested interests, the reason being that the private investment may reduce direct employment in the ports (AfDB, 2010).

The primary motive that drives port reform in Sub-Saharan Africa and generates interest from the private sector, is port capacity and regional competition for transit and transhipment to neighbouring landlocked countries (UNCTAD, 2003). Plus, it is the raising of funds through the sale of port assets on the government's part. Reforms involving private sector participation in Africa is more intense in ports on the international shipping routes such as in Egypt and Moroccan ports as they have vast hinterlands and fierce regional competition (Trujillo et al., 2013). The characteristic of these regional gateways is high transit activity with a case in point being the port of Djibouti, where 75% of shipments presently are destined for Ethiopia. Ocean Shipping consultants (2008) and Kostianis (2004) have observed that ports in North Africa are rapidly reforming, with a few exceptions. Nevertheless there are still some hurdles to cross in terms of institutional and regulatory aspects.

As previously observed, concessions have become the preferred method of privatisation in the port sector, rather than an outright sale of port infrastructure assets, and Africa is no exception. The World Bank AICD report (2008) and Trujillo et al. (2013) underscored the need to keep granting concessions as 90 of the top 100 ports follow the Landlord model, characterized by public-private partnership (Baird, 2002; Cullinane & Song, 2002). Many African port authorities have embraced this trend especially in the container port market (Trujillo et al., 2013) . In Sub-Saharan Africa, 26 container terminal concessions have successfully being awarded in 24 countries with only one cancelled contract at the Mombasa container terminal (see Table 2.4). Foster (2008) is of the view that the concessions are yielding positive results in terms of productivity. Overall, the level of private sector participation in ports in Sub-Saharan Africa, based on the World Bank's Private Participation in Infrastructure (PPI) (2008) database, is 42 transactions affecting 26 ports in 19 countries. Most of them are concession contracts, the majority in Nigeria (Table 2.4). A review of the concessions by Ocean Shipping consultants (2008) and Trujillo et al. (2013), revealed that the concessions have been partial in many cases. The port authorities are reluctant to divest of operating assets, for example, the whole concessions in Mozambique and the Tema container terminal concession in Ghana. Most of the transactions are won by the leading names in the World in container terminal concession; APM Terminals, DP World and ICTSI. This scenario may create private monopolies and hinder the much-needed competition, which is one of the main reasons for concession. Despite this scenario, private sector involvement in the port industry is desirable. The question is how best to introduce private participation in Sub-Saharan African ports to yield the maximum benefit (Ocean Shipping consultants, 2008; UNCTAD, 2003). This is so that Africa will benefit from the enhanced productivity, efficiency, cutting down on port costs and improved quality of service, like in other regions of the World.

Table 2.4: Private sector transactions in African countries

Transaction	Countries	Ports	NO. of Transactions	No of Cancelled Transactions
Management or Lease contract	Cameroon, Kenya, Mozambique	Douala, Mombasa, Maputo	4	1
Concession Contract	Algeria, Angola, Comoros, Egypt, Equatorial Guinea, Gabon, Ghana, Madagascar, Mozambique, Nigeria, Sudan, Tanzania	Luanda, Mutsamudu, Luba, Owendo, Tema, Toamasina, Beira, Maputo, Quelimane, Apapa, Calabar, Port Harcourt, Lilypond, Onne, Warri, Tin Can, Juba, Bejaya, Alexandria	34	0
Greenfield Projects	Cote d'Ivoire, Egypt, Equatorial Guinea, Ghana, Kenya, Mauritius, Morocco	Abidjan, Luba, Tema, Mombasa, Free port, Sokhna, Suez canal, Tangier	11	0
Total			42	1

Source: World Bank (2008)

2.5.2 Port ownership and administrative model in Nigeria

Under the 1999 constitution, Nigerian seaports are on the exclusive list that implies they are under the jurisdiction of the Federal (Central) Government. The NPA which oversees the ports is a statutory agency under the Federal Ministry of Transport (FMOT). It is charged with the responsibility of regulating the shipping and navigational activities, port planning, development and construction, tariff determination, regulation of the private operations at the ports and the operation and management of port activities. Thus, Nigerian ports were administered as public ports because of the crucial role ports play in the country's economic development and to protect public safety and security (Ndikom, 2004). However, with the commercialisation of the ports in 1992 and the Port Act of 1999, the NPA adopted the Tool port system of administration.

Prior to 2006, all ports in Nigeria practised the Tool port model of port administration, except Onne port, that leaned towards the Landlord model. Under the Tool model, the Federal Government through the NPA provides the port infrastructure and superstructure, as well as cargo handling equipment, such as quay cranes and forklifts, which are operated by port authority staff. However, cargo handling on board vessels, aprons and quays are the responsibility of cargo handling companies contracted by shipping agents, or other entities licensed by the port authority. As observed by the World Bank (2007a), the sharing of responsibility between the PAs and stevedoring companies creates operational problems and inefficiency in the Tool port model. Although private firms play some role in cargo handling in this model, they are not obliged by agreement to bring in new investments. Thus, pre-concession Nigeria seaports were littered with a small number of private firms involved in cargo handling with a weak capital base and lacking innovation. It resulted in chronic underinvestment in the Nigerian port system. Therefore, the port system could no longer cope with the rapid global development in the shipping sector and regional competition from the Cotonou port in the Benin Republic as well as Lome in Togo, Tema port in Ghana and Douala port in Cameroun, due to infrastructural decay. In order to mitigate the general dissatisfaction with the Nigerian port system by stakeholders, a massive port reform was initiated from 2003-2005, which culminated in the adoption of the Landlord model of port administration and the handing over of terminal operations to the private sector in May 2006.

The belief is that the adoption of the Landlord model will attract the much needed investment in the Nigerian port sector, as terminal operators are encouraged by the long-term contract between them and the Federal Government to invest. The reform programme includes the deregulation of port labour and privatisation of terminal operations. Thereafter, the terminal operators took over the terminals in accordance with the terms of the concession agreement. Almost all cargo handling activities are under the jurisdiction of the terminal operators; however services such as pilotage, towage and warehousing are still being handled by the NPA.

Furthermore, the NPA is still involved in operating some port businesses and although most of them have been transferred to the private sector, such roles have been criticised by Wu and Lin (2008). In other words, port authorities as regulators are also directly engaged in operating port activities, which is a contradiction, as they self-regulate their activities.

2.5.2.1 Administrative structure of the NPA

Figure 2.4 shows the current administrative structure of the NPA, 8 years into the implementation of the concession program that began in 2006. The managing director (MD) who is responsible for decision-making is appointed by the President on the advice of the Minister of FMOT and also the board members. The executive directors (ED) (Marine, Engineering, Finance & Admin) assist the MD with administrative affairs, port management and operation, and port construction and maintenance. In addition, the EDs are assisted by general managers (GM) that deal with the day to day running of the ports. The organisational structure of the NPA shows that the administration is top-heavy. For instance, the ED Marine is assisted by 5 GMs, the ED Engineering by 4 and ED Finance and Admin by 4. This massive number of high profile personnel is still being maintained by the NPA after relinquishing most of the operational responsibilities to the private sector.

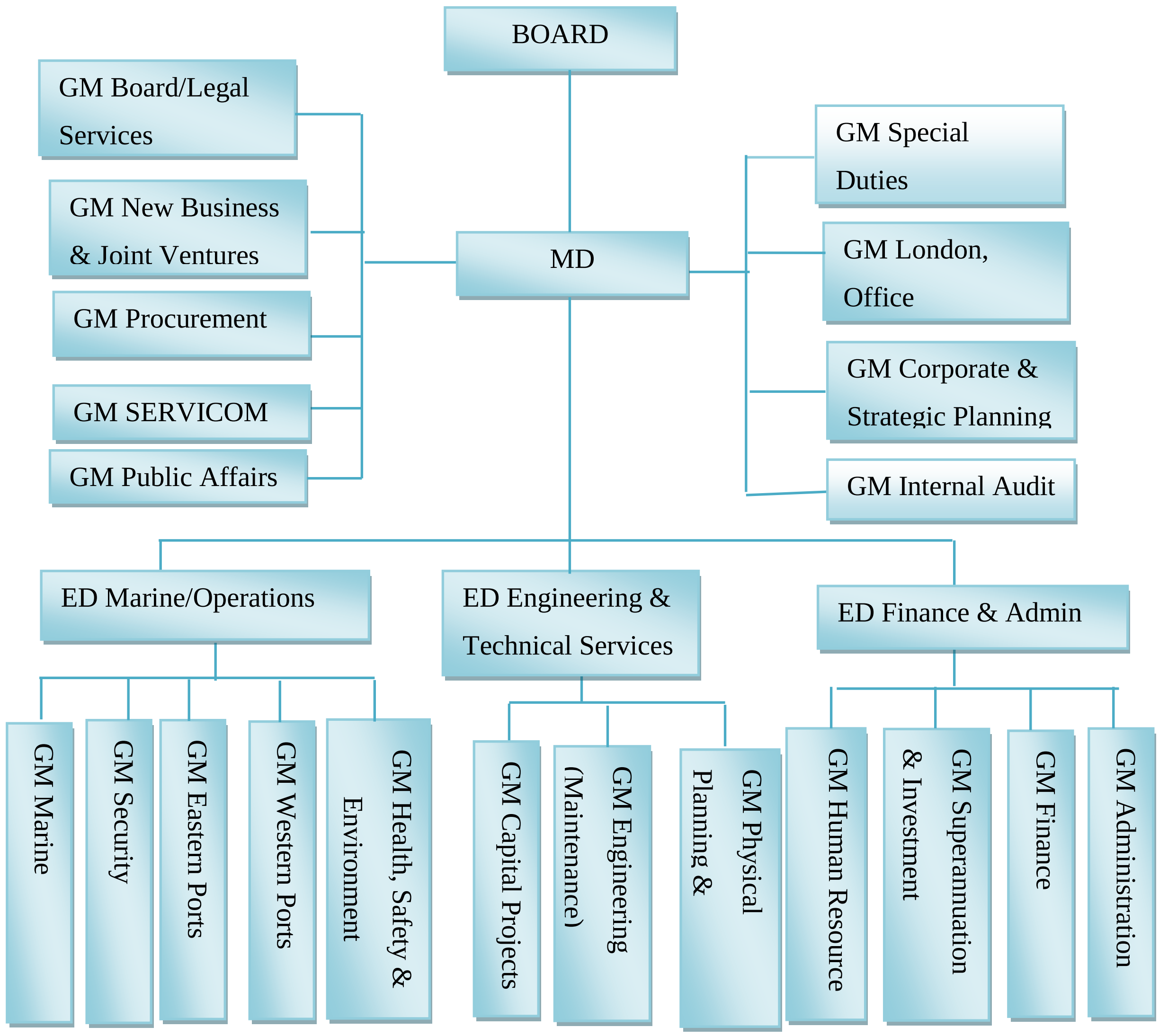


Figure 2.4: Organisational structure of Nigerian Ports Authority (NPA)

Source: NPA Website

The administrative structure of the NPA resonates as a public enterprise structure and its accompanying shortcomings. The adverse effect of running the NPA as an agency under the FMOT, with the attendant political patronage, is evident in the rate of turnover of MDs of the authority after the concession program. As at July, 2012, 6 different Chief Executive Officers (CEOs) have been in control of the NPA after concession started in 2006. The running of port authorities as public enterprises has been criticised by Chen (2009) in the study of Taiwanese port authorities. The study highlighted the irregularities due to government intervention, financial restrictions, bureaucracy and civil servants' attitudes towards institutional change. Goss (1999), questioned the rationale for the involvement of public authorities in ports, as they are not responsive to market forces and hence do not act commercially. For example, the

Nigerian ports authority is still an agency under the Federal Ministry of Transport as such lengthy procedures are still involved for the budget approvals. It impacts on the efficiency of responding to the needs and requests of customers. As such the Nigerian ports authority lacks the flexibility to respond to any changes in the market environment and the proactiveness required to ensure contestable markets. That is necessary to tame the anti-competitive behaviour of operators and ensure that the gains from the concession are transferred to the stakeholders.

The present administrative structure still maintained by the NPA after the introduction of the Landlord model of port administration, poses a significant challenge to the success of the reform process. Since the Royal Haskoning BV of the Netherland, the concession adviser, observed prior to the concession that, the over-centralisation of the NPA administration is not suitable to run an efficient port it as is enmeshed in too much public sector bureaucracy and political interference (Palsson & Leigland, 2007). Therefore, it recommended the unbundling of the NPA into two autonomous port authorities, alongside the adoption of the Landlord model of port administration, as part of the concession programme.

Eight years after the reforms took effect, Nigeria has not gone beyond the proposition stage. The two most important bills, the New Ports and Harbours and the Transport Commission Bills are not yet passed into law by the national assembly. The non-passage of these bills implies that the transfer of terminal operations to the private sector could be considered illegal, as the New Ports and Harbours Bill which redefined the duties of the NPA has not been passed into law. It constitutes a major challenge as observed by the terminal operators (Oghojafor et al., 2012).

It is evident from the analysis of the different ownership and privatisation models that port ownership and administration differs from country to country. It is also obvious that no country concession its entire national ports at once. The trend shows that only container terminals in most of the countries are transferred to the private sector while the other cargo types remain in the public domain. It is also observed that the pace of privatisation is gradual, even the UK with the most advanced forms of port reform phased its privatisation process. Another observation is that the governance structure of ports differs and in most countries it is devolved to state and local authorities. Again in some countries, for example, the Port of Singapore it is corporatisation that is being practised. No country still maintains public national port authorities after concession; rather responsibility is devolved to autonomous municipal, regional or provincial port authorities. However, the Nigerian port concession was regarded as the most ambitious and far-reaching concession that have taken place globally by Ocean Shipping consultants (2008), as the operations of the national ports were transferred to the private sector within a year.

This review also shows that both corporatisation and privatisation as methods of injecting the private sector ideals into the ports can be successful, if well managed. For example, the Port of Hong Kong and Port of Singapore, with similar geographical and cultural backgrounds adopted opposite approaches to privatisation. While Hong Kong is private sector dominant, the Singapore port authority is corporatised and performs all the port operations. However, the two ports are among the top 5 efficient ports globally. Therefore, it is evident that the primary decision factor is that the port system should tally with the general system of government and the beliefs of the people, for an efficient port operation, not the type of privatisation *per se*. Liu (1995) argued that the concept of "best port" that is applicable to all situations does not exist and therefore port organisations should not be treated as if they were mechanical, rather than social bodies. In conclusion, due to different port governance configurations, privatisation, though a universal concept, should be modelled to suit the socio-economic characteristics of each country.

2.6 Port Reform in Nigeria

The pre-1999 period when Nigeria's port system was under public ownership and operation, was marked by inefficient operations. In order to overcome the observed deficiency, Nigeria embarked on a number of reforms that culminated in the transfer of port operations to local and international terminal operators. Table 2.5 shows the timeline of the various development initiatives undertaken by the government to turn the fortunes of Nigerian ports around.

Table 2.5: Timeline of port reforms in Nigeria

YEAR	DEVELOPMENT
1999	Creation of the National Council on Privatisation (NCP) and the Bureau of Public Enterprises (BPE) by Privatisation and Commercialisation Act No. 28/1999.
2000	Formation of the Transport Sector Reform Committee (TSRC) an arm of the NCP.
2001	Commissioning of Ports Modernisation study project by the BPE with funds from the World Bank.
2003	Contracting of third-party transaction advisors by the BPE to perform due diligence, prepare bidding documents and advise on negotiations.
2004	Initiation of the first four bidding and negotiation rounds.
2005	Effective date of the first concession.
2006	Transfer of terminals from the NPA to concessionaires.

Source: Adapted from Pallis (2012)

Prior to 1999, the six major ports were under public ownership and operation, with the exception of Onne that practised the landlord model that is allowing private operations in the terminals. The pre-1999 Nigeria port was characterised by poor performance compared to other West African ports. The port system was characterised by an over bloated workforce, corrupt practices, insecurity of cargo, underinvestment, limited integration with inland transport and excessive charges (Mohiuddin & Jones, 2006). In addition, there were serious ship delays, cumbersome and bureaucratic clearing procedures and limited storage space. In order to decongest the ports, ships bound for Lagos ports were diverted to the Eastern ports of Port Harcourt, Calabar and Warri and even to other neighbouring West African countries' ports. It did not go down well with the local and international shipping community and other stakeholders in the ports. It resulted in steady agitation to change the *status quo* and this led the government to a drastic decision to reform the port system.

The government sought clear-cut objectives that could improve service delivery in the ports. The processes employed to achieve improved delivery included: a) enhancing management capabilities, b) creating a competitive institutional, legal and regulatory framework, c) developing private participation in financing, management and operations of port facilities, d) achieve operating targets, including decreased costs to users, faster cargo clearance and vessel turnaround and e) reduce pressure on government finances (Pallis, 2012).

The reform involved series of activities. Firstly, the Nigerian Ports Act was enacted in 1999, to further strengthen and streamline the activities of the ports. The Act retained the NPA as a public entity, but granted it power to unbundle some aspects of its activities and pass them to the private sector, to provide through agreements. As a result of the new powers bestowed on the NPA by *s.8 (1) (l)*[2] of the 1999 Act, it leased out some terminals and engaged the private sector in industrial activities, stevedoring and warehousing. Thus, the NPA remained as a parastatal under the Federal Ministry of Transport (FMOT). However, the new responsibilities overwhelmed the NPA and due to poor management and infrastructural and institutional deficiencies, it could not perform these activities efficiently. The inadequacies of the NPA were evident from the damning report of PORTCON, 2003, that reviewed cargo handling procedures in the ports of Apapa, Tin Can Island, Port Harcourt and Onne ports. The report revealed that the activities at various ports, with the exception of Onne, were failing to facilitate trade efficiently. The exoneration of Onne, the only port that was then under private operation, from poor performance, set the tune for the experimentation of other reform alternatives.

Secondly, the concession of the ports, which is hinged on Public-Private Sector Partnership (PPP), where the private sector is in-charge of operations, while the ownership of portland and regulations are retained by the public. The restructuring and reform of Nigerian ports were consistent with the Government's overall economic objective of invigorating private sector participation in the economy. Thus, the port reform policy was rooted in the disengagement of the public sector in the operation of ports and constraining it to regulation and provision of an enabling environment for the private sector economic growth to flourish.

The port reform policy is crafted to achieve the following objectives:

• To increase the efficiency of port operations
• To decrease the cost of port services

[2] s.8(1)(l) in the1999 Act to, 'enter into agreement with any person for the operation or provision of any of the port facilities which may be provided by the Authority'

• To decrease the flow of funds from limited Government resources
• To boost economic activity and accelerate development
• To make Nigeria the hub for international freight and trade in West and Central Africa

2.6.1 The concession structure

Section 36 of the Infrastructure Concession and Regulatory Commission Act (ICRCA) of 2005 defines the basic principle of public service infrastructure concession in Nigeria. However, for ports, section 168 of the draft Ports and Harbour Authorities Bill defines a general framework for the concessions, the operations and the contractual obligations of parties. The Bill provides for international competitive bidding as a means of selecting terminal operators for available concessions. Private companies are allowed to bid for concessions that involve terminal operations, cargo handling, warehousing and delivery. It also provides for the delineation of the ports into terminals to encourage intra-port competition. In other words, it provided for the carving out of several terminals handling similar cargo in order to create a competitive environment.

It also empowers the NPA to transfer operating rights in Nigerian ports to the private sector while still retaining ownership of portland. The arrangement confers Landlord status on the NPA and in addition empowers it to license operators and regulate their activities. Many ports in both developed and developing countries have adopted the concession arrangement for their ports, such as the Argentina Port Authority, the Antwerp Port Authority (Belgium), the Brazilian Ports Authority, the Ghana Ports and Harbour Authority and the Ports Authority of Chile.

A new institutional structure to provide the operational basis for the Landlord model and concession programme has been devised. Under this new structure, two new autonomous port authorities, namely Lagos and Port Harcourt, are to be created (NPA Brand Manual, 2005). The autonomous authorities will have a number of functions, including:

- Ensuring safe and expedient access for ships within the port limits
- Concession and licensing of private operators to provide cargo handling and marine services
- Collecting port authority tariffs

- Acting as a landlord on behalf of the Federal Government
- Planning and developing the port infrastructure, including acquisition of new land for port use where required
- Facilitating the financing and construction of new port infrastructure through build-operate-transfer (BOT) arrangements

It is envisaged that after the implementation of the reform process, the NPA will be wound up, and the functions will be undertaken by the Transport Services Commission, to act as an independent regulatory body. The port regulator will be responsible for providing economic regulation of the ports, including rates charged by private operators and autonomous port authorities. As well as ensuring equal access to port facilities, adjudicating disputes, ensuring competition and compiling and publishing a statistical review.

The role of the lead department, the Federal Ministry of Transport, has also been revised as part of the reform process. The new functions of the Ministry are as follows:

• Establishing national port and maritime policy
• Initiating port and maritime related legislation
• Planning for adequate port capacity and inland multimodal transport
• Reporting on port performance and contributing to the National Transport Plan
• Liaising with state authorities as necessary
• Representing Nigeria in international bodies
• Playing a role in choosing federal-appointed directors of the port authorities, with the approval of the President.

The role of the unbundled NPA, under the Landlord port model, entails performing only landlord and regulatory functions, while the private operators are responsible for all operational activities in the ports. These include cargo handling, stevedoring, warehousing and delivery, as well as towage, mooring, bunkering supplies and ship repairs. In this regard, the terminal operators will have contracts with the shipping lines without interference from the landlord. Each autonomous port authority will determine the tariffs for marine services and the use of the harbour. However, the tariffs for cargo handling are set by the terminal operators in a free and competitive setting. The original concession sets the initial maximum tariff chargeable by the concessionaires (Pallis, 2012).

The terminal operators will be responsible for the safety, security, liability and insurance in their areas of the concession. They will also be responsible for investments and maintenance of superstructure, equipment and vessels. Under the BOT arrangement, the superstructure and equipment will be transferred to the Government after the agreed number of years. In this way, concessioning not only enables terminal operators to provide terminal services to carriers, importers and exporters, but also to invest in the infrastructure development of the ports. The responsibility for the provision of nautical services, such as channel conservancy, pilotage, stowage, pollution control and general access management is vested in the NPA and not the concessionaires. The NPA may decide to privatise these activities outright, or go into a joint venture with the private sector for their provision. Part of the NPA restructuring involves the transfer of core assets to the new autonomous port authorities and sale of non-core assets.

2.6.2 The concession process

The appointment of CPCS Transcom as the consultants to advise to the handling of the concession programme set in motion the Nigerian seaports concession process. The Bureau of Public Enterprises (BPE) called for expression of interest (EOI), by placing advertisements in both local and international media on 5th December, 2003. The submission deadline for the EOIs was 20th February, 2004. 110 EOIs were received; 94 scaled through the pre-qualification stage. Successful applicants placed bids on individual concessions of interest from the 24 separate concessions, delineated from 10 seaports. The ports were grouped into four based on the time of concession. The concession involved series of rounds, which commenced from the first quarter of 2004 and ended in the third quarter of 2005 (NPA Brand Manual, 2005).

Round one consisted of twenty-six bids which commenced on 24th September, 2005 and covered the Apapa container terminal and the Apapa break-bulk terminals C & D. The bids were opened in January 2005 and technical evaluation followed in February 2005. Financial proposals were called for, for bids that scaled through the technical assessment. Afterwards, the financial proposals were opened, and the organisations with the highest financial bids were declared winners. Bids for round two started in January 2005, from the prequalified bidders for Port Harcourt terminals A and B. By February 2005, calls for financial and technical bids were sent out and the bids were opened in April 2005. The competitive bidding for round three, which comprised of the Tin Can Island terminals bulk and break A, B & C, the Ro-Ro terminal and the Lily Pond inland container depot (ICD), started in June 2005 and was concluded in August 2005. Lastly, the round four concessions which consisted of Calabar Old port, Warri (old and new port) and Koko port commenced on September 2005 and were concluded in January 2006.

However, some concessions were negotiated rather than open bids (Table 2.6). Negotiations were applied only to existing tenants in the ports that were invited to enter into a new concession agreement based on the new reform programme. If new agreements were not reached with existing tenants through negotiations, the bids were opened to other bidders in respect of those terminals. The ten terminals that were opened for negotiation includes: the Apapa break bulk terminals E, A and B, the Kirikiri phase 1and 2, the Onne Federal Lighter (FLT) terminals A and B, the Onne Federal Ocean terminals (FOT) A and B and Calabar new port (Kieran, 2005).

2.6.3 Implementation of the concession programme

The post-bidding negotiations with the highest bidders followed international standards of transparency and fair competition (NPA, 2005). The various agreements were sent to the President for approval. Afterwards, the NPA and the BPE confirmed the compliance of the agreement with the overall strategy as the "confirming party", thereafter the understanding was conveyed, and the contract signed between the NPA and the private investors.

Although the nitty-gritty of each agreement remains confidential, some of the general issues covered in the agreements were discussed in order to boost the commitment and confidence of the signing parties, other stakeholders and the public at large. One of the general issues discussed was project lifespan, which is usually found in most concession agreements (Pallis, 2012; Pallis et al., 2008). Others include clear-cut definition of transition terms, execution dates and conditions. Likewise, general implementation issues i.e. obligations to finance operations and submitted development plan execution, maintenance obligations, provision of utilities, safety and security requirements plus environmental issues. Additionally, worthy of discussion were general performance standards and requirements i.e. development plans and marketing plans to promote cargo throughput. As well as other cargo-related business to achieve maximum utilisation and quality of service conditions for tracking and evaluation of performance. In other words, the rights of the NPA to monitor and inspect; obligations of operators to submit reports on planning and investment, volumes of traffic and number of vessels. This is a means of clarifying the risk sharing assumed between the investor and the Government.

Agreement was reached on three central issues of utmost importance, because they are fertile grounds for potential conflicts. First is *pricing of operations;* the maximum cargo dues chargeable for each cargo was provided for and for a transparent, non-discriminatory pricing policy. It includes publication of rates, announcement of any preferential rates and transparent handling of complaints. Additionally, agreed upon was the setting up of a pre-defined free storage time for the different types of cargoes, (import/export, in transit to neighbouring countries, or transhipment) before charging the demurrage.

The second is *labour issues.* To ensure a hitch-free transfer the government terminated all the stevedoring contracts and requested all stevedores to vacate the port premises before the effective handover date for each new operator. In addition, the NPA revised restrictive labour practices that may constitute a hindrance to hiring of personnel by the terminal operators, giving the investors room to organise their terminal management and operations. Labour reform was crucial to the success of the concession programme and needed to be carried out expeditiously to demonstrate political commitment. The downsizing of the workforce by 75% is one of the contentious issues because the NPA is highly unionised and overstaffed. The Government initial plan to give the terminal operators the power to "hire and fire" was strongly resisted by the unions and was reversed through dialogue. Afterwards, a multidisciplinary committee, comprising of Ministries of Transport, Finance and Labour, the NPA and the representatives of the trade unions was set upt o handle the downsizing of the workforce and to avoid exacerbating the already charged work environment. Furthermore, experts were involved in the negotiations via an unofficial group of international peers, for agreement on a voluntary scheme. The International Labour Organisation (ILO) also participated in the discussions and recommended structures for the agreement. Terminal operators were also not left out as they mounted pressure for a deal with the unions and the development of a dockworkers minimum standard agreement. At the end of the negotiations, an agreement was reached for $110,000 for the voluntary scheme. The severance package cost the Government US$ 400 million to downsize the ports' workforce from 14,000 to 4,000 staff (Borha, 2010).

The practice today is that concessionaires are allowed to employ their workers. However, they are bound to give details of employment policies (organogram and expected staff strength of the terminal), training schemes and the job opportunities for host communities. They are also allowed to employ expatriates (Non-Nigerians) in management positions, if reasonable efforts to employ a Nigerian yielded no eligible candidate. It has helped international operators to bring in their management staff, with prerequisite experience in their other operations outside the country (Pallis, 2012).

The third issue is *Lease fees;* another important point that is necessary to gain entry into the market is that operators must agree to a commencement fee. It is a fixed amount payable annually for each operating year and a throughput fee (Pallis et al., 2008). An addendum to the third issue is the submission of a performance bond. Terminal operators are under an obligation to submit an unconditional and irrevocable bond, guaranteeing full and timely compliance to performance obligations.

In addition, the terminal operators are required to submit detailed development plans for their various terminals, showing the scheduling of investments in infrastructure, equipment, tug boats and barges. Likewise, the plans for land use allocation and provision of any dedicated areas i.e. for oil related cargoes vs general and containerised cargo handling, or stacking areas and warehouses primarily dedicated to companies. Additionally, there is provision for mutual consultation in case of disputes, with the assistance of experts and international arbitration in London or any other place mutually agreed by the signing parties to disputes that need arbitration.

The NPA retains the responsibility for harbour services. It includes the maintenance of the berths, canals, breakwaters and navigation aids, the timely and efficient provision of maritime services i.e. pilotage, towage and channel dredging. These services could be provided directly by the NPA, or licensed competent operators, who will compete to provide these services in such a way that guarantees efficient performance of the operations.

In terms of tariff structure, in several instances the maximum tariffs chargeable are set in the concession agreement, but competition was endorsed as the primary tool for ensuring reasonable tariffs (Notteboom, Verhoeven, & Fontanet, 2012; Pallis, 2012; Pallis et al., 2008). However, the NPA is responsible for determining the tariffs for marine services and the use of the harbour according to the recommendation.

The winners of the different concessions (Table 2.6) entered into an agreement with the NPA (representing the Government), to operate the terminals allocated in line with the conditions of their contracts. The operations of the Nigerian ports have been the responsibility of the concessionaires since the handover date.

Table 2.6: Concession transactions and handover dates

S/N	Transactions	Terminal Operators	Local/Foreign Participation	Name of Port	Concession Rounds	Concession Duration in years	Bid Amount (NPV@10 % Discount rate) Value in US$ million	Handover Date
1	Apapa Container Terminal	A.P. Moller Terminal Ltd.	APM Terminals as Lead with Local participation	Container Terminal Apapa	Round 1	25	1061.14	3rd April, 2006
2	Apapa Terminal A	Apapa Bulk Terminal Ltd.	Local lead with Atlantic Bulk Carriers Mgt. from Greece as Technical Partners	Apapa, Lagos	Direct Negotiation	25	18.10	3rd April, 2006
3	Apapa Terminal B	Apapa Bulk Terminal Ltd.		Apapa	Direct Negotiation	25	12.07	3rd April, 2006
4	Apapa Terminal C	ENL Consortium Ltd.	Local lead with Dublin Port Company and ICIL from Ireland and Civil & Coastal from South Africa	Apapa Lagos	Round 1	10	13.58	3rd April, 2006
5	Apapa Terminal D	ENL Consortium Ltd.		Apapa Lagos	Round 1	10	12.25	3rd April, 2006
6	Apapa Terminal E	Greenview Dev. Nigeria Ltd.	Local Dangote Group	Apapa Lagos	Direct Negotiation	25	25.07	3rd April, 2006
7	Port Harcourt A	Ports & Terminal	Local Lead with P&O	Port Harcourt	Round 2	15	90.81	23rd June,

		Operators Nig. Ltd.	Nedlloyd					2006
8	Port Harcourt B	BUA International Ltd.	Local Lead with Apec Antwerp Port Consultants	Port Harcourt	Round 2	20	12.36	23rd June, 2006
9	Tin Can Island Port A	Josepdam & Sons Ltd.	Local Lead with Techserve and South Africa Sugar Company	Tin Can Island	Round 3	10	14.05	10th May, 2006
10	Tin Can Island Port B	Tin Can Island Container Terminal Ltd.	Bollore Group as Lead with Zim Integrated Shipping Services and Local participation	Tin Can Island	Round 3	15	83.31	10th May, 2006
11	Tin Can Island Port C	Port & Cargo Handling Services Ltd.	Local firms as lead with Bremen ports	Tin Can Island	Round 3	10	104.42	10th May, 2006
12	Tin Can Island Port RORO	Five Star Logistics Ltd.	Local Lead with Eurogate Int. and MSC	Tin Can Island	Round 3	15	86.63	10th May, 2006
13	Lilypond ICD	A.P. Moller	APM Terminals as Lead with Local Participation	Lagos port Complex	Round 3	10	9.65	3rd April, 2006
14	Onne FLT A	Brawal Nig Ltd	Local Group	Onne	Direct Negotiation	25	16.66	21st June, 2006
15	Onne FLT B	Intels Nigeria Ltd.	Local Group with International Partners	Onne	Direct Negotiation	25	29.06	21st June, 2006
16	Onne FOT A	Intels Nigeria Ltd.	Local Group with	Onne	Direct	25	38.13	21st June,

			International Partners		Negotiation			2006
17	Calabar Old Port	Addax Ltd	International company with Local base	Calabar	Direct Negotiation	25	2.01	26th May, 2007
18	Calabar New A	Intels Nigeria Ltd.	Local Group with International Partners	Calabar	Direct Negotiation	25	2.51	23rd June, 2006
19	Calabar New B	Ecomarine Ltd	West African Group	Calabar	Round 4	10	30.03	1st August, 2007
20	Warri Old A	Intels Nigeria Ltd.	Local Group with International Partners	Warri	Direct Negotiation	25	2.55	23rd June, 2006
21	Warri Old B	Associate Maritime Services	Local Group with International Partners	Warri	Round 4	10	1.90	12th June, 2007
22	Warri Old C	Julius Berger Nigeria Ltd.	Local Sub. Of an Int. firm with Bremen Ports	Warri	Direct Negotiation	25	5.50	4th May, 2007
23	Warri New A	Global Infrastructure Limited	An Indian Group based in UK	Warri	Direct Negotiation	25	2.00	Negotiating
24	Warri New B	Intels Nigeria Ltd.	Local Group with International Partners	Warri	Direct Negotiation	25	6.60	23rd June, 2006
25	Koko Port	Greenleigh Limited	Local Group with International Partners	Koko	Round 4	10	2.90	12th June, 2007

Source: (BPE, 2006)

Therefore, to support this volume of trade, the Nigerian government through the NPA engaged the private sector; through concession contracts to improve efficiency in seaport operations and to ensure that port services are internationally competitive. As seaports are a vital link in the overall supply chain, seaport efficiency contributes to a country's overall competitiveness (Jiang & Li, 2009). Thus, monitoring and comparing ports against one another, or at different periods, to see the effect of reform programme in terms of productive efficiency, has become an important strand of a country's macroeconomic reform. Hence, the purpose of this research to evaluate the operational performance of Nigerian seaports after a major reform programme. This involves understanding if the ports are on the path of efficiency and to identify the operators that are making efficient use of the resources allocated to them. Also, to examine other factors that affects the performance of the ports. This research concentrates on evaluating pre- and post-concession technical and scale efficiencies and the identification of efficiency sources to determine the influence of change of ownership on operational efficiency. For ports, the study concentrates on identifying the datum performers (benchmarks).

2.7 Perception of Port Users to the Concession Programme

The object of this section is to assess the perception of port users to the concession programme, to determine their level of satisfaction with the implementation process. The implementation of the concession has elicited a barrage of opinions and criticism from port users, civil society, workers unions and policy makers, as evident from so many newspaper articles on the subject (Appendix 1.2). In order to obtain a hands-on view, the research sought the opinion of players in the industry through interviews. The perception of users illustrates whether the expectations from the programme have been met. If the perception of the actual services delivered by the private sector (terminal operators) falls short of expectation, port users will shift patronage to neighbouring ports, negating the purpose of the concession. The port users' views were solicited from the representatives of the various pressure groups that operate at the port. The chairmen of ANCLA, NAGAFF and CMDLCA were interviewed as representatives of freight forwarders. While the executive vice chairman of ENL, who doubles as chairman of STOAN, chairman of PTML and APMT operations, represents STOAN, and the general manager public affairs of NPA was interviewed for the opinion of the landlord. Finally, a representative from ISAN was included for the perspective of the shipping lines, and a representative of the maritime union was interviewed for the views of port workers. A checklist of ten questions was used as a guide for the semi-structured interview which was crafted based on the objectives of the concession.

Table 2.7 shows the analysis of the interview responses. The analysis shows that from the perspective of port users and terminal operators, the implementation of the concession is on average moderately successful. The various stakeholders operating in ports are of the opinion that both the government and the terminal operators have reneged in fulfilling some parts of the agreement. It has resulted in the increase in port charges that has spiralled into the economy to the high cost of consumer goods. The stakeholders were unanimous in calling for an independent regulator if the gains of the concession programme are to be harnessed in the medium to long term.

Table 2.7: Level of compliance to concession objectives from the port users' perspective

Issues	Success	Comments
Compliance with Concession Agreement	●●	Both the NPA and terminal operators accuse each other of complacency in keeping to the contract terms. The NPA has reneged on providing and maintaining common user facilities: access roads to the port and reactivating the rail lines for easy evacuation of cargo. Terminal operators have not brought the required investment in facilities (cargo handling equipment) as provided for in the agreement.
Achievement of Concession Objectives	●●	Moderate improvements in terms of cargo throughput and ship turnaround time. However, the cost of doing business in Nigerian ports has increased instead of reducing. As a result, 25% of imported goods still come into Nigeria through ports of neighbouring countries. In terms of investment in modern equipments and terminal equipment, the level of compliance by the terminals is below 40%. Although some operators have invested more than the others especially ABTL, PTML and APMT. Lack of clarity in the interpretation of objectives creates conflicts between the NPA and terminal operators, meddlesomeness from the FMOT, which may have discouraged proper intervention.
Fair Distribution of Benefits from Privatisation	●	Lack of the institutional framework to ensure that gains accruable to a well-implemented concession trickle-down to stakeholders. All the actors in the port were unanimous in calling for an independent regulator. They believe that the NPA

		as presently constituted, lacks the requisite skills in dispute and crisis management as it intends to avoid issues relating to equity and subjective judgement.
Compliance with Government Policy	•	The Government is yet to implement the regulations on a 24-hour cargo clearing policy. As importers fail to genuinely make honest declarations leading to 100% physical examination of imports. The Government directive to reduce the number of agents involved in cargo clearing from 14 to 7 is yet to be implemented. The NPA is not an independent regulator, but rather under the FMOT, which exerts tremendous political pressure on the organisation which impinges on its ability to discharge its role to the cargo community.
Protection Against Abuse of Monopoly Power	••	The inability of the National assembly to pass the relevant laws 6 years after concession, coupled with the unwillingness of the FMOT to set up an independent regulator means operators are not protected. In other words, the government insisting on the NPA as a quasi regulator means there is no institution to address issues of anti-competitive behaviour. As the NPA lacks the requisite skills to handle complaints involving operators and port users, this has led to frictions between the various stakeholders in the port.
Protection of the Investor from Government Interference	••	The Concession agreement has clauses that deter government interference embedded in it. Therefore, there are few instances of regulatory intervention to protect investors.

Increased Competition	•	No inter-port competition because the NPA is yet to be unbundled. There is evidence of entrants into the Nigerian port industry by way of Greenfield projects. The construction of a deep seaport at Lekki, Lagos is a public-private-partnership (PPP), between the Federal Government of Nigeria (FGN), the Lagos State Government (LSG) and the Tolaram group in Singapore. It is projected to be delivered by 2017. There is a bigger seaport being planned for Badagry, Lagos, another PPP between AP Moller, FGN and LSG.
Creation of Efficient Markets	•	Focus has been on intra-port, rather than inter-port competition. Action has just begun to create a level playing field for ports privatised on different terms.
Replication of the Outcomes that would Result from Competition	•	No action towards this area because it seems too technically and/or beyond the NPA's responsibility.
Cost Effective Provision of Non-commercial Services	•	The provision of non-commercial services has remained an NPA responsibility, with no requirement for competitive outsourcing.
Terminal Operators Performance	••	The views of the NPA and freight forwarders, that some are performing well in terms of service delivery, ethical considerations and are customer-oriented. PTML was particular singled out by port users while others are performing below average.

Note: (a) ••• most successful, • moderately successful, •• and least successful

2.8 Determinants of Port Operational Performance

There are conflicting views among authors on why ports outperform one another. The United Nations Conferences on Trade and Development published a monograph in 1976 and another in 1987 dedicated to indicators of port performance. The document provided several indicators of operational and financial performance. The authors of the UNCTAD monograph were of the view that the performance of a port cannot be determined on the basis of a single value or measure (UNCTAD, 1976, 1987). According to the authors, indicators of a port's operational performance should cover areas relating to the duration of a ship's stay in port as well as the quality of cargo handling and the quality of services to inland vehicles that call at the port. The implication of port performance having a multivariable behaviour entails the use of many operational indicators simultaneously. These include; the number of ship calls and amount of cargo handled per year as well as financial performance indicators of the Port Authorities (PAs).

There is evidence in the literature of studies that have applied several of these indicators to evaluate port performance. Some of these key indicators include; total throughput in tonnes or TEU (Twenty-foot equivalent unit) and the frequency of ship calls aggregated by cargo type. That is RORO, containerised cargo, break bulk, dry bulk and liquid bulk. Many authors have used only absolute value of total throughput as the output variable in performance analysis (Garcia-Alonso & Martin-Bofarull, 2007; Herrera & Pang, 2005; Park & De, 2004; Trujillo & Tovar, 2007). These are the regular indicators that appear in port websites, annual reports, container international yearbooks and other trade journals. The indicators capture only controllable variables under the PAs' control. As a result, they are referred to as partial indicators; although they were the only indicators considered by early studies on the subject, as comparisons between ports were mainly endogenous. However, with globalisation and the viewing of ports as a node in the global logistics network, external variables begin to appear in port performance and competitiveness evaluations. The other factors that have been used by other authors include; geographical location of the port, port size, investment in infrastructure, port specialisation, efficiency, competitiveness and ownership (Caldeirinha, Felício, & Coelho, 2009; Tongzon, 2002). Additionally, other factors such as port handling charges, waiting times and direct-call by liners are among the indicators highlighted by Tongzon (2002) as influencing port performance.

Geographical location

The geographical location of the port has been suggested by Liu (1995) and Tongzon (1995) as a factor in port choice, efficiency, throughput and competitiveness. This factor is quite significant, as ports are often located close to centres of economic activity, except possibly ports dedicated solely for transhipment. According to Song and Yeo (2004), there is a strong relationship between the volume of cargo a port handles and its geographical location. Likewise, Caldeirinha et al. (2009) were of the view that it is the primary decision variable for the choice of Bangkok as a port of call for shipping lines. Location has become vital because the demand for port services is driven by the traffic generation and consumption volumes of the region (Cheon, 2007a; Tongzon, 2002). In other words, the proximity of the port to small economies impacts negatively on throughput and by extension its performance. While the location of a port in the proximity of developed regions influences the level of infrastructure, equipment and accessibility, thereby improving performance.

Port size

A key variable that is put into consideration in determining performance is port size as the port sector seems to be affected by agglomeration economics and economics of scale requiring high initial investments. In the literature there has been evidence suggesting that port size influences the operational performance of ports (Liu, 1995; Wiegmans, 2003). However, there are disagreements among authors as to the direction of this influence. Furthermore, port size is considered an indicator of port performance, as there is evidence from studies to show that productivity increases with port size. After all, that is the main reason suggested by Neufville and Tsunokawa (1981) for concentrating investment in larger ports, than in smaller ones. In support, other authors affirmed that the learning curve effect experienced by larger ports leads to improved performance (González & Trujillo, 2009; Trujillo & Estache, 2005; Turner, Windle, & Dresner, 2004). Furthermore, Herrera and Pang (2005), argued that the size is an instrumental variable to efficiency. On the other hand, Barros and Peypoch (2007), were of the view that environmental factors, such as location and regional concentration, as well as economies of scale and scope, can lead ports to operate below their capacity as the infrastructure is used as a proxy for size during operationalisation. This position is affirmed by Cullinane, Song, and Wang (2004), who argued that it is an increase in a competitive environment, rather than size, that influences efficiency.

Port Specialisation

The specialisation rate refers to the weight of cargo, or the rate of traffic attracted to a port in all cargo types (Merk, Ducruet, Dubarle, Haezendonck, & Dooms, 2011). The containerisation rate is mainly identified as influencing the performance of ports (Laxe, 2005; Medda & Carbonaro, 2007; Trujillo & Tovar, 2007). However, Tongzon (2002) argued that the unitisation rate (weight of general cargo in total throughput) is equally important as it shows the stage of development of the port, from industrial to modern commercial port. In addition, Tongzon and Heng (2005) observed that port choice by shipping lines is affected by global alliances and logistic networks. It is the reason for ports integrating with global terminal operators aligned to shipping networks. The World's chief ports and inland global logistics companies are in alliance with GTOs and with parent companies as shipping lines. For instance, APMT, a global terminal operator is aligned to a shipping company the Maeserk line. The influence of shipping services and equipment on port performance has been studied by Turner et al. (2004). All these factors impact on frequency and transit time of ships, terminal handling charges, freight charges and inland transport charges, which in turn impacts on the performance of ports.

Ownership

Traditionally, the organisational model of ports globally follows the similar a pattern. That is the ownership of property rights is with the state, that delegates power to the PAs to develop, organise and operate the ports. The PAs in turn transfer operating rights to the private sector through privatisation. The transfer of ownership of infrastructure and superstructure to the private sector, through concession contracts, gives rise to the Landlord model of port administration. According to Liu (1995), port ownership is among the port characterising factors that influence performance. The author suggested that the profit motive of the private management is the driving force towards efficiency, while there is not enough incentive to propel public management to improve performance. Thus, there is no consensus among authors on which one performs better between public and private management. However, Estache et al. (2001), argued that the Mexico port reforms resulted in the efficiency gain. Furthermore, Barros and Athanasiou (2004) assert that the privatisation enhances the efficiency of ports.

In addition, Liu, Liu, and Cheng (2006) suggested that reform programmes involving partnerships between local and foreign terminal operators have contributed greatly in the performance of Chinese ports. However, terminals that operate inter-continental services are more efficient than those that operate only regional routes. In support, Notteboom, Coeck, and Van Den Broeck (2000), argued that hub ports have higher efficiency levels than feeder ports as they are usually managed by local authorities and are not linked to global operators. On the contrary, González and Trujillo (2009) were of the view that there is no evidence to demonstrate a causal relationship between ownership and port efficiency.

Therefore, this research argues that privatisation has a direct influence on efficiency and throughput of ports (scale of production). It is consistent with the findings of Tongzon (1995), Tongzon and Heng (2005), Tongzon, Chang, and Lee (2009) and Caldeirinha et al. (2009) that identified port throughput as one of the factors that determine port efficiency. Another gain from privatisation is that it leads to the provision of port services that are globally competitive, which can result in an adjustment of port charges. It also leads to improved competitiveness between terminals or ports, or between countries with adjacent hinterlands. The adoption of the Landlord model of port due to privatisation implies that the port authority is no longer responsible for port operation and provision of port services. The role of the port authority becomes that of the regulator, policy making, planning, marketing and promotion and performance monitoring. The relationship between privatisation, efficiency and throughput is depicted in Figure 2.5. The diagram shows that efficiency is influenced by throughput levels and vice versa, while there is a direct relationship between both and privatisation.

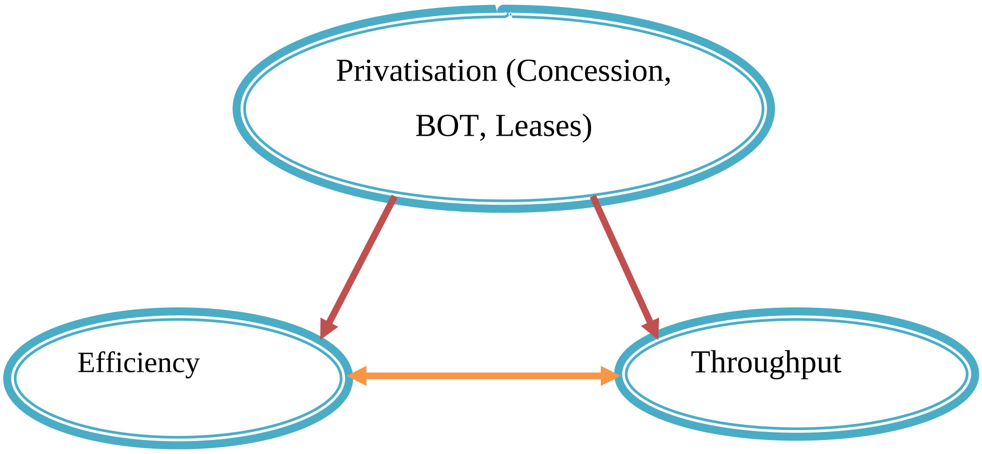


Figure 2.5: Relationship between privatisation, efficiency and throughput

2.9 Port Competition

Winklemans and Van de Voorde (2002), define port competition based on three broad categories. First, as competition among terminal operators within the same port called intra-port competition. Secondly, there is competition between operators from different ports, known as inter-port competition at operator level. This second tier of port competition occurs mainly between ports within the same range, serving more or less the same hinterland, for instance the Apapa and Tin can Island ports in Lagos. It implies that competition can or may occur within port ranges. Such as competition within the Hamburg-Le Havre range in Europe and within the Lagos, Cotonou and Lome range in West Africa which are only restricted to those ranges. It is rare to see ports outside the range being involved, because there is little or no overlap between hinterlands of ports from different ranges. Thus, operators in a particular range do not feel threatened by operators from another range and therefore there is no evidence of competition at that level. Thirdly, there is competition between port authorities, regional or local, which directly affects the determinants of port competition, particularly the infrastructure in and around a port. It is, of course, vital to the competitive position of operators and it is called inter-port competition at port authority level.

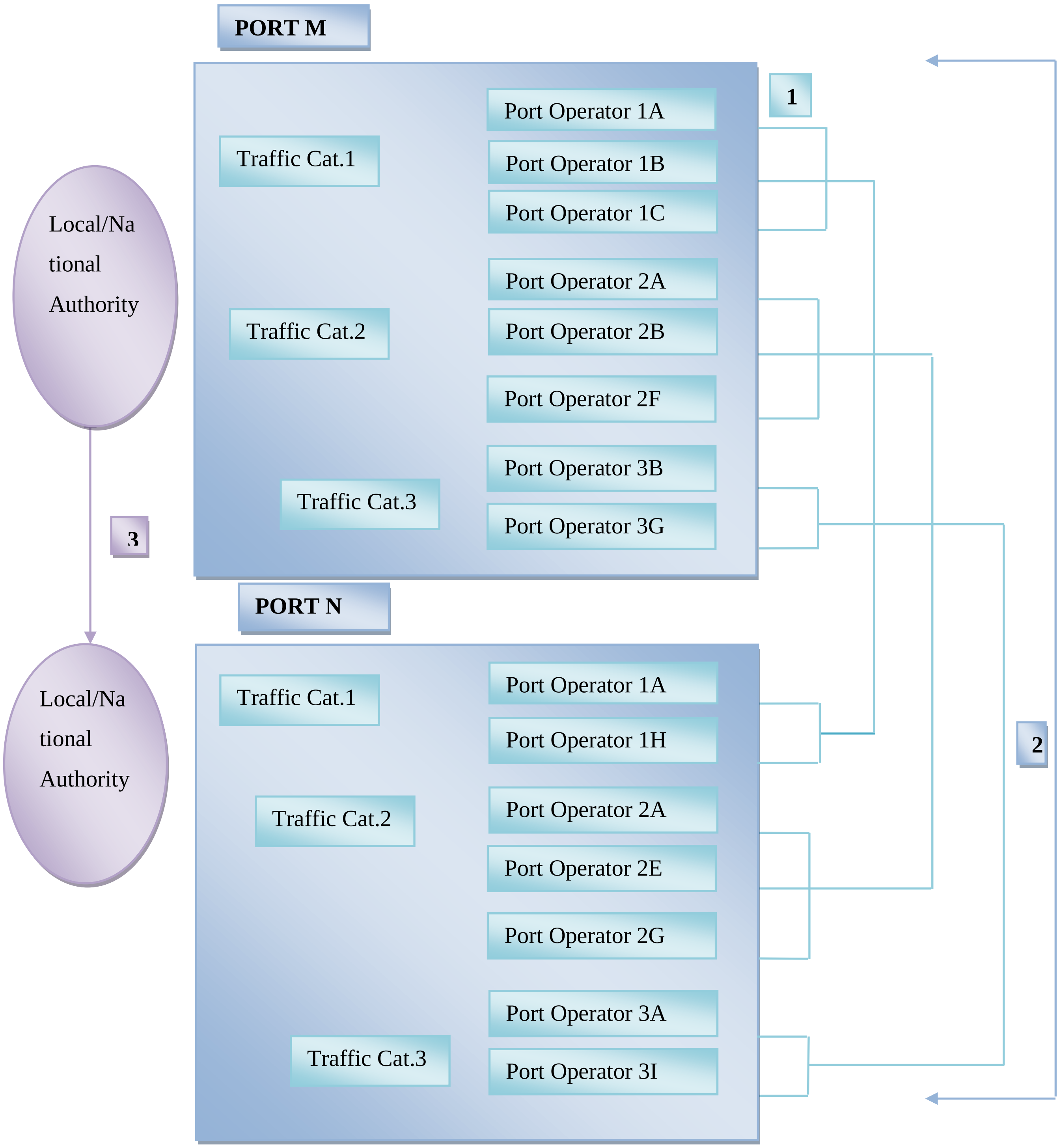


Figure 2.6: Conceptual definitions of port competition

Source: Adapted from Winklemans and Van de Voorde (2002)

Figure 2.6 indicates the different levels and complex nature of port competition. Even competition within the same port, say Port M or Port N, intra-port competition, can only occur between operators handling the same cargo category. Intra-port competition also exists between the same cargo types in different ports sharing the same hinterland (shown in Figure

2.8 as “1”). While the competition between ports or between port authorities is labelled “2” and “3” respectively in Figure 2.8.

2.9.1 Port market and intra-port competition

Intra-port competition does not imply many firms competing at the same time, rather it denotes a deregulated port market with free entry and exit (Goss, 1990a). The debate on intra-port competition revolves around port ownership and administration, as there is no competition within a single port under the management of a public port authority (Cullinane, Teng, & Wang, 2005c). Different port ownership arises as a result of the distribution of property rights of infrastructure, superstructure and services. It is in this context that this research treats port competition, because of the focus on private participation in terminals through concession. Theoretically, the concept of contestable markets entails that the ease of entry and exit to markets leads to efficiency. In short, contestable market implies low entry barriers, while a perfectly contestable market assumes the total absence of such barriers (Baumol, Panzar, Willig, & Bailey, 1982). The belief is that the threat of competition will force operators to act in a competitive manner; therefore barriers to entry render markets non-contestable.

Leveraging from this economic theory, the cargo handling business could be regarded as a non-contestable market for the following reasons: entry is difficult because expensive and specialised equipment is required for operation and concession agreements are of a long-term nature, normally 20 years or more. In addition, the option to enter or exit the market requires that capital invested by concessionaires be liquated without any loss, or removed for alternative use. The market is also characterised by high sunk cost, unless on anticipation of a reasonable rate of return, the motivation for entry is limited (Notteboom & Winkelmans, 2001b). Despite that the cargo handling, business lacks contestability i.e. existence of an imperfect market, but workable competition can still be introduced.

According to Clark (2001) in industries with small economies of scale in terms of market size, operated by a few firms the competition among terminals can be innovative and also lead to efficient service over time. The positive outcomes of competition are achieved through rivalry among a few terminals that are allowed to operate independently. The nature of the port market is such that there are many buyers in the market for port services. However, it is not feasible to structure the supply side into many sellers with equal opportunities (Van Niekerk, 2005). Therefore, some sort of government intervention is necessary to create workable competition. In order to derive the benefits of competition, regulate supply in order to avoid exploitation of monopoly rents and to plan resource utilisation to prevent excess or under capacity.

The ability to introduce a workable competition in cargo handling is influenced by the following: the volume of cargo, the potential traffic growth and the amount of debt that can be allocated to the business units. As well as cross-subsidisation of essential uneconomic port services, employment requirements and the potential to raise productivity with technologically obsolete equipment (Van Niekerk, 2005). Investment in small businesses that cannot guarantee the advantages of economies of scale and margins of return on investment is little, requiring other cost saving measures, for example on labour issues. It sometimes leads to policy somersaults where ports are considered as social tools to create employment and at the same time competition is promoted.

However, it is a consensus that competition is needed to improve productivity through market forces. For small terminals to introduce private participation on a competitive basis requires strict regulation, if such units are too small to attract public interest. To avoid transferring public monopoly into a private monopoly and at the same time ensure that the goals of private participation are met, the crafting of regulation should be done with great caution. Private operators will have to be subjected to both price and performance regulation, to control monopolistic pricing and to ensure that operators do not unproductively occupy and monopolise portland (Van Niekerk, 2005).

Government and port users prefers intra-port competition, although it is not always practicable in all ports. It depends on the volume of the cargo, which may be inadequate to allow the delineation of the port into two or more terminals and therefore unprofitable to operators to run an efficient business. Establishment of competition in the port sector requires an assessment of the economic and financial viability of creating more than one terminal to handle the same cargo as well as adoption of a new port management model if not already in existence. Plus, conclusion of concession and lease agreements including tariff regulation mechanism in ports where lack of intra-port is envisaged and finally, enactment of port competition law that deals with issue of tariffs in a monopolistic market situation, which will help the government in regulatory oversight.

In the port industry there is a keen debate on the correlation between intra-port competition and performance, as in other sectors. The proponents of competition assert that it encourages modernisation, enhances accountability among staff and frees a port from bureaucratic administrative bottlenecks and in so doing paves the way for higher efficiency. As a result, governments all over the world support policies that encourage inter-port competition, competitive market structure and decentralisation (Heaver, 1995). On the other hand, there are certain economists and governments that support a centralised and monopolistic market for the port industry. Their arguments are hinged on the fact that central planning for the port industry reduces the problem of over capacity. Ports may experience excess capacity due to the quest for ship owners to minimise delay and the over extrapolation by port management of cargo growth and the long life nature of port infrastructure and terminals.

Numerous studies on traditional industrial organisation theory (Megginson and Netter (2001); Tirole (1988); Vickers and Yarrow (1988)) suggest that competition can have both positive and negative effects on any organisation. Other studies by Goss and Stevens (2001); Cullinane et al. (2005c), have on the contrary, a unanimous agreement that intra-port competition improves port performance and should be encouraged. It is becoming increasing difficult to ignore the influence of intra-port competition on efficiency, as Goss (1990a) points out that landlord ports achieve efficiency by introducing intra-port competition. Therefore, the primary role of port authorities should be encouraging within port competition. This is supported by Heaver (1995), who expounded that encouraging competition should be a new policy direction. Among other advantages, privatisation is a useful approach to introducing intra-port competition. It is what is pushing ports globally to adopt privatisation as a way of improving their economic efficiency. However, caution should be applied, as introducing privatisation without appropriate regulation to enhance inter-port, or intra-port competition, may not guarantee improved performance and rather a new monopoly could emerge. It is especially necessary in port concessions as it involves long-term contracts between operators and port authorities, or the Government. Port infrastructure investments are expensive and are of a long-term nature so it takes a long time for operators to recoup.

This research argues that competition is a market-based regulation to curb monopolistic tendencies of terminal operators. Competition prevents the private operator from pricing port services too high and above the long-run marginal costs. However, if the environment is non-competitive, as is the case with Nigeria, the private operator is encouraged to put price continuously above marginal costs, or institute a system of regulating prices. In the absence of competition, the transfer of port services from the public to the private becomes a mere exercise, which in the end may not bring the much anticipated change in service quality and pricing.

2.10 Why Regulate a Privatised Port?

Thus, for ports and maritime services to function efficiently and competitively in a privatisation environment an appropriate regulatory framework covering the labour management and the regulation of fees that create a conducive environment for contestable markets, must be put in place. The framework should encompass various aspects, such as the functioning of markets, setting of tariffs, revenues, or profits. As well as controlling market entry and exit and ensuring fair and competitive behaviour practices within the port sub-sector (World Bank, 2007a).

However, the advancement of ports into Landlord Port Authorities entails a reduction in monopoly powers in certain port services, allowing free entry by private service providers due to liberalisation and deregulation. For services where there is a high inclination that private service providers will engage in monopolistic practices and other anti-competitive behaviour, a regulator is needed to oversee pricing practices to improve efficiency. Also, regulatory institutions are necessary to exert control over the infrastructural assets used by private terminal operators.

Regulatory systems are also required for contestable services formerly run by public port authorities. It includes pilotage, tug assistance, stevedoring activities, cargo handling, storage and yard services, which as a result of deregulation could fall within the purview of private operators. Private participation in these activities reduces subsidies, as operators can recover costs directly from users

(Notteboom & Winkelmans, 2001b). According to the authors, the profit maximisation objective of the private sector calls for regulatory oversight over the exercise of market power, to ensure that they public goods attributes of many port sector activities are not in short supply and to safeguard public interest.

In developing countries, especially those in Africa, where there is a need to surmount challenges negating the competitiveness of the ports, the need to strengthen the institutions in charge of regulating the port sector becomes paramount. Therefore, the need for transparent rules that will nurture the administration's capabilities to regulate terminal operators and services becomes necessary. Only a well-endowed institution can develop a data collection mechanism to promote inter-port and intra-port competition and to adopt an innovative regulatory instrument, such as yardstick competition.

2.11 Relationship between Port Privatisation, Competition and Performance

The impact of whole concessions of a nation's ports, on the operational performance of the ports, has become necessary, as it is less evident in the literature. Most port efficiency studies in the literature focused on the effects of privatisation on the container ports/terminals, or worldwide ports where in most cases the operations of these ports are already adjudged successful. For example a study of the top 100 container terminals by Baird (2002), as well as Cheon, Dowall, and Song (2010) study of the influence of institutional changes on 98 major ports in the World. Figure 2.7 shows the relationship between port privatisation and performance.

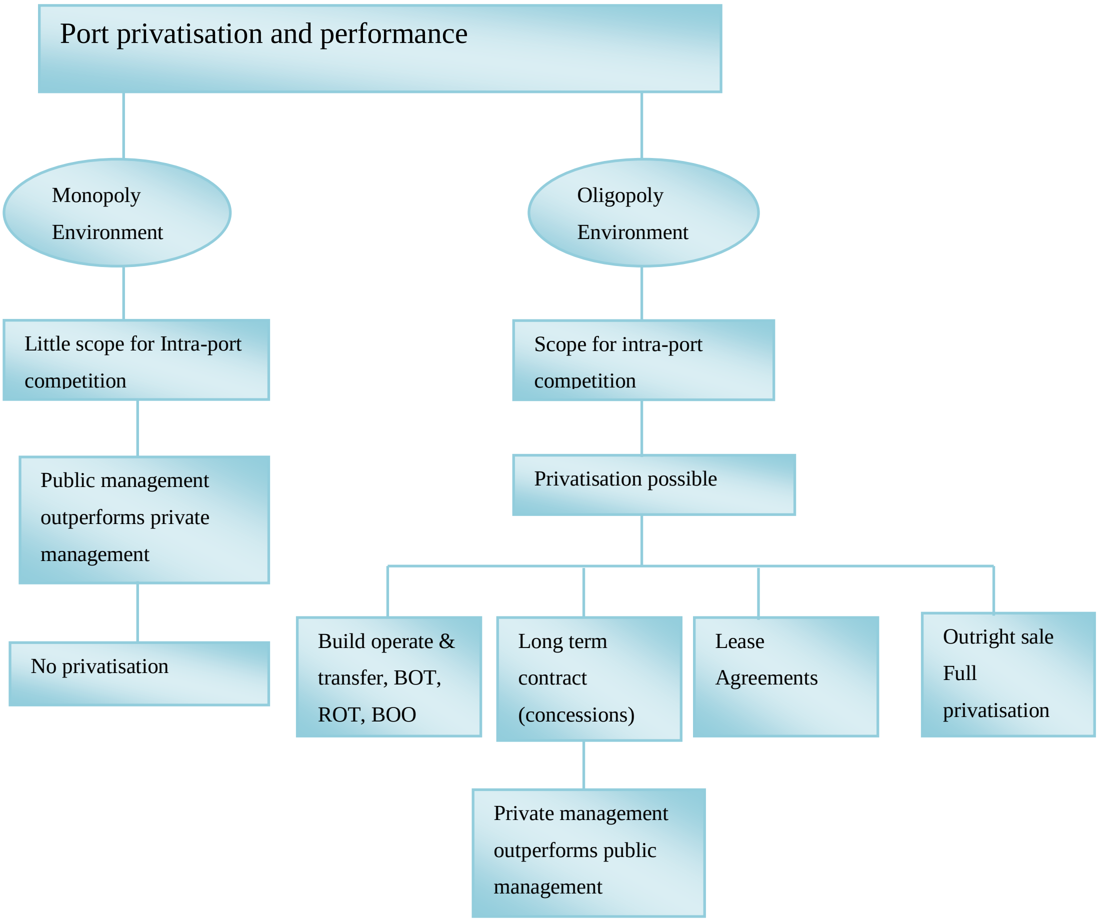


Figure 2.7: Relating port privatisation, competition and performance

From Figure 2.7, it could be deduced that port privatisation does not on its own bring about performance improvements. That is why there is a general belief among researchers that it is rather intra-port competition that leads to improved performance and therefore should be encouraged. Cullinane et al. (2005c), observed that public ports achieve efficiency by having skilful and competent management, while ports practising the Landlord model of port administration derive their efficiency by introducing intra-port competition. Thus in a landlord setting, the primary role of port authorities is to guarantee and sustain intra-port competition within the port system (Goss, 1990b). Likewise, Baird and Valentine (2006) argue that the reason for privatisation is the introduction of profound competition. Therefore, the overwhelming global interest in port privatisation as a means of improving economic efficiency is hinged on competition.

However, the issue of port privatisation as a viable way of introducing within port competition should be treated with caution, because privatisation may not always guarantee improved performance as depicted in Figure 2.7. It is as a result of the lumpiness of port investment and the long life of most port infrastructure. Thus, port privatisation is always accompanied by long-term contracts between port authorities and the private investors. It may create a new monopoly within the port. Therefore, in the absence of inter, or intra-port competition, it is virtually impossible to categorical conclude whether public or private-sector management is superior to the other, in terms of performance.

Thus, it could be said that some controversies exist as to the relationship between port ownership and performance in the absence or limited competition. It is as a result of these circumstances that economists such as Vickers and Yarrow (1988), argue that economic efficiency is better in public management than private management. As in an oligopolistic market, private sector port operators may not be motivated to improve performance, because in such markets uncontrolled high port charges, inefficiency and excessive costs abound. As a result public management could perform better than their private counterparts.

On the other hand, if public ports are characterised by bureaucratic red tapes, lack of clear-cut objectives and excessive government intervention and meddling in operational decisions, introducing private participation could improve performance. Taking from this perspective, some economists argued that public enterprises are inherently less efficient than private enterprises. It is through this prism that privatisation is perceived as ushering in improved performance (Song et al., 2001).

Figure 2.7 indicates that with the introduction of inter-port competition, which is an attribute of ports, especially container terminals in developed countries which are mostly Europe and Asia, some of a today's private sector port operators should more likely perform better than their public peers. Cullinane et al. (2005a) argued that private enterprises, in order to maintain profitability and self-perpetuation, are motivated to seek viable options to survive in a competitive market.

Thus, this research will demonstrate that the introduction of privatisation through concession contracts leads to port efficiency by exploring this primary hypothesis, "The efficiency of Nigerian seaports improves with increased private sector participation".

2.11.1 Ownership and efficiency

The debate on which has the greater efficiency between private and public entities has reached the port sector, just like other economic sectors and the results are inconclusive. Most of the studies that analysed this relationship are based on container terminals. Even though there is no clear-cut agreement on the relationship between privatisation and efficiency in this cargo segment, most evidence point to improvements in efficiency after the introduction of the private sector in cargo handling operations.

The study of the world's top 100 container terminals revealed the wide range application of privatisation policies in ports globally- Juhel (2001), Baird (2002), and Cheon et al. (2010). Likewise, detailed implementations in Asia, North America, Europe and Latin America-Cullinane and Song (2001), Ircha (2001), Notteboom and Winkelmans (2001a), Hoffmann (2001) and Cullinane et al. (2005a). In contrast, there is no study detailing the effects of privatisation on African ports. Baird (2002) further revealed the variations in private sector involvement because of the diverse methods employed to bring about private participation in the port industry. In summary, Baird (2002) observed that, despite the enthusiasm for privatisation, the role of the public sector i.e. the port authorities will still be considerable.

Despite the clamour for port privatisation and many studies by experts on the subject, there is no consensus on the relationship between privatisation and port performance, mainly as a result of the approach employed by different authors. For example, Cullinane, Song, and Gray (2002) assessed the influence of administrative and ownership structures on major container terminals in Asia, using the Stochastic Frontier Model. The study revealed a positive relationship between privatisation and enhanced productive efficiency, although the study was not able to determine the degree of private sector participation and the level of productive efficiency. Tongzon and Heng (2005) show that privatisation is indeed an effective way of improving port efficiency. However, for ports with full privatisation, operational efficiency did not improve. Hence, the relationship between privatisation and efficiency is non-linear; rather it is a U-shaped relationship. In addition, Tongzon and Heng (2005) also showed that the best model of private participation that can maximise efficiency is the private/public ownership model. In other words, it is better for the port authority to restrict private participation to ‘landowner and operation private’ functions and take over the regulatory function. Cullinane, Wang, Song, and Ji (2006) studied top container terminals in the world and showed that the ports with the greatest level of private participation are the most efficient, with the exception of the port of Singapore. Cullinane and Song (2003) used cross-sectional data to demonstrate that the higher the level of private property, the greater the level of efficiency. The study also showed that the introduction of competition in the South Korean port sector increased terminal efficiency, although the study made use of only five terminals. In addition, Cheon et al. (2010) analysed the effect of ownership on the efficiency of 94 seaports worldwide. In 39 that have gone through ownership transfer from public to the private sector, they found a positive impact of privatisation on efficiency and productivity.

On the contrary, Valentine and Gray (2001b) examined the subject of efficiency and the ownership structure of 31 World container ports, using cluster analysis and discriminant analysis. They classified the container ports into three types of models: Public, Private and mixed. The result of the analysis of the 31 container ports investigated showed no correlation between ownership structure and efficiency. Additionally, the study of European and Asian terminals found no relationship between privatisation and efficiency (Cullinane et al., 2005a; Cullinane et al., 2002; Notteboom et al., 2000). In addition, the study of the Myanmar ports’ performance based on privatisation, shows that for those ports practising BOT there is no positive correlation between efficiency and port ownership (Lin & Hualong, 2010).

2.11.2 Efficiency and port size

The suggestion in most literature on ports is that larger ports have a greater level of efficiency as a result of the learning curve effect, due to greater activity. However, ports provide for future demand growth, by investing in a large amount of infrastructure and equipment. It may result in excess capacity at the time these investments are made and therefore to achieve higher efficiency in terms of economy of scale may not be possible (González & Trujillo, 2008). Also, some large ports may be at the physical limit of their growth, which makes an increase in efficiency difficult, while smaller ports find it easier to grow to optimum scales. According to González and Trujillo (2008), it is the preponderance of these issues that makes a definitive relationship between size and efficiency difficult. Thus, there is also no clear-cut and conclusive view regarding the effect of port size on efficiency for container terminals and port authorities.

Tongzon and Heng (2005) indicated a positive relationship between port size and technical efficiency. In the same vein, Wang and Cullinane (2006) suggested that most container terminals with higher production scales are likely to be more efficient. Cullinane et al. (2002) also concluded that the efficiency of a terminal is directly related to its size, when it is a non-temporal (non-sequential) comparison among terminals. However, if temporal effects are taking into consideration in the comparison, the result is inconclusive. Contrarily, Cullinane et al. (2004) showed that the efficiency of terminals is not influenced by size. Likewise, the results of the study by Notteboom et al. (2000) did not indicate that small terminals are less efficient than larger ones. Rather, they concluded that high levels of competition among small terminals within a port lead them to greater efficiency. The corollary to this finding that is supported by Cullinane et al. (2006), is that the mean efficiency level of terminals in hub ports is greater than in feeder ports, although there is a higher level of dispersion within each group. This may not be surprising, as hub ports are always faced with high competitive pressure. The study of Spanish ports, using panel data from 1985-1989 for a frontier cost function model, concluded that smaller ports under central control are more efficient than their counterparts under private control (Coto-Millan, Banos-Pino, & Rodriguez-Alvarez, 2000). Turner et al. (2004) used 14-year (1984-1997) panel data for 20 ports in North America and the study found out that on average, larger ports are more productive than the smaller ones. They concluded that there are economies of scale in container terminal production. In the same vein, Laxe (2005) study of 16 Asian ports found that larger ports are more efficient than smaller ports. Likewise, Al-Eraqi, Mustafa, Khader, and Barros (2008) study of 22 major ports in the Middle East and East Africa, shows that bigger ports are more efficient than smaller ones. However, Rajasekar, Sania, and Malabika (2014) analysis of the operational efficiency of selected Indian ports from 1993-2011, revealed that size has no influence on the efficiency of ports and that both big and small ports are efficient.

2.12 Chapter Summary

This chapter has surveyed the various theoretical concepts underpinning privatisation and the application in developing countries, with a focus on Nigeria's port concession. The chapter has presented a theoretical framework for port privatisation through concession contracts and ownership models, which form the basis of this research. The chapter has also introduced the various arguments on the interplay of intra-port competition and regulation on port performance. A survey of selected port privatisation programmes worldwide was undertaken and the various outcomes highlighted. A review of the literature on privatisation and performance in the port sector yielded an inconclusive result, with some reporting a positive relationship, while others were of a contrary view.

Finally, the chapter examined privatisation in Africa and found that Africa lags behind other regional groupings in embracing privatisation. As at 2008, about 65% of African ports practise the service model of port administration. Even in the countries that adopted the Landlord model, it is mainly for container prts/terminals, except in Nigeria where the concession was for all ports in one go. However, there are no studies detailing the outcome of these privatisation programmes, as is the case in the Caribbean, Asia and Europe. Hence, the assessment of the influence of privatisation on the performance of ports of the top reformer in the region becomes paramount in order to encourage others to follow the trail. Chapter 3 discusses the review of different approaches that have been employed in the literature to measure performance and the method chosen for this research.

Chapter Three: Literature Reviews on Performance Measurement

3.1 Introduction

The objective of this chapter is to review the alternative approaches employed in the measurement of port performance, with emphasis on the two main methods used by the researchers: productivity and efficiency. The two concepts are related, but they differ conceptually, as will be explained later in the chapter. The structure of the chapter follows thus: first the various benchmarking and performance measurement approaches employed in the port industry, such as performance metrics and frontier techniques will be reviewed. It also highlights the advantages and disadvantages of each method. Secondly, it discusses the various productivity measures and spotlights the merits and demerits of each approach with particular emphasis on the Malmquist Productivity Index (MPI). Thirdly, the chapter focuses on the methods employed in this research; the frontier techniques and total factor productivity (TFP) measures. The literature on the two frontier techniques, parametric and non-parametric, will be reviewed. It also explores the applications of the two modern methods of; parametric, the stochastic frontier analysis (SFA) and non-parametric, the data envelopment analysis (DEA) and highlights the weaknesses and strengths of each approach. Fourthly, the chapter discusses the different DEA methods and models and their applications in the port industry. Finally, it undertakes an in-depth review of DEA applications in seaports globally and discusses the shortcomings of some of the various studies.

3.2 Port Performance Metrics and Productivity Measures

"You cannot manage it if you do not measure it" (Pallis & Vitsounis, 2008). It is an old management proverb that has not changed with time. Performance refers to the degree of success in achieving intended goals and objectives (Devine, Lee, Jones, & Tyson, 1985; Song et al., 2001). In other words, performance is a concept that focuses on the status of outcomes that are achieved through certain behaviours (production and service), as a result of pursuing goals. In contrast, the efficiency concept is based more on the behaviour of production and service activities.

Performance measurement involves presenting metrics numerically to quantify some characteristics of the object, product, process, or any other applicable factor. It usually incorporates comparison and evaluation of goals, benchmarks and/or historical figures (Bichou, 2008). There are three categories of performance metrics; input measures (time, cost and resource), output measures (throughput, production and profit) and ratio indices (productivity, efficiency). The ratios are presented in the form of input-output that may have input minimisation, or output maximisation, as the overriding objective. Depending on the approach and dimension, the ratio could be looked at from two perspectives: engineering and production economics. The engineering perspective from the literature, includes both cost efficiency (low production) and capital efficiency (low investment) Wheelwright (1978) cf. Bichou (2008). While from the production economics perspective, efficiency is broken down into technical, allocative and scale efficiencies. It is the economic point of view that is relevant to this research. To measure performance both the productivity and efficiency approaches are employed. The following sections review these techniques.

3.2.1 Port financial performance metrics

Financial metrics is mainly used in costing and management accounting to estimate a firm's financial performance, but it has also been widely quoted in published annual reports of port authorities and terminal operators. For example, the annual survey of financial performance of US public ports MARAD (2003) is widely cited. The regularly used port financial indicators include; operating ratio, the operating surplus, the return on investment (ROI) and the return on assets employed (RAE). Other financial indicators used by UNCTAD (1976) for benchmarking seaports include; capital and labour expenditures per ship/cargo unit handled and the revenue per cargo tonne handled.

The use of financial metrics for performance benchmarking may not be the best. However, there may not be any diminutive correlation between financial performance and efficient use of resources. Higher profitability, for example, could be driven by cost deflation or price inflation, or other external factors, rather than efficient resource utilisation or productivity. This is supported by Kaplan (1984). The author argued that superior financial performance may be a result of other factors, such as adoption of new financing and ownership methods, rather than the outcome of efficient operation and management systems. Additionally, Bichou (2012) viewed financial ratios as inappropriate, because of the inability to assess intangible activities such as innovation. In the same vein, Holmberg (2000) argued that financial metrics show results of past actions and are designed to meet external evaluators needs and expectations. Based on this, Bichou (2008) argued that the use of logistics costing approaches, such as activity-based costing (ABC) and direct-profit profitability (DPP), have taken precedence in recent years over traditional financial performance.

In the case of ports and terminals, the secrecy in which financial data is held, coupled with the absence of cost and price information in most financial reports, makes the use of financial performance in port benchmarking difficult. In addition, financial ratios focus mainly on short-term profitability, while port investments are in the long term. In terms of comparisons between ports from different countries, financial benchmarking becomes a herculean task because of the dissimilarity in costing and accounting procedures between countries. Even if ports are in the same country, the financial and institutional structure of different port administrative models (public, private, landlord, tool.) may differ, rendering them incomparable. In addition, port financial performance may be influenced by other factors such as; price regulation, statutory freedom and access to private equity (Bichou, 2008). As stated previously, the scope of this research is based on the objectives of the Nigerian port concession, which focused on efficiency and productivity. Therefore, financial performance is not considered.

3.2.2 Partial indicators/snapshot measures

There is a broad range of indicators regarded as port performance indicators, as presented in the UNCTAD classic monograph, UNCTAD (1976). As well as in other literature: Bendall and Stent (1987); Fourgeaud (2000); Frankel (1993); Talley (1988) and UNCTAD (1987). The performance indicators presented in these studies can be described at best as partial indicators, or snapshot measures, as only a single port resource is measured, such as labour, capital, facilities (crane, berth, warehouse) and/or operation (handling, movement, storage). The throughput volume of cargo is an example of a snapshot measure that is widely used to rank ports globally, though misleading. Throughput volumes also feature prominently on websites of port authorities and growth in throughput is regarded as evidence of performance. Though the use is widespread, it is fraught with limitations. Firstly, throughput volumes do not tell much about the economic impact of ports. Secondly, growth in throughput volumes is an indication of international trade flows and not the performance of the port. There are also non-quay activities that are used as performance indicators. For example, cargo dwell time that gives an indication of the time duration cargo spends from unloading from a ship, till, when it leaves the port gate and vice versa. At times, a partial indicator is a measure of the relationship between two partial indicators. For instance, berth throughput per square-of-metre capacity and the number of TEUs per hour versus ship's size (Drewry Shipping Consultants, 2005). Likewise, the net crane rate by liner shipping trade (Australian Productivity Commission, 2003).

The difficulty with using partial measures is that it gives activity measure, instead of performance measurement. Performance index is defined as the ratio of output quantity to input quantity. Depending on the definition and scope of selected outputs and inputs and the approaches employed for the estimation, there are two broad categories of port productivity measurement. They are single and partial productivity indices and multi-factor and total factor productivity indexes.

3.2.3 Single and partial productivity indexes

"A single productivity index or single factor productivity (SFP) compares the volume measure of an output to a volume measure of an input use" (Bichou, 2006b). Inputs are measured based on resources employed in port production (land, labour and capital), while outputs are expressed in the form of a quantity index, or value-adding index. The use of a quantity index is mostly preferred in economic impact and productivity growth studies, because it is not very sensitive to processes of substitution between factors of production. The application of a single input and single output model allows for the computation of the average productivity (P) of the firm or port, by differentiating between the port's output and input quantities or values. A single productivity index for two ports A and B could be computed to measure their productivity over time $\emptyset_{A(t+1),A(t)}$ or relative to one another $\emptyset_{A,B}$ in the same period, as expressed in Bichou (2008), Coelli, Rao, O'Donnell, and Battese (2005) and Wang et al. (2002) thus:

$$P(A) = \frac{Output\ A}{Input\ A} = \frac{y_A}{x_A}\ and\ P(B) = \frac{Output\ B}{Iput\ B} = \frac{y_B}{x_B}$$

Equation 3.1

$$\emptyset_{A(t+1),A(t)} = \frac{P(A_{t+1})}{P(A_t)}, \qquad \emptyset_{B(t+1),B(t)} = \frac{P(B_{t+1})}{P(B_t)}$$ **Equation 3.2**

$$\emptyset_{A,B} = \frac{P(A)}{P(B)} = \frac{y_A/x_A}{y_B/x_B}$$ **Equation 3.3**

Partial factor productivity (PFP) is similar in concept to single factor productivity (SFP). The only difference is PFP tends to compare a subset of outputs to a subset of inputs when dealing with multiple outputs and inputs. The purpose is to construct a performance index that compares one or more outputs to one or more inputs. It can be illustrated using a hypothetical example of two ports, A and B, each using multiple inputs and multiple outputs. We will compare the use of subsets of two inputs(x_1, x_2), to produce a set of two outputs(y_1, y_2), in each port. Assuming availability of market prices, we can use input prices (θ_i) and output prices (θ_o) to compute a total index of average productivity from the following equations:

$$P(A) = \frac{y_A}{X_A} = \frac{\theta_O 1^y 1A + \theta_o 2^y 2A}{\theta_i 1^x 1A + \theta_i 2^x 2A}$$ **Equation 3.4**

$$P(B) = \frac{Y_B}{X_B} = \frac{\theta_o 1^y 1B + \theta_o 2^y 2B}{\theta_i 1^x 1B + \theta_i 2^x 2B}$$ **Equation 3.5**

$$\emptyset_{A,B} = \frac{P(A)}{P(B)}$$ **Equation 3.6**

In the estimation of single and partial factor productivity indexes, either monetary or physical units can be used. However, in using monetary units to calculate SFP and PFP, it is more appropriate to use data on market prices and cost while quantities of production (tonnes, TEUs, moves) and resources (time, workers.) are classified as physical units. The secrecy surrounding divulging port financial data leads to unavailability of market prices for ports. It creates a problem for researchers interested in monetary units. As a result, physical units are preferred in relation to monetary units in most port studies, despite the difficulty involved in establishing a relationship between variations in number and type of physical indicators in the port industry.

Wang, Cullinane, and Song (2005) have argued that there is a variety of SFP and PFP index in use to capture one aspect of port productivity or the other. Although, there is no agreement among researchers and professionals as to which indicator(s) best reflects actual port production process or physical performance, even for a single operation or port. Besides, there is difficulty involved in trying to aggregate SFP and PFP measures (UNCTAD, 1987). Another problem is that the concept of productivity measured by one or a subset of output-input volume(s) is compromised when SFP and PFP indicators are used for multiple-input and multi-output port production (Bichou & Gray, 2004; Cullinane, 2002). Furthermore, in order to capture change in productivity over time, or between ports, some port studies tend to compare SFP and PFP indicators, for instance equipment or labour productivity. However, comparisons of a SFP and PFP used to capture total factor productivity may not be desirable, because they do not take into account other input and output quantities involved in port production.

In general, partial factor productivity indicators do measure productive efficiency, but not economic efficiency, or cost efficiency. They reflect aspects of the application of labour or capital resources on the production of ports and terminals. They thus do not indicate whether cargo handling rates are achieved using the most economically efficient mix of the resources, given their relative costs. In addition, since the partial indicators demonstrate limited views of port operation, they do not often produce analytically consistent results. In most cases, since one single measure cannot suffice for the purpose of productivity evaluation, multiple indices are examined. However, in analysis when using partial productivity indicators, it is common to observe conflicting indexes at the same time, which makes it difficult to show benchmarks (Zhu, 2003). Furthermore, partial indicators are often used for simplicity so that internal and external stakeholders can understand.

In conclusion, in assessing productive efficiency, even the benchmarks based on partial indicators can be misleading. Port productivity stems from the joint contributions of various inputs and the use of a single factor may ignore the effects of interaction, substitution and trade-off among input factors on production (Estache et al., 2002).

3.2.4 Total factor productivity measures:

Total factor productivity (TFP) can simply be defined as the rate of change of total output in relation to total input. The concept of TFP is used to measure or decompose change in productivity over time, or between firms, by aggregating multiple inputs (M) and outputs (S). The concept can metamorphose into multi-factor productivity (MFP) when used to relate a single output to a collection of inputs. Song and Cui (2013) identified three major indexes that are used in productivity studies. TFP is derived by computing the ratio of the weighted sum of outputs to the weighted sum of inputs, expressed as:

$$TFP = \sum_{s=1}^{S} \emptyset_S Y_S \Big/ \sum_{m=1}^{M} \emptyset_m X_m$$ **Equation 3.7**

Where $\emptyset_s$ and $\emptyset_m$ are output and input weights respectively, whose summation must be equal to unity (1). If we assume the input and output markets to be productively efficient, then the weights represent cost shares for inputs and revenue shares for outputs.

Equation 3.7 assumes the input and output markets to be productively efficient, therefore, the weights represent cost shares for inputs and revenue shares for outputs. That is the assumption adopted in Törnqvist index and Fisher index, Estache (1997) and Estache and Carbajo (1996) respectively, which have been used extensively in productivity studies.

Therefore, the basis of TFP derived from the Törnqvist and Fisher indexes is quantity data and market prices, which are neither available in most cases, nor well suited for weight aggregation. Most port research, especially at ports globally, is bogged down by inadequacy of data for effective comparison. In addition, price may not be meaningful economically in the estimation of productivity of non-market activities, such as port operations in certain countries and under some institutional arrangements and management systems. Furthermore, the application of non-frontier TFP requires that firms should be competitive and efficient, but in reality this assumption does not always hold. Another problem with this approach is the inability to differentiate between scale effects and efficiency differences. Grifell-Tatjé and Lovell (1995), identified these assumptions as major drawbacks of the above indices.

In order to overcome the limitations inherent in a non-frontier TFP approach researchers rely on the Malmquist TFP Index, which is estimated from a distance frontier. The Malmquist Productivity Index MPI, measures TFP change of data points by computing the ratio of distances of each point relative to a common technology. To remove the uncertainty that surrounds which technology to adopt as the reference technology, it is suggested in Fare, Grosskopf, and Lovell (1994), that the geometric mean of the two indexes is evaluated between periods t and $t + 1$, as the base and reference technology periods respectively. This approach removes the need for price data and the assumption of the efficient behaviour of the firm (i.e. profit maximisation or cost minimisation).

3.2.5 TFP estimation techniques

Conceptually, the measure of efficiency is directly related to the measure of productivity. Although the two concepts are considered equivalent, Figure 3.1 distinguishes the two terms. To conceptually determine the sources of efficiency and productivity change, let us assume a production for the port industry. The efficient ports are located on the frontier, while inefficient ports are below the frontier. There are at least two ways of improving port productivity; technical progress and change in previous efficiency. Though, in an industry characterised by variable returns to scale, productivity can also improve due to changes in scale efficiency. The former can be achieved by introducing modern cargo handling equipment, thus shifting the frontier upwards. For the latter, improvement can be the result of the port industry acquiring a higher level of efficiency that could be conferred by improved work processes. In Figure 3.1, point A, the frontier, is defined by the fraction f(x, t), and the productivity is P_t, where x is the input employed to obtain the output y. In the following period (t+1), the firm operates now at point B, as a result of improved productivity (P_t + 1). It is due to technical change (shift of the frontier to f(x, t+1)) and an improvement in the technical efficiency (firm approaching the frontier). The distance from point A to the frontier in time, t, is greater than the distance from B to the frontier in t+1. Logically, it implies that a technological improvement as well as increase in efficiency, will lead to higher productivity (González & Trujillo, 2009; Wilson, Johns, Miller, & Pentecost, 2010). However, for a firm operating at decreasing returns to scale, this positive behaviour is undermined as production has increased by a lower proportion than the input (Pastor & Lovell, 2005).

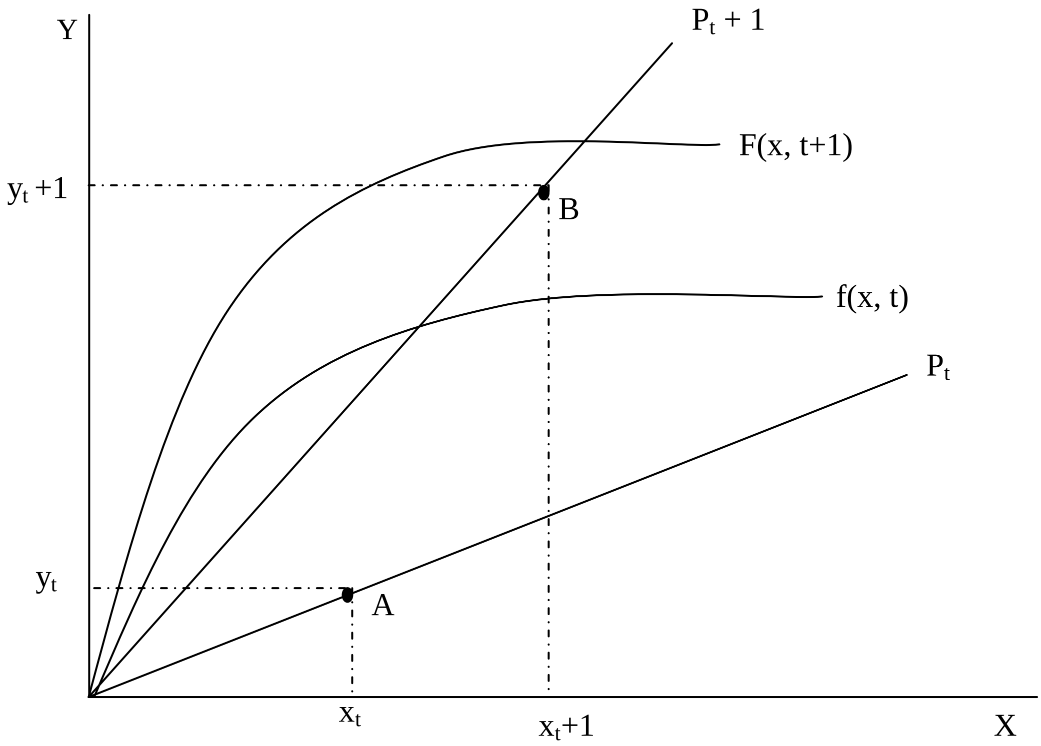


Figure 3.1: Productivity change: efficiency change, scale and technical change

Source: González and Trujillo (2008)

3.2.6 Productivity change over time (Malmquist productivity indexes (*MPI)* Concept)

Caves, Christensen, and Diewert (1982) have demonstrated that productivity change can be measured relative to two time periods, t and t+1, as depicted in Figure 3.1. The productivity index developed, based on distance functions is called the Malmquist Index. Färe, Grosskopf, Norris, and Zhang (1994) applied it to decompose the productivity growth into two mutually exclusive components: technical efficiency change and technical change over time. It measures the change in efficiency; the frontier shift and the catch-up effect, respectively (Froot & Klemperer, 1989). If *MPI* is expressed based on DEA efficiency measures, it is defined as the ratio of the efficiency measures for the same production unit in two different time periods or alternatively, between two different observations for the same period (Odeck, 2000; Rezitis, 2008).

Hence, the measurement of port efficiency changes and the identification of sources of technical change are achieved by employing the concept of DEA and the Malmquist Total Factor Productivity Index or Malmquist Productivity Index (MPI). MPI can be calculated from standard DEA scores to benchmark port efficiency between two-time periods. The basic idea is that if efficiency change has occurred over an extended period, temporal changes in efficiency can be attributed to two different sources related to port conditions, planning and management. These are: (a) frontier shift effects and (b) catch-up effects (Cheon, 2007a; Estache, De La Fe, & Trujillo, 2004; Estache et al., 2001; Nishimu & Page, 1982). The frontier shift effect involves the shift of the productive efficiency frontier and occurs as a result of significant changes in technological progress. Port efficiency gains from the frontier shift effects is attributable to the ability to keep up with the latest technologies. It is driven by institutional reforms, such as concession to increase, or decrease, market competition. To continuously keep in touch with the latest technology requires effective long-term strategic planning and timely capital investment at the port and policy making level.

Conversely, the catch-up effect, also known as technical efficiency change, is represented by a port movement along the production frontiers, which can occur even within a short period. The catch-up effect is so named because the concept implies the capacity of ports to managerially follow best practices in order to operate on the frontiers at any point in time. The efficiency gains emanating from the catch-up effect can be mainly attributed to the managerial capacity of ports to respond to port demand by flexibly adjusting production scales (changes in scale efficiency). Additionally, to adjust input factors in a timely fashion (changes in “pure” technical efficiency). Not only incentive changing policies, but also many other management systems and conditions could promote this type of behavioural change.

The time periods under measurement for this research are the pre- and post-concession port efficiency of Nigerian ports over a 12-year period (2000-2011). Nigerian ports during this time have undertaken a major port reform programme, described as the most ambitious and far-reaching port reform to be conducted in Africa or the World by the African Infrastructural Diagnostic Study (2008). Therefore, in order to determine the influence of port concession on port efficiency, it is meaningful to decompose the efficiency change into different primary sources of efficiency in order to determine among the factors which one is responsible for technical progress or deterioration. Then the MPI model is adopted to separate temporal changes in productive efficiency into technological progress and change in technical (managerial efficiency) as shown in Chapter 4, equations 4.12 & 4.13. The differentiation has policy implications, because it identifies the different sources of inefficiency. For example, if a port does not efficiently utilise its existing assets and input factors, but tries to attribute its inefficiency to the level of technology and lack of long term investment. The result of the courses of action would be the creation of ineffective and unreasonable policies. Based on this, examining sources of inefficiency not only enriches the efficiency analysis, but also helps to examine the influence of port concessions on port efficiency.

3.2.7 MPI applications in the port industry

There have been some early attempts in the literature to measure the TFP index of port such as Kim and Sachish (1986), who used a combination of labour and capital expenditure as inputs and throughput in metric tonnes as output, to derive the aggregate TFP index. Thereafter, the index was decomposed into measures of scale economies and technical change. Afterwards, in Sachish (1996), weighting was introduced in the estimation of partial productivity, while Talley (1994) suggests calculating a TFP index using a shadow price variable.

Recent studies have however, mostly employed MPI to measure efficiency change in the port industry such as in Liu, Liu, and Cheng (2007), they estimated the productivity of major container terminals in mainland China from 2004-2006, using MPI. The study discovered that the most efficient are the large ports and in terms of ownership, that Sino-foreign joint ventures performed better than domestic companies. De (2006) investigated the total productivity growth of Indian ports from 1981-2003 using MPI and the study revealed that there was no substantial impact on TFP for Indian ports after reform. In assessing the productivity change after Mexico's port reform, Estache et al. (2004) found short-term improvement in technical efficiency after the reform. Likewise, Guerrero and Rivera (2009) study of the total productivity of principal container terminals in Mexico showed improvement in all the ports. Barros, Felício, and Fernandes (2012) employed the Malmquist Index with a technology bias, to analyse the productivity of Brazilian ports. The result of the analysis suggests that Brazilian ports on average became less productive, with improvements in efficiency and deterioration in technological change. Díaz-Hernández, Martínez-Budría, and Jara-Díaz (2008) used MPI to measure the productivity of cargo handling in Spanish ports and attributed sources of productivity change to technical change, rather than efficiency change. In the same vein, Haralambides, Hussain, Barros, and Peypoch (2010) employed the Malmquist Index and a Luenberger Indicator, to assess the productivity of 16 Middle East and East Africa seaports. Luenberger is a productivity indicator that can contract inputs and expand outputs simultaneously. The study concluded that ports in the region declined in technical efficiency, despite positive developments in the adoption of new technology. Additionally, Song and Cui (2013) used the DEA-based Malmquist Index approach to measuring the productivity of Chinese container terminals from 2006-2011 and found improvement in productivity and the source of the growth to be technological progress. Cheon et al. (2010) assessed the productivity of 98 World ports in 1991 and 2004 and concluded that the change in ownership improved the operation of container terminals, especially the large ports. Yuen, Zhang, and Cheung (2013) analysed 21 container terminals in China, South Korea and Singapore from 2003-2007, using the MPI approach. The research found that foreign participation in the terminals has a positive impact on their productive efficiency.

The merits of a TFP index lies in its ability to reflect the joint impacts of changes in combined inputs to output(s). This feature is absent in single or partial productivity. As the TFP approach is a non-statistical method, it does not consider uncertainty (noise) associated with the results. In addition, as results obtained from the TFP are sensitive to the technique used and the definition of weights, it implies that efficiency results could be different depending on the TFP indices employed for the investigation. In any case, an econometric approach is better suited for studies involving large datasets, while researchers adopt the TFP approach due to the simplifying assumptions associated with the index number approach.

However, in applying productivity index techniques, it is of utmost importance to consider the fundamental differences between productivity and efficiency. The two phenomena may be similar, but each denotes a different performance measurement concept. Productivity is a descriptive measure, while efficiency is a normative measure (Bichou, 2008). In other words, a productive index compares two firms without a reference technology for a benchmark, while efficiency measures are used to benchmark firms based on the underlying technology. Lastly, a TFP approach uses technology for aggregation; it derives from the estimation of cost/production or distance functions. As a result of this the TFP approach is not used as a stand-alone technique in performance benchmarking. It is used in conjunction with efficiency techniques or other qualitative measures.

3.3 Efficiency Measures

The process of production involves ways of converting individual inputs into outputs. The relationship between the quantity of input and output is usually expressed by a production function, Y= f (K, L). It illustrates the maximum amount of the product that can be produced by using alternative combination of inputs, such as land, labour and capital (Nicholson & Snyder, 2011). The maximum amount of the product, given the inputs, can define a production frontier that sets a limit to the range of possible production.

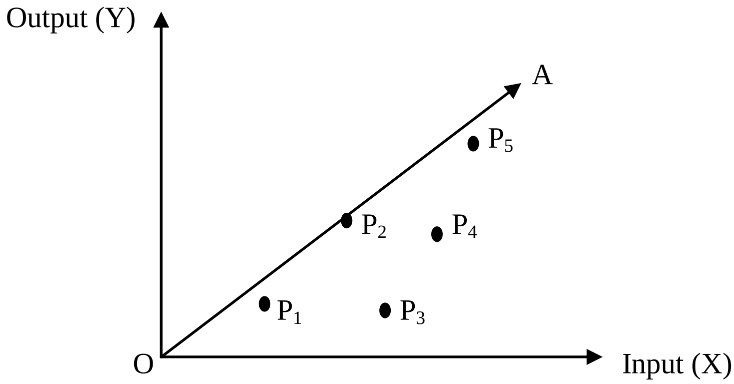


Figure 3.2 Production function and frontier

Source: Adapted from Cheon (2007b)

Figure 3.2 is a hypothetical illustration of the production function and the frontier. Line OA represents the efficient frontier and a firm, or an industry's productivity, cannot exceed limits set by the frontier. Firms that lie below the production frontier (such as p_1, p_3, p_4 & p_5) are regarded as inefficient. According to Cheon (2007b), the variation in productivity could be attributed to the differences in the environment in which production occurs and differences in the efficiency of the production process, as well as differences in production technology. In Figure 3.2, the point P_2 lies on the frontier and is considered efficient.

However, the modern discussion of efficiency concepts is based on the pioneering works of Farrell (1957), that followed from the works of Debreu (1951) and (Koopmans, 1951). The seminal work of Farrell (1957) identified two different ways of defining an inefficient unit.

The two distinct concepts of production efficiency identified by Farrell (1957) are: technical efficiency and allocative efficiency.

***Technical Efficiency (TE*): A firm (port) is said to be technically efficient if it achieves maximum potential output from given amounts of inputs, taking into consideration physical production relationships. The measurement can be performed by assuming either an input or output orientation. In the input-oriented approach, the technical efficiency measurement gives the potential input reduction a port could apply, without reducing the output level. Whereas the output-oriented framework provides the potential output increase a port could achieve, without increasing the use of inputs. Both the input and output oriented approach can be calculated by assuming constant returns to scale (CRS) or variable returns to scale (VRS) models. In the case of constant returns to scale, both orientations give very close results. On the other hand, in the case of variable returns to scale, which could be increasing or decreasing returns to scale, the scale efficiency needs to be taken into consideration in computing technical efficiency.

Allocative Efficiency (AE): Refers to a measure of the distance between the port and the point of maximum profitability, given market prices of inputs and outputs. In other words, allocative efficiency gives an indication of whether the different proportions of port production factors guarantees the attainment of maximum production with a particular market price.

Economic Efficiency (EE): Also known as overall efficiency. It is a product of technical and allocative efficiency. In other words, it is the potential reduction in production costs (cost efficiency), or the potential increase in revenue (revenue efficiency) that a port could apply in order to be both technically and allocatively efficient. It gives an insight into whether the port is operating at optimal or suboptimal scale. It is measured by assuming either an input or output-oriented approach, depending on whether the port is constrained in input reduction or output expansion. In any case, the measurement of adjustments necessary for the port to be technically efficient should be limited to economically viable points which implies taking the price structure into account (Cesaro & Sonia, 2009).

Scale efficiency

The scale efficiency of the firm (port) is an indication of the size and activity level of the firm. The scale efficiency index is the ratio of constant and variable returns to scale technologies.

The seminal work of Farrell (1957) on efficiency measurement followed an input-oriented framework, while Färe, Grosskopf, and Lovell (1985) introduced the output-oriented approach which is applied in this research. Figure 3.3 illustrates the two concepts.

A: Input-Oriented Model **B: Output-Oriented Model**

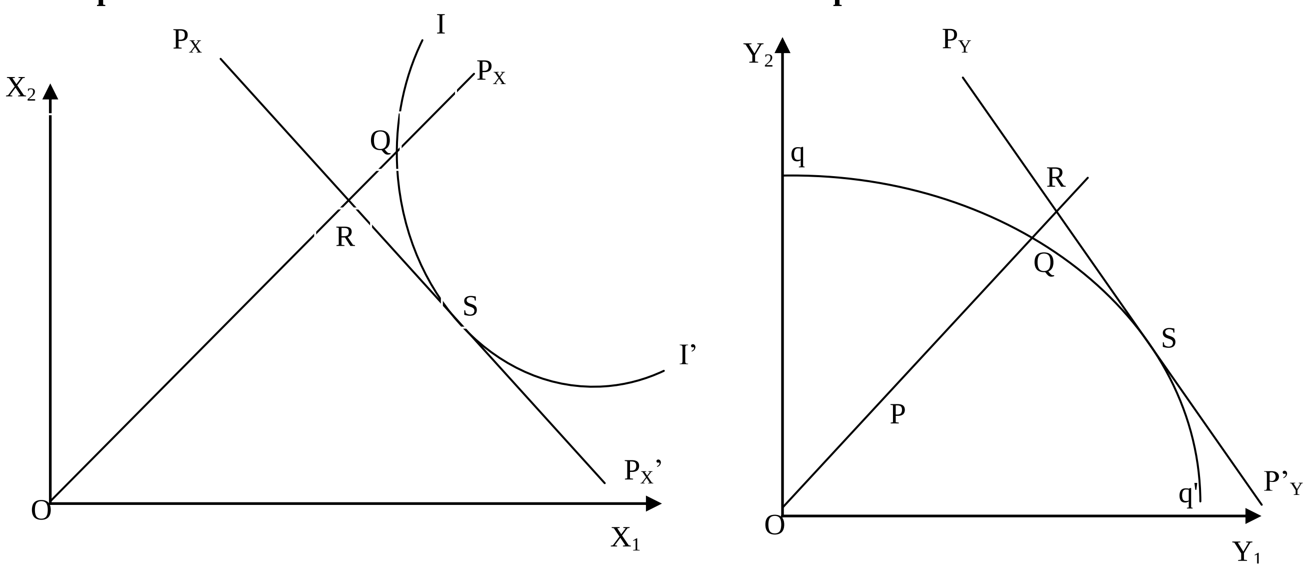


Figure 3.3: Economic efficiency

Source: Adopted from Cesaro and Sonia (2009)

In Figure 3.3, B shows the efficiency estimation by assuming output orientation. It shows how much output quantities can be proportionally increased without changes in given inputs. The input orientation reflects how much input quantities can be reduced by the firm without change in output produced. Assuming constant returns to scale, the two orientations provide the same efficiency scores, but will give unequal scores in the presence of increasing or decreasing returns to scale (Färe & Lovell, 1978). In figure 3.3 B, let qq' represent a production possibility curve for a port. Y_1 and Y_2 are two outputs produced with one input. While P_Y and P'_Y is the output price line; the slope is the ratio of output prices ($-P_Y1/P_Y2$). It implies that ports that lie on the curve such as Q and S are regarded as thoroughly efficient, while port P is inefficient because it is below the curve. The radial output ratio line which projects P to the frontier exactly at point Q, estimates the technical efficiency. The distance PQ reflects the proportional amount by which both quantities could be increased. The ratio OP/OQ gives the technical efficiency score of port P. The allocative efficiency can be computed from the output price line (PP'), by projecting the technically efficient ports to this line. It also shows the allocative efficiency of port P and Q, as OQ/OR. In the same vein, economic efficiency is achieved by ports operating at the point of tangency, between the production possibility curve and the price line (port S). The ratio OP/OR gives the port aggregate efficiency (economic efficiency) score for P. It is also a product of technical and allocative efficiency (EE= TE*AE=OQ/OP*OR/OQ=OR/OP). From the diagram, it is obvious that efficiency is a relative term that can only be evaluated by the process of benchmarking.

In figure 3.3, A, II' represent a production frontier that is the Isoquant II' that captures the minimum combination of inputs needed to produce a unit of output. X_1 and X_2 are two inputs used to obtain one output, while $P_X P'_X$ is the Isocost line; the slope is the ratio of input prices ($-PX_1/PX_2$). Any combination of inputs along the Isoquant is regarded as technically efficient, while any point above and to the right of the Isoquant is considered technically inefficient. Consequently, technical efficient DMUs are located at the frontier, while the technically inefficient DMUs appear below the frontier, because the actual outputs they produced are less than the target output. Therefore, the technical efficiency measure is computed as the relationship between actual output and the potential output the unit would have produced, if operating on the frontier.

3.3.1 Frontier techniques

Figure 3.3, A and B present a formal illustration of Farrell efficiency measures. Both orientations measure the extent of inefficiency at which a firm's actual input usage, or output production, can be radially decreased (increased) in the direction of the frontier (or boundary of the production possibility set) and still allow the firm to produce the same amount of output (or using the same amount of inputs). In implementing the above measures, it is necessary to identify the frontier a firm faces in order to determine how far it is from the frontier. The frontier concept just refers to the lower or upper limit of a boundary-efficiency range. This approach defines efficient firms as those that operate on the frontier and inefficient firms as those that operate away from the frontier that could be below for a production frontier and above for a cost frontier. Depending on the method used to construct the frontier, it could be absolute or relative, or parametric versus the non-parametric estimation. The parametric approach uses econometric techniques to measure the frontier, with the residual considered as a measure of inefficiency, and the non-parametric method involves linear programming techniques. The application of the frontier method has gained acceptance in the last two decades, due to its application in various production sectors. Bauer (1990) deduced three reasons for this development. First, the concept is consistent with the economic theory of optimising firm behaviour. Secondly, the deviation from the frontier can readily be interpreted as a measure of the efficiency through which the firms achieve their objectives. Thirdly, the information provided in terms of the relative efficiency of firms can have significant policy implications and is of high value to regulators and administrators. The next section of this chapter reviews the two methodologies, starting with a parametric approach.

3.3.2 Parametric approach

The parametric approach involves econometric specification of the model represented and interpreted by parameters. The first version of the parametric production function assumed all firms share common fixed frontier lines, the so-called deterministic model (Afriat, 1972; Aigner & Chu, 1968). It is however, criticised in the sense that the assumption is unreasonable. It ignores the possibility that the observed efficiency of the economic unit may be affected by exogenous (i.e. random shocks), as well as endogenous (i.e. inefficiency), factors (Song et al., 2001). The econometric point of view, instead of questioning it, generalises these factors into a single disturbance term by referring to them as inefficiency.

In order to address this anomaly, the stochastic frontier model was introduced, as a replacement for the deterministic frontier models. Unlike the deterministic model, this approach takes into account the fact that the production frontier is not entirely under the control of economic units. The approach develops further to refined econometric techniques that apparently split an error term into two different error structures. One part represents inefficiency of firms with a negative skewed half-normal distribution, while the other part indicates normally distributed noise. Measuring stochastic frontier models requires several conditions. There should be one single overall output measure, or relative complete price data (Nishimu & Page, 1982). It is not often the case for many analysts, researchers and planners in port authorities, given the limitations of compatibility, comprehensiveness and quality of data in the sector. In addition, the models require two critical methodological conditions; the distributions underlying productive inefficiency should be either half-normal or exponential. However, the distribution of statistical noise has a normal distribution. Additionally, the regressors, i.e. input variables and productive inefficiency are mutually independent. The latter is an unrealistic assumption. However, if a firm knows its level of inefficiency, it will normally take actions that influence its input choices in management and production processes Cullinane et al. (2002). Unless it is inhibited by external conditions and forces. The most common parametric frontier method is Stochastic Frontier Analysis (SFA). Generally, the SFA constructs a production frontier based on input and output variables, to give a technical efficiency assuming econometric principles. As an econometric technique, it relies on restrictive assumptions that ports use efficient technology regularly, which is not always the case. Secondly, the production frontier follows a predetermined function.

3.3.2.1 Applications of SFA in the port industry

The SFA methods have been applied several times in seaport efficiency studies. The survey of port efficiency studies that covers the period 1993-2006 by González and Trujillo (2009), showed 14 studies employed the SFA. The argument for the use of the SFA is that it considers random noise. Thus, it separates the measurement errors from efficiency estimates and allows hypotheses to be contrasted. However, in the cost frontier version or distance function, it estimates frontiers that consider more than one output. Some of the recent studies in the port industry are Yang, Lin, Kennedy, and Ruth (2011) and Trujillo and Tovar (2007). The latter assessed the efficiency of 22 European ports based on the TENT-T reform (European future plan for an integrated network), as short sea shipping will be competing with the railway. The study used cross-sectional data and could not identify clearly the factors that need improvement. The former looked at the efficiency of 5 Asian ports after privatisation; the results indicated that technical efficiency increased with the level of privatisation. The study concluded that the relationship between privatisation and efficiency is non-linear, but rather a U-shaped pattern, pointing out that the best privatisation option is public-private. In terms of size, they concluded that larger ports are more efficient than smaller ones.

Despite previous studies, the SFA methods do not allow for relative comparisons with best practice, as this requires the specification of functional forms. In terms of port operations, the burden of having to specify a functional form is restrictive and may not be consistent with the nature and operational characteristics of port production technologies. Another drawback of the parametric approach is that it may create additional errors in trying to specify error terms, which complicate the analysis. The frontier and efficiency value depends on the choice of functional form for each bundle of input/output variables used, coupled with the sensitivity of parameter estimates to the probability distribution specified by error terms. In addition, the use of single outputs of most SFA models contravenes the multi-output nature of port production.

Plus, the use of parametric techniques may not be appropriate in benchmarking ports with different operational, management and institutional features. It is because the application of the SFA models is most useful in situations involving a single overall output measure or complete price data, but this is not the case in the port context. Sachish (1996) and Braeutigam, Daughety, and Turnquist (1984) argued that the structure of ports' production may reduce the econometric estimation of cost or production function to the level of a single port or terminal. In the same vein, Bichou (2007) argued that the theoretical assumption underlying the use of econometric approaches to efficiency measurement are not consistent with operations and management structure. Therefore this may be more significant in studies with strong policy bias.

3.3.3 Non-parametric approach

The Non-parametric Approach uses non-stochastic and mathematical programming optimisation methods to determine the efficiency frontier. Unlike econometric models, it is deterministic in nature and does not require specifying a functional form. The most popular of the non-parametric approaches is Data Envelopment Analysis (DEA). Another non-parametric technique that has been used by researchers is the Free Disposal Hull (FDH). It assumes strong input and output disposability. In other words, any given level of outputs remains feasible if any of the inputs is increased. Conversely, with given inputs, it is always possible to reduce outputs (Wang, Song, & Cullinane, 2003). According to the authors, DEA adds convexity to the FDH assumption i.e. it allows for linear combinations of observed production units. All linear combinations of observations are feasible. Hence, FDH’s main difference from the DEA is that it does not allow for inclusion of linear combinations of production units in the analysis (Wang et al., 2003). The main attraction of using DEA is its ability to yield results with a relatively small amount of data, for the DMUs under analysis.

3.3.3.1 Introduction to DEA technique

The seminal work of Farrell (1957) is the foundation for the DATA ENVELOPMENT ANALYSIS (DEA), although it is applied in the evaluation of DMUs with multiple inputs and only one output. It was Charnes, Cooper, and Rhodes (1978) that coined the name DEA. However, it was extended to include multiple outputs and multiple inputs in the model popularly known as the CCR model, which is an acronym obtained from the first letter of their surnames. The model popularised the use of DEA in performance evaluation (Wilson et al., 2010). Subsequently, the variable returns to scale model was introduced by Banker, Charnes, and Cooper (1984), popularly called the BCC model after the surnames of the pioneering authors. The former computes aggregate or overall technical efficiency (AE), while the latter measures pure technical efficiency (TE). The ratio of AE and TE (AE/TE) gives the scale efficiency (SE). The process allows for the identification of sources of inefficiency. Panayides et al. (2009), defines technical efficiency as relative productivity over time or space or both. Whereas scale efficiency is a measure of the deviation of actual and target production size (Wang et al., 2005).

The DEA is a linear programming technique that converts multiple inputs and outputs into a measurement of efficiency. The conversion is carried out by analysing the resources (inputs) used and the results (outputs achieved for each decision-making unit (DMU). Then the inputs and outputs of each DMU are compared to the same quantities for all the remaining units. The process involves the identification of the most efficient unit in the sample and the provision of a measurement of inefficiency for the remaining units by the DEA. The measure of efficiency provided by the DEA is not absolute efficiency, rather a relative or comparative efficiency (Thanassoulis, 2001). In other words, it applies the concept of “pareto optimization” that implies that an increase in the output variable can only be accomplished by an increase in the volume of inputs.

DEA is classified as nonparametric, because it provides for the analysis of input–output efficiency relationships without specifying production functions for the organisations. The primary objective of the DEA is to compare a sample of DMUs that perform the same task, but differ from each other in the amount of inputs they use and the outputs they generate (produce) (Lins, Gomes, Soares de Mello, & Soares de Mello, 2003). In addition, the DEA identifies not only efficient DMUs, but also measures and locates inefficiency and estimates linear production that provides a benchmark for the inefficient DMUs. It has been used to measure the relative efficiency of both profit and non-profit organisations, such as banks, restaurants, schools and hospitals.

Since the introduction of the DEA by Charnes et al. (1978), the methodology has gained wide acceptance within the research community. Such that between 1978 and 2000, over 3,000 articles have been published on the subject Tavares (2002), while Emrouznejad, Parker, and Tavares (2008) discovered 4,000 articles published in journals and book chapters in the first three decades since the introduction of the DEA (1978-2008). The versatility of the DEA is due to the definition of a DMU which is quite flexible; it can be individuals, branches of an organisation or entire organisations. It only operates on the basic assumption that all DMUs exist in the same environment and convert the same set of inputs and outputs. In other words, it is concerned with measuring the relative efficiency of homogenous units. Officially, the DEA approaches focus on frontier rather than statistical central tendencies. That is it assumes a piecewise linear surface display to all observations, as an alternative to fitting a regression plane through the centre of the data as in regression statistics. Viewed from this angle, the DEA has proved useful in revealing hidden relationships, more than previous methodologies (Cooper, Seiford, & Zhu, 2011c). In the area of benchmarking DMUs, the DEA accomplishes this task explicitly without requiring formulated assumptions and recourse to alteration of other models, as is the case in linear and non-linear regression models. Therefore, the DEA's relative efficiency model fits the definitions of an efficient unit put forward by Cooper et al. (2011c), that assumes no *a priori* weights to any input or output:

A) Extended Pareto-Koopmans Definition**:** A DMU is said to be 100% efficient, if and only if, an improvement of any one of its inputs or outputs will not lead to a worsening of its other inputs or outputs.

B) Relative Efficiency: A DMU is to be rated as fully (100%) efficient on the basis of available evidence, if and only if, the performances of other DMUs do not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs.

These two definitions circumvented the use of price, assigning of weights to inputs and outputs and the expression of formal relationship between input and output. Efficiency measures described by the above definitions are referred to as "technical efficiency" in economics. To encourage its application to different activities, the phrase 'Decision Making Unit (DMU)' is adopted as a reference to any entity that has the capability of converting inputs into outputs. Based on the fact that the DEA defined above measures only the technical efficiency, it can be used to evaluate the operational efficiency of both private and public organisations. As well as profit and non-profit organisations, as far as the entities can convert inputs to outputs. Also as each DMU chosen for evaluation is measured against each other, thus the efficiency concept is regarded as being measured relative to the best performing DMU in the selected sample, hence the name relative efficiency. Any DMU that lies on the efficient frontier is regarded as DEA efficient and is accorded a value of 1 or 100%.

3.3.3.2 Other DEA models

This research applied other DEA models, apart from the traditional CCR and BCC models, there are also the DEA super-efficiency and window models. The CCR and BCC separate DMUs into efficient and inefficient DMUs, based on the efficiency score. All the DMUs with a score of 1 or 100% are termed efficient, making it difficult to distinguish between the efficient DMUs. As a result, Andersen and Petersen (1993) proposed the super-efficiency model for ranking efficient DMUs. The super-efficiency model follows the pattern of the traditional DEA models described previously. However, it excludes the DMU under evaluation from the reference set. It causes DMUs to be located above the efficient frontier, resulting in the concept of super-efficiency. It implies that a super efficiency score can take any value greater than 1 or 100%. Thus, the ranking of efficient DMUs becomes possible. That means the higher the super efficiency index, the greater the rank. However, the index for inefficient DMUs is the same as the standard models.

3.3.3.3 Window analysis

Windows analysis is a time-dependent version of the DEA. In order to capture the variations in efficiency over time, Charnes, Cooper, Golany, Seiford, and Stutz (1985) proposed the 'window analysis' version of the DEA. The Window Analysis Method is adopted for this study to overcome the constraint of using a limited number of DMUs. Window analysis evaluates the performance of a *k DMU* over time, by treating it as a different DMU in each reporting period. This approach allows for tracking the performance of a unit or a process (Soltanifar & Hosseinzadeh Lotfi, 2011). The Window Based DEA adopts the principle of a moving average, but each k DMU is treated as if it was a different k DMU at each of the reporting dates. However, in the analysis, each *k DMU* is compared with alternative subsets of panel data, rather than the whole data set. The window analysis operates on the underlying assumption that what was feasible in the past remains feasible forever. Therefore, time is only treated as an average over the periods covered by the window (Chou, Sun, & Yen, 2012; Khodabakhshi, Gholami, & Kheirollahi, 2010; Tulkens & Vanden Eeckaut, 1995). Some of the initial studies that adopted the DEA used cross-sectional data for analysis, thereby ignoring the role of time. Using only a year's data in the estimation of efficiency of a k DMU may be misleading, because of the fluctuation in production due to dynamic environments. However nowadays, the use of panel data prevails over cross-sectional data. The use of panel data not only allows a k DMU to compare with other DMUs under study, but the performance of each DMU can be traced over time. In essence, panel data gives a better reflection of the real efficiency of a *kth DMU* (Lin, 2010; Lozano, Villa, & Canca, 2011; Odeck, 2000).

The window DEA model allows the tracking of performance of a unit or process. Authors have applied this method to measure port efficiency in literature, such as Pjevčević, Radonjić, Hrle, and Čolić (2012) to benchmark five ports along the Danube River in Serbia. Al-Eraqi et al. (2008) applied it to study the efficiency of Middle East and East African seaports, while the Cullinane et al. (2005a) study was based on 30 largest world ports. Cullinane et al. (2004) applied the same model to 25 leading container terminals around the World. This study employed the contemporaneous and Intertemporal DEA Window analysis over 12 years (2000-2011) of panel data to assess the efficiency of six Nigeria ports.

In a DEA model, it is not necessary to convert inputs and outputs variables to either monetary or physical units as each variable is measured in its original unit e.g. tonnes, pounds, hectares. The DEA identifies efficient peers for the inefficient units. It indicates the efficient DMUs in the sample closest to an inefficient DMU, in terms of combinations of inputs and outputs. The data requirement in a DEA is put to three times the number of DMUs (Bowlin, 1998), but it is less than the number required for the SFA analysis. The application of the DEA makes it possible to determine potential improvements that can be provided to inefficient ports in order to be efficient (Barros, 2006). All these features have made the DEA a choice model for efficiency in the port industry and the number of studies using the DEA model attests to that. For the formalization of the different DEA concepts and the returns to scale types see section 4.5.1 of this thesis.

3.3.4 Problems with DEA application in port efficiency literature

In the last two decades, the DEA has been applied extensively in the measurement of seaport efficiency. The survey of the previous studies in seaport using DEA by González and Trujillo (2009) and Panayides et al. (2009), identified 15 major journal papers between 1993 and 2006. However, 10 out of the 15 papers analysed by the authors were the same. There is a notable synthesis by Cullinane (2002), while a review by Wang and Cullinane (2005) focused on the container port industry. A review by this researcher, has identified over 30 publications from 1993-2013 (Appendix 1.1). Most of these papers have been reviewed repeatedly by different authors.This study highlights the common conclusions from the previous surveys and reports in-depth on the most recent, in order to put its application in the present research in perspective.

There have been issues raised about the use of a frontier approach with both parametric and non-parametric, in seaport efficiency measurement. Most of these criticisms stem from the difficulties and controversies surrounding the discussion of the limitations of the selected methodology, or difficulty in modelling port operations. This section presents some of these misgivings associated with the use of frontier methods in the literature and despite the drawbacks identified, why most researchers still find them very attractive.

I) a crucial aspect of reliable port performance measurement and benchmarking is to ensure the appropriate definition and selection of homogenous DMUs (ports). However, most port literature does not adhere to it. Although of late, some port studies have tried to address the issue by restricting their investigation to ports with similar traffic, as failure to do so will make typically specialised units, such as oil and cruise ports, to appear as outliers. While González and Trujillo (2009) have argued that the inability of researchers to define precisely the activity being studied creates confusion. Some authors based their evaluation on the operations performed by the port authority, which is vague (Cullinane & Wang, 2010; Cullinane & Wang, 2007). There are many activities performed by the port authority based on the ownership and the administrative style adopted by the port. However, segregating ports based on traffic type, is not enough to constitute homogeneity (Bichou, 2006a; Cochrane, 2008). In the context of ports, the lack of homogeneity may arise due to differences in production, handling technologies and the accounting methods between ports/terminals in different countries. This research addressed this by studying ports in the same country and by treating port and terminal benchmarking separately.

II) The selection of variables is very crucial in a DEA analysis, as badly selected variables can cause the system to go in the wrong direction (Wang et al., 2003). However, most studies using the DEA techniques do not justify their variable selection. At best variable selection is haphazard, subjective, or based on existing literature. Justification based only on variables used in previous research may not be able to address the objectives of a particular study, or give a clear-cut definition on which factors should be used as inputs or outputs. The studies on container terminals define the output variable appropriately as TEU; Estache Estache et al. (2004), and others (Cullinane et al., 2005a; Cullinane et al., 2004; Cullinane & Wang, 2010; Cullinane & Wang, 2006b). On the other hand, studies based on ports combine unrelated variables as output, for instance Barros and Athanasiou (2004) distinguished number of ships, movement of merchandise, cargo handled and containers, as output. Park and De (2004), identified number of ships, income and customer satisfaction as outputs combining both physical and financial indicators. González and Trujillo (2009) argued that identifying the cargo specialization requires special infrastructure, in terms of equipment to suit the differentiated goods. In this study, the DMUs are explicitly defined as the major Nigerian seaports and terminals excluding oil terminals. Variables are clearly defined based on the aspect of port being researched, which is pre- and post-concession operations and therefore only operational factors were considered. The inclusion of each variable is justified in Chapter 4.

III) The hallmark of most port benchmarking studies is to estimate the frontier (efficiency) and the extent of deviation from the frontier (a measure of inefficiency) of ports and terminals, based on current technology. However, it is not the whole story; another aspect of the assessment is the frontier shift effect i.e. how the frontier might change over time. The measurement of the shift in port frontier over time can be achieved by employing the DEA window analysis and the Malmquist productivity index techniques. However, only a few studies have used the former (Al-Eraqi, Mustafa, & Khader, 2010; Cullinane et al., 2005a; Cullinane et al., 2004). Other studies (Cheon et al., 2010; Choi, 2011; Fu, Song, & Guo, 2009; Halkos & Tzeremes, 2012; Lozano, 2009; Núñez-Sánchez & Coto-Millán, 2012) have made use of the latter. This study employed CRS, VRS and the window analysis to ensure diversity and reliability of results.

IV) Application of the DEA method requires that an increase in the input should lead to a resultant increase in output and not a decrease, this property of the DEA is referred to as isotonicity. In the context of port efficiency, isotonicity may occur due to the way input and output variables are recorded, or inbuilt characteristics of the port industry. For instance, turnaround time of ships is recorded in such a way that a lower value is an indication of superior performance by the port or terminal. Secondly, port operational process is structured in such a way that a glitch in one sub-system may compromise the performance of the whole system. For instance, an increase in inputs, such as berth and the number of cargo handling equipment, may affect yard output negatively and likewise an increase in the terminal area may not have any effect on quay throughput. To test variables for compliance with the isotonicity requirement, correlation analysis is carried out to show that all the variables are suitable for inclusion in a DEA analysis, but this is hardly the norm in most port studies.

V) In a DEA model, another essential requirement is that all input and output values of variables should be non-negative, but this attribute may not hold in port efficiency for variables with zero values. Instances abound in port operations where input and output variable may take zero values. First, if ports handle different types or mix cargo (wet bulk, dry bulk, container, passengers), which are not aggregated to a single output in the analysis, then zero output values may occur, or a port handles negligible or zero quantity of a particular cargo output relative to the other DMUs. Secondly, the differences in production technology and handling equipment, especially if DMUs are selected globally, as is the case with most container port studies (Cheon et al., 2010; Cullinane et al., 2005a; Valentine & Gray, 2001a). These imply that some ports due to their level of operation may have little or no need for some inputs, thus their values will either be zero or tending to zero. It is the case of terminals designed exclusively to operate with certain equipment, if the number of equipment is not aggregated then certain DMUs in the analysis could have negligible or zero value for certain equipment. That is the main reason this study used aggregated output i.e. total throughput in tonnes for all the port analysis.

VI) Furthermore, there is no consensus among authors in terms of model specification and orientation. Although the proponents of the input-oriented model argue that the port industry is typically associated with long-lived infrastructure and facilities and a long-term planning horizon. In essence, once a port is built, its output could be predicted in the short run because *ceteris paribus* a port can determine the shipping lines that call at its terminal. Additionally, it could predicate throughput based on historical data. Therefore, a port should be concerned with how to utilise its inputs efficiently, as a cost saving measure in production. However, as a result of the increase in international trade due to globalisation. As well as, the re-organisation of traditional ways of administering ports worldwide to a more pragmatic approach that will usher in competition and less dependence on government for funds. There is also a need to design an adequate regulatory framework to guarantee efficient outcomes in the absence of government support, especially in developing countries. Therefore, ports should often review their strategies in order to provide satisfactory services to their customers and maintain a competitive edge in these changing circumstances. To achieve these, ports need to access their existing capacity to find out if the output has been maximised in the presence of available input. Taking into account the above scenario, the output-oriented model provides a more appropriate benchmark for the port industry.

VII) Another limitation of the frontier model in port literature is that it focuses mainly on container ports/terminals. In fact, it has become a common denominator for most port efficiency measurements. The problem is that evaluating the efficiency of one particular type of port traffic cannot be equated to an overall assessment of performance of the whole country's port system. To assess the overall performance of the ports under study after concession, the entire cargo terminals based on cargo type (DBC, Container and GC) were evaluated.

The above inconsistencies and controversies constitute the drawbacks of the use of frontier techniques in port efficiency measurement and accounts for the discrepancies and differences in results obtained by various studies. For instance, in the study of the relationship between port size and efficiency Coto-Millan et al. (2000) and Cullinane et al. (2002) obtained different results. In terms of ownership structure, Liu (1995) and Estache (2002) also came out with differing results.

3.4 Chapter Summary

This chapter looked at the different performance categorisations and dimensions to productivity and efficiency measurement. It observed that, depending on the design of the productivity and efficiency measuring instrument, it could be used to capture the performance of an activity, a process, or both. Efficiency and productivity measurement could be extended to various fields of human endeavour, because it depicts different dimensions, but their definition and particular application has been inconsistent among researchers or disciplines.

This chapter has presented a literature review of the various efficiency benchmarks and measurements available to the port sector and the merits and demerits associated with their application.

The reviews reveal some level of inconsistency in the application of these techniques. Some of these discrepancies stem from the definition of the unit of study. Some studies do aggregate ports and terminals together in a single study, while others benchmark ports from different parts of the World, without recourse to the homogeneity assumption inherent in a DEA application.

There is also disagreement among authors in the definition and application of the following terms: efficiency, productivity, utilisation and effectiveness in relation to port performance.

The multi-institutional nature of port stakeholders (Port authorities, terminal operators, regulators, shipping companies and customers/users) creates perception differences in the reviewed literatures. It impacts on the design, objectives and implementation of the performance and analytical models.

Additionally, complexities arise in other areas, such as operational (types of cargo handled, ships serviced, terminals managed and systems operated), as well as institutional differences (landlord, tool and service) and spatial (quay, yard, terminal, port, cluster etc), in terms of what to measure and benchmark. This chapter argues for the need to study ports in a particular country that are comparable, in order to maintain the homogeneity assumption in a DEA application.

Chapter Four: Research Design and Methodology

4.1 Introduction

There are two expressions used by many authors interchangeably to refer to the research process: research " methodology" and research " methods", however the terms have been distinguished by Greener (2008). The research methodology, or design, deals with the overall strategy chosen by the researcher to answer the research questions. Therefore, the research design shows how samples are selected, the units to be included, the distinctions that should be made and the variables to consider and measure and how the measures are related to other external factors. The research design is a guide on how to generate precise answers to the research questions. It is also defined as the overall procedures involved in the research process, which includes theoretical underpinnings, data collection and analysis (Hussey & Hussey, 1997; Leedy & Ormrod, 2001). While, research methods refers to techniques employed for data collection, collation and measurement, to ensure that the instruments are reliable, appropriate and valid.

This chapter, therefore, provides the structure of the research process which includes the development of a suitable research philosophy, identifying an appropriate approach and strategy. As well as the data collection methods upon which data collection and analyses are based and implications of the methods adopted. This chapter also discusses the operationalisation of concepts to enable facts to be measured quantitatively and justifies the variable selection.

The primary objective of this research is to assess the influence of the transfer of port operations from public to the private sector through concession agreements, on the operational performance of the ports. However, as the two main approaches applied to the measurement of performance are efficiency and productivity, the methodology develops a multivariate model for assessing the efficiency and productivity change.

4.2 An Overview of Methodological Approaches

Figure 4.1 is an illustration of the various methodological considerations available to the researcher when conducting research (Saunders, Saunders, Lewis, & Thornhill, 2011b). The layers of the onion indicate the different aspects that have to be determined and completed for an acceptable research project. The following subsections explain the philosophical positions, research approaches, strategies and the time horizon of the present research.

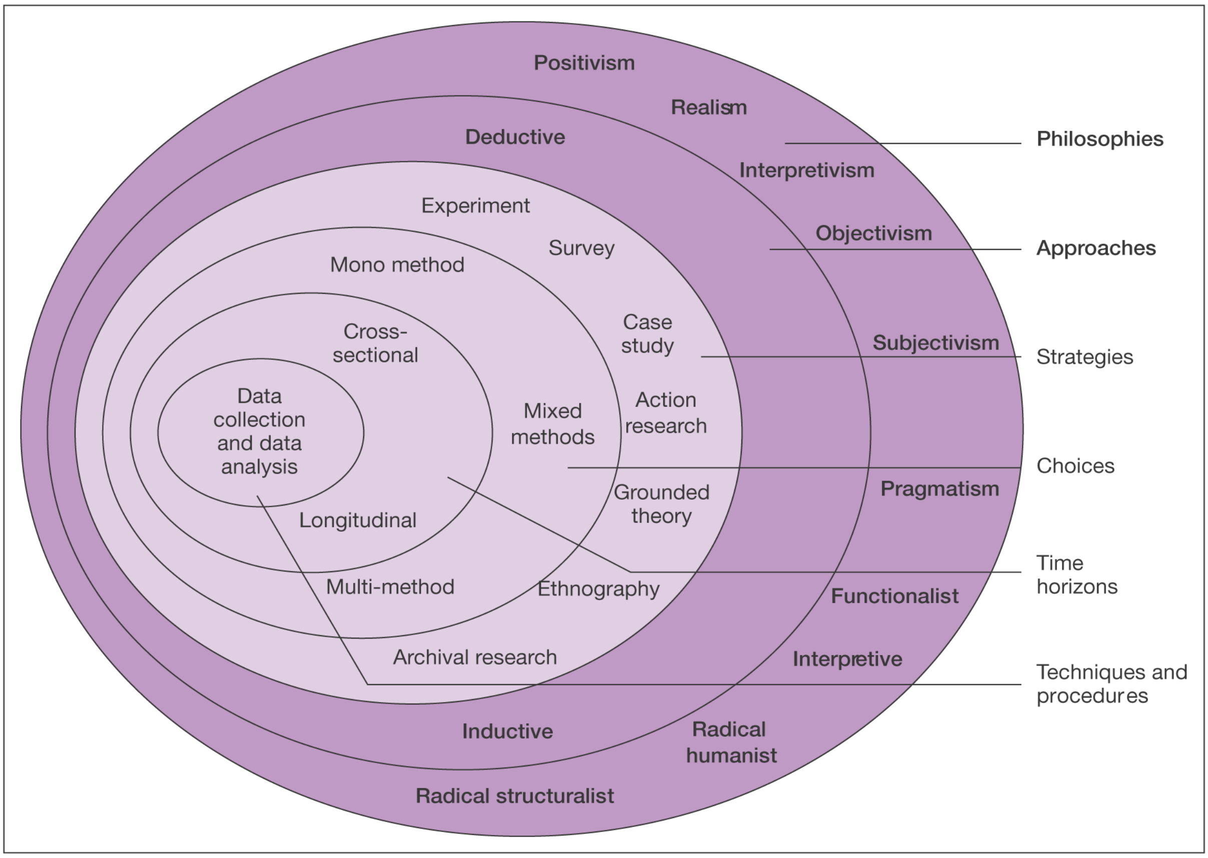


Figure 4.1: Research Onion

Source: Saunders et al. (2011b)

4.2.1 Research philosophy (Paradigm)

The view of research from a paradigmatic perspective is used to manipulate the research process in all study disciplines. It is applied in such a way that each paradigm has a particular research strategy and method associated with it (Näslund, 2002). A paradigm has been described as " a set of basic beliefs, or Worldview, that defines, the nature of the "World" and the individuals placed in it. It also shows the range of possible relationships to that World and its parts" (Guba & Lincoln, 1994, p. 107). A paradigm is viewed as the basic belief system that guides the research investigation in answering the ontological, epistemological and methodological questions (Krauss (2005), Collis et al. (2003) and Sauders, Lewis, and Thornhill (2007). In other words, in order to understand the nature and concept of research and discuss the limitations and potentials of each research method, the starting point should be the research paradigm also known as the research philosophy, as depicted in the first layer of the research onion in Figure 4.1. Ontology considers what constitutes reality, while epistemology considers views about the most appropriate ways of enquiring into the nature of the World.

According to Creswell (1994) and Mangan, Lalwani, and Gardner (2004) there are two broad philosophical perspectives that underpin a research process; positivism and non-positivism or the phenomenological approach. Saunders et al. (2011b) identified four research paradigms: positivism, interpretivism, realism and pragmatism (Figure 4.1). The authors classified all research that is anchored in the belief of the existence of an objective real World, and applies procedures and approaches used in natural science as a positivistic approach. The positivistic paradigm has been described as traditional, quantitative and empiricist, hypothetico deductive and social constructionism in nature (Creswell, 2013; Easterby-Smith, Thorpe, & Jackson, 2012; Gill & Johnson, 2002)

However, based on the seminal works on social paradigms and organisational analysis, Burrell and Morgan (1979) identified four paradigms: functionalism, interpretivism, radical structuralism and radical humanism. In their framework, radical realism is associated with assumptions about the nature of society, while radical structuralism is concerned about social science. Mangan et al. (2004) argued that research in business is more aligned towards radical structuralism and researchers tend to anchor their research along interpretivism and functionalism beliefs. Thus, in Burrell and Morgan (1979), framework interpretivism is a subjective approach and is concerned with understanding the World, as it is based on subjective experience. On the other hand, the functionalist paradigm approach explains the research from an objective point of view. It tends to provide a rational explanation of a phenomenon by applying models and methods of natural sciences to human affairs (Burrell & Morgan, 1979).

Generally, most management research is basically discussed in terms of two opposing schools of philosophy (Gummesson, 2000; Hussey & Hussey, 1997). Loosely referred to as a positivism and phenomenology paradigm, which is also consistent with the Burrell and Morgan (1979) framework of interpretivist and functionalist. However, Woo, Pettit, Beresford, and Kwak (2012) adopted the Burrell and Morgan (1979) framework in the structural review of methodological issues in seaports studies from 1980-2000s. The analysis indicated that the functionalist paradigm, which is aligned to positivism, is the most widely used philosophy in seaport research. In fact, Woo et al. (2012) reviewed 840 papers, out of which 830 papers are classified under the functionalist paradigm. The interpretivist paradigm, which tend to seek understanding of the real World within the ambit of individual consciousness and subjectivity, has 6 studies. While the structuralist paradigm that is focused on the structure and analysis of economic power relationships has four papers. Most of which were on industrial relationships in the port industry (Carter, Clegg, Hogan, & Kornberger, 2003; Herod, 1998). It shows the dominance of the functionalist paradigm for the three decades 1980-2000s.

On the other hand, the non-positivistic or phenomenological paradigm is based on the belief that the World is socially constructed and subjective. Researchers try to understand the World from the inside, rather than the outside (Näslund, 2002). Different methods are employed by researchers to actualise this paradigm, but basically they are qualitative (Mangan et al., 2004).

The phenomenological paradigm has also been described as qualitative, subjectivist, humanistic, interpretivist/hermeneutic and inductive (Collis et al., 2003; Hussey & Hussey, 1997; Saunders, Lewis, & Thornhill, 2007).

In line with the discussion, the essential characteristics of the positivist and phenomenological paradigms are summarized as follows (Table 4.1):

Table 4.1: Key characteristics of the Positivist and Phenomenological paradigms

Features	Positivist Paradigm	Phenomenological Paradigm
Basic notions	The world is external and objective	The world is socially constructed and subjective
	Observer is independent	Observer is part of object of observation
	Science is value-free	Science is driven by human interests
Responsibilities of the Researcher	Focus on facts	Focus on meanings
	Look for causality and fundamental laws	Try to understand what is happening
	Reduce phenomenon to simplest events	Look at totality of each situation
	Formulate hypotheses and then test them	Develop ideas through induction from data
Preferred methods include	Operationalising concepts so that they can be measured	Using multiple methods to establish different views of phenomena
Sample size	Large samples	Small samples investigated in-depth over time.

Source: Adapted from Easterby-Smith et al. (2012)

Discussions show that different names are used to describe apparently similar paradigms, which may be partly due to the development of similar approaches in parallel across various branches of the social sciences.

Based on the discussions of the research questions and the objectives of this study, it is evident that this research is tilted towards the positivist perspective, rather than the interpretive perspective. The study is anchored in the ontological belief that the essence of knowledge is simply to describe the phenomenon we experience, while the purpose of scientific investigation is to observe and measure the phenomenon around us, on the epistemological understanding that the World and Universe are deterministic and operate by laws of cause-and-effect that are observable, if the unique approach of the scientific method is rigorously applied. The research, therefore, is positioned within the functionalist philosophy, which is aligned with a positivist paradigm. It understands research from an objective point of view and seeks to provide a rational explanation of a phenomenon by applying models and methods of natural sciences to human affairs. Moreover, it has been judged as a very successful research perspective when adopted in seaport studies (Woo et al., 2012).

In addition, the influence of port ownership change on operational performance is a "cause-and-effect" phenomenon. It involves an enquiry into the impact of the process (transfer of port operations from public to private hands) that has already taken place (ex-post). Then measures the outcome of the process in terms of efficiency and productivity of the ports. Therefore, it is natural to choose the positivist approach for this type of investigation. The interpretist, which is associated with a phenomenological approach, was considered, but it was not adopted because it is subjective. Firstly, it tends to interlock the researcher and the object of research in such a way that the outcome of the investigation just mirrors the enquiry process (Krauss, 2005). The criticisms of the phenomenological approach stem from the fact that it is rather expensive to conduct research using the process. Secondly, it involves sophisticated interpretation of data that often requires special skills, a lack of a well-thought-out hypothesis and finally the validity and reliability are often called into question due to researcher bias.

4.2.2 Research approach

Mangan et al. (2004) and Saunders et al. (2011b) argued that the choice of philosophy in logistics (port) research, like in other disciplines, has implication for the whole research process. As strategy, time horizon and approach to the study is attached to the paradigmatic preferences of the researcher. The adoption of the positivist paradigm by the researcher implies that this research is bound by the features of the positivist framework. Except in the aspect of data collection, where mixed methods of quantitative and qualitative data collection techniques were applied to better the understanding of the phenomenon.

In Figure 4.1, there are two main research approaches that could be considered when undertaking a research project, the quantitative (deductive) or qualitative (inductive) approach (Saunders et al., 2011b). A deductive approach as depicted in Figure 4.2 involves developing a hypothesis (hypotheses) from existing theory and designing a research strategy to test the hypothesis (Wilson et al., 2010). Deductive reasoning means working from the more general to the more specific. It is a "top-down" approach and follows the path of logical reasoning. The deductive approach emphases causality and it is commonly associated with quantitative data.

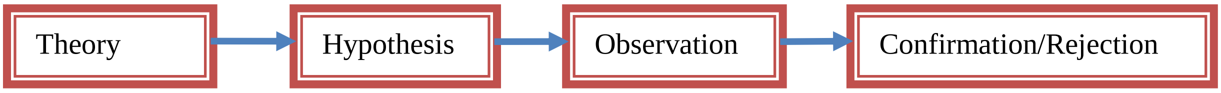


Figure 4.2: Deductive approach process

On the contrary, an inductive approach uses the "bottom-up" approach; the researcher begins with specific observations to broader generalisations and then theory (Figure 4.3). In other words, inductive research is based on generating theory from observed data; it uses research questions to narrow the scope of the study. Its focus is on exploring new phenomena or observes new phenomena from a different perspective and it is associated with qualitative data. According to Babbie (2013), there are no set rules and some qualitative studies may have a deductive orientation.

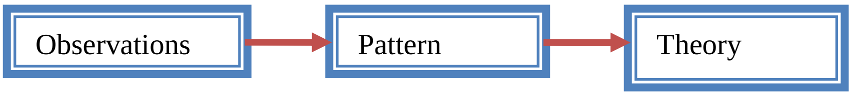


Figure 4.3: Inductive approach process

It is clear from the explanation of the two methods, that this study of post-concession Nigerian ports performance is best fitted to the deductive approach. This study involves exploring the relationship between the changes in ownership of port operations from public to private (privatisation theory) on the operational performance of Nigerian ports. This research involves the generation of quantitative time series data, encompassing both the pre- and post-concession periods from the major ports under study.

4.2.3 Research strategy

Saunders, Saunders, Lewis, and Thornhill (2011a) identified the strategies available to the researcher to undertake a research project as: experiment; survey, case study, action research, grounded theory, ethnography and archival research. According to Yin (2009) and Babbie (2013), each of the strategies can be used for exploratory, descriptive or explanatory purposes. Some of the strategies are mainly associated with the deductive approach (experiment, survey) while others are commonly associated with an inductive approach (grounded theory, ethnography). However, Saunders et al. (2011a) observed that no strategy is superior or inferior to the other. Rather the choice of a strategy should be based on the research questions, objectives and extent of existing knowledge, the amount of time and other resources available and the philosophical underpinnings of the research.

Experimental research is more associated with studies in the natural sciences. In its purest form, it is laboratory-based and seldom used in management research. According to Saunders et al. (2011a), experiments are used in exploratory and explanatory research to answer the "how" and "why" questions in research. However, it may not be suited for this study on post-concession evaluation.

Survey has been described by Butts (1983) as a significant way of generating knowledge about existing phenomena. According to Saunders et al. (2007), survey is the most common strategy employed in business and management research and it is more often associated with deductive research. The authors were of the view that survey strategy is used to answer the "who", "what", " where" and "how" questions in the research process. Survey strategy allows for the collection of quantitative data that can easily be analysed using descriptive and inferential statistics. The data collected from the survey can be used to suggest possible reasons for particular relationships between variables and to produce models for the relationships (Saunders et al., 2011a). Applying the survey strategy gives the researcher more control over the research process. As observed previously, the survey strategy can be used for explanatory, exploratory and descriptive purposes. Exploratory strategy can be employed at the initial stage of research to gain a first insight into the topic of study, before an in-depth study of the subject (Babbie (1990) and Kerlinger (1986)). While descriptive survey strategy is used when research aims to understand the relevance of the phenomenon. It describes the distribution of the phenomenon in the population in order to ascertain facts. The third survey strategy is explanatory, which is deployed to discover causal relationships among variables in theory testing or confirmatory research. The Explanatory strategy is theory-based and uses well-defined concepts, models and phenomenon to investigate causal relationships between variables. According to Malhotra and Grover (1998), it is hard to establish or draw causal inferences based on cross-sectional evaluation in survey design, without putting into consideration the temporal changes in the phenomenon. The authors advocated explanatory survey to be accompanied by longitudinal design, in order to capture changes in the phenomenon of interest over time.

The explanatory survey strategy with the longitudinal design seems most suitable for addressing most of the objectives of this research, as the study is based on examining the effect of privatisation theory on the performance of seaports. In addition, to make sure that the change observed is not a one-off thing due to some inexplicable factor, the study made use of 12 years (2000-2011) of series data. This approach is chosen as the researcher has no control over the variables of the pre- and post-concession, nor can manipulate them. This is because the concession programme is already in place and not only that, a researcher is not in a position to implement this change. In these circumstances, to tease out the possible events that have taken place in the past, the study attempts a reconstruction by surveying the operational statistics for the ports under study. This was done by examining factors that influence port performance and also solicit for the perceptions of port users on the concession programme, through interviews. In addition, the research adopted the survey strategy as it is field-based and data is gathered from the port (business) context in which the practice of privatisation occurred. Data is collected from the real World. The study ties the privatisation of ports in practice, to theory. It has been used in supply chain management studies to document the state of the art, as well as baseline data for longitudinal studies (Gable, 1994).

A case study strategy is used in research for its ability to capture reality and detail by studying the phenomenon in its natural context. It gives impetus to study of different aspects of the phenomenon that may not have been previously determined, because it allows for inclusion of a vast number of variables (Galliers, 1985; Yin, 2009). Thus, the purpose of using a case study is to have an in-depth understanding of the phenomenon. So, a case study investigates a pre-defined phenomenon although it may or may not *Apriori* define constructs and relationships. According to Saunders et al. (2011a), a case study can be used in exploring or in challenging existing theory, as well as providing a source for new research questions. The standard techniques used for collecting data for a case study are interviews, observation, documentary analysis and questionnaires. However, a triangulation of different sources is not only possible, but also advantageous to ensure the validity and reliability of the research process (Easterby-Smith et al., 2012). However, the use of the case study has been criticised, that research findings from a case study are not statistically generalisable to the entire population. This is due to the inability of the researcher to control the independent variables which may limit the internal validity of conclusions obtained from the research. Finally, although, a case study may establish relationships between variables, it does not show the direction of causation (Cavaye, 1996).

Action research strategy is mainly employed in research that involves the resolution of organisational issues and the study of those who experience the issues directly (Saunders et al., 2007). Grounded theory is described by Goulding (2005) as helpful in research in predicting and explaining behaviour, with focus on developing and building theory. Both may not be useful strategies for this research, as they are leaning towards the phenomenological paradigm and involve the use of inductive approaches.

It is clear from the strategy discussions that this study, which is based on establishing whether there is a relationship between privatisation through concession contracts and port performance, using Nigerian ports concession as a case study, incorporates some elements of both case study and explanatory survey strategy. Therefore, the use of survey strategy as part of the case study is most appropriate for this type of study.

4.2.4 Time horizon

In terms of time, there are two perspectives: cross-sectional and longitudinal. In cross-sectional view, the data is collected from research participants at a single point in time, or over a relatively short period, referred to as a contemporaneous measurement (Johnson, 2001). The data is applied to each case at that point in time and comparisons are made between variables of interest. Whereas, the longitudinal technique implies collecting data at more than one point in time and comparisons are made across time. It also allows for the collection of data on one group or multiple groups.

The longitudinal technique is further categorised into trend studies and panel studies. In trend studies, independent samples are from a population over time, using the same questions, while for panel studies, the same companies/individuals/organisations are studied at successive points over time. Johnson (2001) suggested that panel studies are very useful in establishing evidence of causality, because data on variables could be collected at different periods that help build a proper time order. Panel studies could also be retrospective as the name implies; this involves looking backward in time to collect data on the dependent and independent variables that will help explain current differences in the independent variable. Thus, in retrospective research, comparison is made between the past, as estimated by the data and the present for the cases in the dataset. This technique is used by researchers to approximate or simulate a longitudinal study, to obtain data that is representative of more than one period (Johnson, 2001).

Finally, this research made use of the longitudinal time horizon. As the study is causal-comparative, that involves tracking the performance of the ports (DMUs) for a 12-year period, which are panel evaluations. In other words, evaluating the performance of the system involves tracking the efficiency and productivity over time that requiring the use of contemporaneous and intertemporal analysis, whic means longitudinal examination.

4.2.5 Research methods

The last layer of the research onion is called data collection methods, which simply entail techniques that are used to collect empirical research data. In other words, it is how researchers " get" their information (Johnson & Turner, 2003). According to Saunders, Lewis, and Thornhill (2009), there are two methods used in collecting research data: mono method and the multiple methods. Mono method as the name implies, means employing a single data collection technique and its corresponding analytical procedure in a research process. On the other hand, multiple methods refer to the use of more than one data collection and analysis method for answering the research questions. However, there is also the mixed methods' research, which uses quantitative and qualitative data collection techniques. It undertakes the analysis either in parallel (at the same time), or sequentially (one after another), but does not combine them (Saunders et al., 2009).

Johnson and Turner (2003) identified two types of mixed methods of data collection i.e. intra-method and inter-method mixing. They defined intra-method mixing as; "the concurrent or sequential use of a single method that includes both quantitative and qualitative components, e.g. the concurrent use of open- and closed-ended questionnaires in a single research". Conversely, inter-method mixing involves concurrently or sequentially mixing of two or more methods. The use of secondary data and interviewing in a single study is an example of inter-method mixing. Intra-method mixing is also known as "data triangulation", while inter-method mixing is also called "method triangulation" (Denzin, 1989). Denzin has argued that for intra-method to be achieved, a combination of qualitative and quantitative approaches must be included within a single method, or the use of a method that is neither purely quantitative nor purely qualitative. In contrast, inter-method mixing requires the use of multiple (different) methods of data collection in a single research. The multiple methods can be only quantitative approaches, qualitative approaches, or a combination of qualitative and quantitative approaches. The mixing of qualitative and quantitative methods results in the most accurate and complete depiction of the phenomenon under investigation (Johnson & Christensen, 2008; Johnson & Onwuegbuzie, 2004; Patton, 2005; Tashakkori & Teddlie, 1998). The reason for triangulating data collection methods is to obtain convergence or corroboration of findings. As well as to eliminate or minimise key plausible alternative explanations for conclusions drawn from research data and to elucidate the divergent aspects of the phenomenon (Johnson & Turner, 2003). The authors further argued that triangulation can be applied at different stages of the research process.

For this research, mixed methods (inter-method mixing) are considered the most appropriate, as the different data collection methods (secondary data and interview) were used. The researcher recognises that all methods have inherent limitations as well as strengths. Therefore, the combination of methods could provide the convergent and divergent evidence to the research questions. The use of the quantitative approach allows for the collection of numerical data of the ports operational statistics, while the qualitative approach is used to collect information on the perception of stakeholders to the privatisation programme. Thus, the objective of adopting mixed method is to balance efficient data collection and analysis, with data that provides context. In other words, the qualitative data collected from stakeholders provides the contextual information and facilitates the understanding and interpretation of the quantitative data. It has been argued by Gillen (2001) and Tashakkori and Teddlie (1998) that the inclusion of quantitative and qualitative data in research may deepen the results more than one type of data can allow.

4.3 The Research Design

Having undertaken an overview and discussion of the various methodological approaches involved in carrying out a research project, the researcher decided on the appropriate research philosophy as well as the research approach, the research strategy, the research methods and the time horizon that underpins this study. The various methodological approaches the researcher adopted for the study are presented in Figure 4.4.

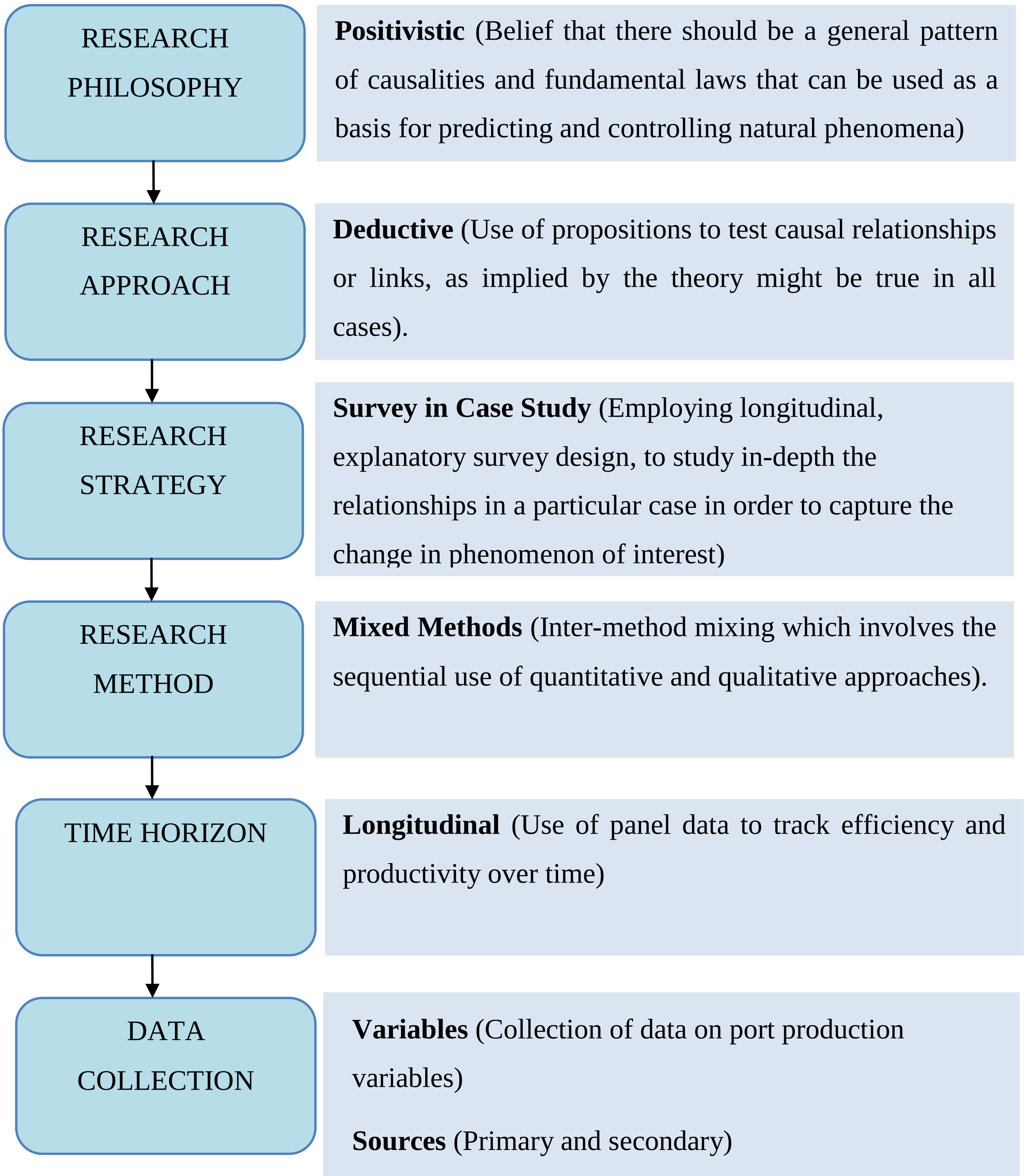


Figure 4.4: Selected methodology for the research

A step-by-step process is followed by the researcher to adapt the study to the selected research design, in order to understand the complicated issues of port operations, port ownership, competition and regulation in a national port context. In addition, the methodology of linking the outcome of this understanding to measurement of operational efficiency of ports and providing comparative benchmarks of productive changes before and after the change of ownership. Afterwards, the influence of concession on efficiency is then assessed, based on efficiency gains or losses over time and across ports. There are two main types of theoretical models providing an explanation for within-industry variations in efficiency. Firstly, the strategic group theory by Caves and Porter (1977), which sees differences in efficiency scores as being a result of differences in structural characteristics of the units within the industry. It equally brings about differences in performance. Furthermore, Porter (1979) explains that units with similar asset configurations pursue similar strategies, which in turn leads to similar performance. For this research, it could be argued that there are different strategic options available to the various ports in the Nigerian port industry. However, due to certain encumbrances, not all options are available to each port and this gives rise to varying efficiency scores among ports. The second is the resource-based model; it explains that different scores are due to the heterogeneity in resources and skills on which seaports base their strategies (Barney (1991), Rumelt (1991) and Wernerfelt (1984)). That is to say that the resources and competencies are in continuous flux in the industry, resulting in the best performing ports having a competitive edge over the others.

4.4 Defining Concepts and Research Design

The research design adopted for this study is based on these two precepts which have been expounded in chapter 2 and are given below:

- *Although changes in the performance level of ports may be traceable to market forces, the production scale and some location factors; there is a relationship between ownership of port infrastructure and superstructure and performance.*
- *The process of competitive bidding of port terminals, the delineation of ports into terminals to be operated by different concessionaires and the creation of autonomous port authorities, creates intra-port and inter-port competition, which induces efficiency.*

It is based on these two precepts, this research attempts to answer the central research question:

- *What is the influence of privatisation through concession contracts on the efficiency and productivity of Nigerian ports?*

Five research questions were created to capture the problem more aptly and to address the specific objectives of the study:

1. *Are ports with terminal operations in the hands of the private sector more efficient?*
2. *Are ports under intense intra-port competition more efficient?*
3. *What factors influence port efficiency and productivity?*
4. *What role does ownership of port institutions play in influencing operational port performance?*

4.4.1 Research hypothesis

It is based on the above questions; the study seeks to test the hypothesis that productive inefficiency is associated with public ownership, in comparison with private ownership, using Nigerian ports as a reference. This is because performance measurement techniques are also known as: comparative efficiency technique, total factor productivity method or multi-factor productivity technique. Therefore, the study proposes that the introduction of private participation in seaport production, through concession contracts, influences the operational performance of the ports through the following hypotheses:

- H0: There is no relationship between the transfer of the port terminal operations from public to the private sector and port performance.
- H0: There is no relationship between port size and port efficiency
- H0: There is no relationship between port efficiency and port competition.

It is in an attempt to investigate these null and corresponding alternate hypotheses that the applicable research tools and analysis techniques discussed above were selected. Then, based on the conceptual framework of this study, privatisation is captured through the port ownership models based on the practice in the Nigerian port system. Thereafter, it is related to the measurement of operational performance efficiency, providing a benchmark comparison of productive changes before and after concession. Consequently, the influence of concession can then be evaluated in terms of efficiency gains or losses over time and across Nigerian seaports. The research employed four analytical techniques to execute this design:

1. Modelling port efficiency and throughput variables and relating them to the ownership change using regression
2. Analytical benchmarking of Nigerian ports’ efficiency
3. Productivity change analysis for assessing the influence of concession

4. Competitiveness analysis to ascertain the relationship with efficiency

4.5 Port Performance Measurement Processes

The study employed multi-approach performance evaluation, using a multivariate two-stage regression model based on determinants of port production scale (throughput) and efficiency, to test the hypotheses in section 4.4.1. The factors that determine port production scale in the Nigerian port context were regressed against throughput, to obtain the projected throughput. In the second regression, efficiency was regressed against ownership, the port production scale (represented by projected throughput from the first regression) and competition, to determine their influence on Nigerian port performance. The processes are explored in Chapter 6.

4.5.1 Analytical benchmarking for port and terminal efficiency

The main purpose of benchmarking is to compare the efficiency of carrying out a particular activity or group of activities, either at a particular point in time or over time. This study has reviewed several benchmarking methods applicable to the port industry in chapter 3 and has shown that it is better to set benchmarks relative to best practice i.e. measured relative to the efficiency frontier. From the discussions of the various performance measurement techniques in Chapter 3 and putting into consideration the peculiarities of port operating systems, it has been demonstrated that the programming techniques are most appropriate for benchmarking the operational efficiency and evaluating the influence of Nigeria's ports' privatisation through concession contracts on the operational performance of the ports. Especially as the Nigerian ports under consideration are multipurpose ports, with different operational and handling systems. Additionally, the small number of ports under study makes the application of the SFA technique difficult in the context of Nigerian seaport terminals' benchmarking. The programming techniques are less sensitive to sample size than econometric models and could estimate technical efficiency for both individual ports and whole production processes. In addition, the multi-output nature of port production, coupled with the lack of detailed data, may render the use of econometric techniques unreliable. Based on this, the study argues for the use of the programming techniques in the form of the Data Envelopment Analysis (DEA).

A contemporaneous and intertemporal DEA analysis was carried out in order to compare the pre- and post- concession efficiency scores, using cross-sectional and panel data. The contemporaneous analysis compares observation sets within the same period. Thus, it makes use of cross-sectional data, while the inter-temporal analysis deals with panel data and pools data over the period of the study. The application of the two approaches ensures that a DMU is benchmarked against varying sample sizes and at the same time assumes a constant technology over time. Furthermore, the contemporaneous, inter-temporal and window approaches were employed to analyse the efficiency of observation sets relative to alternative DEA models for the pre- and post-concession periods. Application of different DEA models to data sets is consistent with the objective of this study, in terms of analysing the relationship between institutional changes. In this case, the handing over of port terminal operations to the private sector and the performance efficiency of the ports. It is necessary, as port production exhibits both constant and varying returns to scale, which require alternative DEA models that can track the variations in handling and production technologies between and within ports/terminals.

4.5.2 Productivity change analysis: Total factor productivity (Malmquist Index)

In order to understand the productivity concept and measurement and the causes and consequences of productivity change, so that the appropriate policy to raise productivity can be made, the concept of TFP is employed. According to Fabricant (1974), total factor productivity (TFP) is the best single measure of productive efficiency, as it is a measure of real output per unit of actual resources expended. TFP is used in finding the sources of economic growth. The early economist in trying to decipher the sources of productivity growth and how to measure them grouped the sources into two. The first, a change in resources available for use in production, that was termed total factor input. The second is a change in the efficiency with which available resources are used in the production, called total factor productivity. Therefore, TFP is used to observe patterns of change in productivity, and identifying sources of change in productivity especially change due to technological innovation. To measure TFP, the MPI described in Chapter 3 is used. Although the MPI requires the estimation of the distance function, this can be specified directly under the DEA. The approach opted for by this research is to apply ordinary DEA based on the MPI, both on a year-by-year basis and pre- and post-concession period basis.

The application of the DEA-based Malmquist Productive Index (MPI), allows for the use of the panel data for both efficiency estimation and analysis of TFP growth. The computation of the MPI gives an indication of whether productivity has improved or deteriorated over time, especially after the privatisation through concession contracts. A further reason for choosing the MPI is its ability to decompose TFP into different sources of efficiency change: total technical efficiency change (EFFCH), which represents a catch-up effect and technological change (TECHCH), that is a measure of change in frontier technology. The total technical efficiency change (EFFCH) can further be decomposed into pure technical efficiency change (PECH) and scale efficiency change (SECH). The result obtained from this analysis gives an insight into sources of observed increase or deterioration in efficiency over time, particularly after the introduction of the Landlord port model through concession contracts.

4.6 Operationalisation of Concepts

Operationalisation is the process of converting concepts (constructs) into empirical reality or variables (Jonker & Pennink, 2010). In this section, theoretical, empirical and methodological aspects of measuring port performance will be explored. In researching port performance, two interrelated and overlapping concepts; efficiency and productivity are employed as depicted in Chapter 3. It involves identifying the factors responsible for a port's operational efficiency and productivity and converting the same to variables. The two techniques the DEA and the MPI used for measuring efficiency and productivity are formalised. Finally, the sampling frame and variable selection are identified. This is followed by the description of the methods and sources of data collection. Thereafter, the definition and choice of the datasets are validated based on the DEA and MPI analyses.

4.6.1 Formalising the DEA methodology

Formally, the analytical techniques selected in this research for benchmarking efficiency and productivity change analysis are introduced. Many models have been used to estimate operational performance as identified in Chapter 3. This study has identified why the model that uses data from the input, output and production function theory, by means of the DEA to generate production frontier across port-year observations, is the most appropriate for this study. The DEA is used to benchmark the operational efficiency of ports and terminals under study. It also allows for the assessment of the influence of scale and technical factors on the efficiency of those ports under consideration.

The DEA attempts to measure technical efficiency using physical quantities to specify the functional forms. However, in the presence of price and cost data, it allows for the estimation of allocative efficiency. The fractional or linear programming formulation is started by defining some of the notations. Let n = DMUs (in our case ports) for evaluation and the DMUs make use of *m*, different inputs (controllable inputs), to produce *s*, different outputs (controllable outputs). In other words, DMU_j consumes $\{X_j = x_{ij}\}$ of inputs$(i = 1,2, \dots, m)$ and produces $Y_j = \{y_{rj}\}$ of outputs$(r = 1,2, \dots, s)$. The matrix of outputs $(s \times n)$ and inputs $(m \times n)$ is denoted as Y and X respectively. The DMUs are assumed to have at least one positive input and one positive output i.e. $x_{ij} > 0$ and $y_{rj} > 0$. Putting into consideration the fractional formulation of measuring the relative efficiency of DMU_0 for any one of the *n* DMUs, then the relative efficiency of DMU_0 is measured as the ratio of outputs to the inputs, subject to the constraint that no DMU can obtain a relative efficiency value of more than unity, or 100%.

Max $U_0(u, v) = \frac{\sum_r u_r y_{r0}}{\sum_i v_i x_{i0}}$, Where u_r, v_i = weight assigned to output *r* and input **Equation 4.1**

Subject to $\frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \leq 1$ for $(j = 1, \dots, n)$ **Equation 4.2**

$u_r, v_i \geq 0$ For all *i* and *r*

The above equations are a fractional programming problem and will yield an infinite number of optimal solutions if additional constraints are not added.

Assuming that $u^* \, and \, v^*$ is optimal, by implication $\alpha u^* \, and \, \alpha v^*$ will also be optimal for $\alpha > 0$. To resolve the problem, Charnes and Cooper (1962) developed a transformation that allows for a representative solution i.e. the solution (u, v) for which $\sum_{i=1}^{m} v_i \, x_{i0} = 1$ yields an equivalent linear programming problem, in which the Charnes-Cooper transformation changes variables from (u, v) to (μ, v), thus we've:

$$\text{Max } Z = \sum_{r=1}^{s} \boldsymbol{\mu_r y_{r0}}$$ **Equation 4.3**

Subject to

$$\sum_{r=1}^{s} \boldsymbol{\mu_r y_{rj}} - \sum_{i=1}^{m} \boldsymbol{\nu_i \chi_{i0}} \leq \boldsymbol{0}$$ **Equation 4.4**

$$\sum_{i=1}^{m} \nu_i \chi_{i0} = 1$$

$$\mu_r,\ \nu_i \geq\ 0$$

For which the linear programming dual problem is

$$\theta^* = min\theta$$

Subject to

$$\sum_{j=1}^{n} \boldsymbol{x_{ij}\lambda_i} \leq \boldsymbol{\theta x_{i0}}\ \ \boldsymbol{i = 1, 2, \ldots, m}$$ **Equation 4.5**

$$\sum_{j}^{n} y_{rj}\lambda_j\ \leq y_r\ \ \ r = 1,2, \ldots s$$

$$\lambda_j \geq 0\ \ \ j = 1,2, \ldots, n$$

The model in Equation 4.5 is also referred to as the "Farrell model", as it was popularised by Farrell (1957). In economics, the DEA model is said to conform to the assumption of "strong disposal", because it ignores the presence of non-zero slacks. The phenomenon is referred to as "weakly efficient" in operational research DEA literature (Cooper et al., 2011c).

By the nature of dual theorem of linear programming $Z^* = \theta^*$, thus either of the problems can be used to solve Equation 4.1 to obtain efficiency scores. Hence if $\theta = 1$, is a feasible solution to 4.1, the solution implies $\theta^* \leq 1$. However if $\theta^* = 1$, this means that the current input levels cannot be reduced further proportionally and this implies that the DMU_0 is on the frontier. However if $\theta^* < 1$, then DMU_0 is dominated by the frontier (Cheon, 2007b). The optimal solution θ^* gives an input oriented efficiency score for a particular DMU. To obtain all the efficiency scores, the process is repeated for each DMU_j. Hence, DMUs for which $\theta^* < 1$ are inefficient, while DMUs for which $\theta = 1$ are boundary points.

From the evaluation of 4.5, some boundary points appear to have non-zero input and output slacks:

$$s_i^- = \theta^* x_{i0} - \sum_{j=1}^{n} \lambda_i x_{ij}\ \ \ i = 1,2, \ldots, m$$

$$s_r^+ = \sum_{j=1}^{n} \lambda_j y_{rj} - y_{r0}\ \ \ r = 1,2, \ldots, s$$

Where s_i^- = input slack and s_r^+= output slack

The following linear programming formular is employed to determine the slacks in Equation 4.5, assuming the maximal value of the slacks:

Max $\sum_{j=i}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$

Subject to

$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta^* x_{i0} \quad i = 1,2 \ldots, m$ **Equation 4.6**

$\sum_{j=1}^{n} \lambda_i y_{rj} - s_r^+ = y_{r0} \qquad r = 1,2, \ldots, s;$

$\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall \; i, j, r$

Furthermore, DMU_0 is efficient if and only if $\theta^* = 1$ and $s_i^{-*} = s_r^{+*} = 0$, for all $i \; and \; r$. This condition is referred to as "DEA efficient". However DMU_0 is regarded as weakly efficient if $\theta^* = 1$ and $s_i^- \neq 0$ and/or $s_r^+ \neq 0$ for all $i \,\&\, r$. In other words a DMU is said to exhibit a condition of "weakly efficient" if it has an efficiency score of 1 and some non-zero slacks.

Therefore, to account for slacks in a DEA model requires solving a linear programming problem in two stages i.e. combining Equations 4.5 and 4.6 thus:

$\min \theta - \varepsilon\left(\sum_{j=i}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$

Subject to

$\sum_{j=i}^{m} \lambda_j x_{ij} + s_i^- = \theta x_{i0} \quad i = 1,2, \ldots, m$ **Equation 4.7**

$\sum_{j=i}^{n} \lambda_j y_{rj} - \; s_r^+ = y_{ro} \qquad r = 1,2, \ldots, s$

$\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall i, j, r$

Where $\varepsilon > 0$ is normally referred to as a non-Archimedean element, smaller than any real positive number. This is the same as solving Equation 4.5 in two stages; first minimising θ and secondly setting $\theta = \theta^*$. This type of formalisation is equivalent to granting 'pre-emptive' priority to the determination of θ. By so doing, the non-Archimedean element ε, described as being smaller than any real positive number, can be accommodated without specifying the value of ε (Cooper et al., 2011c).

The Equation 4.3 represents the input-oriented constant returns to scale (CRS) envelopment model. In input orientation, there is an assumption that DMUs improve efficiency by input reductions and output is fixed at their present levels. In contrast output orientation, efficiency is enhanced through output increase and fixing inputs at their current level. The DEA orientation concept is illustrated in Figure 4.5.

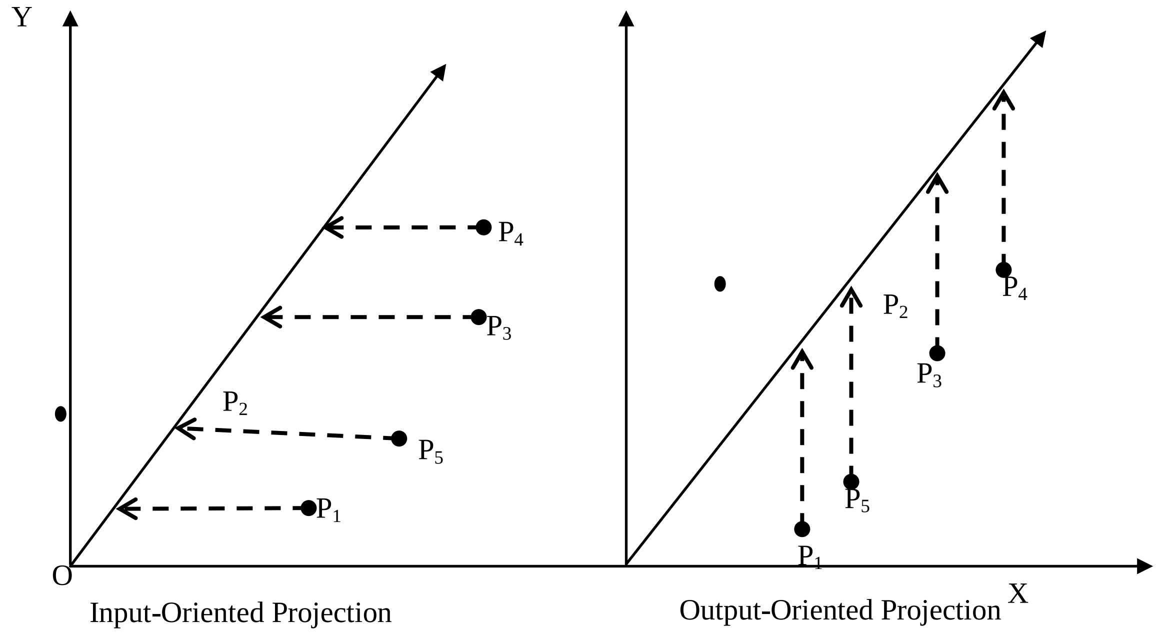


Figure 4.5: DEA-CCR model input and output orientation projection to the frontier

Source: Adapted from Cooper, Seiford, and Zhu (2011b)

Therefore, the output-oriented model can be formalised thus:

$Max\phi - \varepsilon\left(\sum_{j=1}^{m} s_r^- + \sum_{r=1}^{s} s_r^+\right)$

Subject to

$\sum_{j=i}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \quad i = 1,2,\dots,m$ **Equation 4.8**

$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi y_{r0} \quad r = 1,2,\dots,s;$

$\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall i, j, r$

In Equation 4.6, slacks were notable, as they are put into consideration in the calculation. To optimise the Equation, the linear programming problem can be solved by fixing slacks as $\phi = \phi^*$ to arrive at the following:

Max $\sum_{j=i}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$

Subject to

Equation 4.9

$$\boldsymbol{\sum_{j=i}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad i = 1, 2, \dots, m}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi^* y_{r0} \qquad r = 1,2, \dots, s;$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall i, j, r$$

Hence DMU_0 is considered efficient if and only if $\phi^* = 1$ and $s_i^{-*} = s_r^{+*} = 0$ for all $i \; and \; r$. On the other hand, DMU_0 is weakly efficient if and only if $\phi^* = 1$ and $s_i^{-*} \neq 0$ and/or $s_r^{+*} \neq 0$ for all $i \; and \; r$. While it is relatively inefficient if $\phi^* > 1$.

The models are evaluated under constant returns to scale otherwise called the CCR model named after the authors (Charnes, Cooper and Rhodes) that developed the model (Charnes et al., 1978)**.**

4.6.1.1 DEA model extensions and returns to scale

The constant return to scale (CRS) assumption does not regard the size of DMU as a factor in estimating port efficiency. So, under the CRS model for smaller DMUs to be considered efficient, they must produce outputs with the same ratios of input to output as larger DMUs can, or vice versa (Cheon, 2007b). This model is considered in this study, just due to the reason that there is no economy of scale at the industry level. Theoretically, ports should be able to operate at a point where a doubling of inputs should lead to doubling of all outputs $(f(ka, kb) = kf(a, b))$, as it is the most efficient point to operate. Considering the attributes of port production, this assumption may be on the extreme side if economies of scale do exist in the port sector at some point (Turner et al., 2004). In other words, if ports are allowed to produce at increasing returns to scale, for instance a doubling of all inputs would lead to more than a doubling of all outputs $(f(ka, kb) > kf(a, b))$. This normally occurs when organisations take the opportunity of certain managerial and external market advantages, such as stronger purchasing power and the spreading of the overhead over different products over time. On the other hand, ports sometimes become too large and unwieldy and operate at decreasing returns to scale, or diseconomies of scale. In this type of scenario, a doubling of all inputs will lead to less than a doubling of all outputs ($f(ka, kb) < kf(a, b)$) that is there are diseconomies of scale at that production level. Instead of the CRS model, the DEA can also assume the varying returns to scale (VRS) model, which allows the measurement of the output to input ratio to vary in accordance with the size of the DMUs in the sample. The difference between the two different approaches is illustrated in Figure 4.6. Let OBC represent the CRS frontier line, which is the highest ratio of outputs to inputs obtainable, irrespective of the size of the DMUs. Additionally, let VABDE be the frontier under the VRS assumption, where VABDE passed through the points where the DMUS can achieve the highest ratios of output to input, according to their respective sizes. It can be observed that some parts of the frontier (VA and DE) are parallel to the respective axes, further than the extreme points. The technical efficiency of a DMU is the distance from the CRS and VRS frontier to the DMU respectively. The technical efficiency/inefficiency of a DMU obtained from the VRS measurement is a result of factors other than the scale of production. Generally, this implies that technical efficiency obtained from the VRS model will be greater or equally to those calculated from the CRS model, implying that inefficient ports under the CRS model could become efficient under the VRS assumption.

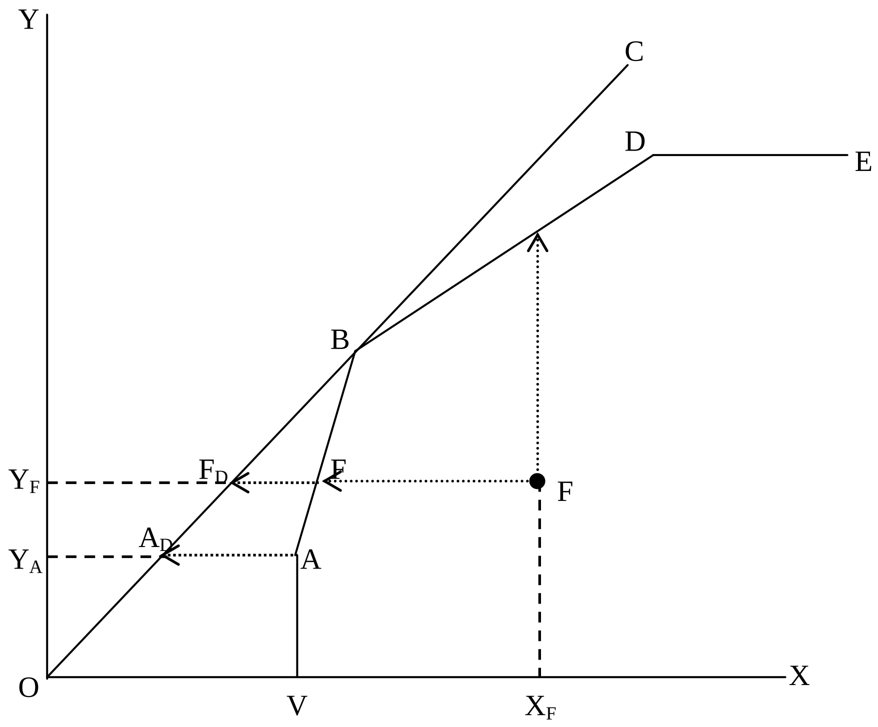


Figure 4.6: Production frontier and returns to scale

Source: Adapted from Herrera and Pang (2005)

Scale efficiency is measured by the distance between the CRS and VRS frontiers, while the point at which the CRS and VRS frontiers meet is regarded as the optimal level of production. In Figure 4.6, the point is B; therefore DMU B operates at optimal efficiency i.e. B has both the scale and non-scale efficiency. Points A, D & E are said to be scale inefficient, but non-scale or pure technically efficient, as they constitute the VRS production frontier. The scale efficiency of DMU A is measured by the ratio of the distances Y_AA_D to Y_AA (Y_AA_D/Y_AA). If the ratio is less than one or hundred percent, that implies that the scale efficiency is less than unity, the DMU is regarded as operating at an increasing return to scale assumption. Therefore, if the DMU increases its size it could operate at optimal production level relative to the peers in the sample. On the other hand, DMUs D and E are operating at decreasing returns to scale. As a result of large and unwieldy production scales they could not achieve efficiency under the CRS model, but they are considered efficient under the VRS model. In addition, the technical efficiency F under the CRS assumption can be determined by the ratio of Y_FF_D/Y_FF. As it consists of both scale inefficiency (Y_FF_D/Y_FF_V) and pure technical inefficiency (non-scale inefficiency) (Y_FF_V/ Y_FF).

To incorporate scale of operation to the CRS model, it has to be transformed to the VRS model and a constraint has to be added to the original CCR model (Banker et al., 1984). To relax the constant returns to scale assumption, a constraint $\sum_j^n \lambda_j = 1$ is added to equations 4.5 and 4.6, making the sum of the weights equal to one. The resultant model after the transformation is the BCC model, which allows ports to operate at varying (increasing, constant and decreasing) returns to scale. Table 4.2 is a summary of the different DEA models based on surface orientation of the envelopment and returns to scale.

There have been a lot of various enhancements (extensions) to the DEA model literature since the seminal works of Banker et al. (1984) and Charnes et al. (1978). The models discussed so far in this section work under the assumptions of constant returns to scale and variable returns to scale but there is also the additive model introduced by Charnes et al. (1985). The additive model uses the piece-wise linear envelopment, similar to the variable returns to scale methodology. The difference is based on the projection path and the additive model surface orientation is based on the concept of Pareto minimum function, while the BCC model is based on input-output orientation.

Table 4.2: DEA model, surface orientation and returns to scale assumption

Frontier Type	Input-Oriented	Output-Oriented
Constant Returns-to-scale	$\min \theta - \varepsilon\left(\sum_{j=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$ Subject to $\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{i0} \;\; i = 1,2,..m;$ $\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro} \;\; r = 1,2,\dots,s;$ $\lambda_j, s_i^-, s_r^+ \geq 0 \; \forall i,j,r$	$max\phi - \varepsilon(\sum_{j=1}^{m} s_r^- +$ r=1ssr+ Subject to $\sum_{j=i}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \;\; i = 1,2,\dots,m$ $\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi y_{r0} \;\; r =$ 1,2,...,s; $\lambda_j, s_i^-, s_r^+ \;\geq 0 \; \forall i,j,r$
Variable Returns-to-scale	Add $\sum_{j=1}^{n} \lambda_j = 1$	
Non-increasing Returns-to-scale	Add $\sum_{j=1}^{n} \lambda_j \leq 1$	
Returns-to-scale	Add $\sum_{j=1}^{n} \lambda_j \geq 1$	
Efficient Target	$\begin{Bmatrix} x_{i0} = \theta^* x_{io} - s_i^{-*} \; i = 1,2,\dots,m \\ y_{r0} = y_{r0} + s_r^{+*} \;\; j = 1,2,\dots,s \end{Bmatrix}$	$\begin{Bmatrix} x_{i0} = x_{i0} - s_i^{-*} \;\; i = 1,2,\dots m \\ y_{r0} = \phi^* y_{r0} + s_r^{+*} \;\; r = 1,2,\dots \end{Bmatrix}$

Source: Cheon (2007b)

4.6.2 Malmquist productivity index decomposition

The measurement of changes in port efficiency and identifying sources of efficiency gains and losses can be achieved by employing the MPI concept. The Malmquist productivity index measures the total productivity change between two time periods, t_1 and t_0 (pre- and post-concession). It calculates the ratio of the distances of each data in each period relative to a common technology. The technology in period t_1 is regarded as the reference technology and the base year for the comparison is period t_0. The Malmquist or total factor productivity change index between t_0 and t_1 is represented as the following:

$$\frac{TFP_{t1}}{TFP_{t0}} = \frac{d_{t1}\,(x_{t0}, y_{t0})}{d_{t1}\,(x_{t1}, y_{t1})}$$ **Equation 4.10**

Where $d_{t1}(x_{\propto}, y_{\propto})$ represents the distance from the observation in period 't0' to the period t1 technology a value of the above index greater than one indicates a percentage improvement in total factor productivity during the two periods, t0 and t1.

Fare et al. (1994) redefined this index, suggesting the alternative practice to avoid having to choose between technologies in period's t0 and t1. The alternative concept is based on the geometric mean of two indices that are comprised by two times of benchmarking of one period in comparison to the other. The first is evaluated with respect to the period t1 technology and the second with respect to time t0 technology.

$$\frac{TFP_{t1}}{TFP_{t0}} = \left[\frac{d_{t1}\,(x_{t0}, y_{t0}) d_{t0}\,(x_{t0}, y_{t0})}{d_{t1}\,(x_{t1}, y_{t1}) d_{t0}\,(x_{t1}, y_{t1})}\right]^{\frac{1}{2}}$$

$$= \frac{d_{t0}\,(x_{t0}, y_{t0})}{d_{t1}\,(x_{t1}, y_{t1})}\left[\frac{d_{t1}\,(x_{t1}, y_{t1})\; d_{t1}\,(x_o^t, y_0^t)}{d_{t0}\,(x_{t1}, y_{t1})\; d_{t0}\,(x_{t0}\,, y_{t0})}\right]^{\frac{1}{2}}$$ **Equation 4.11**

Equation 4.11, represented by the distance functions, can be mathematically rewritten as the following; which is represented by output-oriented scores (φ), since the efficiency scores are the ratios of distance in the production frontiers:

$$\frac{\varphi_{t0}\,(x_{t0}, y_{t0})}{\varphi_{t1}\,(x_{t1}, y_{t1})}\left[\frac{\varphi_{t1}\,(x_{t1}, y_{t1})\; \varphi_{t1}\,(x_0^t\,, y_0^t)}{\varphi\,(x_{t1}\,, y_{t1})\; \varphi_{t0}(x_{t0}, y_{t0})}\right]^{\frac{1}{2}}$$ **Equation 4.12**

A × $[B]$

Where, $\varphi_{t\alpha}(x_{t\beta}, y_{t\beta})$, represents the output-oriented efficiency scores produced by the benchmarking of a DMU in the year β, in comparison to the year of α.

The part of "A" in equation 4.12 represents change in technical efficiency (catch-up effect) between periods t0 and t1. While "B" measures technological change (frontier shift effects) during the same period. It has been argued that in order to measure total factor productivity properly using this concept, constant returns to scale (CRS) distance functions are required. This is because, a change in technical efficiency, representing catch-effect, consists of changes in scale efficiency and changes in non-scale technical efficiency, or 'pure' technical efficiency. As the DEA under the VRS do not measure the impact of production scale efficiency, the MPI with the VRS distance functions cannot measure change in scale efficiency (Fare et al., 1994). It thus leads to the misspecification of size of frontier shift effects.

By introducing some variable returns to scale DEA models, Equations 4.11 and 4.12 can be turned into a more refined index in Equation 4.13 (Cooper et al., 2011b; Färe et al., 1994; Zhu, 2003). It has also been applied in some recent port production studies (Cheon, 2007b; Estache et al., 2004).

$$\frac{d^v_{t0}\,(x_{t0}\,,y_{t0})}{d^v_{t1}\,(x_{t1},y_{t1})}\left[\frac{d^v_{t1}\,(x_{t1},y_{t1})d^c_{t0}(x_{t0},y_{t0})}{d^v_0\,(x_0,y_0)\,d^c_{t1}\,(x_{t1},y_{t1})}\right]\left[\frac{d^c_{t1}\,(x_{t0},y_{t0})\,d^v_{t1}\,(x_{t1},y_{t1})}{d^c_{t0}\,(x_{t0}\,,y_{t0})\,d^v_0\,(x_1\,,y_1)}\right]^{\frac{1}{2}}$$

$$= \frac{\varphi^v_{t0}\,(x_{t0},y_{t0})}{\varphi^v_{t1}\,(x_{t1},y_{t1})}\left[\frac{\varphi^v_{t1}\,(x_{t1},y_{t1})}{\varphi^v_0\,(x_0,y_0)}\;\frac{\varphi^c_{t0}\,(x_{t0},y_{t0})}{\varphi^v_0\,(x_0,y_0)}\right]\left[\frac{\varphi^c_{t1}\,(x_{t0},y_{t0})}{\varphi^c_{t0}\,(x_{t0},y_{t0})}\;\frac{\varphi^v_{t1}\,(x_{t1},y_{t1})}{\varphi^v_0\,(x_1,y_1)}\right]^{\frac{1}{2}}$$ **Equation 4.13**

A'   A''

Where φ is output-oriented efficiency scores under the VRS and φ^c is output-oriented efficiency scores under the CRS.

In equation 4.13, the changes in technical efficiency, A equation (4.12) , is separated into change in "pure" technical efficiency (A') and the change in scale efficiency (A") and technological progress (B). The product between "pure" technical efficiency (A') and scale efficiency (A") is called total technical efficiency change (TTEC), representing the total catch-up effect. This decomposition is interesting, because the changes in scale efficiency of ports are often determined by variations in external demand driven by the economic size and strengths of port hinterlands. Port authorities and managers may not have active control over them, while it is possible to do something about it, through port planning and strategic management in the long run. It is possible to carefully examine the influence of different factors on port productive performance, by decomposing the sources of inefficiency.

In summary, applying the above MPI equations in measuring TFP requires CRS, a distance function. It is so, because the technical efficiency obtained from CRS is an amalgam of scale efficiency and pure technical efficiency. Secondly, the DEA-BCC measures only non-scale efficiency. Therefore, the MPI distance functions obtained from the VRS approach does not capture changes in scale efficiency.

Fare et al. (1994) and Lovell (2003) introduced the enhanced decomposition that allows for relaxing the CRS model in order to measure scale efficiency. Thus, to further decompose technical efficiency, VRS distance function is introduced, to obtain pure technical efficiency (PECH) and scale efficiency change (SECH). This particular feature of the Malmquist Productivity Index lends itself as a measurement option for decomposing changes in production.

4.6.3 Model orientation

A DEA model can be classified based on whether it is minimising inputs for a given level of output (input-oriented), or maximising output for a given level of input (output-oriented). It should be noted that both the CCR and BCC models have a dual input and output orientation. The focus of an input-oriented model is on how to reduce input whilst maintaining the same level of output. On the other hand, the output-oriented model dwells on how to increase output whilst keeping the level of input constant. The difference between the two orientations lies on the projection path to the frontier; in the input-oriented model the projection path is horizontal. It is vertical in the output-oriented model. The orientation of the model depends on the nature of production and the given constraints. Each of the orientations has been applied to different studies in the port industry. The input-oriented model is closely related to operational management issues, while the output-oriented model is more associated with planning and strategies (Cullinane, Song, & Wang, 2005b).

The proponents of the input-oriented model argue that the port industry is generally associated with long-lived infrastructure and facilities and a long-term planning horizon. In essence, once a port is built; its output could be predicted in the short run, because *ceteris paribus,* a port can determine the shipping lines that call at its terminal. Additionally, it could predicate throughput based on historical data. Therefore, a port should be concerned about how to utilise its inputs efficiently as a cost saving measure in production.

As a result of the increase in international trade due to globalisation, the re-organisation of traditional ways of administering ports to a more pragmatic approach will usher in competition and less dependence on government for funds. There is also a need to design an adequate regulatory framework to guarantee efficient outcomes in the absence of government support, especially in developing countries. Therefore, ports should often review their strategies in order to provide satisfactory services to their customers and maintain a competitive edge in these changing circumstances. For ports, to adapt to the changing environment requires accessing existing capacity, in order to find out if the output has been maximised in the presence of available input. Taking into account the above scenario, the output-oriented model provides a more appropriate benchmark for the port industry.

In this study, output-oriented models are employed as the basis for the analysis. The fundamental reason for this choice is that the study is investigating the outcome of the privatisation policy as a performance enhancement tool. Since the primary interest of the research lies in investigating the results of a policy decision at national level, an output-oriented model is deemed more suited to such an objective.

4.7 Data Collection

The primary goal of the data collection is to show the step-by-step approach used in sourcing the data that is employed in answering the research questions. The data collection is based on the survey of the six Nigerian ports to obtain the operational data required for the years under study. The data required is collected through multiple methods. The need to use multiple sources of data collection for theory testing in case study research is captured aptly by Leonard-Barton (1990): “Survey research shows the history of past or current phenomenon, drawn from multiple sources of evidence. It can include data from direct observation and systematic interviewing, as well as from public and private archives. In fact, any fact relating to the stream of events describing the phenomenon is a potential datum in a survey research, since the context is necessary” (p249).

The researcher first and foremost conducted a pilot survey at the premier Nigerian seaport Apapa from April 22nd to 6th May; 2011, to achieve the following objectives:

- To familiarise with the *modus operandi* of the port system in Nigeria
- To have an insight into the types of performance indicators that ports in Nigeria collect
- To test the adequacy of the interview questions to elicit the desired answers based on the conceptual framework

Secondly, since the purpose of this research is to study in-depth the influence of privatisation through concession contracts on operational performance of Nigerian seaports. Secondary data from a broad range of documents were reviewed. Plus, key port users were interviewed in order to understand the whole story from multiple perspectives. Reviewing and extracting data from relevant documents is of particular importance for an ex-post longitudinal field study. A longitudinal study in its purest form involves mainly daily participant observation Leonard-Barton (1990), which is not feasible for this study. Therefore, the operational data of the ports was obtained through retrospective reports, gathered after the events have occurred. Documents were retrieved from various print and internet sources, the Nigeria port authority website, terminal operators' websites, printed and online reports, manuals and handbooks. Additionally, from scientific literature, including books and peer-reviewed journal articles, maritime magazines and news reports.

The literature review and pilot study provided a prior view of the general constructs or categories that needed to be examined and their relationships. During the pilot survey, the port users that needed to be interviewed were identified. In addition, the researcher undertook a semi-structured interview to solicit the views of the stakeholders on the concession programme, to supplement the operational data from the field. The interviews were conducted on 4 different port locations (Lagos, Port Harcourt, Warri and Calabar). The participants were selected in such a way that all categories of stakeholders were represented. For example, the shippers (exporters and importers) are represented by the freight forwarders, who as agents handle the day-to-day activities in the port on their behalf. The terminal operators were represented by two representatives from the Seaport Terminal Operators Association of Nigeria (STOAN), an umbrella body for terminal operators working in

Nigerian ports. The shipping companies' participants were selected from the Indigenous Ship Owners Association (ISAN). The landlord the NPA is represented by the General Manager (GM) Public Affairs and workers by a representative from the maritime union. Subsequently, the researcher made sure the interviews covered participants from the two port complexes i.e. the Lagos and Eastern port complexes, so that the opinions obtained were representative of the sample.

4.7.1 Sampling framework

Sampling deals with the criteria employed in selecting the units of analysis. Only two criteria guided the selection of the sample i.e. participation in the 2006 reform program and the ports must not be solely a dedicated crude port or terminal. A container terminal with a shorter history than the other terminals (West African container terminal WACT, Onne concession to APMT in 2010) was also excluded. In this study, each port-year is regarded as a distinct unit or DMU, in order to satisfy the homogeneity assumption inherent in a DEA analysis. As the focus of this study is to provide an in-depth understanding of the influence of wholesale concessions on the performance of a national port system, seaports in Nigeria were only considered for the analysis.

Hence, the population of this study consists of 20 Nigerian seaports and the 20 terminals delineated from those ports, but only six ports that are multipurpose ports and part of the 2006 concession program were chosen as a sample for the port analysis. The remaining 14 ports handle only crude oil and other wet bulk cargoes and at the same time is not part of the 2006 concession programme and is not considered for this study. Moreover, they are more aligned with the energy sector than the port system. The operations of the six ports are similar because they are all multipurpose ports i.e. they handle different types of cargo.

Additionally, this research follows the suggestion by Bryman and Bell (2007) that the selection of the object of study should not be restricted to ports or terminals with high volume of throughput. Therefore, all ports that participated in the 2006 Nigerian port reform (concession program) no matter the size were selected. That is why the study included the biggest and oldest port in Nigeria the Apapa port and also small ports such as Calabar and Warri.

The sample size of this research is six seaports. Two (2) of the ports are located in Lagos State (Apapa & Tin Can Island port), two in Rivers State (Port Harcourt and Onne port), one in Delta State (Warri port) and one in Cross River State (Calabar port) and from the six ports, 20 terminals were carved out during the concession programme. In the analysis, the six Nigerian ports operations are compared against each other, because they are multipurpose ports.

For this research, the unit of analysis would have been port or terminal depending on which one is being analysed. However, consideration of the small sample size and satisfying the general rule of thumb for DEA application are required, as suggested by Raab and Lichty (2002) that; the minimum number of DMUs in a DEA analysis should be three times the combined number of inputs and outputs to ensure sufficient degree of freedom as well as to enhance the discriminatory power of the DEA. Additionally, as this study is a longitudinal study in which data is collected over a relatively long period (2000-2011), the particular unit of analysis is port-year, thus bringing the number of DMUs for the analysis to 72.

In addition, another factor that could impair the integrity of the DEA analysis is the variations in traffic and operational arrangements between sampled ports as it may compromise homogeneity. However, it is reduced to the barest minimum as sampled ports are from the same operating environment and share common hinterlands. Though there may be instances of non-homogenous data in the set because the sampled contain large ports alongside small ones. The problem is tackled by using returns-to-scale model (BCC) and sensitivity analysis to identify different scale properties and performance levels of the production frontier.

4.7.2 Variable selection

The application of Frontier models such as the DEA in research, involves the identification of resources (inputs) and the transformation of the resources (outputs). There are two criteria employed in selecting the variables used in this research. The first one considered is availability. The second is a literature search to ensure validity and conformity of the research with the existing body of knowledge This is necessary as misspelt variables could lead the model to point in the wrong direction (Wang et al., 2003). Plus, the wrong choice of variables could introduce bias in the results.

Therefore, care is taken in the selection of input and output variables so as to give accurate representation of actual objectives and processes of port production (Cullinane et al., 2004; Norman & Stoker, 1991). In port production, the observed performance of the port is closely related to its objective. This research assumed the primary objective of the port is the minimisation of the use of input(s) and maximisation of the output(s). As a result of secrecy and difficulty involved in obtaining financial data, this assumed objective is not in agreement with profit maximisation. Therefore, financial variables will not be considered for this research.

For this study, the researcher adopted the following procedures in the selection of the input/output variables to ensure objectivity as much as is possible. First, a review of the various port efficiency and performance studies, press reports and leading shipping tabloids was carried out and the types of input and output variables used in each case (Appendix 1.1). However, because most articles pertain to European, American and Asian ports, the selection of operational variables that is consistent with port operations in Nigeria presented a considerable challenge, since the study was not conceptualised to have a global character. Secondly, the available inputs and outputs were analysed and scrutinized from the pool of the resources used in previous studies. Thus, a selection of the inputs and outputs used for this study was made based on the objectives of the Nigerian port system. Finally, the verification of the pre-selected variables was carried out in order to find out which ones are available from the data sources.

4.7.2.1 Output variables

In the DEA application to the evaluation of port operations, there are many productive output indicators that could be considered, such as: the volume of cargo (General, Container, Dry bulk, Wet bulk, RORO), including total number of passengers loaded/unloaded i.e. the throughput, the turnaround time of ships and the number of ship calls. From the synthesis of DEA applications in seaport (Appendix 1.1), it is evident that the *total throughput* is arguably the most significant output measure. It is consistent with the objective of seaports. The total number of passengers handled is considered as an output variable, as ports also maintain infrastructure for passenger handling. However, for Nigerian seaports this data is not available, as passenger traffic is mostly on inland waterways that are not under the management of the NPA. Therefore, number of passengers is not included as an output variable in this research. Likewise, the number of ship calls is excluded due to collinearity between it and total throughput. Moreover, what is the benefit of having a higher number of ship calls if there is no increase in total throughput? It may be argued that it is an indicator of the frequency of service, but that is not enough to justify adding it as another variable in the model, as too many variables will reduce the quality of the result.

However, the selection of suitable output variables for the present DEA analysis depended on data availability and correlations among these variables. On this basis, two output variables, turnaround time and total cargo throughput were chosen. The reason for the choice of total cargo throughput as an output variable is borne out of the wide acceptance of the variable as an indicator of port or terminal output production. The majority of port efficiency/performance studies have treated it as an output variable, as it is closely related to the need for facilities for cargo handling and services. In addition, it provides the basis on which ports are compared in terms of relative size, magnitude of investment, activity level and most importantly it forms the basis for revenue generation. The yearly average turnaround time is chosen to take care of service quality. Its inclusion is justified because there is a definite relationship between it and the objectives of the concession programme. So, only two output variables are selected for this study: total annual throughput and average annual turnaround time of ships.

The choice is restricted to two output variables due to the frontier characteristic of the DEA, which implies that many variables give rise to many efficient DMUs. In other words, too many variables reduce the viability of a DEA analysis. If a higher number of variables in relation to the sample size are chosen, most of the DMUs will appear as efficient (Marques & Carvalho, 2009). This may not be desirable, as it reduces the DEA analysis to a worthless exercise. In order to circumvent the undesirable outcome of having too many efficient DMUs, it is advisable to consider fewer variables in a DEA implementation.

Another aspect that was discussed in the output definition is how to measure the variables. Some of the previous studies measured the quantum of cargo that is moved. While others used the capacity of ships that call at the ports as measured in gross registered tonnage (GRT) or dead weight tonnage (DWT), as a proxy for the quantity of cargo that is moved through a port. It will be unreasonable and unnecessary to use a proxy variable when the real volume handled by each port under study is available. Though it may be argued that it will benefit ports to have large ships calling, the assumed objective of this study is how to efficiently handle cargo and not to receive bigger ships. Another crucial issue is on the definition of units for each category. For instance Ro-Ro traffic is measured in different ways in countries, but as a tonnage figure for all the cargo types is available, the study adopted tonnes as unit of measurement for throughput.

4.7.2.2 Input variables

The input variables consist of the various resources employed to produce the output, such as Land, Labour and Capital. Economic theory implies that effective handling of cargo volumes depends mainly on the efficient use of port land, labour and capital (Dowd & Leschine, 1990). In port operations, terminal capacity, size of storage area, quay length, berth length, piers, handling equipment (gantry cranes, yard cranes, straddle carrier, forklifts etc) and warehouse capacity are suitable for consideration as possible input variables in a port's production. Other input factors that could be considered for efficiency estimates include: berth occupancy, berth accessibility, proximity to major trade lanes and crane operating hours. As well as different handling speeds of yard and ship-to-shore cranes, equipment age and maintenance, the capital invested in a terminal and associated equipment, average container interchange per ship and quayside water depth (see Appendix 1.1). The herculean task involved in obtaining practical data on each of these variables across the six ports for a twelve-year period (2000-2011) proved insurmountable. Plus, to consider all these factors as potential inputs in port efficiency, the multicollinearity among the factors must be significant.

The issue of what type of labour to be considered as input to port production has been problematic due to availability and unreliability of direct data. As a result, Neufville and Tsunokawa (1981) and Notteboom et al. (2000) proposed a predetermined relationship that then number of gantry cranes and number of dockworkers are directly related in a container port. However, Cullinane and Wang (2006a) pointed out that although this relationship may be true in container terminal production, it may not be relevant to other types of ports or terminals because of different characteristics of production. In fact they pointed out the danger involved in applying the relationship to container ports or terminals with different production scales because different equipment and labour arrangements are employed. For labour input, stevedoring labour (dock workers) is arguably the most important in port production as they are directly involved in loading and offloading cargo. However, due to non-availability of this data across all the ports under investigation, this study employed the total number of staff employed in a port as a proxy for labour input, because the six ports are involved in handling heterogeneous cargo.

Therefore, this study uses four input variables; Storage capacity and berth length were chosen for land input, the total number of equipment for capital input, whilst the total number of staff employed by each port/terminal represents labour input. There is no agreement among authors on the type of variables to be used in undertaking port performance benchmarking, as evident in literature review of input/output used in different port studies (see Appendix 1.1). Rather, each author selects input/output based on the purpose of the research. For instance, Tongzon (2001), and Cullinane and Song (2003) used number of berths to reflect berth side productivity. While Cullinane et al. (2002), Wang et al. (2005) and Notteboom et al. (2000) proposed the use of total berth length instead. The description of input and output variables selected for the analysis is presented in Table 4.3.

Table 4.3: Input and output variables of Nigerian ports

Variables	Descriptions	Units of Measurement
	Inputs	
Number of berths	Total berths available to a port or allocated to a terminal	Units
Number of staff	The total staff strength of a port or terminal	Units
Storage capacity	Total available cargo storage space	1000 Tonnes
Number of equipment	Total number of equipment available for cargo operation purposes	Units
	Outputs	
Throughput	Total cargo handled annually by a port or terminal	1000 Tonnes
Turnaround Time	The yearly average time a ship spends at port or terminal from arrival to departure.	Days

In summary, for the efficiency and productivity analysis, the samples size for this research is six major Nigerian ports and the twenty terminals delineated from the ports in 2006. The period considered for each port is 2000-2011. The study made use of four input variables and two output variables. The input variables are: Number of berths, total number of equipment, total storage capacity and the total number of staff in each port. The output variables used are total yearly throughput and turnaround time.

However, as explained in Chapter 2, port performance is influenced by several variables, some of which are outside the control of the PAs such as level of economic activity, geographical location and frequency of ship calls. To capture these variables, two structural equations representing the functional relationship between throughput and efficiency were formulated. A two-stage multiple linear regression is applied to the model for parameter estimation. The definition of these variables and the procedures for generating functional equations are presented in Chapter 6.

4.7.3 Data justification

To justify that the selected variables fit the model, the output variables throughput (THRUP) and turnaround time (TAT) were regressed against the input variables (Number of berths, number of equipment, number of staff and storage capacity of the ports). The results obtained are shown in Table 4.4. The R-square values show that 72 and 52 percent of the variance in throughput and turnaround time (output variables) respectively can be explained by the linear combination of the input variables (Number of berths, number of equipment, number of staff and total storage capacity). The remaining 28% and 48% of throughput and turnaround time respectively can be attributed to other factors (exogenous factors). However, as port size as represented by throughput has a higher R^2 value and is also a significant factor in determining the efficiency as observed in Chapter 5, it is the only factor considered in the multivariate analysis in Chapter 6.

Table 4.4: Summary statistics of regression of output variables against input variables

SUMMARY OUTPUT		
Regression Statistics	*THRUP*	*TAT*
Multiple R	0.8475	0.7235
R Square	0.7183	0.5234
Adjusted R Square	0.7015	0.4949
Standard Error	3860.7079	3.3175
Observations	72	72

In order to apply the DEA for performance benchmarking, there are certain conditions that the data employed for that purpose should fulfil. In this section, the researcher justifies and validates the definition and selection of the variables in the dataset.

4.7.3.1 Validation and accuracy

The need for factual data in a research of this nature cannot be overestimated and that is why the data for this study are carefully selected. First and foremost, articles or reports that were outdated were discarded, unless it is used to express an idea that is relatively constant. Also to ensure that the data obtained from internet sources are factual, editable sites (excluding Wikipedia), blogs and forms and non-copyrighted materials and sites that accept open contributions, were ignored. Secondly, the analysis considers all shades of opinions and relevant evidence. Thirdly, the port and terminal documents (annual reports) were not solely relied upon; both corroborating and contesting information were harmonised before inclusion in the analysis.

Therefore, collection of accurate data for all DMUs is vital for the reliability of results and to ensure that data used for the DEA analysis is a representation of the operations of Nigerian ports. Data was collected from the individual ports/terminals operational reports to the NPA Headquarters, the terminal operators' annual reports and the compliance reports to the NPA. The data from the different sources was examined, scrutinised and compared for accuracy and conformity with one another. In the case of a significant discrepancy, clarification was sought from the port statisticians. For minor differences between figures from different sources, the average of the numbers obtained from the various sources was taken as the input/output value. The researcher's knowledge of the Nigerian port system also came in handy in the review and adjustment of data that is not in conformity with the size and operational arrangements of the ports and terminals in the sample.

Another phenomenon that can compromise data accuracy is what the economists describe as congestion which is attributable to the choice of input and output variables. Congestion is said to occur when reductions (increases) in one or more inputs generate an increase (decrease) in one or more outputs. For example, if an increase in the number of stevedores and other port labour leads to lower throughput and production levels (Bichou, 2008). The selected variables for this study were screened for congestion, in accordance with various models suggested by Brockett, Cooper, Wang, and Shin (1998) and Cooper, Deng, Seiford, and Zhu (2011a). Thus, the input and output variables are carefully selected to avoid congestion. However, in cases of congestion due to excessive use of inputs, as is the case in some port-year operations in this study. The congestion is identified as the amount of input or output slacks and the influence on the efficiency benchmarks is discussed in order to help policy makers reallocate resources and avoid waste.

4.7.3.2 Data scaling, exclusivity and exhaustiveness

To avoid round-off errors inherent in the DEA measurements, the input/output variables with excessively large numbers compared to other variables, had their values scaled down. In this study, the values of throughput and storage capacity were scaled down and recorded in 1000 tonnes instead of tonnes, as mentioned in Table 4.3.

The rule of exclusivity and exhaustiveness as applied in a DEA measurement implies that only the inputs selected should influence output levels and that this influence should also be limited to the selected output variables. It is necessary to observe this rule so as to avoid assigning output and input resources tasks that have been exogenously determined.

To ensure that there is exclusivity and exhaustiveness between variables used in this research, the researcher identified only the input and output variables that influence only a port's operational performance. In addition, only ports that have handed over terminal operations to the private sector were included. Furthermore, the analysis was carried out on two levels to explicitly determine the operational scope of each DMU under study and only utilised those factors that experts have described as influencing a port's operational performance to build the model.

4.7.3.3 Positivity and isotonicity property

In a DEA application, it is required that the value of all input and output variables should be positive and non-zero. As shown in Appendix 5.1, all data used for the DEA analysis is all positive, thereby satisfying the positivity requirement.

The corollary to positivity is the isotonicity property. Before using a DEA model, the functions relating inputs to outputs must have the mathematical property called *isotonicity*

(Charnes et al., 1985). It implies that an increase in any input should be accompanied by some increase in output and not a decrease. In order to test compliance to this property by the input and output variables selected for this study, a Pearson correlation of the selected inputs and outputs was taken. The result of the Pearson correlation in Table 4.5 is positive and significant at a 5% confidence level, which means that the isotonicity assumption has not been violated.

Table 4.5: Pearson correlation between variables

Descriptive	*THRUP*	*TAT*	*NOB*	*NOE*	*NOS*	*TSC*
Throughput	1	0.076	0.225	0.541*	0.599*	0.830*
Turnaround	0.076	1	0.372	0.162	0.451	0.090
No. of Berths	0.225	0.372	1	0.384	0.219	0.430
No. of Equip.	0.541*	0.162	0.384	1	0.622*	0.592*
No. of Staff	0.599*	0.451	0.219	0.622*	1	0.694*
Capacity	0.830*	0.090	0.430	0.593*	0.694*	1

4.8 Software

Many standard optimization software packages such as Solver Pro, On Front, Warwick DEA, DEA Excel Solver, DEAP, EMS and Pioneer have been used in estimating efficiency scores. However, this study used the commercial software package, Frontier Analyst professional version 4 developed by Banxia holding, Banxia Frontier Analyst User Guide (2012) for efficiency and the Malmquist Productive Index analysis in this research. The Frontier Analyst from Banxia Software is a stand-alone Windows application which evaluates and documents most professional user interface. It organises analysis as projects and sample data could be accessible from a wide range of sources, including text, Excel, SPSS files, the Windows clipboard, the current Excel selection and direct entry. It displays the input data of DMUs as a matrix, where individual DMUs and variable data can be easily edited. Each variable is classified as output, input, or uncontrolled input (non-discretionary); DMUs in the sample can be screened using filtering rules in the software, to form subsets for analysis. It allows for specification of bounds on individual factor weights.

The frontier software Linear Programming models discussed previously are solved 72 times (number of DMUs), once for each of the ports in the sample. The software operates by searching for a linear combination of ports in the sample that produces a maximum number of outputs, using less number of input resources for each port in the data set. For each port in the analysis, the software model identifies output slacks or excess input usage for each unit of the analysis. Prior to running the programme, the study specified the returns to scale, the valuation system and the orientation system. The programme presents the results of the efficiency analysis as a percentage; a DMU with a score of 100% is regarded as efficient, while a score of less than 100% is considered inefficient.

4.9 Chapter Summary

This chapter discussed the different research methods available to the researcher to undertake an empirical study. The various research philosophies were examined, and the reason for the choice of the positivist paradigm as the most appropriate for the study was established. Subsequently, a deductive approach is adopted based on survey in case study strategy. The study employed the survey in case study strategy to test the theoretical concepts of port privatisation, performance and competition using the practice in Nigerian seaports. Therefore, this study's survey in case study research is associated with the deductive approach and is conducted to advance scientific knowledge. As a result, the study adopted the explanatory research design, which is devoted to finding causal relationships among variables. As drawing causal inferences from a cross-sectional survey design is difficult, the study employed a longitudinal design which is more appropriate for studying temporal changes.

The data collection uses mainly secondary data sources from documents obtained from the Nigeria Ports Authority and terminal operators. However, interviews are used to solicit the opinion of stakeholders about the concession program. The data collected was designated as either an input or output variable and that constitutes the database used for the analysis.

Efficiency and productivity measurement were employed in answering the research questions and ascertain the relationship between concession and operational performance. The chapter equally justified the use of DEA for the analysis and benchmarking of port/terminal efficiency, MPI for analysing productivity and evaluating the influence of concession.

This chapter later dealt with the operationalisation and formalisation of the analytical methods and techniques selected for the research. It equally focused on other aspects of the methodology, such as a sampling frame, data collection and variable selection.

Chapter Five: Benchmarking Nigerian ports operational efficiency

5.1 Introduction

This chapter undertakes a benchmark analysis of the six Nigerian ports for the period 2000-2011. The chapter adopts the different DEA methodologies; inter-temporal, contemporaneous and window, for the analysis. This is because of the small sample size of six ports, so as to increase the discriminatory power of the DEA. This allows for identification of the sources of efficiency (technical, scale or both), which can be very useful as this will enable the right policy to improve the performance of inefficient ports. Thereafter, window analysis is employed to determine the efficiency over time (2000-2011) of the six ports. This chapter also evaluates the pre- and post-concession efficiency of the six Nigerian ports operations from 2000 to 2005 and from 2006-2011 representing pre- and post-concession respectively.
To determine the change in productivity over the study period, the MPI was employed to decompose sources of efficiency into frontier shift effects and catch-up effects.

The operational hypotheses are tested to examine the impact of scale (size) on efficiency of operation and also the influence of concession on efficiency. The strategy employed in this chapter is to analyse data based on the specific objectives of the research, then, validate the empirical results that will help in the understanding of Nigerian ports production, with emphasis on the influence of concession.

5.2 Analysis and Results

5.2.1 Intertemporal analysis (2000-2011)

The input and output data used for the analysis and the descriptive statistics is shown in Appendix 5.1-5.3. The primary objective of the inter-temporal analysis is to measure the port-year efficiency of Nigerian seaports across the different time periods of the study (2000-2011). As there is no clear-cut information on the returns to scale in the port production function, the dataset was subjected to both constant returns to scale and variable returns to scale models, by assuming output orientation. First, the overall efficiency index is computed from DEA constant returns to scale model (CCR) and the pure technical efficiency is isolated by applying the varying returns to scale model (BCC). Secondly, the scale efficiency index is calculated from the efficiency score obtained from the CCR and BCC models, as scale efficiency is the ratio of overall and pure technical efficiency (CCR/BCC). Both exercises made use of the database for the 6 Nigerian ports for the period 2000-2011 (Appendix 5.1). The results obtained by applying the above models to the input and output variables in the dataset is shown in Table 5.1.

Table 5.1: Nigerian ports pure technical efficiency scores (BCC) for 2000-2011

YEAR	PORTS							
	APAPA	CALABAR	ONNE	PH	TCIP	WARRI	MEAN	STDEV
2000	68.4	21.7	100	88.6	64	34.8	62.92	30.18
2001	83.3	43.8	100	100	56	34.9	69.67	28.6
2002	100	43.2	100	100	57.4	36	72.77	30.62
2003	100	36	84.4	100	50.2	47.8	69.73	28.45
2004	100	100	98.9	100	45.9	61.5	84.38	24.28
2005	89.9	54.5	100	96	46.6	38.3	70.88	27.42
2006	100	65.1	100	100	49.1	46.1	76.72	26.31
2007	97.5	61.7	100	83.2	63.2	42.3	74.65	22.73
2008	100	100	100	88.7	80.1	54.4	87.2	18
2009	98.2	39.3	87.1	85.4	87.1	80.6	79.62	20.58
2010	96.2	100	100	95.2	77.5	83.9	92.13	9.291
2011	100	40.1	100	100	89.1	81.2	85.07	23.33
MEAN	94.5	58.8	97.5	94.8	63.9	53.5	77.14	20.49
STDEV	9.70	27.39	5.54	6.48	15.83	18.92		

As discussed in chapter 4, the DEA empirical analysis employs two output variables: *total yearly throughput handled in tonnes and average yearly ship turnaround time in days.* The inputs measures used are: *number of berths in the ports and total cargo handling equipmen,t* as a proxy for capital. *Total number of staff employed* by the ports as a proxy for stevedore labour and *total storage capacity* of the port represents land input. The result obtained from the analysis shows that the overall mean efficiency (CCR index) is 64.9% (Appendix 5.6). While the average pure technical (BCC index) and scale efficiencies are 77.14% and 82.78% respectively, for the period under study (Appendix 5.6). A comparison of the mean overall and pure technical efficiencies indicates the presence of inefficiency related to production scale. This is because the overall efficiency estimates and pure technical efficiency index differ in value. The gap in efficiency between the mean overall and pure technical efficiency is a measure of the degree to which production scale inefficiencies undermine technological efficiency (Merk & Dang, 2012). However, inefficiencies related to technology are determined by the gap in technical efficiency score in relation to a given port-year operation and its efficient benchmark (the efficiency frontier). The higher the gap, the greater the adjustments needed to bring the given port-year operation towards efficiency. To bring inefficient port-year operations to be technical efficient, the detailed estimates to be made of input and output variables are shown in Appendix 5.3. While the potential improvements needed to bring all the ports under study to the efficient frontier based on the dataset, is shown in Figure 5.1. In Appendix 5.5 it is observed that for the efficient port-year operations, the input and output variables have no adjustments (slacks). In other words, there are no slacks because they are operating at optimal levels.

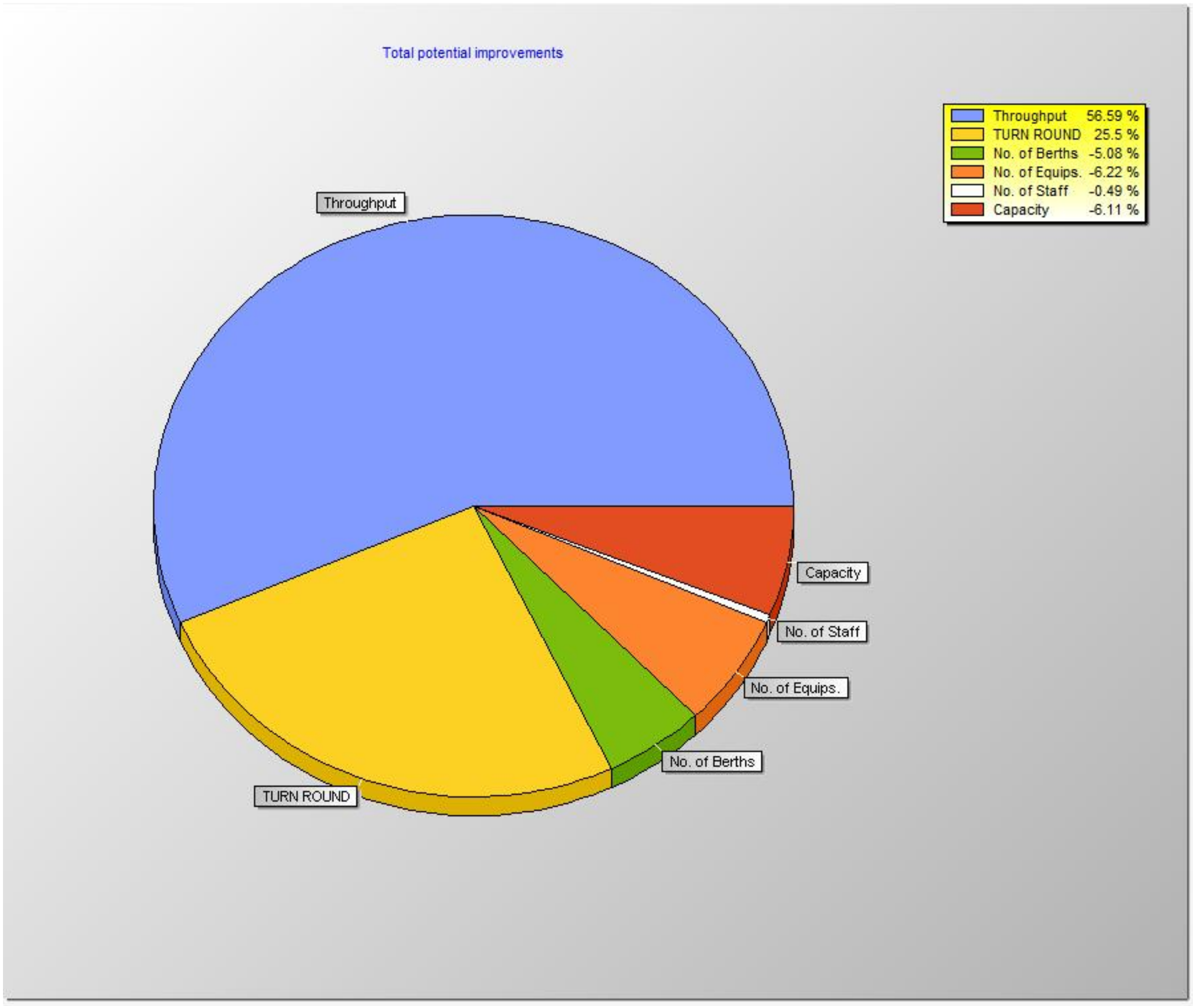


Figure 5.1: Nigerian ports' BCC potential improvements

Figure 5.1 indicates that for the ports under study to operate at optimal efficient level overall, total throughput has to increase by 56.59% and turnaround time improved by 25.5%, at the same level of inputs. Conversely, the inputs should be reduced by 5.08%, 6.22%, 0.49% and 6.11% respectively, for the number of berths, total number of equipment, total number of staff and storage capacity at the present level of output. The type of adjustment needed to bring the ports to efficiency depends on the returns to scale characteristics i.e. whether the ports are operating under increasing or decreasing returns to scale. For the sample, 35 port-year operations are under increasing returns to scale and 25 under decreasing returns to scale (Appendix 5.6). For the port-year operations with increasing returns to scale to achieve benchmark efficiency, output levels should be increased, while those operating at decreasing returns to scale should reduce input consumption.

Figure 5.2 shows the port-year efficiency score distribution frequency for both the CCR and BCC models. The pink and blue bars represent the number of port-year operations within the efficiency index range for the BCC and CCR respectively. For example, 12 port-year operations were efficient under the CCR model, whereas it is 24 for the BCC model. It is not surprising that the DEA-BCC model generates more efficient port-year operations than the CCR model, since the DEA model with constant returns to scale assumption provides information on technical and scale efficiency combined. While the variable returns to scale identifies only pure technical efficiency. The ANOVA of the efficiency scores obtained from the DEA-BCC and DEA-CCR analyses shows that the efficiency scores computed from these two models are significantly different at the 5% level (F=7.8; critical value of 3.91). The correlation coefficient between the efficiency scores derived from the DEA-BCC and DEA-CCR analysis is 0.825. The positive and high spearman Rank Order correlation indicates that the efficiency scores of the port-year operations obtained from the two models, are highly correlated. However, statistically, the efficiency scores computed from the two models based on the data are different. A combination of the ANOVA and Spearman’s Rank Order correlation coefficient leads to the conclusion that the efficiency estimates yielded by the two approaches are different and that they follow the same pattern across the port-year analysis. As observed, the result further confirms the presence of inefficiencies arising from scale of operation. That is why the 12 port-year operations considered inefficient under the DEA-CCR have become efficient under the DEA-BCC (port-year efficiency score highlighted in yellow), when scale of operations is not taken into consideration (Appendix 5.6). This is in view of the fact that smaller ports may have some inherent disadvantages that could bar them from performing as efficiently as the larger scale counterparts. Therefore, assuming VRS suppresses this limitation and brings the smaller ports closer to the efficient frontier, if strategically managed and despite the size disadvantage.

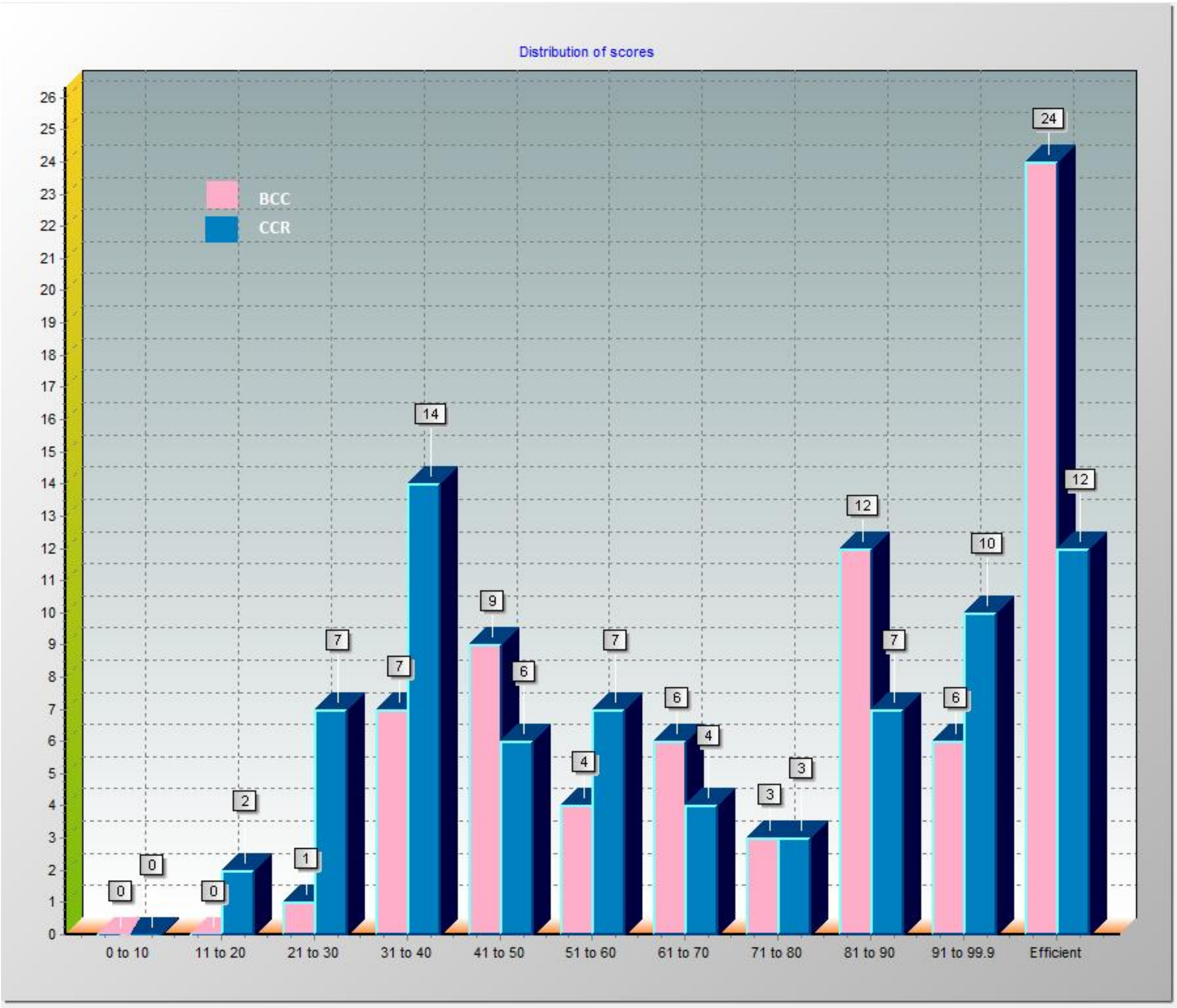


Figure 5.2: Comparison of the DEA-CCR and BCC models port-year efficiency score and distribution frequency

Table 5.1 shows the technical (DEA-BCC) efficiency scores of the six Nigerian seaports from 2000-2011. For the period under review, none of the ports operated at 100% technical efficiency level throughout the period. Although the ports operated at high efficiency, as indicated by the mean efficiency of 77.15% for the whole period. It can equally be observed that the Onne port has the highest mean technical efficiency score of 97.5%. It may not be surprising, as it is located at oil and gas free trade zone and acts as a transhipment centre for Angola and Sao Tome and Principe. It is the only port whose whole operation for the period under consideration is in the private domain, because it started operation as a Landlord port. It is followed by the PH port with a mean efficiency of 94.8%; the two ports are located outside the Lagos zone and are free from the perennial congestion associated with Lagos ports. The most efficient port-year operation is PH2006, with super-efficiency score of 207 (Appendix 5.6 highlighted in the colour blue). It is also observed that the TCIP and Warri ports did not achieve efficient operation in any of the 12 years under consideration. The TCIP operated under IRS throughout the period i.e. it is operating below optimal scale in order to achieve efficiency relative to its benchmark, it needs to increase throughput and reduce ship turnaround time to attract shippers. On the other hand, the Warri port operated at both IRS and DRS. There is high variation in the efficiency scores of Warri port for the period (standard deviation 18.92%) and exhibited both IRS and DRS production characteristics for the period. It may not be unconnected with the security situation in the Niger Delta due to youth unrest. At the height of the youth militancy in the region (2000-2006), ships were scared away from using the ports in the Warri zone. However, with the disarming and embracing of amnesty by the youths, the situation has been put under control and ships have started patronising the ports, hence the improved efficiency from 2007 when the amnesty programme came into effect.

5.2.1.1 Influence of production size on port efficiency

The Pearson correlation between the DEA efficiency scores and total cargo throughput, with a two-tailed t-test, is used to evaluate the effect of production size on efficiency. Assuming the null hypothesis (H_O): **Port size has no effect on the efficiency of port operation**. In order to determine the direction of influence of port size on port efficiency, an alternative hypothesis (H_1): **Port size influences the efficiency of ports (2-tail test)**. The DEA efficiency scores derived from the CRS and VRS were compared against throughput values.

The result obtained is presented in Table 5.2. The mean BCC efficiency for the period is 77.15%, and the correlation between the technical efficiency score and port size is 0.6222 (Figure 5.3), which is significant at the 5 percent confidence level. The absolute value of the t-stat, 10.2457, is much greater than both the t-critical, one-tail (1.6666) and two-tail (1.9939) tests. It implies that port size has an effect on the efficiency of ports. In other words, even if the concepts of scale economies are not put into consideration, the larger ports with their DEA scores obtained from VRS intertemporal analysis are still more efficient. It is in tandem with global perception, as the larger ports can attract bigger ships and the skills to manage them more efficiently for higher productivity without scale advantages, by investing in modern equipment. It may not be surprising, as larger ports in the world today are technology leaders and have locational advantages. In addition, they can formulate better strategies, because they have the requisite management skills to convert given inputs optimally to increase their outputs. The drawback of intertemporal analysis is in the treatment of time, as it treats the ports of the different years as if they exist and operate in the same period. The result that bigger ports operate more strategically and employ better managerial skills to become more efficient, as obtained from intertemporal analysis, should be treated with some degree of caution until similar results are verified by the window analysis. The reason being, that during the 12 years covered by intertemporal analysis, a significant reform (concession) has taken place in Nigeria. The concessions may have brought changes in technology, regulation, economic conditions or competitive situation, rendering comparisons of ports during such an extended period unfair and unrealistic. The Window analysis is the time-dependent model of the DEA and compares the operations within a short time. The assumption is that within such a brief time, changes in port conditions may not be such that they can render the results obtained from the analysis unfair or unreasonable.

Table 5.2: Relationship between DEA intertemporal scores and port size

t-Test: Paired Two Sample for Means			
	CCR	*BCC*	*Throughput*
Mean	64.88	77.15	8609.56
Variance	797.34	591.28	49932873.16
Observations	72	72	72
Pearson Correlation	0.613	0.622	
Hypothesized Mean Difference	0	0	
df	71	71	
t Stat	-10.2856	-10.2677	
P(T<=t) one-tail	5.1988E-16	5.6019E-16	
t Critical one-tail	1.6666	1.6666	
P(T<=t) two-tail	1.0398E-15	1.1204E-15	
t Critical two-tail	1.9939	1.9939	

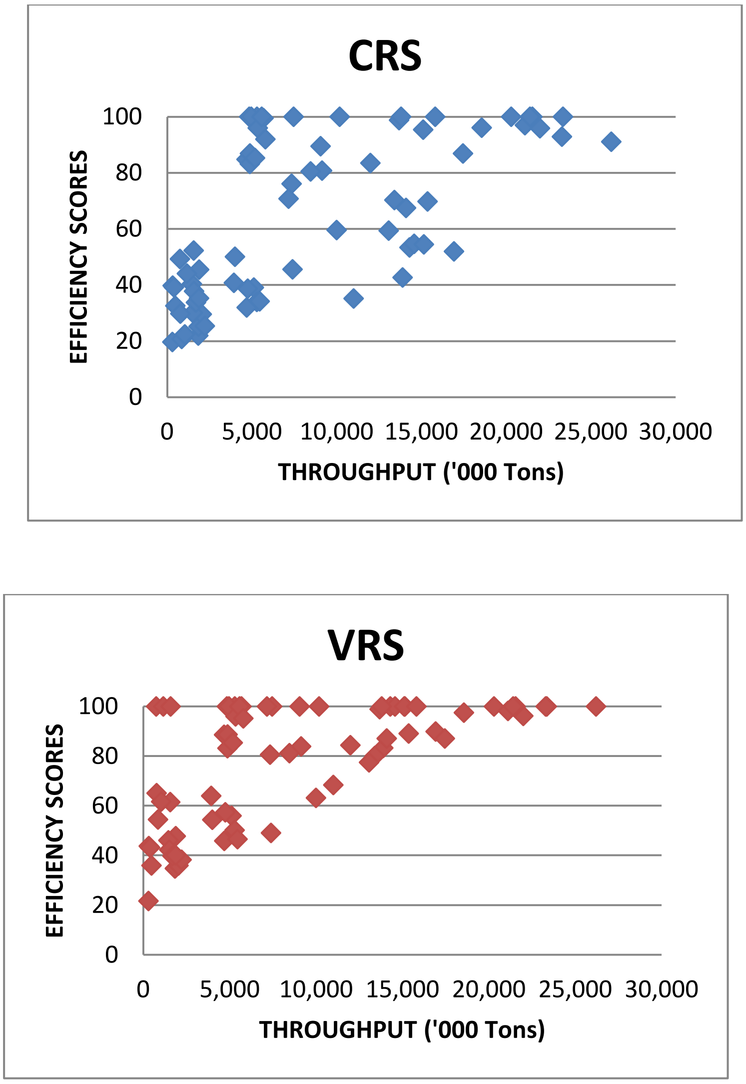


Figure 5.3: Relationships between Nigerian ports' overall and technical efficiency scores and production scale

Table 5.3: Intertemporal BCC efficiency of the ports and production scale

PORT SIZE (Tonnes)	**DEA SCORES**				
	DEA EFFICIENT DEA=100% N=24	GROUP 1 81-99% N=18	GROUP 2 61-80% N=9	GROUP 3 41-60% N=15	GROUP 4 21-40% N=6
CATEGORY 1 >10Million N=27	Apapa 2002-2004, 2006, 2008 & 2011, Onne 2002, 2005-2008, 2010-2011	Apapa 2001, 2005, 2007, 2009 & 2010, Onne 2003, 2004 & 2009, TCIP 2009 & 2011	Apapa 2000, TCIP 2007, 2008 & 2010		
CATEGORY 2 <10Million>5Millo N=16	PH 2001, 2002, 2006 & 2011, Onne 2000 & 2001	PH 2005, 2009 & 2010, Warri 2010 & 2011	Warri 2009	TCIP 2001, 2003, 2005 & 2006	
CATEGORY 3 <5Million>2Million N=11	PH 2003 & 2004	PH 2000, 2007 & 2008	TCIP 2000	TCIP 2002 & 2004, Warri 2008	Warri 2002 & 2005.
CATEGORY 4 2Million>300,000 N=18	Calabar 2004, 2008 & 2010		Warri 2004, Calabar 2006 & 2007	Calabar 2001, 2002 & 2005, Warri 2000, 2001, 2003, 2006 & 2007	Calabar 2000, 2003, 2009 & 2011

Furthermore, to increase the discriminatory power of the DEA in the intertemporal analysis, each port operation in a particular year was regarded as a DMU in each of the operating years. To differentiate the yearly operations as unique ports, the year of operation is attached to the port name. In other words, Apapa 2003 means the operations of the Apapa port in 2003 which is regarded as a separate DMU (port) from the Apapa port operations in say 2010, which is equally another port defined as Apapa 2010. Therefore, the yearly operations of the six Nigerian seaports for 12years (2000-2011), gave rise to the 72 datasets (DMUs) used for this analysis.

A cross tabulation of the yearly efficiency of ports (DMUs) in relation to production scale was constructed in Table 5.3, based on production scales (throughput volumes). The ports were classified into 4 categories and placed under 5 groupings (DEA efficient, group1, group2, group3 and group4) according to their BCC efficiency scores. Generally, the expectation would be for small ports (Category 4 DMUs) to be in the inefficient group. However, the Table indicated that some small ports are performing efficiently for example Calabar 2004, Calabar 2008 and Calabar 2010. Table 5.3 shows that 25 out of the 27 DMUs that are in category 1 (i.e. ports with the largest production scales) fall into high efficiency groups (DEA efficient and Groups1-2). The DMUs where their operations are considered the least efficient in category1 are: Apapa 2000 and TCIP 2007. On the other hand, 11 out of the 18 DMUs in category 4 (ports with the smallest production scales) are classified under the inefficient groups that is groups 3 & 4. However, 3 of the port-years under this group are fully efficient and also, 4 port-years in category 4, operate within the high efficiency realm of 61-80%.

Again, from the analysis of the 72 port-years, 24 port-years have a technical efficiency score of 100% are categorised as DEA efficient: Apapa (2002, 2003, 2004, 2006, 2008 & 2011), Onne (2000, 2001, 2002, 2005, 2006, 2007, 2008, 2010 & 2011), PH (2001, 2002, 2003, 2004, 2006 & 2011), and Calabar (2004, 2008 & 2010). However, only 12 port-year operations are considered overall efficient that is operating at optimal level based on available data (Figure 5.2). The three ports Onne, PH and Apapa which accounted for the most efficient operations, are the biggest ports in Nigeria. The Apapa port is the oldest port in Nigeria and is located in the heart of Lagos, the commercial nerve centre of Nigeria and

Africa's second most populous city after Cairo, the capital of Egypt. Additionally, the biggest container terminal (the Apapa container terminal, now named AP Moller terminals) in Sub-Saharan Africa is situated in the Apapa port. Despite these, the port recorded an overall operational efficiency in 2008 & 2011 after concession. It could be that the takeover of the terminals by the private operators brought some relief to the notorious problem of the Apapa port's congestion. Though, evidenced by a reduction in the congestion surcharge two years into the concession, the problem is creeping back (AfDB, 2010; Oghojafor et al., 2012). Onne has an advantage of having started operations from inception as a Landlord terminal and has deep berths, with high draughts, at the federal ocean terminal, which can accommodate larger ships. The port is being packaged as a hub port for West and Central Africa because of the oil and gas services it renders to Angola and Sao Tome and Principe. As a result of the ripple effects from the oil and gas sector, Port Harcourt has emerged as the second commercial centre in Nigeria after Lagos. So, the ports of PH and Onne are being positioned to service the Port Harcourt area and other commercial cities in the eastern zone, such as Aba, Onitsha, Nnewi and Enugu. Therefore, it could be deduced that the most efficient ports in Nigeria are those that support commercial hinterlands. On the other hand, the years that the PH port operated efficiently overall (both technical and scale) were during the pre-concession period. It indicates that the concession of the ports may not be a panacea for all the problems faced by the nation's ports. The operations of some ports should have been left in the public domain, or other methods of incorporating private sector ideologies (corporatisation or commercialisation) could have been explored in such cases.

The ports in group1 are those with BCC efficiency scores of between 81-99%. In the DEA frontier analyst version 4 developed by Banxia Frontier Analyst User Guide (2012), 100% is considered efficient for DMUs in the data set. Therefore, any DMU in the sample with an efficiency of less than 100% is regarded as relatively inefficient in comparison to the other units in the sample. Hence, the inefficient ports should improve their throughput, or reduce their input mix for a given throughput, in accordance with their reference efficient peers in the sample, in order to operate efficiently. For instance, Apapa2000 port with a DEA score of 68.4% in order to operate closer to the frontier of its efficient peer group (Apapa 2002, Apapa 2011, Onne 2006 and PH 2004), should reduce the input variables: the number of equipment by 47.04%, the number of staff by 16.76%, increase the throughput by 46.24% and improve turnaround time by the same margin (Appendix 5.5).

Although it is observable that the 18 ports in group1 are not entirely efficient, but they are however, operating at a higher efficiency level than ports in groups 2-4. The port-years in group1 are ports with large production scales and commercial hinterlands. Apapa (2001, 2005, 2007, 2009 and 2010), Onne (2003, 2004 and 2009), PH (2000, 2002, 2005, 2008, 2009 and 2010), TCIP (2009 and 2011) and Warri (2010 and 2011). It is worthy of note that some medium sized ports; TCIP and Warri have some of their operations after the concession classified in this group which shows some improvement towards efficiency after the concession.

Port-years with efficiency scores of 61-80% are classified under group2, indicating a moderately (medium-high) high level of productive efficiency. Port-years in this category should increase their efficiency by 20-39% in order to operate on the frontier of their efficient counterparts. This group includes port-years with low levels of production scale, for example Warri 2004 and Calabar 2006 and 2007. The other port-years in the group are: Apapa 2000, TCIP 2000, 2007, 2008 and 2010 and Warri 2009. These periods fall under post-concession, except TCIP 2000. Despite that, some of the years have low throughput levels and their efficiency is above average. It shows the efficiency level is attributable to technical rather than scale and that could mean that the private terminal operators have brought their expertise to bear on the operations.

The third group includes port-years with DEA scores of 41-60%. In comparison to other port-years in the sample, they are considered to be operating at medium to low efficiency levels. Thus for port-years in this group to catch up with best practice among their contemporaries, they need to increase their output levels by 40-59%, while maintaining the current input levels. Examples of port-years in this group are: TCIP 2001, 2002, 2003, 2004, 2005 and 2006, Warri 2000, 2001, 2003, 2006, 2007 and 2008 and Calabar 2001 and 2002. As observed earlier, a port’s efficiency improvement over time may be due to technological progress and acquiring better managerial skills. It is interesting to note that most of the ports in group3 are pre-concession operations except Warri port with its 3 years post-concession operations included that group. Although the amnesty has been introduced which has improved security situation in the Niger Delta during the period under study, most shipping lines that patronise Warri ports are still sceptical and have not returned for operation.

Lastly, port-years with very low efficiency scores of 21-40% are classified under group4. Therefore, for port-years in this group to compete with their efficient counterparts, they need to improve their efficiency by 60-79%. Most of the port-years in this category are small ports and pre-concession operations. They are ports located in remote and non-commercial hinterlands. The Calabar port's post-concession operations in 2009 and 2011 found in this group and show the problem that the port is having in improving efficiency, even with private participation in port operations. The port-years in this group are Warri 2002 and 2005 and Calabar 2000, 2003, 2009 and 2011. It may not be surprising that the Calabar port operations after concession (2009 & 2011) appeared in this group. Despite being strategically located to provide services for the Calabar export processing zone (EPZ) and North-east geo-political zone, its low draught coupled with the problem of the Ikom Bridge prevents bigger ships from accessing the port. The Ikom bridge is located in the central corridor to the port. It is a covered bridge with low overhead clearance, which prevents heavy goods vehicles (HGVs) and container carrying vehicles from accessing the port from the north-east corridor. The concessionaires during the interview observed that the government, through the NPA, has yet to fulfill its part of the concession contract. The dredging of the Calabar port as at 2011 and the reconstruction of the Ikom Bridge, have yet to happen even six years into the concession. Although the Calabar port has been concessioned, it has not overcome the problem of low utilisation. As a result, the over two hundred plus industries in the Calabar EPZ and the Tinapa business resort use the Onne and PH ports to import and export trade.

5.2.2 Contemporaneous analysis

Contemporaneous analysis involves constructing reference observation subsets at each point in time, with all the observations made at that point in time. Each reference observation subset for that point in time can be represented thus:

$$\left\{\left(x_k^t, y_k^t\right)/k = 1,2,----K\right\}$$ **Equation 5.1**

For $t = 1,2,----T$

Over the whole period covered by the analysis, in this study 12 years, a sequence of T reference observation subsets are constructed, in such a way that there exists one for each period t. Thus, the efficiency of each port in the sample is analysed against only 6 observations (number of ports in our study), for each of the 12 years covered by the analysis. The probability of having higher efficiency scores is greater with small samples (Cullinane, 2010) and the means of each port's 12 years individual efficiency scores will be relatively high.

Hence the relationship between intertemporal, contemporaneous and window analyses depends on the treatment of time. In intertemporal analysis the window width $w = T$ (12 years in this study), there are 72 observations (12 annual observations per port for 6 ports) and the efficiency is computed relative to each other. The individual efficiency estimates derived for each port in each year will obviously average out to a lower value than when the window width is smaller. The result obtained from the contemporaneous analysis assuming both the CCR and BCC models, is presented in Tables 5.4 and 5.5 respectively.

Table 5.4: Contemporaneous analysis: CCR efficiency scores

PORTS	YEARLY CCR EFFICIENCY SCORES IN PERCENTAGES (100= 'EFFICIENT')												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	MEAN	STDEV
APAPA	72.7	72.1	72.8	74.5	72.6	60.5	99.9	100	100	100	100	100	85.4	15.6
CALABAR	58.6	100	92.6	61.5	70.1	29.2	38.3	37.9	100	73.4	100	100	71.8	26.9
ONNE	100	100	100	100	100	100	100	100	100	100	100	100	100	0
PH	100	100	100	100	100	100	100	100	100	100	100	100	100	0
TCIP	69.1	55.9	50.2	42.6	37	41.5	52.1	79.9	100	100	92.9	97.7	68.2	24.7
WARRI	56.2	54.5	45.7	50.3	97.3	45.5	53.7	47	68	100	100	100	68.2	23.8
MEAN	76.1	80.4	76.9	71.5	79.5	62.8	74.0	77.5	94.7	95.6	98.8	99.6	82.3	22.9
STDEV	19.5	22.3	24.6	24.6	24.9	30.5	28.9	28.4	13.1	10.9	2.9	0.9		
MIN	56.2	54.5	45.7	42.6	37	29.2	38.3	37.9	68	73.4	92.9	97.7		
MAX	100	100	100	100	100	100	100	100	100	100	100	100		

Table 5.5: Contemporaneous analysis: BCC efficiency scores

PORTS	YEARLY BCC EFFICIENCY SCORES IN PERCENTAGES (100= 'EFFICIENT')												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	MEAN	STDEV
APAPA	100	100	100	100	100	100	100	100	100	100	100	100	100	0
CALABAR	100	100	100	100	100	100	100	100	100	100	100	100	100	0
ONNE	100	100	100	100	100	100	100	100	100	100	100	100	100	0
PH	100	100	100	100	100	100	100	100	100	100	100	100	100	0
TCIP	100	78	65.1	53.5	47.7	54.9	57	87	100	100	96	100	78.3	21.3
WARRI	56.8	100	45.9	51.5	100	46.1	58.3	60	70	100	100	100	74.1	23.8
MEAN	92.8	96.3	85.2	84.2	91.3	83.5	85.9	91.2	95	100	99.3	100	92.1	17.0
STDEV	17.6	9.0	23.8	24.5	21.4	25.7	21.9	16.1	12.2	0	1.6	0		
MIN	56.8	78	45.9	51.5	47.7	46.1	57	60	70	100	96	100		
MAX	100	100	100	100	100	100	100	100	100	100	100	100		

Tables 5.4 & 5.5 shows the efficiency index computed from the CCR and BCC models respectively, for the contemporaneous analysis. However, as previously explained, the discussion is based on the BCC model. There are little differences in the efficiency scores obtained from the two models, although the difference is significant for some of the ports. For instance, Apapa and Calabar that are efficient in the BCC model are inefficient in the CCR model. It could be said that the efficiency of the two ports (Apapa and Calabar) are strongly influenced by port production scale, as they are subjected to increasing and decreasing returns to scale respectively.

Table 5.6: Relationship between contemporaneous efficiency scores and port size

t-Test: Two-Sample Assuming Unequal Variances			
	AVECRS	*AVEVRS*	*AVETHROUGHPUT*
Mean	82.283	92.058	8609.556
Variance	142.732	38.823	8315505.618
Pearson Correlation	0.819	0.666	
Observations	12	12	12
Hypothesized Mean Difference	0	0	
df	11	11	
t Stat	-10.244	-10.232	
P(T<=t) one-tail	2.90479E-07	2.93823E-07	
t Critical one-tail	1.796	1.796	
P(T<=t) two-tail	5.80957E-07	5.87646E-07	
t Critical two-tail	2.2010	2.2010	

The impact of production size was re-assessed using the efficiency scores from the contemporaneous analysis, considering the observed drawbacks of the inter-temporary analysis. A t-test of the contemporaneous efficiency scores obtained from the CCR and BCC approaches and throughput, was carried out. This is was done in order to ascertain whether a worthwhile relationship actually does exist between port size and efficiency for the period covered by this study. For both the BCC and CCR there is a very high correlation between the DEA efficiency scores and throughput (that is the determinant of port size). Table 5.6 indicates a high and positive correlation of 0.8194 and 0.6658. It is significant at the 5% confidence interval for the efficiency scores obtained from both the CCR & BCC respectively and for port size (measured in throughput values). Additionally at the 5% confidence level, the absolute values of the t-statistics are much greater than the t-critical values for both one-tailed (1.7959) and two-tailed tests (2.2010).

The implication of this is that for the period under review and whether economies of scale are considered or not, the larger ports are more likely to obtain higher efficiency scores from the DEA analysis than the smaller ports. The analysis further gave credence to the results obtained from the investigation of the relationship between the DEA efficiency scores and port size, from the intertemporal analysis. Therefore, the relationship that exists between the time and port efficiency is not a bogus one. As the contemporaneous analysis connotes a cross-sectional observation, it shows the relative efficiency scores of the six ports in each of the years under study.

In the contemporaneous analysis, each port is compared to 6 other counterparts and the frontier is defined by the ports in the same set. Due to the small number of DMUs that are involved in the contemporaneous analysis, only 6 DMUs, while it is 72 DMUs and 180 DMUs for the inter-temporal and window analysis respectively, it indicated more efficient ports. For instance, under the contemporaneous analysis, 4 out of the 6 ports operated at 100% efficiency for the 12 years under review, compared to none in the inter-temporal and window analyses. Table 5.5 shows a significant variation in the efficiency of the TCIP and Warri over the period, as indicated by the high standard deviations of 21.3 and 23.8 for the two inefficient ports respectively. From a cursory look at the trend of efficiency for the two inefficient ports (TCIP and Warri) in table 5.5; one may infer that the there is significant variation in efficiency of the two ports over time. It is equally interesting to note that the eastern ports (PH, Onne and Calabar) are performing more efficiently than the Lagos ports (Apapa and TCIP) and the Delta port (Warri). As explained previously, the broad variation in efficiency of the Warri port may be attributable to the unpredictable security situation in the Niger Delta region, which scared away shippers from using the port.

5.2.3 DEA window analysis

The DEA window analysis was carried out, assuming three years window width for the six ports for a 12-year period, which gives 180 DMUs for the sample used for the window analysis. The window analysis identifies the ports that have performed in relation to the other ports used in this research, as well as the most stable and variable ports in terms of the DEA scores. The overall efficiency of each port is evaluated by assuming variable returns to scale and by applying the DEA analysis methodology. The efficiency scores reported above are from the intertemporal analysis using panel data, where the observations for six Nigerian ports in different years are treated as separate observations and measured against each other. This assumption may not be rational. Considering the changes in technology, regulation, economic conditions or competitive situations that may have occurred during the 12-year period under analysis, these may render the comparisons of ports in different years unfair and unrealistic.

In order to evade the problem of unfairness when comparing observations from different time periods, a contemporaneous analysis would have been ideal, including observations from one time period. It is not applicable to our case, due to the small number of DMUs used in the study. The alternative would have been to use sequential analysis that includes previous observations and assume that what was feasible in the past remains feasible. This method leads to the same problem encountered in the intertemporal analysis, especially in the tail end of the study period, where observations are compared to other observations far away in time. In addition, the Nigerian port industry witnessed massive reform in 2006; therefore what was feasible in the past may not be feasible any more.

The result of the window analysis, employing both the BCC and CCR models are shown in Appendix 5.7 and 5.8 respectively, while the yearly mean efficiencies obtained for the two models are in Tables 5.7 & 5.8. There are no remarkable differences in the overall efficiency ranking of the ports. Nevertheless, some ports exhibited some differences in the efficiency for the period. For example, Calabar and Onne with average efficiency scores of 70.8% and 81% under the CRS assumption, had their mean efficiency scores improved to 91.8% and 99% respectively when the VRS model was applied. The port-years Apapa 2003, 2004 and 2005 and Calabar 2004, which operated at a very low efficiency level under the CCR model, are classified as efficient under the BCC assumption. The reason for this is not far-fetched, as the efficiency of these ports is strongly influenced by production scales, because they are still exposed to increasing or decreasing returns to scale. The efficiency scores for the ports under study, obtained from the window analysis, exhibited a similar pattern to those obtained from the intertemporal and contemporaneous analyses. Again the TCIP and Warri showed high fluctuations, as indicated by high standard deviations.

Table 5.7: Window analysis: CCR yearly mean efficiency scores

PORT	YEARLY EFFICIENCY SCORES (100="EFFICIENT")												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	MEAN	STDEV
APAPA	53.2	63.6	64.2	64.0	59.9	71.4	98.9	98.6	100	100	98.2	100	81.0	19.5
CALABAR	47.3	87.7	77.2	56.5	59.4	39.9	72.1	61.6	100	76.1	94.4	82.8	71.3	18.7
ONNE	73.1	95.8	100	92.9	99.5	100	100	100	100	96.1	100	100	96.4	7.7
PH	85.8	100	100	100	100	100	100	88.7	97.8	100	100	100	97.7	5.0
TCIP	55.8	53.8	45.4	37.6	34.9	55.7	54.8	72.4	92.1	97.2	87.6	97.7	65.4	23.0
WARRI	45.3	41.7	40.8	49.3	63.0	33.2	49.0	37.1	61.6	95.8	97.8	100	59.5	24.7
MEAN	60.1	73.7	71.3	66.7	69.5	66.7	79.1	76.4	91.9	94.2	96.3	96.8	78.6	22.8
STDEV	16.0	24.1	25.8	24.7	25.5	29.0	23.7	24.4	15.2	9.1	4.8	6.9		

Table 5.8: Window analysis: BCC yearly mean efficiency scores

PORT	YEARLY EFFICIENCY SCORES (100="EFFICIENT")												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	MEAN	STDEV
APAPA	78.1	98.35	100	100	100	100	100	98.9	100	100	98.8	100	97.8	6.2
CALABAR	66.6	100	100	91.1	100	86.3	88.3	96.5	100	70.5	100	89	90.7	11.6
ONNE	100	100	100	100	96.4	100	100	100	100	100	100	100	99.7	1.0
PH	88.6	100	100	100	100	100	100	91.6	100	100	100	100	98.4	3.9
TCIP	74.1	62.7	60.2	51.9	47.5	52.0	54.0	70.9	94	97.5	89.6	100	71.2	19.5
WARRI	45.4	42.1	41.4	49.9	74.3	43.2	53.9	51.9	65.6	96.2	99.7	100	63.6	23.2
MEAN	75.5	83.9	83.6	82.1	86.4	80.2	82.7	85.0	93.3	94.0	98.0	98.2	86.9	19.4
STDEV	18.8	25.2	26.1	24.5	21.5	26.0	22.7	19.4	13.8	11.6	4.1	4.5		

Using the window analysis, the influence of port size on port efficiency is re-assessed in considering our earlier discussion on the shortcomings of the intertemporal analysis. To test if there is actually a relationship between the port size and port efficiency for the twelve-year period, the column mean from the window analysis is used. Thus, once the window is defined, the observations within that window are viewed in an intertemporal fashion, and the analysis of that window is assumed as locally intertemporal (Tulkens & Vanden Eeckaut, 1995). Therefore, the column means represent the performance of the units in a particular year.

Table 5.9: Relationship between the DEA's window efficiency scores and port size

t-Test: Paired Two Sample for Means			
	BCC	*CCR*	*Throughput*
Mean	86.904	80.385	8609.5557
Variance	377.567	449.589	49932873.16
Observations	72	72	72
Pearson Correlation	0.4646	0.4702	
Hypothesized Mean Difference	0	0	
df	71	71	
t Stat	-10.2471	-10.2563	
P(T<=t) one-tail	6.1E-16	5.87465E-16	
t Critical one-tail	1.6666	1.6666	
P(T<=t) two-tail	1.22E-15	1.17493E-15	
t Critical two-tail	1.9939	1.9939	

The correlation between the CCR and BCC efficiency scores and port size is 0.465 and 0.470 respectively, which is positive and significant at 5 percent confidence level. In Table 5.9, the absolute value of the t-statistics is much greater than the t-critical values for both the one-tail (1.667) and two-tail (1.994) tests. From the t-test values obtained from the CCR and BCC models, it could be suggested that no matter the DEA approach used, ports with large production scales obtain higher efficiency scores. In other words, they are more efficient than ports with smaller production scales. The results obtained from the DEA window analysis tend to confirm the relationship established between the DEA efficiency scores and port size with the intertemporal analysis, is not a false relationship between time and efficiency. Therefore, the results of the window analysis support the interpretation from the intertemporal analysis that rejected the null hypothesis. Hence, there is a relationship between port size and efficiency of port operations for the period under review. Bigger ports around the world are leaders in port technology developments and the strategies for port development and management (Cheon, 2007b).

Table 5.10: **Window analysis: BCC efficiency scores and production scales**

DEA Scores	**Efficient <............2000-2011ports............> Inefficient**			
Port size	DEA efficient=100% N=36	GROUP1 81-99% N=16	GROUP2 61-80% N=8	GROUP3 41-60% N=12
Category1 >10million tonnes N=27	Apapa (2002, 2003,2004,2005, 2006,2008,2009 & 2011) Onne(2002,2003, 2005,2006,2007, 2008,2009,2010 & 2011), TCIP 2011	Apapa (2001, 2007 & 2010), Onne 2004, TCIP (2008, 2009 & 2010)	Apapa 2000, TCIP 2007	
Category 2 <10million>5million tonnes N=16	Onne (2000 & 2001) PH (2001,2002,2005, 2006,2009,2010 & 2011), Warri 2011	Warri (2009& 2010)	TCIP 2001	TCIP 2003, 2005, 2006)
Category3 <5million>2million tonnes N=11	PH (2003,2004 & 2008)	PH (2000 & 2007)	TCIP 2000, Warri 2008	TCIP 2004, 2002) Warri (2002, 2005)
Category4 <2million>300,000 tonnes N=18	Calabar (2001, 2002, 2004, 2008 & 2010)	Calabar (2003, 2005, 2006, 2007, 2011)	Calabar (2000 & 2009) Warri 2004	Warri (2000, 2001, 2003, 2006 & 2007)

Table 5.10 represents the DEA efficient ports and three other groups based on the efficiency scores derived from the window analysis using the VRS approach. The production scales are classified into four categories based on the throughput values. Out of the 72 port-years employed in the analysis for the period 2000-2011, 36 are regarded as DEA efficient and 18

of which are in category1 i.e. ports with high production scale. It may not be surprising as the efficiency of ports improves with port size. It is worthy to note that some of the small ports such as Calabar 2001, 2002, 2004, 2008 and 2010, are under the DEA efficient group, despite their scale of operation. It signifies that small ports could operate efficiently, if managed strategically.

The port-years in group1 are ports with efficiency scores of 81-99%, although they may not be operating wholly efficiently as efficient ports, but they operate at a higher efficiency level than the other two groups. For instance, Apapa 2007 and Onne 2004 with average window VRS efficiency scores of 98.9% and 96.4%, require only 1.1% and 3.6% to be at the frontier of their efficient counterparts. The group includes both ports of high and low production scales. It implies that small ports such as PH 2000 & 2007 and Calabar in 2003, 2005, 2006, 2007 & 2011, are in Category 3 & 4, the class of low production scale. It shows that these small ports are strategically managed. The ports in group2 are ports with medium to high efficiency scores of 61-80%. There are only two category1 ports in Group 2, Apapa 2000 and TCIP 2007 and one category2 port TCIP 2001, in this group also indicating that the ports in the group also operate mostly in the region of medium to low production scales. Group3 comprises of ports with low to medium efficiency scores of 41-60%. There is no category1 port in this group, which still buttresses our argument that port size influences efficiency. The ports in this group are mainly the inefficient ports, such as the TCIP in 2003, 2005 &2006. Although, in category 2, the region of high production scales are not strategically managed compared to their efficient peers (Apapa 2008 and PH 2004). For the ports in this group, to operate on the frontier closest to their efficient contemporaries they need to improve their efficiency by 59-40%. It is impressive to observe that there is no group4 in the VRS window analysis, because all the ports have improved their efficiency scores compared to the scores they obtained under the intertemporal analysis. The window analysis increases the discriminatory power of the DEA.

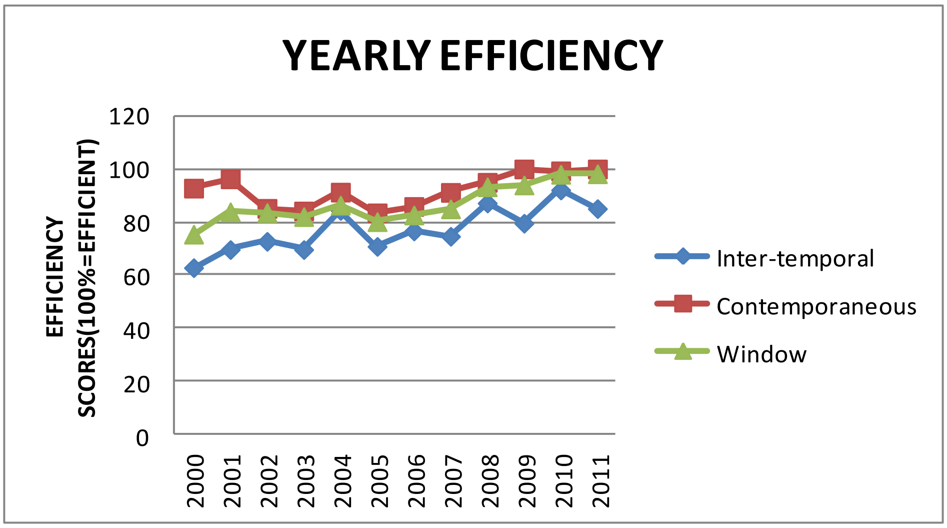
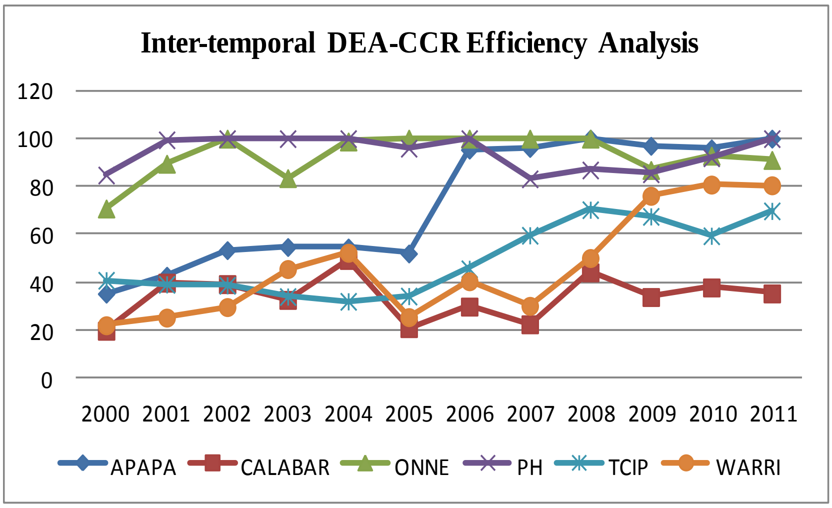


Figure 5.4: Yearly Average Efficiency of Nigerian Ports

Figure 5.4 shows the yearly efficiency scores of Nigerian ports obtained from the three methods; the intertemporal, contemporaneous and window analyses. In terms of trends, it could be observed from Figure 5.4 that all ports show fluctuations in efficiency scores for the period under review. However, the fluctuations are highest with the intertemporal analysis; mean standard deviations of 20.49, 19.4 and 17.0 for intertemporal, window and contemporaneous respectively. In the intertemporal analysis, the DMUs exhibited fluctuations throughout the period compared to the window and contemporaneous analyses, which showed reasonable variations up to 2005 and from 2006, exhibited a gradual but steady increase till the end of the period. The wide variation in efficiency experienced in the intertemporal analysis could be attributable to the inconsistency in adopting technological innovation and best managerial practice, which drives productivity and efficiency improvements in the long run. In other words, there is no plan laid down for investment in infrastructure, and the adoption and deployment of technological and managerial expertise. The lower fluctuation in efficiency scores observed in the contemporaneous and window analyses can be explained by assuming that within the short periods of 3 & 1 years, the DMUs are more inclined to be deploying the same or similar technology and management. The implication is that the efficiency scores obtained during this relatively small period may not be substantially influenced by technology and managerial changes.

In addition, Figure 5.4 shows that the efficiency scores obtained from the window and contemporaneous analyses are higher than the efficiencies obtained from the intertemporal analysis. In fact, the highest efficiency scores are recorded for the contemporaneous analysis. It may not be surprising, as conceptually for the contemporaneous analysis each port is compared with six other counterparts and that defines the frontier for all the ports in that set. While for the intertemporal and window analyses, each port is compared with 72 port-years and 180 port-years respectively.

To further investigate the fluctuation of the efficiencies over time, the relationship between the efficiency scores and the standard deviations was examined. The result indicated a high but negative correlation of -0.857, -0.959 and -0.859 for intertemporal, contemporaneous and window analyses respectively. It shows that the efficiency of all the ports in our observation set, both efficient and non-efficient, exhibit similar levels of fluctuations over time.



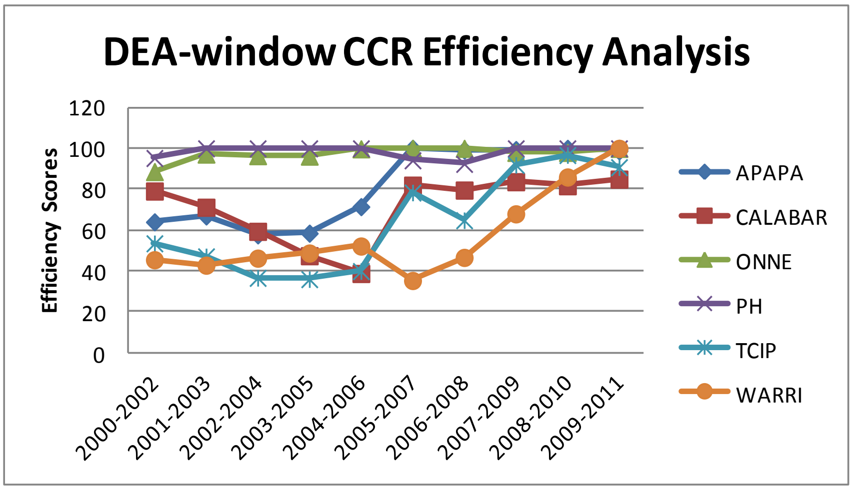


Figure 5.5: Efficiency trends of Nigerian seaports

Overall for the period under review, the most efficient port is the Onne port followed closely by the Port Harcourt port and the inefficient ports are the Calabar and Warri, which are the smallest in terms of size.

5.3 Pre- and Post-concession Efficiency of Nigerian seaports

5.3.1 Pre-concession analysis

The objective of this section is to establish any patterns or trends in the performance of the ports, six years before and six years after concession. Though six year intervals may be considered too short for establishing trends. Nevertheless, it could give an indication of the efficiency levels attained by the ports prior to privatisation and whether the ports are on the path of efficiency as envisaged by the concession programme. The analysis applied both the DEA-CCR and BCC models, assuming output orientation for a panel data comprising of a sample size of 36 port-year operations (6 years of operation of 6 ports). Therefore, pre- and post- Nigerian seaport efficiency was examined using intertemporal analysis; the study compared the operations of the ports for six years before (2000-2005) and six years after (2006-2011), concession. The results of the pure technical efficiency scores estimated for the two-time horizons; before and after concession are presented in Tables 5.11 and 5.12. While the outcome of the overall analysis, pure technical and scale efficiency scores, plus returns to scale, are shown in Appendix 5.9 and 5.10.

Table 5.11: Pre-concession period: pure technical (DEA-BCC) efficiency scores

PORTS	2000	2001	2002	2003	2004	2005	MEAN	STDEV
APAPA	72.6	90.4	100	100	100	100	93.8	11.1
CALABAR	48.4	100	100	82.5	100	100	88.5	20.8
ONNE	100	100	100	88.7	99.2	100	98.0	4.6
PH	88.6	100	100	100	100	100	98.1	4.7
TCIP	64	57.2	57.4	51.3	47.4	51.5	54.8	5.9
WARRI	34.8	34.9	36.9	49.1	61.5	44.7	43.7	10.5
MEAN	68.1	80.4	82.4	78.6	84.7	82.7	79.5	24.1
STDEV	24.4	27.8	28.1	23.0	23.8	26.9		
MIN	34.8	34.9	36.9	49.1	47.4	44.7		
MAX	100	100	100	100	100	100		

Table 5.11 shows for the period under evaluation, that there is no year that all the ports operated efficiently overall, but the mean efficiency for each year is above average. The most efficient year is 2004, with an average efficiency of 84.7%, followed by 2005 with mean efficiency of 82.7%. It is trailed closely by 2002 with a mean efficiency of 82.4. The year with the least efficient operation is 2000, with an average of 68.1%.

The average technical efficiency score for the pre-concession period is 79.5%. The most technically efficient operation for the period is the PH port with a mean efficiency score of 98.1%, followed closely by the Onne port with 98%. The least efficient port operations for the period is recorded in the Warri port with below average efficiency of 44.7%, followed by the TCIP with an average of 69.3%.

Figure 5.6 shows the yearly efficiency trend in pure technical and scales efficiencies for the pre-concession period, while Figures 5.7 & 5.8 indicate an individual port's pure technical and scale efficiency trends. Figure 5.6 shows that the mean scale and pure technical efficiency is almost equal (78.7 & 79.5 respectively). There is no year that all the ports operated at 100% efficiency both technically and in terms of scale. Therefore, the source of inefficiency of the ports can be attributed to both. However, as the mean pure technical efficiency is greater than scale efficiency, the primary source of inefficiency during the pre-concession period is scale. Scale efficiency gap occurs as a result of ports not operating at optimal levels. In other words, it could be said that the pre-concession Nigerian ports performance problem is due to underutilisation of available resources that means available input resources are not put to optimal use.

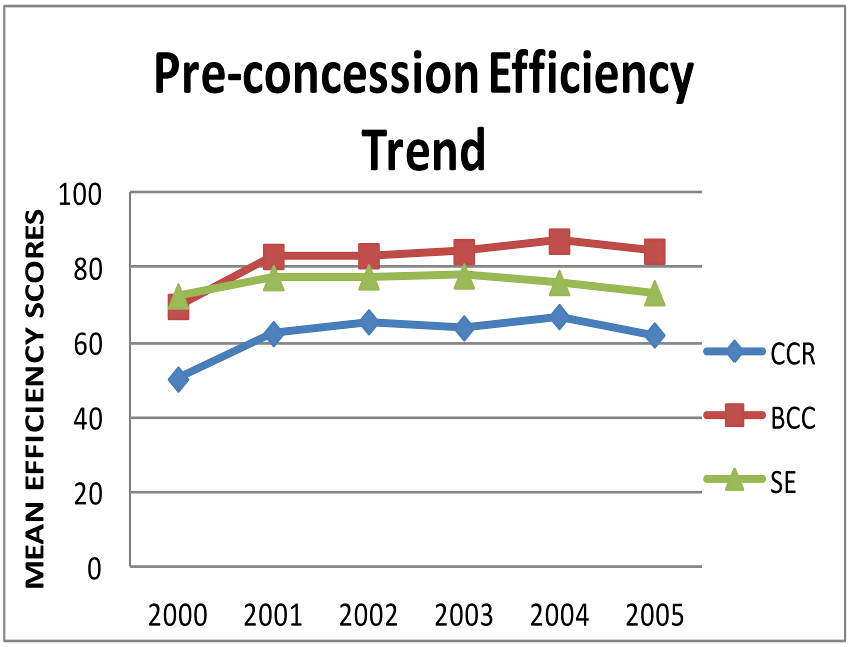


Figure 5.6: Pre-concession average yearly efficiency trends analysis

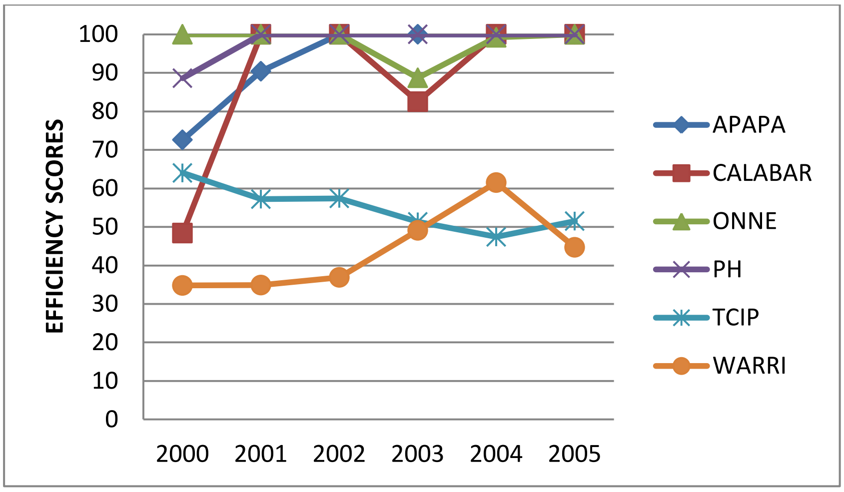


Figure 5.7: Pre-concession pure technical port efficiency (DEA-BCC model) trends

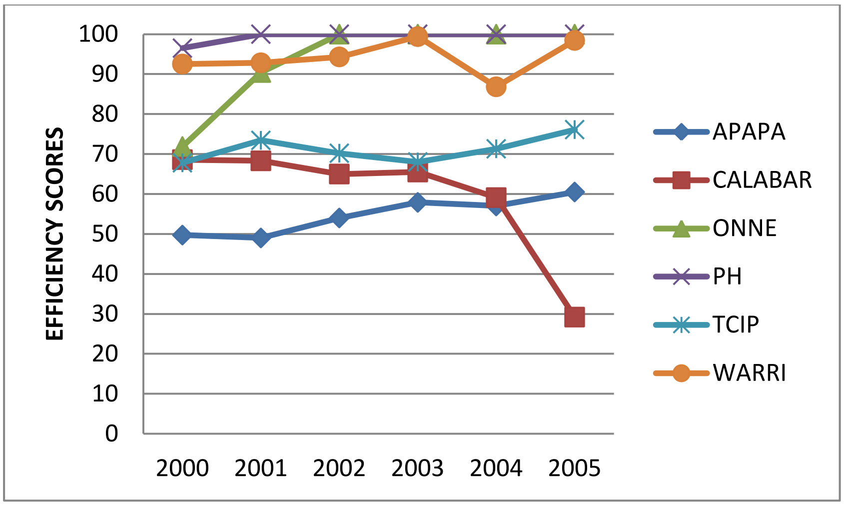


Figure 5.8: Pre-concession port scale efficiency trend

Figures, 5.7 and 5.8 show the pure technical and scale efficiencies' trends of the Nigerian seaports in the pre-concession period. Figures 5.7 and 5.8 reveal that the performance gaps observed in the ports of Calabar, Apapa and TCIP, during the pre-concession period are due to scale inefficiency. While the below average performance of the Warri port is more of a technical inefficiency rather than a scale inefficiency. The PH and Onne ports' performance level show the same trend in both. In other words, the ports exhibited the same performance in pure technical and scale efficiencies and therefore the efficiency gaps of the two ports in the pre-concession are attributable to both technical and scale inefficiencies.

The Apapa and TCIP ports operated under increasing returns to scale in the six years under review. While the Warri port operated in the first three years under increasing returns to scale, and in the other three years of the pre-concession exhibited decreasing returns to scale (Appendix 5.9). Only the Onne and PH ports achieved constant returns for 4 and 5 years out of the six years under investigation respectively. On the other hand, the Calabar port operations throughout the pre-concession period, depicts decreasing returns to scale. Likewise, the Onne and PH ports , that did not operate under constant returns to scale for 2 and 1 years out of the six years under investigation respectively (Appendix 5.9). Therefore, none of the ports achieved constant returns to scale overall during the study period. However, the Onne port operations in 2002 and 2005 and PH port operations from 2001-2005 are considered optimal, as they are operating under constant returns to scale (Appendix 5.9). The implication of the ports operating at increasing returns to scale would have been to increase their budgets, or expand their input capacity, so as to increase throughput levels and improve the vessel turnaround time. Conversely, for ports experiencing decreasing returns to scale, they needed to outsource part of their operations in order to achieve optimum production levels.

Finally, the mean technical efficiency (CCR score) of the ports for the pre-concession period is 62.0% (Appendix 5.9). The technical efficiency (TE) is broken down into pure technical efficiency (PTE), which is represented by the BCC score and scale efficiency (SE). The mean efficiency scores for TE and SE are 79.5% and 78.7% respectively. Judging from the average efficiencies, it could be inferred, as observed earlier that the overall inefficiencies experienced by Nigerian seaports during the pre-concession period are primarily as a result of scale inefficiencies, rather than pure technical inefficiencies. The high technical efficiency indicates that the cause of inefficiency is not poor management practices, but the inability to improve production scales given the available resources. The result further reveals that shippers were deserting the Nigerian ports due to congestion, poor service delivery and high cost of doing business (Leigland & Palsson, 2007; Oghojafor et al., 2012). For the ports that are operating under increasing returns to scale (IRS), increasing input levels should have improved their efficiency. While those operating under decreasing returns to scale require an increase in the output level or a reduction in the input level, as the inputs have been operated over optimal scales.

5.3.2 Post-concession analysis

The results obtained from the DEA-methodology for the post-concession period analysis is displayed in Table 5.12. They show that only 7 port-years obtained an overall efficiency estimate of 100%, but six port-year operations are considered optimally efficient (highlighted in green in Appendix 5.10). The operations of the Onne port in 2009 are weakly efficient, as it operates at decreasing returns to scale, indicating that the output produced given the available input resources is below optimal levels. The average overall efficiency for the period is 76.1%. The port with the highest overall efficiency is the Apapa port, which achieved a mean yearly score of 97.4%. It is closely followed by the Onne port with an average efficiency of 96.2% and the PH port with 94.7%. On the other hand, the least efficient port is, assuming the CCR model, Calabar, with a mean efficiency score of 36.3% (Appendix 5.10). The year that has the highest overall efficiency level is 2011, with an average score of 81.6%, then 2009 with 80.3%, while the lowest average efficiency of 65.1% is observed in 2007. There is no clear and identifiable pattern in the yearly efficiency trends of the six ports under observation. However, what is noticeable is a series of peaks and troughs which indicates high variation (Figure 5.10). Figure 5.10 show that the overall efficiency scores obtained by the Apapa, Onne and PH ports are almost maximum, as they require only 2.4 to 5.3% to be on the relative frontier of their most efficient counterpart.

Table 5.12: Post-concession period: pure technical efficiency scores (BCC model).

PORTS	2006	2007	2008	2009	2010	2011	MEAN	STDEV
APAPA	100	97.5	100	98.4	96.2	100	98.68	1.6
CALABAR	100	64.9	100	46	100	42.3	75.53	27.9
ONNE	100	100	100	100	100	100	100	0
PH	100	84.7	100	92.1	100	100	96.13	6.4
TCIP	49.1	64.3	81	88.7	78.1	89.6	75.13	15.7
WARRI	58.3	50	59.1	83.2	83.9	81.4	69.32	15.2
MEAN	84.6	76.9	90.0	84.7	93.0	85.55	85.8	
STDEV	24.1	20.2	16.9	20.0	9.6	22.5	13.89	

5.3.2.1 Technical efficiency of post-concession Nigerian ports

The empirical results in Table 5.12 show that the DEA-BCC yielded higher efficiency scores than the DEA-CCR model, as expected. The mean technical efficiency score for the period is 85.8%. Onne is the most technically efficient port; its efficiency value is 100% and although it obtained 100% for the six years under consideration, its operation in 2009 is considered weakly efficient. It operated under decreasing returns to scale for that year, which implies that the increase in outputs fell below those of inputs. It is followed by the Apapa and PH ports with DEA-BCC score of 98.68 and 96.13 percent respectively, while the least efficient is the Warri port that achieved a score of 69.32%. All the ports have high, but fluctuating efficiency scores, as depicted in Figure 5.10. The year with the highest mean DEA-BCC efficiency score of 93% is 2010, followed by 2008 and 2011 with 90% and 85.55 respectively, while the year with the lowest score of 76.9% is 2007. Despite the high average technical efficiency estimates, the result reveals that, except for Onne the other ports need to improve technical efficiency levels by between 1.3% and 30.7% in order to operate on the frontier. The direction of improvement depends on whether they are operating at increasing or decreasing returns to scale. Appendix 5.8 shows that 18 port-years operated at increasing returns to scale, the other (9) port-years each operated at decreasing and constant returns to scale.

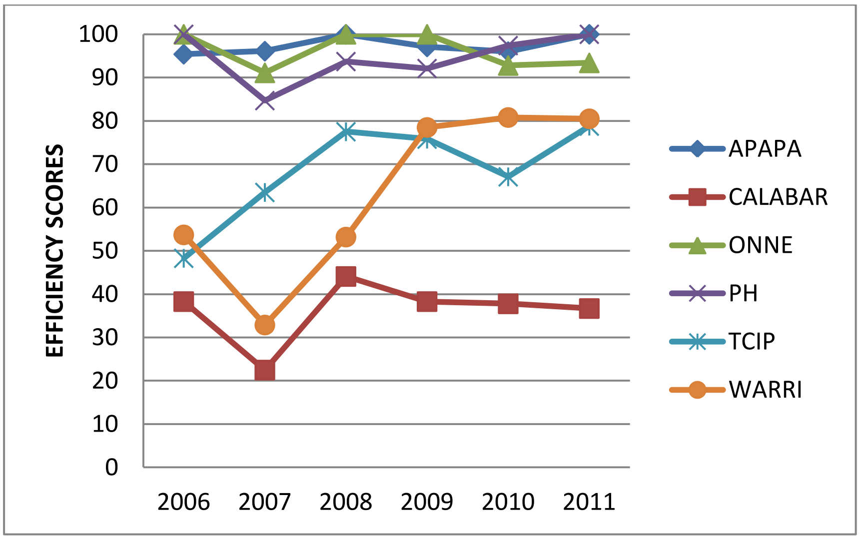


Figure 5.9: Post-concession overall (DEA-CCR) port efficiency trends

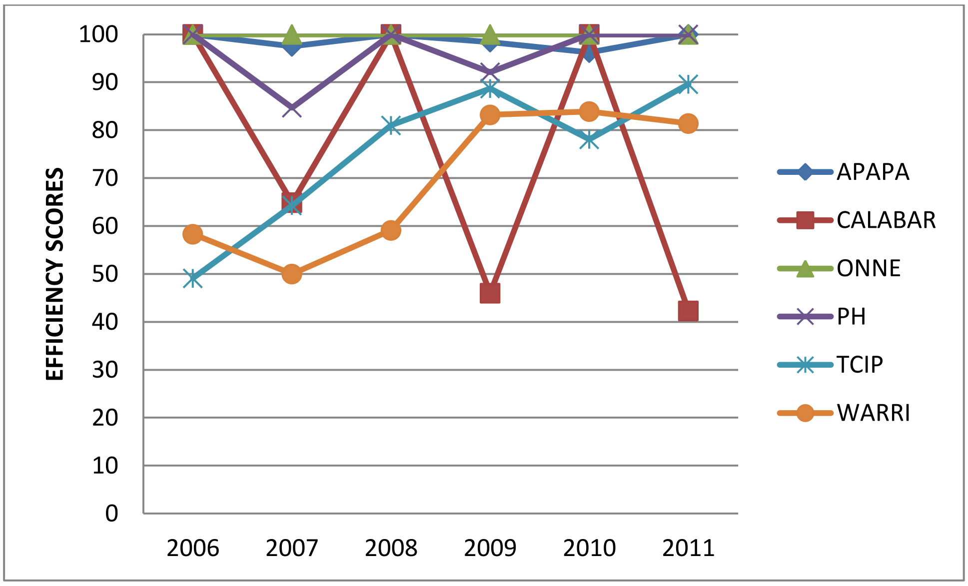


Figure 5.10: Post-concession port technical efficiency trends

5.3.2.2 Post-concession scale efficiency

The technical efficiency scores from the CCR model can be decomposed into pure technical efficiency (BCC) and scale efficiency (SE). Therefore, scale efficiency is the ratio of overall and technical efficiency. Applying this concept, this study determined the sources of inefficiency in post-concession Nigerian ports.

Figures 5.10 and 5.11 indicate a fluctuating trend for both technical and scale efficiencies for the post-concession period. However, the mean pure technical efficiency score (85.8%) for the period is slightly less than the scale efficiency score (88.2%). It could be said that the inefficiency experienced in post-concession Nigerian ports is more due to technical inefficiency than scale inefficiency. About the technical efficiency Figures 5.10 shows that post- concession Nigerian ports can produce the same level of outputs with 8-10% fewer inputs, without changing the current ratio of inputs. At least 50% of Nigerian ports, considering the six years of operation, need to reduce their input levels in order to be on the efficiency frontier (Appendix 5.10). It implies that actual throughput values are lower than target throughput and also that the turnaround time needs further improvement to meet the target values. The ports need to invest in schemes that could attract more shippers to the ports and also employ technology and skills that will improve the turnaround time of ships. The two options are related, as the reason for the low throughput may be that shippers are deserting the ports as a result of the high turnaround time of vessels.

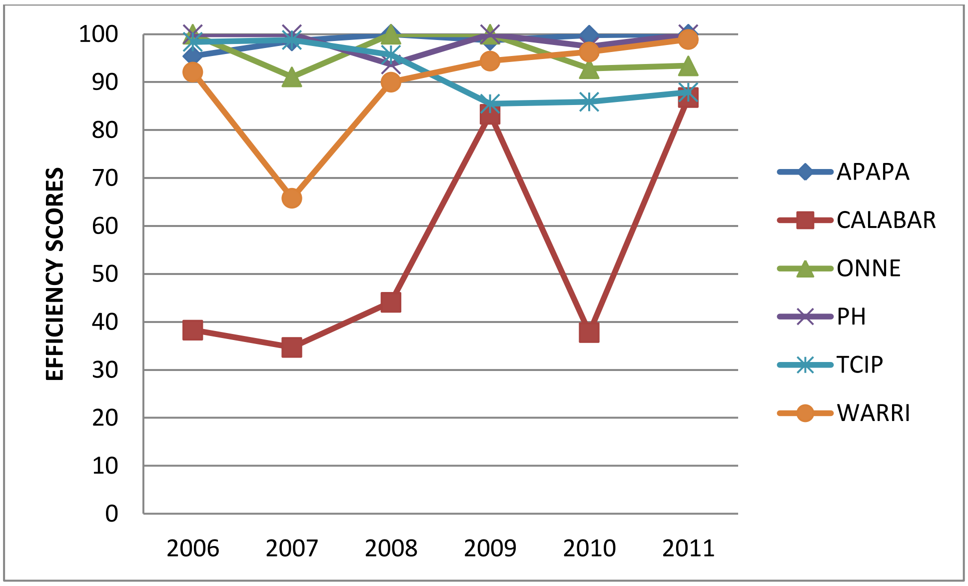


Figure 5.11: Post-concession port scale efficiency trends

This study examined the relationship between efficiency scores and their standard deviations, by evaluating the extent of the fluctuation in the efficiency of the ports over time. The correlation between the intertemporal BCC efficiency scores and their standard deviations for the post-concession period is -0.1064, indicating a very weak negative correlation. It implies that all the ports in our observation set, no matter their efficiency status, either highly or less efficient, exhibit a similar level of fluctuation over the period. The negative correlation could be interpreted as an indication of the truncation of the efficiency scores at unity (100%), rather than high efficiency being always accompanied by low variance (Cullinane & Wang, 2010).

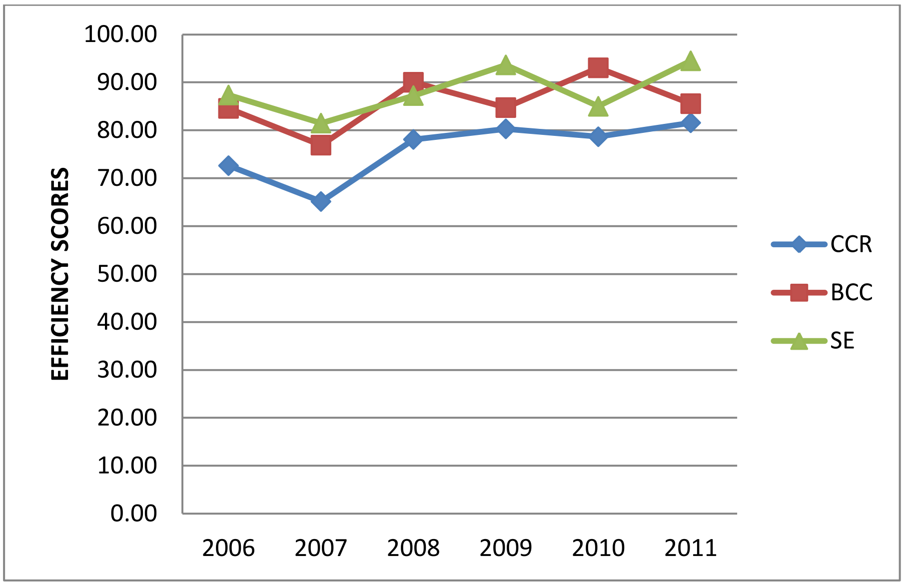


Figure 5.12: Post-concession yearly mean efficiency trends

Figures 5.9, 5.10 and 5.11 shows that the ports of Apapa, Onne and PH exhibited a high and almost constant index for technical, pure technical and scale efficiencies. The mean efficiency scores for the period under review are: 97.4, 98.7 and 98.8, 96.2, 100, and 96.2 and 94.7, 96.1 and 98.5, respectively. The pure technical and scale efficiency scores of the Apapa port are almost equal. In other words, the operations of the Apapa port are indifferent to the scale of operation. The Onne port is technically efficient, but some scale inefficiencies still exist at the Onne port. While little inefficiencies that exist in the PH port are attributable to both scale and technical inefficiencies but as scale inefficiency is higher than technical inefficiency, technical inefficiency has an overriding effect.

For the ports of Calabar, TCIP and Warri that operated at lower efficiencies the mean technical efficiency is classified into pure technical efficiency (BCC) and scale efficiency (SE). The average technical efficiency from the BCC model is 75.5, 75.1 and 69.3 for the Calabar, TCIP and Warri ports, while their mean scale efficiency scores are 54.2, 92.0 and 89.6 respectively. Figures 5.11 and 5.12 further reveal that the primary source of inefficiency in the Calabar port is scale, while it is technical inefficiency for the ports of TCIP and Warri.

The low pure technical efficiency in both TCIP and Warri, compared to the scale efficiency, suggests that the inefficiency is most likely due to the low level of output compared to available inputs, as they are operating under increasing returns to scale. It implies that actual throughput values are lower than target throughput values and also the turnaround time needs further improvement to meet the target values. The ports need to invest in schemes that could attract more shippers to the ports and also employ technology and skills that will improve the turnaround time of ships. As observed previously, the two options are related, as the reason for the low throughput may be that the shippers are deserting the ports as a result of high the turnaround time of ships.

Hence, the need for port managers to concentrate resources on acquiring managerial skills that is in tune with the market requirements of the ports. It in turn encourages ports to improve on their scale efficiencies. The port of Calabar is grossly scale inefficient but this is not surprising as bigger ships do not patronise Calabar due to low draught of the approach channel. Another problem associated with the underutilisation of the Calabar port is the design structure of the Ikom Bridge, which is located at a major gateway to the Calabar port and does not allow for heavy goods vehicles. It implies that the Calabar port could not meet its target outputs, considering the resources available to it.

The returns to scale properties of the six Nigerian ports' production are obtained from the DEA BCC model, indicates that the TCIP and Warri ports operated under increasing returns to scale and the Calabar port showed decreasing returns to scale (throughout). Furthermore, despite the fact that the Calabar port exhibited 100% efficiency in all the six years under consideration, except in 2007, the port operations can be regarded as weakly efficient, as it is not operating at optimal levels. The more efficient ports Onne, PH and Apapa vacillate between three production scales. For example the Onne port production, although it obtained efficiency scores of 100% throughout, exhibited constant returns to scale only for 2006-2008. It showed decreasing returns to scale for 2009 and increasing returns to scale for 2010 and 2011. It implies that for 2009-2011, the Onne port operations can be regarded as weakly efficient, because it is below the optimal level (Appendix 5.8). The Apapa port production indicated constant returns to scale for 2007 and 2011 and increasing returns to scale for the rest of the period. Though it showed an 100% efficiency score for 2006, that year's operation was regarded as weakly efficient because it was not operating at optimal production scale level. The PH port production indicated constant returns to scale for 4 out of the six years of operation and decreasing returns to scale for the remaining two years. Similarly, the efficiency scores for 2008 and 2010 are 100%. They are also considered, as weakly efficient because the production in those two years is not at optimal level. The results from the post-concession efficiency revealed that, although there are more efficient operations, most of the ports had weakly efficient operations for the period under study, as they were not operating optimally.

In addition, the results obtained from the pre-and post concession analysis revealed the tendency for ports in the post-concession to be more technically and scale efficient compared to the pre-concession period. The exception is the PH port that exhibited higher technical and scale efficiencies in the pre-concession period, more than the scores in the post-concession period. The port reform programme should have been carried out based on the peculiarities of each port, indicating that some ports are better left in the public domain.

5.3.3 Comparison of pre-and post-concession efficiency

Figures 5.13, 5.14 and 5.15 indicate the pre-and post-concession efficiency (overall, technical and scale) of the six ports used in the analysis, based on available data. The Apapa port exhibited a phenomenal growth in overall efficiency after concession (Figure 5.13). In fact, the mean DEA-CCR score almost doubled (mean efficiency of 51.6 and 97.4 for pre-and post-concession respectively) for the period. In the same vein, the TCIP and Warri ports showed a high increase in overall efficiency, while the Onne port indicates a slight improvement. On the other hand, the overall (DEA-CCR) efficiency of the Calabar port deteriorated appreciably (mean efficiency scores of 51.5 and 36.3 for pre-and post-concession respectively) and the PH port decreases slightly after concession. It shows that the efficiency gains from concession are not experienced in all the ports, especially for ports located outside the Lagos zone. It is a pointer that the wholesale concessions adopted by Nigeria, without due consideration of the peculiarities of ports in different zones, may not be best after all.

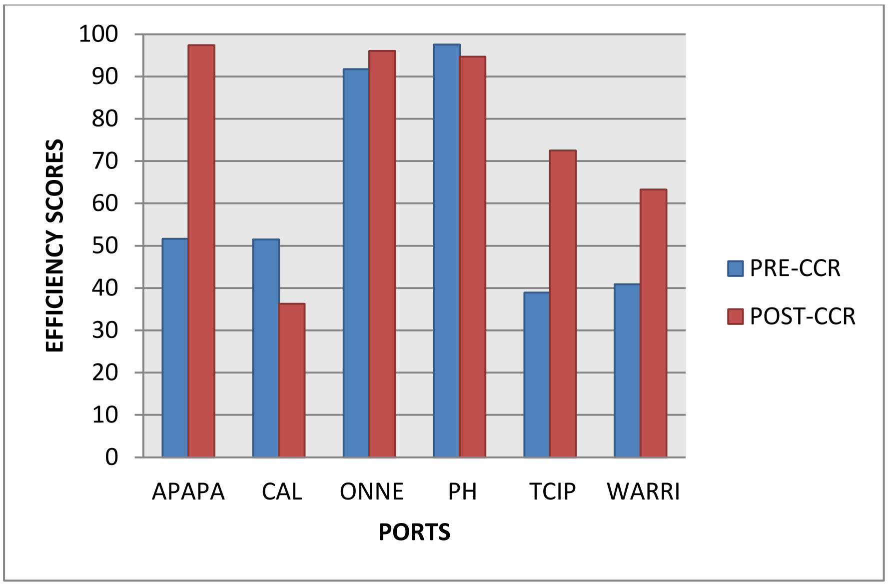


Figure 5.13: Pre- and post-concession overall (CCR model) mean efficiency scores distribution

In terms of technical efficiency; the DEA-BCC scores of the Apapa, Onne, TCIP and Warri ports are higher in the post-concession than pre-concession periods (Figure 5.14). The TCIP and Warri ports indicated the most appreciable increase, while the Apapa and Onne ports demonstrated a slight rise. Onne port has a technical efficiency of 100%, which could be attributable to the learning curve effect (Wright, 1936). It has been operating as a Landlord port since inception in 1982, while the others have only operated as a Landlord port for only six years. In contrast, the Calabar and PH ports' technical efficiency scores (DEA-BCC) for pre-concession dominate their post-concession efficiency scores. However, the ports are operating under decreasing returns to scale (Table 5.13), indicating underutilisation of available input resources. Policies geared towards attracting ships to the ports to increase throughput levels will bring the ports to the frontier of its most efficient counterparts.

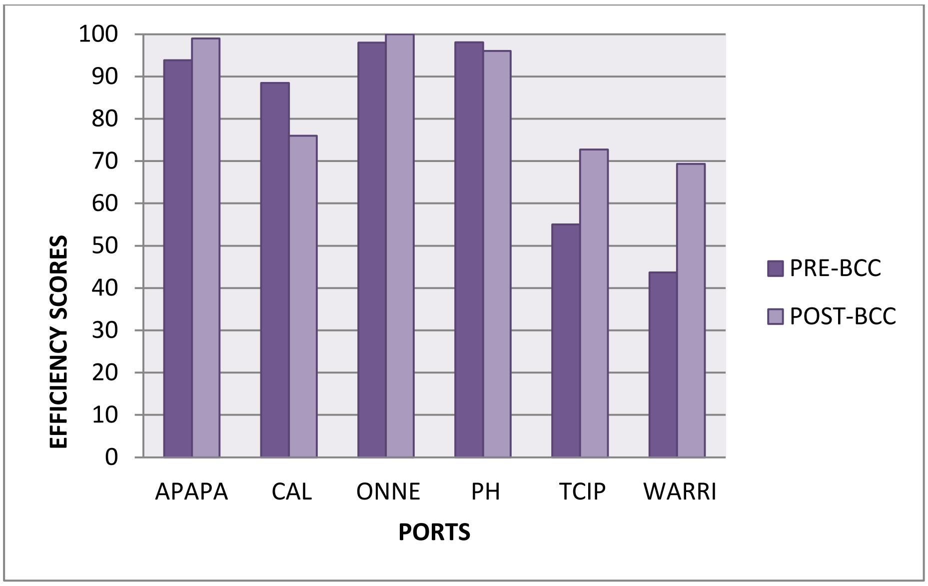


Figure 5.14: Pre- and post-concession mean pure technical (BCC) efficiency scores distribution

The average scale efficiency score distribution of the ports supports the point that the driving force of port efficiency after concession is improvement in production levels. As ports with a high margin of difference in overall efficiency scores also displayed a large margin of difference in scale efficiency scores between the pre- and post-concession periods (Figures 5.13 and 5.15). It is because the overall efficiency is an amalgam of the pure technical efficiency (the DEA-BCC efficiency index) and the scale efficiency estimate (ratio of DEA-CCR and BCC). When it is decomposed into its components, the sources of efficiency emerge. The Apapa port displayed an astronomical increase in scale efficiency, almost doubling the pre-concession score; followed by the TCIP and Onne ports, which also exhibited a slight increase in mean efficiency after concession (Figure 5.15). On the contrary, the scale efficiency of the Calabar, PH and Warri ports declined after concession. Although the decrease in scale efficiency estimates between the two periods is tiny, the differences being only 5.12%, 0.8% and 4.9% for the Calabar, PH, and Warri ports respectively. To be on the frontier of the most efficient port; the Calabar and PH ports operating under decreasing returns to scale, require an increase in output levels, while Warri port which exhibits IRS characteristics, requires a reduction in input resources.

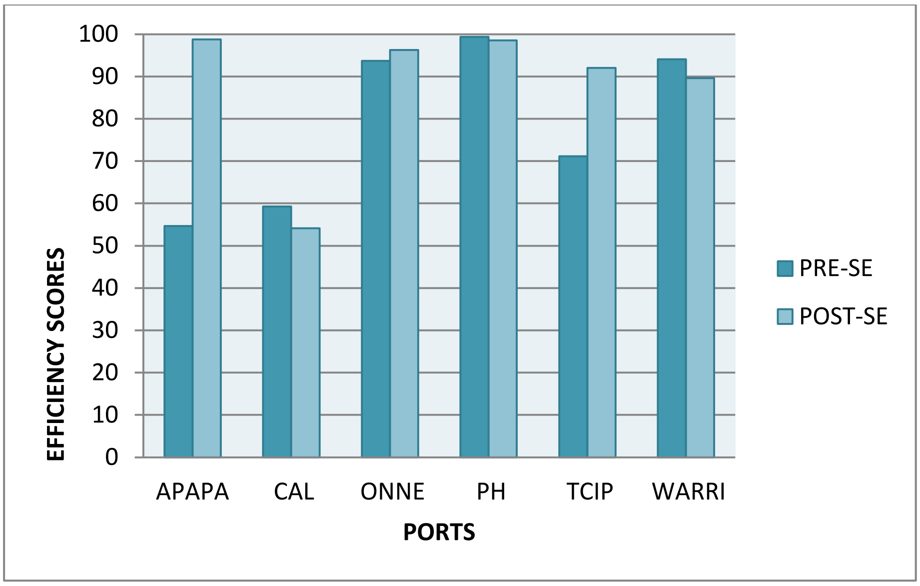


Figure 5.15: Pre- and post-concession mean scale (SE) efficiency distribution

Table 5.13: The relationship between pre- and post-concession efficiency

t-Test: Two-Sample Assuming Unequal Variances				
	PRE-BCC	*PRE CCR*	*POST-BCC*	*POST CCR*
Mean	0.8213	0.6203	0.8959	0.7606
Variance	0.0500	0.0660	0.0236	0.0607
Pearson Correlation	0.7183	0.5330		
Observations	36	36	36	36
Hypothesized Mean Difference	0	0		
df	62	70		
t Stat	-1.6485	-2.3646		
P(T<=t) one-tail	0.0522	0.0104		
t Critical one-tail	1.6698	1.6669		
P(T<=t) two-tail	0.1043	0.0208		
t Critical two-tail	1.9990	1.9944		

The DEA efficiency scores from the BCC and CCR models were subjected to a two-sample t-test to explore the influence of concession on port efficiency. The Pearson correlation between the DEA efficiency scores obtained from both the BCC and CCR models for the pre- and post-concession period are 0.718 and 0.533, which are significant at the 5% confidence interval. The two-tailed t-test is evaluate under the null hypothesis: "***the transfer of port terminal operations from the public to the private sector, through concession contracts, does not influence the efficiency of Nigerian ports***" The alternative hypothesis (one-tail test) ***"the concession of ports increases the efficiency of terminal operations"*** was also tested. The result of the analysis is displayed in Table 5.13. The absolute value of t-statistics (1.649) obtained from the analysis of the pre- and post-concession periods, assuming variable returns to scale model, is less than the t-critical values for both the one-tail (1.670) and two-tail (1.999) tests. In contrast, the absolute value of the t-statistics (2.365) derived from the pre- and concession taking the CCR approach, is greater than the t-critical for both one-tail (1.667) and two-tail (1.994) tests. It suggests, by adopting variable returns to scale, that there is no significant relationship between concession and efficiency of port operations. Probably because scale efficiency which is the driver of Nigerian ports' post-concession efficiency, is not considered under a DEA-BCC assumption. It underscores the need for good managerial practices and adoption of new technologies by the private sector to improve turnaround time and attract ships that, will in turn, impact on throughput levels. On the other hand, adopting the CCR model indicates that the transfer of port terminal operations from the public to the private sector, through concession contracts increases port operational efficiency. This finding could be explained from the scale efficiency perspective. As the port size is taken into consideration in a DEA-CCR model and because scale efficiency dominates technical efficiency in the post-concession period, its effect becomes overriding in the t-test analysis. That is to say that port concessions have increased throughput levels and improved the turnaround time of vessels, but in terms of technical efficiency as measured by the DEA-BCC scores, there is no significant improvement as a result of the concession.

In summary, it could be argued that Nigerian ports performed better overall in the post-concession than the pre-concession period, as depicted by pure technical and scale efficiency scores (mean efficiency BCC= 85.8% and SE= 88.2%) and mean efficiency (BCC= 79.5% and SE= 78.7%) respectively. However, the difference in efficiency between the two periods is statistically insignificant in the absence of scale and does not cut across all the ports. For instance, the PH port is both technically and in scale more efficient in the pre-concession period than the post-concession period while the Calabar and Warri ports have higher scale efficiency scores in the pre-concession than the post-concession periods.

5.4 Productivity Change Analysis of Nigerian Seaports (2000-2011)

This section of the analysis applies the Malmquist total factor productivity index (MPI) to assess the productivity change of DMUs (ports under study), between the pre- and post-concession periods. Port performance is viewed both from efficiency and productivity perspectives. This is investigation is carried out by adopting the DEA-based Malmquist productivity index (MPI). This research uses panel data from 2000-2011 to determine whether there has been growth or decline in the total factor productivity (TFP) of each port over time and across other ports in the observation set. An MPI value greater than 1 indicates growth in productivity change and an MPI less than 1 signifies deterioration, while a score of 1 implies that there is no change.

The principal merit of the MPI is the ability to decompose productivity change into different efficiency sources i.e. overall technical efficiency change (EFFCH), which captures the catch-up effect and the technical change which represents a shift in technology. EFFCH can further decompose into pure technical efficiency change (PECH) and scale efficiency change (SECH). That is why the MPI is employed in investigating efficiency and productivity changes occasioned by the introduction of private participation in the terminal operation of Nigerian seaports through concession contracts.

The technique used in this research involves using the DEA-based MPI to measure the efficiency change on a year-by-year basis. Then the total efficiency of Nigerian seaports' terminal operation, between any two successive years, is benchmarked in order to track down short-term changes in efficiency. Secondly, the analysis is carried out based on the concession period to estimate productivity change between the pre- and post-concession periods' operations.

5.4.1 Total factor productivity (TFP) analysis (2000-2011)

The results of the TFP of the analysis of the year-by-year for the ports, indicates that 34 port-years achieved productivity gains. While 16 port-years recorded productivity losses; another 16 port-years showed no change in total productivity for the period under review.

Table 5.14: Descriptive statistics of the Malmquist Productivity Index and decompositions

			INDEX DECOMPOSITIONS			
		MPI	EFFCH	TECHCH	PECH	SEC
PERIOD	N	66	66	66	66	66
2000-2001	MEAN	1.501	1.080	1.412	1.090	1.048
	STDEV	0.332	0.316	0.180	0.340	0.371
	MIN	1.098	0.809	1.200	0.780	0.551
	MAX	2.048	1.707	1.631	1.762	1.707
2001-2002	MEAN	1.149	0.945	1.215	0.882	1.140
	STDEV	0.217	0.070	0.201	0.218	0.339
	MIN	0.902	0.838	1.005	0.459	0.926
	MAX	1.524	1.010	1.524	1	1.826
2002-2003	MEAN	1.037	0.939	1.110	0.991	0.95
	STDEV	0.172	0.158	0.103	0.096	0.141
	MIN	0.831	0.664	0.955	0.822	0.664
	MAX	1.312	1.100	1.250	1.123	1.032
2003-2004	MEAN	1.061	1.153	0.971	1.139	1.014
	STDEV	0.201	0.392	0.256	0.395	0.063
	MIN	0.772	0.869	0.602	0.892	0.975
	MAX	1.337	1.934	1.337	1.941	1.140
2004-2005	MEAN	0.81	0.806	1.020	0.935	0.873
	STDEV	0.270	0.297	0.067	0.240	0.234
	MIN	0.447	0.416	0.898	0.461	0.416
	MAX	1.043	1.120	1.082	1.151	1.015
2005-2006	MEAN	1.528	1.234	1.241	1.051	1.170
	STDEV	0.361	0.242	0.199	0.106	0.234
	MIN	1.024	1	1.024	1	0.932
	MAX	2.131	1.651	1.580	1.265	1.651
2006-2007	MEAN	0.832	1.066	0.770	1.092	0.974
	STDEV	0.268	0.234	0.118	0.213	0.271
	MIN	0.641	0.875	0.649	1	0.851
	MAX	1.316	1.534	0.961	1.526	1.005
2007-2008	MEAN	0.953	1.034	0.917	1.053	1.006
	STDEV	0.253	0.239	0.131	0.082	0.061
	MIN	0.536	0.734	0.731	1	0.734
	MAX	1.284	1.471	1.098	1.167	1.430
2008-2009	MEAN	1.317	1.390	0.971	1.071	1.317
	STDEV	0.491	0.639	0.083	0.175	0.233
	MIN	0.961	1	0.861	1	1
	MAX	2.272	2.639	1.097	1.429	2.639
2009-2010	MEAN	1.025	1.049	0.978	0.993	1.055
	STDEV	0.157	0.156	0.034	0.016	0.655
	MIN	0.922	0.929	0.922	0.960	0.968
	MAX	1.338	1.362	1.019	1	1.362
2010-2011	MEAN	0.968	1.009	0.959	1.007	1.002
	STDEV	0.168	0.021	0.155	0.017	0.004
	MIN	0.712	1	0.712	1	1
	MAX	1.176	1.052	1.117	1.042	1.010

MPI=Malmquist productivity index representing or Total factor productivity change (TFPCH), EFFCH=Efficiency change, TECHCH=Technical change, PECH=Pure technical efficiency change, SECH=Scale efficiency change, and N=sample size

The analysis of the mean from the year-by-year TFPCH shown in Table 5.14 indicates total productivity gains TFPCH in 2000-2001, 2001-2002, 2002-2003, 2003-2004, 2005-2006, 2008-2009 and 2009-2010. While there was a deterioration in the years 2004-2005, 2006-2007,2007-2008 and 2010-2011. The analysis also shows that Nigerian seaports experienced a decline in pure technical change in the following years; 2001-2002, 2002-2003, 2004-2005 and 2009-2010. On the other hand, there was a steady increase in the scale efficiency change for the period under study, except in the swing years 2004-2005 and 2006-2007. In terms of the technological change (TECHCH) the ports indicated deterioration in the following years; 2003-2004, 2006-2007, 2007-2008, 2008-2009, 2009-2010 and 2010-2011, denoting more years of productivity decline than of increase.

Figure 5.16 shows the variations in average productivity of the combined MPI result from all the years. It illustrates that the efficiency changes from the MPI and its decomposition fluctuates without a definite pattern. For instance, Figure 5.16 revealed that pure technical efficiency (PECH) started with significant fluctuations and almost flattened out from 2004-2005 to the end of the observation period. On the other hand, the total factor productivity change (TFPCH) and the scale efficiency change (SECH) depicted identical patterns of troughs and peaks. The highest peak of TFPCH occurred in 2005-2006, which is the swing year. While SECH was highest during the 2008-2009 period. It is different from the observations from studies using ports from developed countries; where most ports in developed countries witnessed deterioration in throughput levels due to the economic meltdown. However, the ripple effect was not felt in developing countries until 2010-2011. Additionally, the technical efficiency change (TECHCH) as compared to other decompositions, exhibited a different trend for the observation period.

Table 5.14 and Figure 5.16 indicate overall a general trend of fluctuations in productivity in all the indices. Though there were more years with positive changes in efficiency than decrease, except the TECHCH which has more years with deterioration in efficiency. There is an appreciable increase in overall efficiencies in 2005-2006, which is the swing year (transfer of terminal operations from public to the private sector through concession contracts), followed by a noticeable decline. It may be attributable to concessionaires (terminal operators) trying to familiarise themselves with the new business environment and to build a customer base.

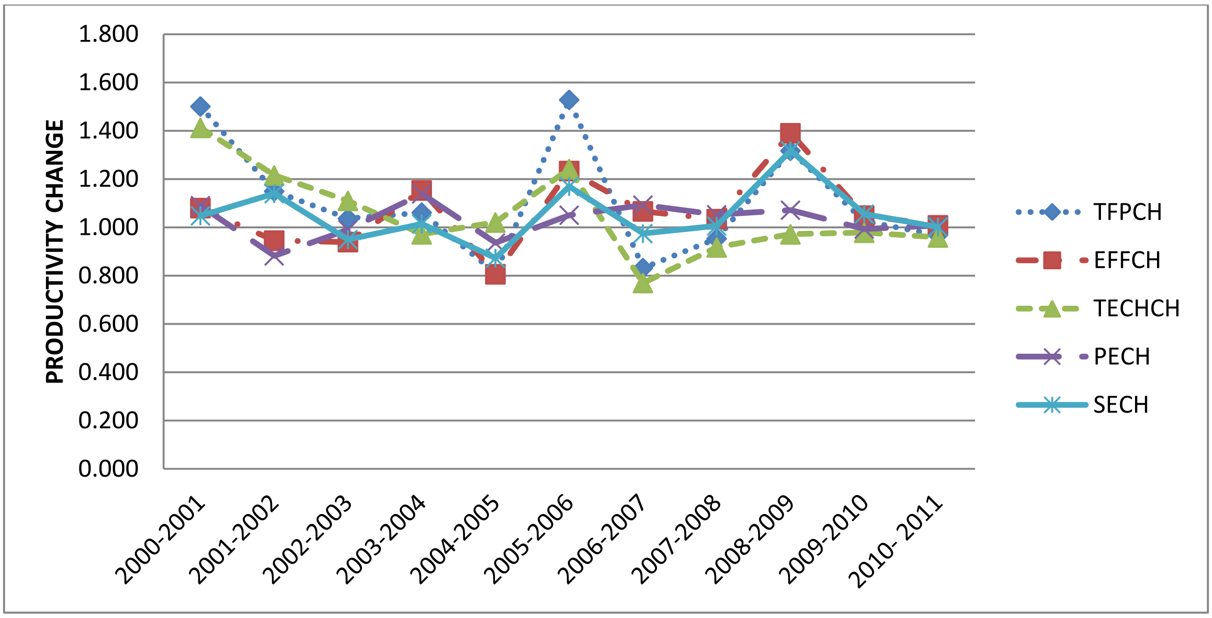


Figure 5.16: Year-by-year averages of the MPI and sources

Table 5.15: Malmquist Productivity Index summary of port means (2000-2011)

PORT	EFFCH	TECHCH	PECH	SECH	MTFPCH
APAPA	1.044	1.088	1	1.044	1.150
CALABAR	1.172	0.990	1	1.172	1.154
ONNE	1	1.012	1	1	1.012
PH	1	1.114	1	1	1.114
TCIP	1.052	1.049	1.018	1.029	1.087
WARRI	1.117	1.055	1.149	1.054	1.128
MEAN	1.064	1.0514	1.028	1.050	1.107

Table 5.15 indicates that the port industry in Nigeria has witnessed an overall positive TFP growth of 10.7% for the period 2000-2001 to 2010-2011. The overall positive TFP growth of the ports is attributable to frontier based capabilities. The technical efficiency change (EFFCH) is more than one signifying a positive growth of 6.4% in technical change, which contributed to boosting the TFP growth in the Nigerian port industry. Technical efficiency change is a product of pure technical efficiency change (PECH) and scale efficiency change (SECH). The result indicates that both PECH and SECH values are greater than unity which shows a positive increase of 2.8% and 5%. It implies that both have contributed to the technical efficiency change, with SECH having an overriding impact.

Productivity growth can also be viewed from the perspective of the level of utilisation of input and output factors. A low productivity growth implies a low growth rate in the output (throughput) and high or medium growth rate in the utilisation of the four input factors. The technical efficiency change involves the use of existing input levels to produce more of the same output. As ports gain experience in terminal production, efficiency sets in and new ways of using labour in terminal production is discovered through adjustments in cargo handling process, which contributes to higher productivity. Another aspect of TFP growth is the change in technology. To underscore this aspect of the TFP growth, it was posited by Squires and Reid (2004) that technological change entails the development of new technologies or new products to improve and shift production upward.

The overall mean technical change (TECHCH) of the ports showed a positive increase of 5.14% (Table 5.15). It equally shows that the total factor productivity growth observed in the Nigerian port industry for the study period is more due to efficiency change (EFFCH) than technical change (TECHCH), since the value of efficiency change is higher than technical change. The result of the MPI decomposition also reveals that four ports (Apapa, Calabar, Onne and PH) have stability in their pure technical efficiency change (PECH=1). While the Onne and PH ports also have stability in their scale efficiency change (SECH=1). Therefore, these two ports have zero efficiency change. The explanation is that these two ports are faced with the problem of using excessive inputs (especially storage capacity) in producing their outputs (throughputs). So the ports are confronted with inefficiencies arising from producing under decreasing returns to scale.

The relationship between the multi-year MPI and its decompositions could statistically provide the explanation for the changes in the TFP, via the various sources of efficiency change. Table 5.16 shows the correlation between the multi-year MPI and the sources of efficiency in the sample.

Table 5.16: Correlation between the multi-year MPI and sources of efficiency change

	MPI DECOMPOSITIONS		
YEAR	MPI-PECH	MPI-SECH	MPI-TECHCH
2000-2001	0.545	0.269	-0.051
2001-2002	-0.011	0.166	0.909
2002-2003	0.514	0.653	0.080
2003-2004	0.306	0.277	0.427
2004-2005	0.630	0.597	-0.623
2005-2006	0.773	-0.037	0.512
2006-2007	0.405	0.875	0.737
2007-2008	0.825	0.633	0.627
2008-2009	0.967	0.004	-0.656
2009-2010	0.981	0.275	0.194
2010- 2011	0.604	0.604	0.993
MEAN	0.594	0.392	0.286

The productivity gain achieved from pure technical efficiency has a strong influence on the improvement of the overall efficiency of Nigeria ports, as indicated by the mean of the year-by-year correlation in Table 5.17. The substantial impact of the non-scale pure technical efficiency implies that terminal operators were more interested in improving the capabilities of productive units (terminals), to increase production with the set of given inputs and available technology. Nevertheless, in 2001-2002, 2002-2003 and 2006-2007, scale efficiency had a stronger impact on the improvement of the efficiency of Nigerian ports than PECH. In 2001-2002 and 2005-2006, there is a weak but moderate relationship between the MPI and PECH and MPI and SECH respectively. The negative correlation between the MPI and the scale efficiency change observed in 2005-2006 highlights the presence of overcapacity, accounting for uneconomical scale sizes. Overall, scale has a statistically reasonable influence on the total factor productivity, though not as much as pure technical change.

The overall average of the year-by-year correlation between the MPI and technological change (TECHCH) is 0.286, which indicates that the shift in frontier technology has a statistically meaningful impact on the total factor productivity. Again the effect of frontier technology on the TFP is less than the scale and the non-scale components. The trend of the relationship indicates that the swing year 2005-2006 is marked by the lowest impact of scale efficiency change on the TFP. This is followed by a sharp rise in 2006-2007, a gradual decline in 2007-2008 and a sharp decline in 2008-2009. It is a period of declining trade volume globally, induced by the banking crisis and the suspension of ship entry into the ports of Lagos due to congestion.

The transfer of the terminal operations of Nigerian seaports to the private sector is through concessions; the ports have been operating under private ownership for six years. The results obtained from the technical change component of the MPI may give an idea of the influence of concession on the operational efficiency of ports, using the Nigerian ports as a case study. The result of the MPI decomposition indicates that PECH has the lowest variance compared to the other components, followed by TECHCH. Pure technical efficiency implies that the ports can produce more by using existing technology and utilising available inputs efficiently. Therefore, a significant relationship between the MPI and PECH (correlation coefficient 0.594), together with low variance, indicates that organisational and managerial factors associated with a better balance between inputs and outputs, is necessary for a port's productivity. Plus, a little, but moderate relationship between the MPI and technological change (TECHCH), together with small variance, suggests that the frontier shift effect does not yield substantial gains in the TFP, at least in the short run. It is because technological change is driven by the ability of ports to invest in modern cargo handling equipment, advanced ICT systems and also cargo tracking and scanning equipment. The relationship between the technological change and MPI further suggests the unwillingness of the port operators to bring in new technologies, as specified in the concession agreements. It underscores the need for an independent regulator to ensure compliance with the concession contract.

5.4.2 Analysis of pre- and post-concession efficiency change

The analysis of the year-by-year MPI, although useful in evaluating the short-term efficiency changes in productivity, does not provide an insight into the influence of concession on productivity. It is because the effect of transfer of operations from public to private could only be noticed in the medium to long term periods. Thus to explore the influence of concession on the TFP growth, the study estimates and compares the MPI and its sources six years before the concession and six years after i.e. the pre- and post-concession period. It is necessary for tracking the overall effect of the different factors on the TFP.

Table 5.17: Descriptive statistics of the pre- & post-concession TFP and its decompositions

		MPI	EFFCH	TECHCH	PECH	SECH
PERIOD	N	30	30	30	30	30
2000-2005	MEAN	1.112	0.985	1.146	1.007	1.015
	MEDIAN	1.119	0.985	1.143	1	1
	STDEV	0.079	0.051	0.042	0.081	0.039
	MIN	0.975	0.909	1.087	0.896	0.966
	MAX	1.204	1.062	1.204	1.149	1.074
2006-2011	MEAN	1.019	1.109	0.919	1.043	1.061
	MEDIAN	1.021	1.077	0.909	1	1
	STDEV	0.111	0.138	0.077	0.067	0.140
	MIN	0.863	1	0.821	1	0.996
	MAX	1.146	1.3448	1.009	1.13538	1.345

The MPI and its decompositions showed positive change for both the pre- and post-concession periods, except the overall technical efficiency change or catch-up effect that deteriorated by 1.5% (MPI=0.985) during the pre-concession period. While technological change decreased by 8.1% (MPI=0.919) during the post-concession period (Table 5.17). In addition, the MPI and its decompositions achieved higher values during the post-concession period compared to the pre-concession period. In contrast, the technological change was greater during the pre-concession period, TECHCH=1.146, compared to the value of TECHCH=0.919 for the post-concession. The mean value of the index for the two periods indicates positive productivity change. However, the TFP percentage growth for the pre-concession period is 11.2% (MPI=1.112) but it is only 1.9% (MPI=1.019) for the post-concession period for the same number of years. In the case of technological change, it increased by 14.6% during the pre-concession period, and deteriorated by 8.1% during the post-concession period. Pure technical efficiency increased by 4.3% during the post-concession period and recorded a slight increase of 0.7% during the pre-concession period. The scale efficiency indicates a small increase in productivity for the two periods, as it only increased by 1.5% (MPI=1.015) and 6.1% (MPI=1.061) for the pre- and post-concession periods respectively.

The analysis further reveals that both the pre- and post-concession productive efficiency is driven by scale, rather than by technical efficiency, as the values of pure technical efficiency change is less than scale efficiency change (Table 5.17). The result also indicates that the influence of the shift in the frontier technology in total factor productivity is overwhelming during the pre-concession era and barely significant after port operations are transferred to private operators. It suggests that the terminal operators have not brought in the much needed investment in ICT, tracking and other technologies, including modern cargo handling equipment, which are capable of fast tracking port development in the Nigerian port sector and reduce the turnaround time.

Table 5.18: Correlation between the pre- & post-concession MPI and sources of efficiency change

	MPI DECOMPOSITIONS			
PERIOD	MPI/EFFCH	MPI/TECHCH	MPI/PECH	MPI/SECH
PRE-CONCESSION (2000-2005)	0.781	0.948	0.599	0.056
POST-CONCESSION (2006-2011)	0.794	0.145	0.504	0.545

The correlation between the pre- and post-concession MPI and its decompositions gives an indication of the trend of productivity change after the transfer of port operations to the private sector. The relationship shows that the TFP change during the pre-concession period is driven by the frontier shift effects rather than the catch-up effect, but the reverse is the case for the post-concession period. The weak but moderate relationship between the MPI and technical change indicates non-investment in technology by the terminal operators. In addition, the very weak but significant relationship between the total factor productivity change and the scale efficiency change during the pre-concession period signifies under-utilisation of available resources. As the ports could not attract the much needed cargo. Therefore, it could be said that the scale efficiency change had an insignificant impact on the productivity of the ports. Thus indicating that the investments in technology during the period did not impact much on the scale of operation of the ports. Therefore, the efficiency change during the pre-concession is more due to improvement in managerial capabilities and skill than scale efficiency (Figure 5.17). Conversely, the post-concession productivity is driven by efficiency changes from both scale and non-scale factors, as the scale change is higher than pure technical change, the post-concession TFP growth is considered to be a product of scale efficiency change (Figure 5.18).

In conclusion, the adoption of the Landlord model of port operation by the Nigerian ports drastically increased the impact of the scale efficiency change on the TFP and slightly reduced the influence of the pure technical efficiency change in the TFP. In contrast, the wholesale introduction of the model in all the ports regressed greatly the influence of technological change (frontier shift effects) on the total factor productivity. It is at variance with the objective of the Nigerian ports concession, which is to attract investment in port infrastructure from the private sector. It is evident from Table 5.18 and Figure 5.16 that the driver of productivity increases during the pre-concession period is technical change, while it is scale efficiency change for the post concession period.

The pre-concession period in comparison to the multi-year MPI suggests that the influence of technological progress on productivity is not quite evident in the short-run. This is as a result of the changes in global trade due to the introduction of bigger container ships and in preparation for the adoption of the Landlord model of port administration. The Nigerian ports invested heavily in infrastructure to attract reputable terminal operators to Nigerian ports. However, the insecurity experienced by the ports in the eastern zone, as well as endemic cargo pilferage (Wharf rat phenomenon) coupled with a high cost of doing business, made cargo diversion to other neighbouring ports an increasing phenomenon. Hence, the investment in port infrastructure was not matched with commensurate ship traffic and throughput levels. It led to underutilisation of port facilities in some of the ports. The resultant effect is observable in the relationship between the MPI and SECH in the last six years before the concession, which indicates that the scale efficiency change has almost an insignificant impact on the productivity growth for the period.

However, comparing the relationship between the multi-year MPI and its components with relationship between the MPI and its decompositions in the first six years of the post-concession period (2006-2011), the result indicates, that the relationship between MPI and SECH is the most significant., when compared to technological progress (TECHCH) and pure technical efficiency change, even in the long run. It suggests that the impact of technological progress on productivity can be noticed in the medium term. However, in the long-run, the effect can only be felt through an increase in the scale of production which leads to an increase in the TFP. It can be explained by observing the relationship between pure technical efficiency change and the MPI, which is equally significant for the period. It implies that the terminal operators are using advanced managerial skills to utilise the available resources optimally to improve throughput, without investing in modern equipment. If this scenario continues unregulated, the resultant effects could be a higher turnaround time of vessels and loss of patronage.

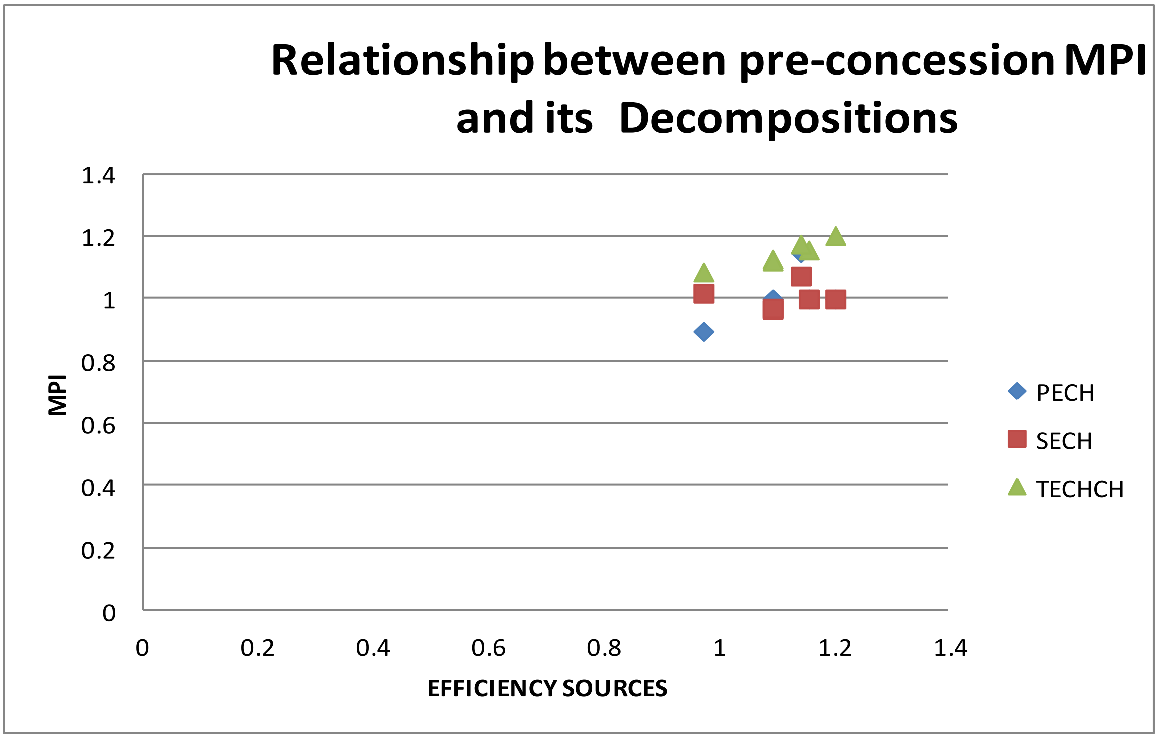


Figure 5.17: Relationship between the pre-concession MPI and its decompositions

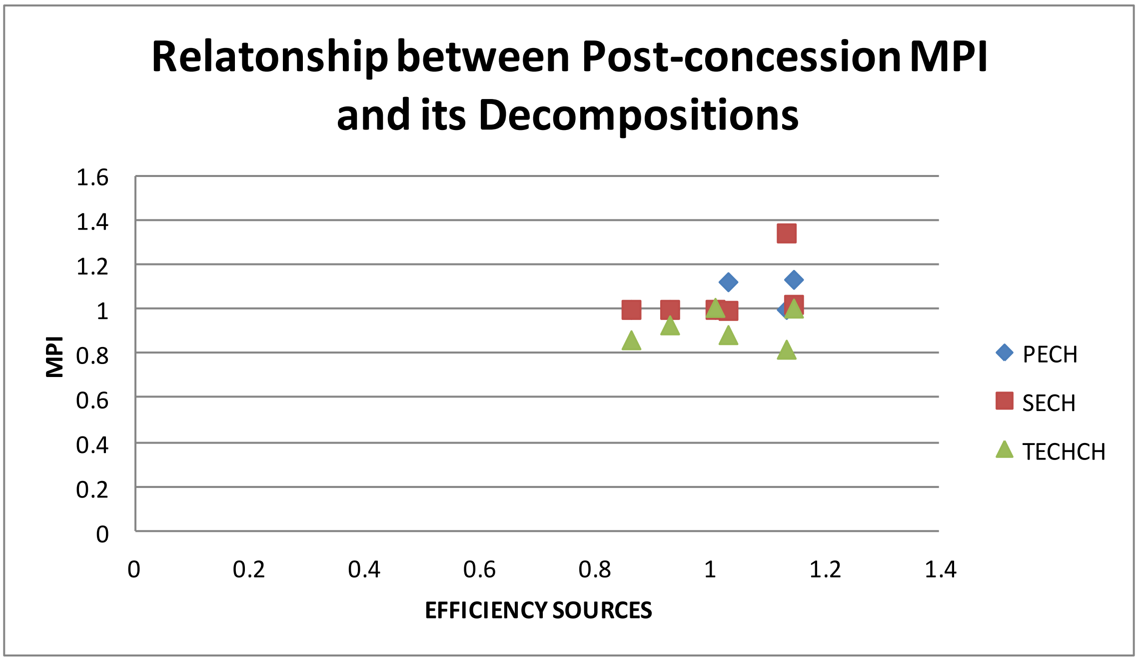


Figure 5.18: Correlation between the post-concession MPI and its components

5.5 Chapter Summary

The chapter benchmarked the overall efficiency of six Nigerian seaports for the period 2000-2011, using different DEA models such as the intertemporal, contemporaneous and window analysis models. The results of the analyses indicated that the most efficient port is the Onne port and closely followed by the Port Harcourt port, while the least efficient ports are the Warri and Calabar ports. Plus, the relationship between port size and efficiency was demonstrated by testing the null hypothesis (Ho): *There is no relationship between port size and operational efficiency.* This hypothesis was rejected. Thus, port size has an influence on the operational efficiency of Nigerian ports. The comparison of the pre- and post-concession's overall, technical and scale efficiency showed that the overall efficiency of the Apapa, TCIP, Onne and Warri ports indicated substantial improvement after privatisation, except for the port of Onne which recorded a slight increase. While the efficiency of the PH and Calabar ports deteriorated after concession. Thus, a blanket approach (transfer of all the ports to the private sector in one go) adopted during the concession could be considered inappropriate, as the results suggested that some of the ports are better off left in the public domain.

Furthermore, the chapter investigated the pre- and post-concession efficiency of the six ports under study to ascertain if there is a significant difference in the operational efficiency of the ports between the two periods. The relationship between the operational efficiency of the ports before and after concession was investigated by using a two-tailed t-test. The result of the t-test is significant at the 5% confidence for the DEA-CCR, indicating that if the scale of operation is considered, concession has improved the operational efficiency of the Nigerian ports. The result demonstrates that the concession of Nigerian seaports has increased the throughput levels and improved the turnaround time. However, in terms of the much sought after infrastructure development through investment in modern cargo handling equipment, not much has changed between the two periods.

To further explore the productivity perspective to performance and the reliability of efficiency results, the total factor productivity for the period under study was investigated using the Malmquist productivity index (MPI) derived from the DEA distance functions. Again, the result obtained is in conformity with the efficiency analysis. Though there is a growth in the TFP in both pre- and post-concession periods. However, the pre-concession period showed higher growth than the post-concession period. The decomposition of the sources of efficiency change revealed the driver of this increase in TFP is technological change for the pre-concession period and the scale efficiency change for the post-concession period.

Chapter Six: Role of Ownership on Nigerian Ports' Performance

6.1 Introduction

The chapter examines the influence of ownership, intra-port competition, efficiency and production scale on the operational performance of Nigerian seaports. This chapter uses the output from the DEA efficiency analysis and the MPI, as the dependent variable. Ownership structure is endogenous, while competition is an exogenous factor to the DMUs (ports). This chapter first assesses the relationship between the transfer of port terminal operations from public to private through concession contracts and the efficiency of Nigerian ports. As well as the relationship between intra-port competition and port efficiency and finally the impact of government regulation or lack of it, on the efficiency of concession, in order to test the hypotheses proposed in this study. This chapter also discusses the impact of Nigerian port reform on the main performance indicators.

In other words, this chapter addresses the impact of the wholesale concession of Nigeria's seaports to the private sector on the efficiency of port operations. The section in chapter 5 that dealt with the influence of concession on port efficiency before and after, only gave a synopsis of the combined impact of introducing private participation in all the major ports in Nigeria. Although the concession, which involved four rounds, commenced on 24th September, 2005 and ended 1st January, 2006 (see Table 2.6), the operators did not mobilise to site at the same time. Therefore, a transitional period existed between the time the bids were won and the actual start of terminal operations by different operators. During this transitional period, some terminals were manned by private operators while the NPA operated others that the operators had not taken possession of. For the purpose of the analysis, this period is treated as one of mixed ownership. As a result, in 2006 all the ports practised mixed ownership. In some ports, the mixed ownership extended into 2007, depending on the date terminal operators took possession, except for the Onne port which operated as a landlord port throughout the study period. In 2000-2005, the ports served as public ports except the Onne port that was privately operated. In order to allow for an unbiased assessment of the impact of the concession on port efficiency, the Onne port operations from 2000-2011 are excluded from the data set. As it is an outlier, the activities of the five ports (Apapa, TCIP, PH, Warri and Calabar) from 2000-2005 are regarded as publicly operated (Tool port model). By so doing, the aggregate data set used for analysis in

Chapter 5 is segregated into three datasets, each with the corresponding port-years (DMUs). For each ownership type, the study excludes from the original dataset the ports to which the particular ownership type does not apply. Thus, the ownership style of Nigerian seaports was compiled based on three categories, namely (I) publicly operated port (II) mixed ownership port and (III) Landlord port. In order to make the comparison as close in time as possible, the data for the publicly operated ports were taken from 2002-2005, the mixed ownership was between 2006-2007 and the landlord port 2008-2011.

6.2 Port Efficiency and Ownership

Table 6.1 depicts the descriptive statistics of the efficiency scores obtained from the DEA intertemporal analysis applying the BCC model to the port-year data obtained from Nigeria seaports, based on the ownership status. It is evident from Table 6.1 that the mean efficiency score of the Landlord port (0.938) is higher than those of mixed port (0.835) and publicly operated port (0.762). It is equally observable from Table 6.1 that the Landlord port has the lowest standard deviation compared to the Public and Mixed ports which are consistent with Charnes et al. (1985). Charnes et al. (1985) demonstrated that DMUs with high efficiency levels tend to have lower standard deviations compared to their peers with lower efficiency levels. The analysis shows that on average, the Landlord ports perform better than the Public and Mixed ports. It is also, consistent with Estache et al. (2002) study of Mexico's ports that showed short-term improvements in performance due to the reform. Likewise, González and Trujillo (2008) and Barros (2003) studies of Spanish and Portuguese ports' performance after privatisation, both showed significant improvement in performance after reform. Therefore, the hypothesis that there is a relationship between the ownership of port infrastructure and superstructure and the efficiency of operation is accepted, based on the comparison of the efficiency of Public, Landlord and Mixed ownerships. However, it should be noted that the mixed ownership port has only 7 observations and a small sample size which may lead to some bias in the result. On the other hand, the public has 30 data points while the Landlord ports have 24 observations; the relatively broad cross-section size of these two sets of port's type makes the comparison between them more convincing and tenable.

Table 6.1: Comparison of mean efficiency scores for different types of ownership

DESCRIPTIVES	***PUBLIC***	***MIXED***	***LANDLORD***
Mean	0.76187	0.83457	0.93825
Standard Error	0.04558	0.08315	0.02448
Median	0.8555	1	1
Mode	1	1	1
Standard Deviation	0.2496	0.2200	0.1199
Sample Variance	0.0623	0.0484	0.0144
Kurtosis	-1.6015	-1.5027	4.0727
Skewness	-0.3570	-0.7822	-2.2091
Range	0.652	0.5	0.435
Minimum	0.348	0.5	0.565
Maximum	1	1	1
Sum	22.856	5.842	22.518
Count	30	7	24
Confidence Level (95.0%)	0.0932	0.2035	0.0506

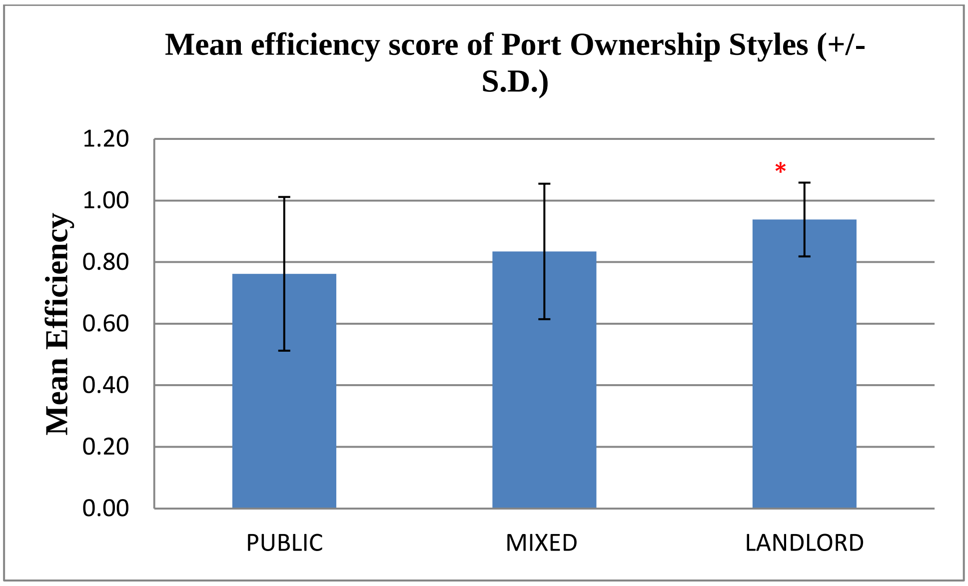


Figure 6.1: **Comparison of mean score efficiency of types of port ownership**

6.2.1 Analysis of the relationship between efficiency scores and ownership types

A single factor ANOVA was carried out to see if there is a significant difference between the port ownership styles. A single factor ANOVA was chosen as only a factor ownership of the ports that is changing. The result of the ANOVA indicates a significant variability within the three ownership groups (p=0.0103).

To determine which ownership is different from the other, a post-hoc t-test was undertaken. The choice of a two-sample t-test assuming unequal variance is appropriate, as this study is not hypothesizing that the mean efficiency of a particular ownership style is greater or lesser than the other. That has been established from the descriptive statistics so rather the study tests ascertain if there is a significant difference. The post-hoc t-test involved carrying out three separate two sample t-tests; first between public and mixed ownership, second between public and landlord and final between mixed ownership and landlord. The result of the post-hoc t-test two-tail indicates there are no significant differences between public and mixed and between mixed and landlord ownership styles, p=0.461 and 0.271 respectively. On the other hand, there is a significant difference between public and landlord p=0.001, which is less than the default significance of p=0.05. To minimise the error associated with multiple comparisons, the study applied a Bonferroni correction to the results obtained from the post-hoc t-test, by adjusting the confidence level. The threshold of the confidence level changed from p=0.05 to 0.0167. It is obtained by dividing the number of comparisons in our case by 3 because the number of t-tests carried out was 3. That gives a p-value of 0.0167 which is the new significance level. The new significance level is used to compare the p-value two-tail to see if the P (two-tail) <p (0.0167). The result of the Bonferroni corrections indicated that there is a significant difference between the efficiency scores of Public and Landlord ownership styles. While there is no significant difference between the efficiency scores of public versus mixed and mixed versus landlord respectively (see Appendix 6.1-6.4). In conclusion, the ANOVA is significant. The results of the Bonferroni-corrected post-hoc t-test indicates a significant difference in efficiency between the public ports and the Landlord system of port ownership as depicted in Figure 6.1. It is consistent with Cheon et al. (2010) and Tongzon and Heng (2005)

However, as the interest is in evaluating the influence of the wholesale concessions on the performance of Nigerian ports, the subsequent analysis is restricted to the two ownership types. In this case, the public and Landlord which have exhibited a significant difference from the previous analysis. Moreover, prior to concession the Nigerian ports were under public ownership and after concession they practise the Landlord model of port ownership. Therefore, the mixed ownership was only a temporary measure which only existed during the transition period from public to private ownership. As a result, the hypothesis is further tested on two ownership styles. The period of the pre- and post-concession analysis covers the 4 years before (2002-2005) and the first four years (2008-2011) of the practice of the Landlord model by all the ports. The mixed ownership period (2006-2007) was excluded in order to match the port-year operations as near as possible and to avoid the effects of extraneous variations.

The relationship between the port ownership structure and efficiency is further examined by carrying out a two-sample t-test on the efficiency scores of the Public and Landlord port ownership styles. The efficiency scores of the ports, when operations were under public and private ownership, were computed from the DEA intertemporal analysis produced from an output-oriented model and assuming both constant and variable returns to scale.

Table 6.2: **Relationship between public and landlord ownership of port operations and efficiency**

t-Test: Paired Two Sample for Means				
	PUBLIC-BCC	*PUBLIC-CCR*	*LANDLORD-CCR*	*LANDLORD-BCC*
Mean	0.7962	0.6728	0.9236	0.934
Variance	0.0608	0.0602	0.0169	0.0166
Observations	20	20	20	20
Pearson Correlation	0.1723	0.5678		
Hypothesized Mean Difference	0	0		
df	19	19		
t Stat	-2.391854	-5.545267		
P(T<=t) one-tail	0.013631	1.19371E-05		
t Critical one-tail	1.729133	1.729133		
P(T<=t) two-tail	0.027262796	2.38742E-05		
t Critical two-tail	2.093024	2.093024		

To understand the influence of privatisation through concession contracts on efficiency; the null hypothesis '*there is no difference in operational efficiency of the Nigeria seaports between when it was under the public and private sector'and* the alternate hypothesis *'the operational efficiency of the Nigerian seaports increased after they were transferred to the private sector'* were explored using paired two-sample t-test. Table 6.2 shows the result of the analysis. It indicates that the absolute value of the t-stat for the BCC (2.392) and the CCR (5.545) models is greater than t-critical (1.729) and (2.093), for one-tail and two-tail respectively. The P-value is less than 0.05 ($p<0.05$), therefore the null hypothesis is rejected. It suggests that there is an increase in the efficiency of the Nigerian seaports when the operation was transferred to the private sector i.e. when the ports adopted the Landlord port model of port operation. In other words, it only shows that the change of ownership of port's terminal operations from public to the private sector, through concession contracts, could encourage efficient port production. However, there is a complex relationship between port efficiency, production scales and other exogenous factors, such as competitiveness, port size, environmental issues and regulation that is discussed later in this chapter.

6.2.2 Temporal changes in Nigerian seaports productivity (MPI) and ownership.

The relationship between port ownership and productivity change and its sources (MPI, TECHCH, PECH, and SECH) is further explored in this section. Table 6.3 compares the productivity change and its decompositions in regards to Nigerian seaports, when operations were in public hands, and now they are in private hands. The comparisons made use of data from the last four years before (2002-2005) and four years after (2008-2011), the adoption of the Landlord model of port administration. The years 2006-2007 were excluded from the analysis because it was a transition period, where some terminals were operated by concessionaires, while others are operated by the NPA, as the owners had not yet taken possession. The result shows that the MPI of the ports under the Landlord system is higher than when it was under the public form of ownership. However, the difference between the two groups' mean ANOVA total factor productivity change (MPI: F=0.056, P=0.8I5) is not statistically significant at the five percent level. The results obtained from the t-test paired two sample for means shows that the MPI means for the public and Landlord port systems are not statistically different at the 5% level (p=0.731). Likewise, the absolute value of the t-stat=0.351 is less than the t-critical one-tail=1.761 and the t-critical two-tail =2.145 (Appendix 6.5 & 6.6). Therefore, a rejection that the means are statistically different based on the t-test. It is consistent with De (2006) study of Indian ports from 1981-2003, which found no substantial impact on the TFP for Indian ports after reform. On the other hand, Cheon (2007b) suggests that the means of the two groups are statistically different based on the results of the study of World top 94 container ports from 1991-2004, 39 of which have experienced private ownership. As explained earlier in the discussion of literature in chapter 2, economic theories and existing empirical evidence have failed to establish a clear-cut relationship between ownership and performance. UNCTAD (1995b), observed that the lack of a clear-cut empirical relationship may be to some extent a reflection of the socio-political environment in which these entities undertake their business.

In addition, the means of the sources of efficiency change of the ports under the public and Landlord system were compared. The results indicate that the average scale efficiency change of the Landlord port system is higher than that of the Public port, while the mean pure technical efficiency change for both systems is equal. Conversely, the average technological change (frontier shift effects) of the Public port system is higher than the Landlord port system. In terms of efficiency change, scale efficiency (SECH: F=0.361, P=0.553) exhibited a more reasonable effect than pure technical efficiency (TECH: F=.0001, P=0.992), although not a statistically significant difference at both the 5% and 1% level between the Public and the Landlord ports. On the other hand, it could be said that technological change has an overriding impact on efficiency, although the technological change (TECHCH: F=1.558, P=0.222) is not statistically significant at the 5% level. It is also reconfirmed by a t-test paired two sample for means for the two groups for scale, for pure technical efficiency change and for technological change. The results reaffirm that the average scale efficiency change between the two groups is not statistically significant at both the 5% and 1% confidence level, as p=0.543 and the t-stat 0.623<t-critical one-tail=1.761 and two-tail 2.145. Likewise, for technical efficiency change, p=0.992 which is not significant at 5% level. The t-stat=0.011<t-critical for one-tail=1.761 and two-tail=2.145. As well as the mean technological change for the two groups is not significant at the 5 percent level, as p=0.284 and the t-stat 1.114<t-critical (one-tail 1.761 and two-tail 2.145), see (appendix 6.7-6.9). Therefore, rejection that the means are different based on the confirmatory t-test. From the results, it seems there are some improvements in productivity due to the ownership change, but it is not statistically significant, especially in the area of technological change. In summary, the transfer of the Nigerian ports' terminal operations from public to the private sector has not brought about the much touted technological change needed to drive productivity. It reflects that the operators may not have brought in the much needed modern equipment, as envisaged in the concession agreement.

Table 6.3: **Port ownership change and productivity (MPI, TECHCH, TECH, SECH)**

	N	Mean	STD. ERROR	MEDIAN	STDEV	MIN.	MAX.
PMPI	15	0.992	0.060	1.070	0.232	0.508	1.266
LMPI	15	1.010	0.049	0.969	0.190	0.536	1.338
TOTAL	30	2.002	0.109	2.040	0.422	1.044	2.605
PTECHCH	15	1.034	1.034	0.043	0.168	0.602	1.250
LTECHCH	15	0.971	0.971	0.025	0.098	0.731	1.140
TOTAL	30	2.004	2.004	0.069	0.266	1.333	2.390
PPECH	15	1.029	0.075	1	0.292	0.461	1.941
LPECH	15	1.029	0.029	1	0.111	1.000	1.429
TOTAL	30	2.058	0.104	2.000	0.403	1.461	3.370
PSECH	15	1.015	0.088	0.982	0.342	0.499	2.093
LSECH	15	1.107	0.096	1.018	0.371	0.478	2.002
TOTAL	30	2.122	0.184	2.000	0.713	0.977	4.096

PMPI= public ownership total factor productivity change; LMPI= landlord ownership total factor productivity change; PTECHCH= public ownership technological change; LTECHCH=landlord ownership technological change; PPECH=public ownership technical efficiency change; LPECH=landlord ownership technical efficiency change; PSECH=public ownership scale efficiency change; LSECH=landlord ownership scale efficiency change

6.3 Measurement of Competition Level

The adoption of the Landlord model of port administration, as a result of the concession programme, implies that ports cannot always be considered as single entities. Nowadays, modern ports contain several terminals operated independently by two or more operators and therefore to an extent, some degree of intra-port competition exists. In such circumstances, port users have several options for where to dock their ship and which terminal to use. In addition, there can be intra-terminal competition in those cases where multiple operators can provide competing services from the same terminal. The existence of intra-port competition implies that a port market can be defined narrower than a port, or where the port is defined as a market, competition within that port may exist (OECD, 2011). De Langen and Pallis (2006) claim that such competition can help to facilitate specialisation, because competitors are competing in the same conditions (labour market, regulation framework, suppliers).

Port competition has been approached from different perspectives, such as concession granting, diversion, the concentration of port traffic, investment in port infrastructure and the subsidisation of hinterland connections (Huybrechts et al., 2002). As discussed earlier, there was no competition between Nigerian ports prior to concession, because all the ports were under one operator, the Nigerian Ports Authority (NPA). Therefore, this study adopts the concession granting approach on a national level, which is closer to former studies by Cheon (2007b) and Tongzon and Heng (2005), although both studies were on a global scale. It is because bidding for concession contracts introduces competition for the market, as distinct from the competition in the market. The evaluation of the level of competition among the different ports (pre- and post-concession) is necessary before delving into the role of competition on port efficiency. There have been many methods used in measuring port competition, such as port the competitive index (PCI) in Tongzon and Heng (2005). There have been many methods used in measuring port competition, such as port the competitive index (PCI) in Tongzon and Heng (2005). In addition, Porter's five forces competitive theory (Lau, 2008), Factor analysis (Yeo, Roe, & Dinwoodie, 2008). As well as, Fuzzy methodology (Huang, Teng, Huang, & Kou, 2003), the Hirschman-Herfindahl Index (HHI) (Hirschman, 1964) and the hinterland accessibility index (Cheon, 2007b). However, this study adopts the Herfindahl-Hirschman Index (HHI) in evaluating the level of competition in Nigerian seaports. This method has been used to assess the relative competitiveness of ports within a particular market or region (Elsayeh, Hubbard, & Tipi, 2011).

The HHI is inspired by the pioneering works of economists Orris C. Herfindahl and Albert O. Hirschman. It measures the sizes of the firms in relation to others in the industry and also indicates the level of competition. The HHI as an economic concept has extensive applications in competition, antitrust and also technology management (Liston-Hayes & Pilkington, 2004; Shapiro, 2010). It is defined as the sum of the market shares of all the firms within the industry, if less than 50, or the 50 largest firms, if more than 50. The HHI index ranges from 0 to 1 i.e. from small firms to single monopolistic producers. An increase in the HHI indicates a decrease in market power and a reduction in competition and the reverse is the case for a decrease. Conversely, the index can range from 0 to 100^2 or 10,000 if percentages are used as whole numbers. The beauty of the HHI lies in the ability to account for the entire size distribution of firms (ports) in the market. It achieves that by attaching a weight to both the number of ports in the market and the inequality of market shares. A market with a HHI of below 1000 is considered un-concentrated according to the US Department of Justice and the Federal Trade Commission, while a HHI between 1000 and

1800 is moderately concentrated. Markets with a HHI above 1800 are regarded as highly concentrated (Cariou, 2007). The advantages of using the HHI are that it takes into account all firms in the industry and secondly, it gives extra weight to a single firm with an unusually large market share.

The standard assessment for testing if ports are competitive should start by looking at factors such as the market share (Jolić, Štrk, & Lešić, 2007; OECD, 2011). This follows logically from the definition of a port market, because a port is more likely to be found to have market power if it has a persistent market share, than if it does not. Volatile market shares will be indicative of more competition, as price reductions, capacity expansions, or innovation by individual ports or terminals results in increased traffic. It is necessary because one of the deliverables of this research is to find out if privatisation through concession has induced competition among the ports under study. In achieving the primary goal of this research, the competitive position of the ports has to be determined. As the competition requires competitiveness, which means in the conditions in which competition exists in the market, terminals need to be competitive. In the case of competitiveness, Jolić et al. (2007) suggested that the most important aspect is to find out which port is competitive towards which other port.

That is why this research employed the concept of the HHI to investigate the competition among the six Nigerian ports before and after the 2006 concession. The HHI method is based on the notion of market share of the ports. The method enables comparison of a single port with other ports within the competitive environment. It allows for objective determination of the ports in relation to other competitors. Secondly, it is entirely based on realised throughput of the ports and not on difficult to get data, such as financial and confidential marketing data. Applying this method is important, because it is simple to assume that creating many terminals for each cargo type in the same port allows for competition and without putting into consideration the potential unequal distribution of services offered by the different terminals and the possible dominant positions of individual terminals. For instance, if there are four ports in a particular industry and operated by four different operators and one port handles let say 80% of the throughput, while the others control 6.67% market share each. Then it is unwise to be speaking of competition in those circumstances. In order to ameliorate this type of problem, the concentration index is often used.

6.3.1 The market structure of Nigerian ports

Geographically, Nigeria is located in Western Africa; the southern edge is a coastline along the Atlantic Ocean in the Gulf of Guinea. The country borders four countries, Cameroon to the South-East, Chad to the North-East, Niger to the North and Benin to the West. Despite the strategic location, Nigerian ports and the ports of the neighbouring countries serve mainly the Nigerian market. Except the Onne port located in the oil and gas free zone that acts as a transhipment port for oil and gas traffic to Angola and Sao Tome and Principe. The reason for the port market scenario described above is due to the country's large population, the inefficiency of the port system and the unwholesome practices of Nigerian shippers. As observed before, it has led to the diversion of Nigerian bound cargo to ports of neighbouring West African countries.

The Nigerian port market for the period under study is characterised by fluctuating growth rates. The driving force of the recent growth can be attributed to privatisation and the dredging of the Lagos ports and Onne ports to receive bigger ships which have in turn led to improved throughput levels. Though there are other factors, such as the return of the country to democratic rule after a long military dictatorship, which improved the purchasing power of the citizenry. Plus the continued increase in oil prices globally have led to improvements in the economy, as the country depends mainly on the revenue from oil for sustenance. Figure 6.2 shows the throughput of the six major Nigerian ports understudy between 2000 and 2011. Apapa is the principal port in the Nigerian port system, with a throughput of 11.01 million tonnes in 2000, which increased to 16.9 million in 2005 and decreased to 15.1 million tonnes in 2006, the swing year. It then rose sharply to 18.6 million tonnes in 2007 and a gradual growth to 23.4 million tonnes in 2011. Another big port is the Onne port which handled 7.2 million tonnes in 2000 and a steady increase in throughput till 2007. Then the yearly cargo volume dropped slightly from 21.6 million to 21.4 million tonnes in 2008 and declined sharply to 17.4 million tonnes in 2009. The throughput increased again from 23.3 million tonnes in 2010 to 26.2 million tonnes in 2011. The sharp drop in 2009 could be attributed to the restriction on ship entry due to the dredging of the Bonny channel. The TCIP handled a throughput of 3.9 million tonnes in 2000, followed by a gradual pattern of rise and fall until 2005 with a throughput of 5.5 million tonnes. Afterwards, the throughput rose sharply in 2006 to 7.4 million tonnes. A remarkable increase ensued until 2009 with a throughput of 14.1 million tonnes, then dropped to 13.1 million tonnes in 2010 and a rise to 15.8 million tonnes in 2011. The ports of PH, Calabar and Warri showed a similar pattern of peaks and troughs. The Warri port showed a remarkable growth in throughput from 2008 to 2011 likewise Calabar port. The PH port showed an increase and decrease in throughput throughout the study period.

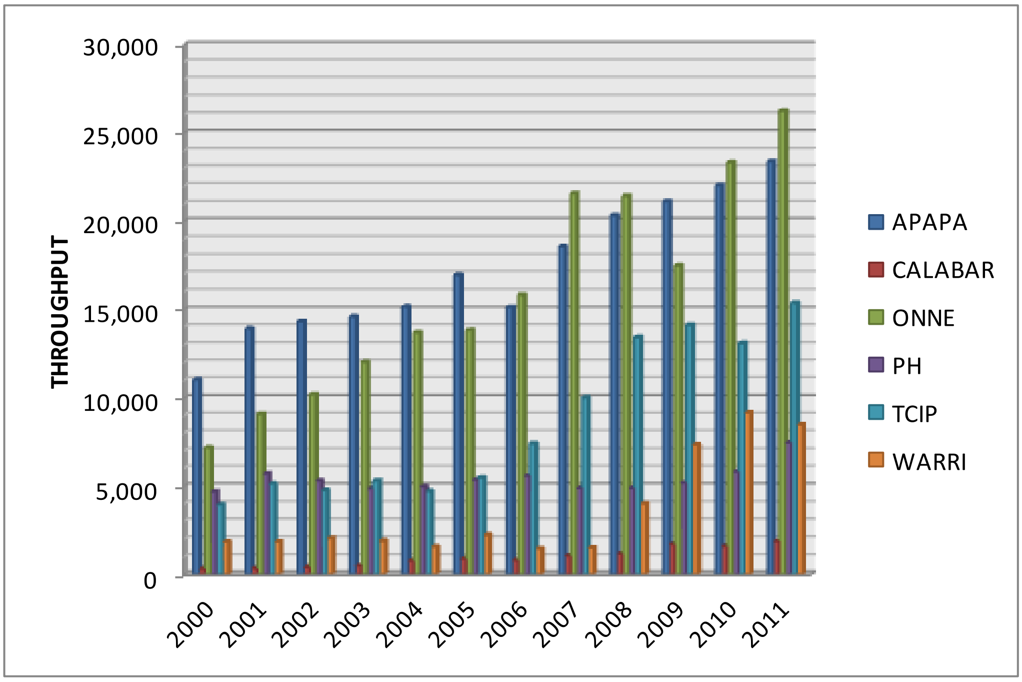


Figure 6.2: Nigerian ports' throughput in million tonnes (2000-2011)

Figure 6.3 shows an increase in throughput in all the ports after concession. The port with the highest growth rate of 64.3% is Warri; it is followed by the Calabar port at 61.7% and closely by the TCIP 60.1%. The Onne port increased by 47.6%, the Apapa port by 28.7%, the least is PH port with 8.8%. The high growth rate in throughput of Warri port is attributable to both the concession and the return of normalcy to the Niger Delta region due to the Amnesty granted to the militants, which led to shippers patronising the port again.

The Apapa port is the biggest port in the country, with a total throughput of almost 85.9 million tonnes between 2000 and 2005 (pre-concession period). It increased by 28.7% to approximately 120.6 million tonnes between 2006 and 2011 (post-concession period).

Notwithstanding that, the Apapa port grew by 28.7% after concession, though the yearly growth rate is lower during the post-concession period compared to the pre-concession. The main reason for the slow growth rate of the Apapa port is the creation of five new container terminals, four in the TCIP and one in the Onne port as a result of privatisation through concession contracts. Prior to concession, the Nigerian port market was served by one container terminal, the Apapa Container Terminal (CTL), now the A.P. Moller Terminals (APMT). As a result of the entrance of new operators into the market, some customers of Apapa container terminal switched a reasonable amount of container traffic to newly created terminals. This is evident from the post-concession throughput of 120.5 million tonnes, which is 4.2% lower than the Onne port's throughput of 125.8 million tonnes. The other ports achieved a growth rate of two-digits in throughput for the period under study, except the PH port where the growth rate was only 8.8%

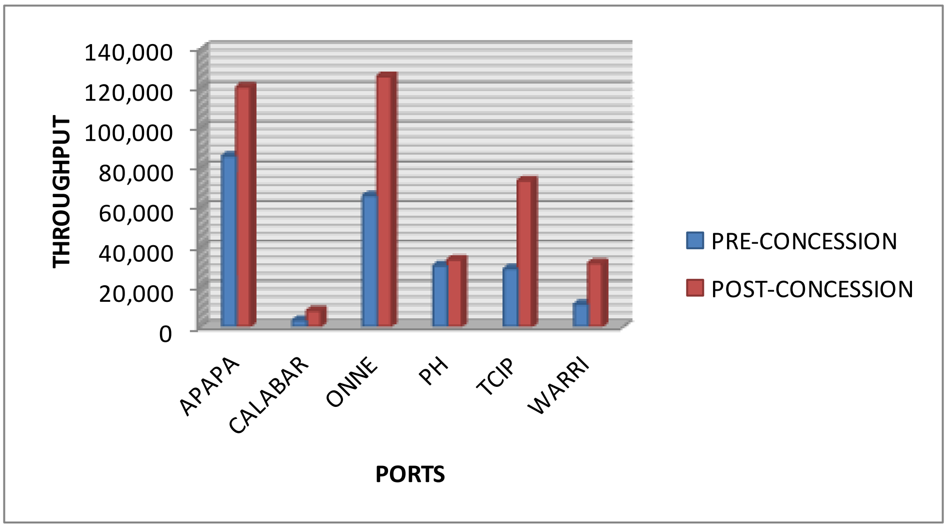
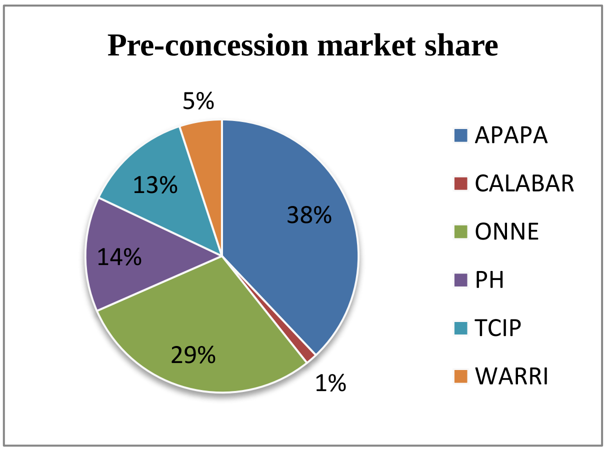


Figure 6.3: Nigerian ports Pre- and post-concession throughput in million tonnes

6.3.2 Nigerian ports market share

Figure 6.4 shows the pre- and post-concession market share of each of the ports understudy, calculated as a percentage of the total throughput of the six ports understudy for the two observed periods. The Apapa port was clearly the market leader prior to concession and it is the Onne port after concession. As explained earlier the Apapa port has lost some its market share to the newly created container terminals in the TCIP. Onne has gained greater market share as the main operator Intels has acquired two more terminals in the Warri and Calabar ports. As the operator has not started full utilisation of the newly acquired terminals, it handles cargo meant for these terminals in the Onne port thereby boosting the throughput of Onne. As Figure 6.4 indicates, the Apapa port's loss became the TCIP's gain and increased market share. The Calabar and Warri port market shares increased after concession, while the PH port decreased considerably. The operation of the PH port by indigenous terminal operators may have affected the fortunes of the port considerably. Although market share and throughput are important factors in determining the competitiveness of ports, however, port location also have a substantial impact in determining port attractiveness to shippers and competitiveness.



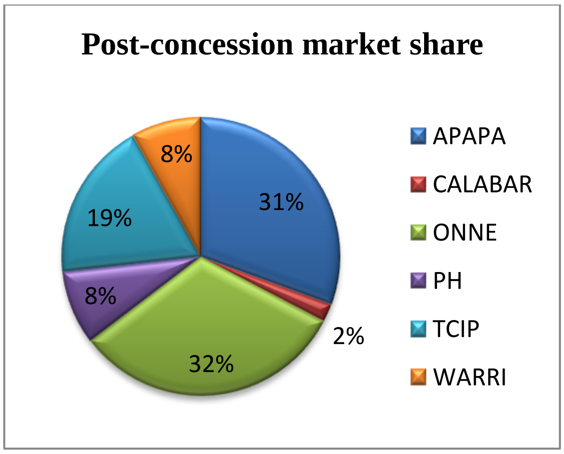


Figure 6.4: Nigerian ports pre- and post-concession market share

6.3.3 Nigerian ports market concentration

As observed previously, the HHI is a measure of size of firms in relation to others in the same industry. It is also an indicator of the level of competition among firms in the market. Table 6.4 shows that the port market is not concentrated as the HHI is below 1000, except the Apapa port before concession and the Onne port after concession which are moderately concentrated. According to Cariou (2007), a decrease in the HHI is an indicator of the loss of pricing and bargaining power among firms and an increase in the competition, while a decrease indicates the opposite. Table 6.4 shows that the post-concession HHI is relatively smaller (2450.65), which is a pointer that the port market in the post-concession period is moderately concentrated. The Apapa and Onne ports account for over 62% of the total market share which implies that the two ports are in an oligopolistic position. TCIP controls another 18.64% and the remaining 20% of the market share is controlled by the PH, Warri and Calabar ports. The high HHI index for pre-concession reveals little or no competition between the market players during that period. It gave credence to the oligopolistic position of the Apapa and Onne ports with market shares of 37.9 % and 29.11% respectively, giving the two ports 67% of the market during that period. The PH and TCIP ports control 13.6% and 12.9% respectively, while the Calabar and Warri ports control 1.38% and 5.04% respectively. The weak competition among ports during this period may have had negative impact on port customers, in terms of service quality, port dues and terminal handling charges.

Table 6.4: Nigerian ports pre-and post-concession market concentration

PORT	THRUP Pre-concession	THRUP Post-concession	MARKET SHARE Pre-concession	MARKET SHARE Post-concession	HHI Pre-concession	HH1 Post-concession
	('000 tonnes)	('000 tonnes)	%	%		
APAPA	85,874	120,478.40	37.93%	30.62%	1438.80	937.43
CALABAR	3,123.00	8,151.00	1.38%	2.07%	1.90	4.29
ONNE	65,896.24	125,779.40	29.11%	31.96%	847.23	1021.74
PH	30,832.25	33,790.70	13.62%	8.59%	185.48	73.74
TCIP	29,257.00	73,362.90	12.92%	18.64%	167.01	347.59
WARRI	11,409.59	31,933.53	5.04%	8.12%	25.40	65.86
TOTAL	226,392	393,495.93	100.00%	100.00%	2665.81	2450.65

6.4 Conceptualization of the theoretical model for operational performance

In order to investigate the determinants of operational performance for Nigerian ports, this study proposes two equations based on the two main factors that influence the performance of seaports i.e. efficiency and port size measured in throughput levels. The model is adapted from Cheon (2007b) and Tongzon (1995).

$$\boldsymbol{EFF = f(TEU \times COM \times OWN \times el)}$$ **Equation 6.1**

Where:

EFF=Port efficiency

TEU=Port throughput (economies of scale)

COM= Intra-port competition at terminal level

OWN=Port ownership

e1=Error term

We derive equation 2 from the determinants of throughput at port level:

TEU = g $(EFF_{t-1} \times WHR \times DEP \times PCTR \times NOS \times PC \times SEC \times e2)$ **Equation 6.2**

Where,

EFF_{t-1} = Port efficiency at previous period

WHR = Service flexibility (24-hours service)

DEP = Berth depth

NOS = Total number of ship calls

PC = Port charges

SEC = Security

PCTR= Port city relationship

e2 = Error term

Equations 6.1 and 6.2 raise some econometric considerations which can be resolved by assuming that a port's output can be endogenous in the relationship among the variables. Thus, by taking this perspective, the complex relationship between port production scales, port efficiency, port ownership and other exogenous variables could theoretically be resolved.

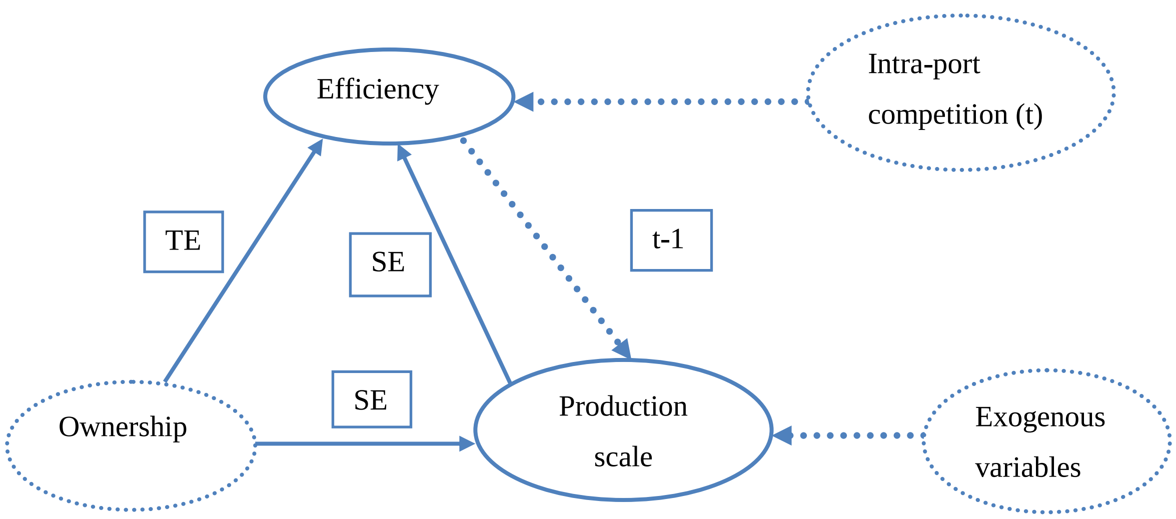


Figure 6.5: **Causal path diagram: Recursive model**

Figure 6.5 demonstrates that the port efficiency at a previous period could be a factor in determining port output increase at time t, by attracting more cargo. Shippers generally choose ports with high efficiency, superior service and lower port charges than their competitors, based on previous knowledge and experience. At the same time, large-scale output at time t could in turn result in higher efficiency at that moment, as a result of economies of scale from the DEA analysis in Chapter 5. Although there is the existence of a loop between port efficiency and port throughput in Figure 6.5, the time of occurrence differs. In addition, it is observed that the error terms from the different equations are independent; this puts equations 6.1 and 6.2 for port efficiency and port output in a recursive path.

Therefore, to estimate the operational efficiency of Nigerian seaports is the hallmark of this section and the following structural forms are adopted for the models:

First stage

$$\widehat{TEU} = C.EFF_{t-1}^{Y1}.\ DEEP^{1/2}.\ PCTR^{1/3}.\ NOS^{1/4}.\ WHR^{1/5}.\ SEC^{1/6}$$ **Equation 6.3**

Second stage

$$\widehat{EFF} = C.\widehat{TEU\_P}^{\beta 1}.COM^{\beta 2}.OWN^{\beta 3}$$ **Equation 6.4**

Where $\widehat{TEU}$ refers to a projected value of TEU from the 1st stage, c refers to constant terms and the error terms are assumed to be normally distributed with constant variances.

From the models, the equations exhibit non-linear relationship, for the equations to comply with the linearity assumption needed for multiple regression estimation the respective natural logarithms are taking. The conceptualized models show that port efficiency is determined by scales of production and change in ownership.

6.5 Factors Influencing Port Efficiency

6.5.1 Port ownership

From Figure 6.5, the influence of port ownership is in two directions. First the creation of terminals from existing ports and the transfer to private operators has induced competition among and between the terminals, which in turn influences terminal efficiency. In other words, the separation of the public port authority from terminal operation, through concession, could affect the efficiency of ports through behavioural changes in terminal operations and management. It is evident that the private sector participation through concession contracts impacted on the technical efficiency of Nigerian seaports from the DEA and MPI analyses in Chapter 5.

Again port ownership could influence port efficiency by increasing production scales (scale efficiency). It is because through leasing and concessions, global terminal operators are attracted to bring in the much needed investment required to finance new construction and expand existing ones. It could lead to ports handling more outputs that will eventually increase economies of scale. Thus, port ownership could theoretically be conceptualised as one of the dependent variables, for both models of port efficiency and port throughput.

In the efficiency model, port ownership is captured by dummy variables (0=Public Operating and 1=Landlord). Therefore, the sources of the Nigerian ports' efficiency could be attributed to intra-port competition at the terminal level as well as the concession of terminals to private operators and port size.

6.5.2 Level of port competition

Another factor that influences the post-concession Nigerian ports' efficiency is competition. It involves the assessment of the market power of the terminals. The degree of competition among or between the ports is captured by the HHI attempts to assess the market concentration of each port, as a yardstick for potential competition among or between the ports. Since the delineation of ports into terminals for privatisation induces intra-port competition among or between terminals, that enhances port efficiency. Another aspect envisaged by the Nigerian ports' concession is the introduction of inter-port competition. However, this has not been achieved as the unbundling of the NPA into autonomous port authorities is yet to take place.

6.6 Determinants of Throughput

Apart from ownership and competition discussed above, another factor that influences the efficiency of Nigerian seaports as suggested by the analysis in Chapter 5, is the scale of production (throughput/cargo size). Ports tend to be more efficient when they have higher production scales and can enjoy the benefits of economies of scale. The scale of production is modelled in the first stage based on the factors that previous analyses suggest as affecting port size. It includes; terminal efficiency, frequency of ship calls, terminal depth/draught, location, port charges, measures to reduce ship turnaround time (introduction of 24 hour service) and security.

Terminal Efficiency

The operational efficiency of ports that is a measure of the ratio of output influences the efficiency of ports. A port could be considered efficient based on the previous knowledge and experience of port users. As a result, more shippers are attracted to the port, which in turn increases the throughput level.

Terminal depth/draught

Depths of berth and approach channels determine the type of ship that calls in a terminal. Therefore, the berth depth is a factor in attracting bigger ships and Post-Panamax vessels that allow ports to reap the benefits of economies of scale. In West Africa, WAFMAX with a 4500 TEUs capacity is the largest container ship that visits the region, but only calls at selected ports with a high draught (Apapa-Nigeria, Walvis Bay-Cote d'Ivoire and recently at Onne-Nigeria). That is why a large chunk of infrastructural investment in ports is for dredging in order to increase the chances of attracting bigger vessels. Since the lack of deep water ports and facilities prevents large ships from calling at ports (Tongzon, 2002; Tongzon & Heng, 2005).

Frequency of ship calls

The number of vessels that call at a port is a critical factor, as it influences the volume of cargo that can be moved through the port. Plus the increased frequency of ship calls is attractive to importers and exporters. The inclusion of frequency of ship calls as determinant of throughput is supported by studies carried out by Slack (1985) and Bird and Bland (1988) on port choice criteria. In each of the studies, the increased frequency of ship calls was ranked first as the most important criteria that freight forwarders consider in port choice.

Port Charges

Another important factor that influences cargo size is port charges, although shippers are more concerned with indirect costs associated with delay, loss of market or market share, loss of customer confidence and opportunities forgone due to inefficient service. In Nigeria, the issue of port charges has been particularly problematic due to multiple agencies involved in cargo clearing. It has contributed to the tag of Nigerian ports as one of the most expensive ports to do business in the World. The problem of multiple charges is captured by Niyi Labinjo, the General Secretary of the Indigenous Ship Owners Association of Nigeria (ISAN), in the following statement:

"*Shipping cost contributes about 40 percent to the total import transaction, where the transport element is just 11.5 percent. The other costs are associated with the handling costs because there is a problem of double handling. So, our shipping cost is 40 percent, whereas Europe's cost is five percent, including the handling costs. The transportation element in our case is 11.5 percent of the total cost of goods. The other 28.5 percent comes in as a result of double handling, where more than one agency or contractor is doing one job".*

Although it is an important factor, it is not included in the final model due to the unavailability of data.

24-Hour Service

Proactive measures to improve the turnaround time of ships, for instance, the 24-hour service, when adopted by ports, ensures that vessels are attended to, as they arrive. Such actions, attracts shippers to the terminals and improves the throughput levels. The effect of this service is captured by ordinal values, by assigning 1 if a terminal practices 24-hour service and 0 if the terminal does not.

Security

Another important factor that is considered by shipping companies in the choice of port of call is safety (Tongzon, 2002). As ships will not call at ports where the safety of the vessel, cargo and crew, is not guaranteed. If ships do not call, cargo will not be discharged, and this will impact on the throughput of the ports. The advent of militancy in the Delta region of Nigeria where some of these ports are located, makes security an important issue in considering determinants of throughput levels in Nigeria. It is indicative of the low throughput of the Warri and Calabar ports, especially in the heat of the militancy in 2006 and 2007. The influence of security is captured by a dummy variable. If the port is located in the Niger Delta region with a high incidence of kidnapping and youth militancy, a value of 1 is assigned, while ports located outside the security prone zone are assigned zero (0).

Port-city Relationships

The closest cities to a port are its direct economic hinterland. Moreover, efficiency could be conferred on ports as a result of the economic performance of the surrounding cities. Therefore, the social and environmental issues that accompany port cities influence the efficiency of ports located therein or nearby. Thus, a non-acrimonious and sustainable relationship between city and port is necessary for ports to achieve higher efficiency. In addition, the resources in terms of skilled labour that a port requires to enhance its competitiveness are sourced from port-cities. In line with this, for ports to increase their outputs, port-cities need to prosper in economic and demographic terms. Consequently, it is projected that the larger populations of port-cities could attract more cargo to ports.

6.7 Result of the Regression Analysis

The OLS result of equations 6.3 and 6.4 are presented in table 6.5. As the DEA efficiency is non-negative, and there are no zero values in the equation, therefore the dependent variable cannot be said to be normally distributed. Therefore, to allow for a parameter estimation by multiple linear regressions, both equations are made linear by taking their respective logs (Cheon, 2007b; Tongzon, 1995; Windle & Dresner, 1995).

6.7.1 First Stage: Port output model

Table 6.5 shows the result of the first-stage ordinary least square regression (OLS). It indicates that most of the variables are significant except for service flexibility, captured by the 24-hour service that is not statistically significant at the 5% level (Appendix 6.10 and 6.11). Berth depth is one factor that influences the throughput level of Nigerian seaports, followed by terminal efficiency. Other factors include the number of ship calls, security and also geographical factors captured by the population of the state in which the port is located, as the closest hinterlands are also significant at the 5 percent level.

Table 6.5: Results of the OLS estimation

	Dependent Variables		
	LNTHRU (Throughput)	LNDEA (Port Efficiency)	
Explanatory	Coefficients (a)	Variables	Coefficients
CONSTANT	9.69 (-)	CONSTANT	0.103 (-)
LNEFF	0.610 (+)*	LNTHRU_P	0.426 (+)*
LNDEP	1.899 (+)*	LNCOM	0. 085 (+)
LNCALLS	0.490 (+)*	OWN	0.403 (+)*
SECURITY	0.390(+)*		
24HRS SERVICE	0.014(-)		
LNPCTR	0.541 (+)*		

LN (EFF=CCR efficiency scores, DEP=Channel depth, CALLS=Total number of ship calls, PCTR=Population of port city), Security= Dummy representing security challenge of port location (0, 1), 24HRS service=Dummy which is 1 if a port has adopted 24hours service and 0 if it has not, LN TEU_P= Predicted throughput obtained from first stage regression, COM=competition level represented by yearly market share values, OWN=Ownership dummy, 0=public ownership and 1= for private (landlord), *=statistically significant at the 5% confidence level

6.7.2 Second stage OLS: Port efficiency model

To predict the effects of the concession (captured by change of ownership) on Nigerian ports efficiency, second stage OLS regression analyses were conducted on Equation 6.4. The null hypothesis is that the amount of explained variance is zero. The F-score that indicates the probability of arriving at a model based on the sample data under the hypothesis is almost zero (2.855E-23) (Appendix 6.13). The analysis shows that the efficiency of Nigerian ports is a function of throughput (measure of production scale), competition and ownership. The R-Square indicates that the predictors (throughput, competition and ownership) taken together, explain more than 79.4% (R-Square value) of the variance in efficiency due to throughput, competition and ownership change. The F-score indicates that there is some element of a relationship between the predictors and the dependent variable (efficiency). To determine the influence of each predictor (throughput, ownership and competition) on performance of

Nigerian ports. The coefficients derived from the log-transformed regression model give an indication of the expected change in efficiency, relative to one unit change in the individual predictors holding all others constant, while the P-value gives the level of significance.

The result of the second stage log-transformed regression (Table 6.5) shows that the coefficient of the three variables indicates a positive sign as expected. The coefficient of throughput indicates that a one percent change in throughput results in 53 percent (exponential of throughput coefficient 0.426) change in efficiency, holding ownership and competition constant. However, as ownership is an indicator variable, a switch from public to private ownership results in a 49.7 percent (exponential of ownership coefficient 0.403) change in efficiency, holding the other two variables constant. Additionally, a one unit change in competition leads to a 0.09 percent change in efficiency (exponential of competitive level coefficient 0.085), holding throughput and ownership constant. A focus on the p-values at the 5% significance level shows that $p=0.027$, 0.340 and 0.001 for throughput, competition and ownership respectively, indicating that competition is not significantly correlated to Nigerian ports efficiency at the port level. The researcher has demonstrated above that the HHI decreased slightly after concession, indicating that the adoption of the Landlord model of port administration has ushered in a semblance of competition in the Nigerian ports' market. However, taking the predictors (production scale, competition and ownership) together shows that the influence of competition on the overall efficiency is not statistically significant.

Although there is a decrease in concentration index after concession, the effect of the induced competition is not significant in the presence of throughput and ownership. Therefore, it is included in the efficiency model (Equation 6.1), because it is part of the theoretical explanation for a seaport's efficiency. The researcher concludes on the basis of the data that the level of competition captured by the HHI does not appear to have a direct effect on the efficiency of the Nigerian ports. At the same time, we can say that production scale captured by the throughput volume and change of ownership from public to private, has an influence on efficiency, independent of competition.

Another important factor is the throughput (scale of operation) of the ports, in other words the economies of scale that accompany handling large amount of cargo is an important determinant of the Nigerian ports' efficiency. The fact that the size of the port expressed by throughput levels influences the efficiency of operation has been demonstrated in chapter 5, which indicated a high and positive correlation between size and efficiency.

In the previous bivariate analysis it was reported that the Landlord port model was more efficient than the Public and Mixed port models, this assertion has also been confirmed by the results of the second stage OLS analysis. The results show that the influence of ownership on the Nigerian ports' efficiency is statistically significant. This is in conformity with previous studies of port ownership change in Asia, North America, Europe and Latin America by Cullinane and Song (2001); Ircha (2001); Notteboom and Winkelmans (2001a); Hoffmann (2001), and Cullinane et al. (2005a). The authors argued that the transfer of port operations from the public to the private sector improved the efficiency of the ports in those countries.

In summary, the results indicate that the primary drivers of a Nigerian port's efficiency are port size captured by throughput levels and the change in ownership of cargo handling operations. The influence of competition as captured by the concentration index on efficiency of the ports is statistically insignificant. It shows that the mere transfer of terminal operations from public to private, without judicious implementation of the accompanying institutional reforms and an active regulatory oversight, will not induce competition in the ports' sector. Therefore, identifying the factors responsible for improved performance of the Nigerian ports after concession from the result of analyses, it is possible to identify the roles of ownership change, port size (economies of scale) and the statistically insignificant contribution of port competition.

6.8 The Impact of Concession on Key Port Performance Indicators

The interviews of the various stakeholders in the Nigerian ports' industry revealed general unhappiness, which stems from the failure of the NPA to regulate the terminal operators, so that the gains achieved from port concession, can be transferred to shippers and other customers in the form of reduced charges, or improved services. For example, six years after the concession, the cost of doing business is still higher than its rivals in the sub-region (see

Table 6.6). The shipping agency fee in Nigeria is more than that of Ghana by 33.5% and 236.5% more than the Benin Republic. The container clearing fee in Nigeria is four times that of Ghana, while it is more than twice that of the Benin Republic. This list goes on and on.

Table 6.6: Comparison of port charges in West Africa

Port Charges	**Countries (Naira)**		
	Benin Republic	Ghana	Nigeria
Shipping line agency fee	7,875	17,600	26,500
Manifest amendment fee	9,450	2,400	18,000
Container Clearing fee	945	500	2,000
Demurrage (First period)		1,512	2,850
➢ **(Second period)**		1,890	3,000
➢ **(Third period)**		1,890	4,500
No of days free of dwell time	7	7	3

Source: Fieldwork (2011)

6.8.1 Port Charges

Adopting a business perspective for port systems implies that the optimal cost should be determined based on the level of port services (Mahrouz & Arisha, 2009). After all the port charge is a full recovery, that is applied to port users to cover port sunk costs (Luo & Grigalunas, 2003; Martin & Thomas, 2001). The need for continuous monitoring of port charges so that they do not spiral out of control cannot be overemphasised. In addition, service quality and time costs are the primary factors that determine the demand for port services (Dasgupta & Ghosh, 2000; Gardner, Marlow, & Pettit, 2006). Though port demand is also affected by other factors, such as an international trade pattern and the geographical location of the port with respect to sources and markets. As well as the availability of multi-modal transportation networks and the associated general total cost (Luo & Grigalunas, 2003). The most knotty issue after concession, between the shippers and terminal operators, is port charges. As it has continued escalating without any sign of abating due to the lack of a commercial regulator to oversee the activities of the various stakeholders in the port.

The interviews with the stakeholders (shipping companies, freight forwarders) revealed that the increase in tariffs after concession has seen an astronomical rise in the cost of doing business in Nigerian ports, mainly due to the costs of clearing and demurrage. Interviews with Chief Nweke, the National president of National Association of Government Approved Freight Forwarders (NAGAFF) and Mr. Olayiwola Shittu, the Chairman of Association of Nigerian Customs Licensed Agents (ANCLA) revealed a rising cost of clearing containers. For instance, the cost of clearing a 20-foot and a 40-foot container in the Lagos ports has increased by 5.97 and 6.61 times respectively. The interviewees were of the view that the astronomical increase cannot be explained away by inflation, as inflation has remained below 2-digits for most of the period. Table 6.7 shows the pre- and post-concession costs of clearing containerised cargo and the accompanying demurrage (extra charge on goods for staying in the port beyond the grace period granted by law).

Table 6.7: Costs of clearing containers at the Lagos ports

Activity	**Pre-concession (Naira)**	**Post-concession (Naira)**	**Increase**
Total Clearing cost: 20-Foot container	11,715.50	70,000	5.97 times
40-Foot container	18,158.50	120,000	6.61 times
Demurrage (First Phase after 6 days)	95	900	9.47 times
(Second phase after 12 days)	250	4200	16.8 times
(Third phase beyond 12 days)	1300	6000	4.61 times

Source: Fieldwork (2012)

6.8.2 Labour issues

Figure 6.6 shows the total yearly staff strength on the NPA from 2000-2011. The figures from 2000-2005 indicate the staff strength of NPA before privatisation, while those for 2006-2011 represent the total number after concession. The post-concession figures represent both the staff of the NPA and the terminal operators. In 2006, 75 percent of the NPA staff was disengaged, which reduced the workforce from 12,716 in 2004 to 4,012 in 2011. The difference between the staff strength of the ports in 2006 (6,024) and the total number of the NPA employees (4,012), gives the staff strength of the terminal operators in the first year. In the short term, the number of staff was reduced drastically, as the terminal operators, take-over the control of terminals. The number of staff started to increase, with the improvements in traffic levels, due to new recruitments by the terminal operators. This in tandem with the findings of Brooks and Cullinane (2007), which revealed that short-term employment suffered after the privatisations in Argentina, Columbia, Mexico, and Brazil.

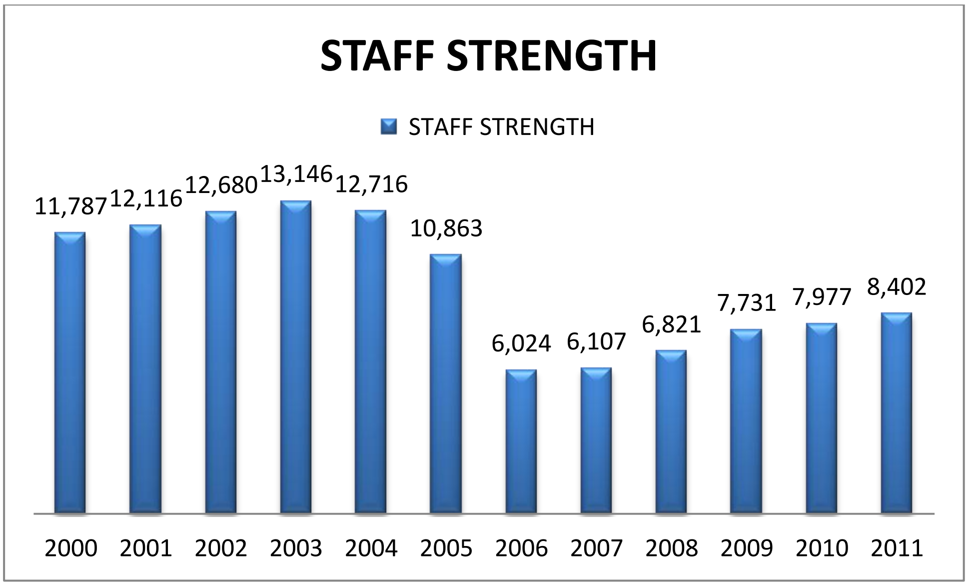


Figure 6.6: Pre- and post-concession Nigerian ports' labour force

Source: Researcher's fieldwork (2012)

6.8.2.1 Throughput

All the three cargo types (Container, Dry Bulk and General Cargo) exhibited fluctuations after privatisation. Figures 6.7, 6.8 and 6.9 show an increase in the throughput levels for containers, dry bulk and general cargo. In terms of containers, the main container terminal at Apapa port, considered the highest single port concession transaction in the continent, was awarded to the APM terminals to manage. It has the mandate of increasing capacity from 220,000 TEUs per annum to 1.6 million TEUs. Within months of taking over the terminal, the delays for berthing spaces at the terminal have been reduced significantly. It culminated in shipping lines dropping the congestion surcharge from 525 to 75 Euro per TEU which has saved the Nigerian Economy US$200 million per year.

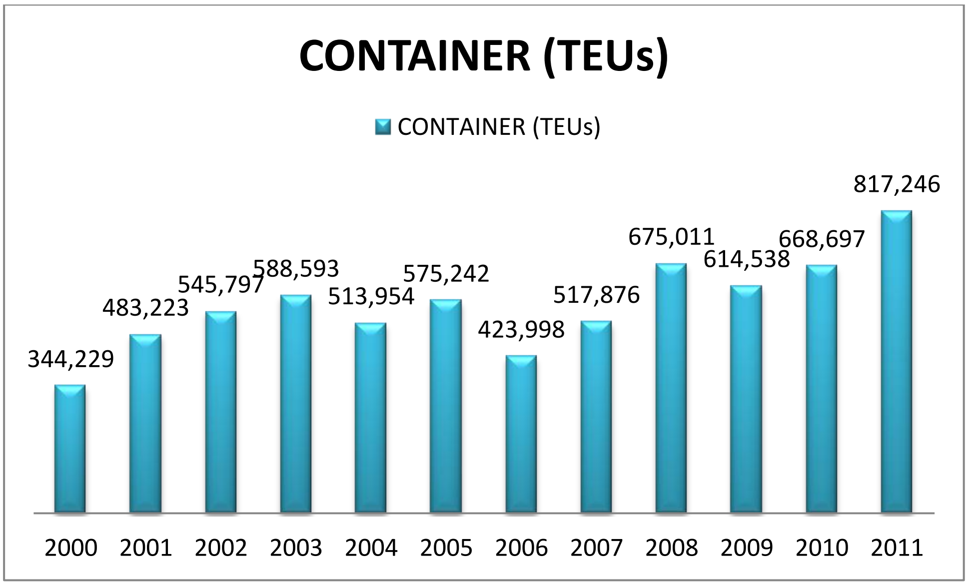


Figure 6.7: Pre- and post-concession container throughput

Source: Researcher's fieldwork (2012)

By 2009, new gantry cranes had been brought in that triple the capacity of the port. The new equipment can handle more than 500 containers per day for customs examination and at the end of the day most of them are returned for stacking. By January 2009, the port was clogged with uncollected containers. By the end of February 2009, the situation had become so severe that the Managing Director of the NPA announced a temporary suspension of ship entry with immediate effect. The suspension that lasted until the middle of April was to clear what the NPA described as an alarming "backlog" of uncollected containers. The customs controller in the Apapa port blamed the backlog on the 100 percent physical examination of cargo, due to false declarations and concealments by importers. However, this is not the only problem as even cleared containers were left uncollected. This is evident from the 9741 containers waiting for delivery to shippers by end of January 2009; 851 of these had been cleared by customs, all charges paid and all documentation completed. To force the importers to move their containers out of the port the NPA imposed a demurrage surcharge of US$ 4 per TEU for all uncollected containers. The agents blamed the delay on the inability of shippers to move out the cleared containers and the lack of trucks. The Apapa port case is an example of how privatisation, unaccompanied by related reforms from other relevant sectors, could impinge on the efficiency.

The dry bulk cargo category also recorded an increase in throughput, but not so high compared to the containers and general cargo terminals. This may not be surprising, as most of the bulk terminals are dedicated terminals and the growth in throughput is dependent on the demands for the product in the economy. For instance, as Nigeria intensified its efforts to produce the quantity of cement needed by the country locally, the importation of bulk cement reduced drastically. Figure 6.8 shows the fluctuations in throughput for both pre- and post-concession periods.

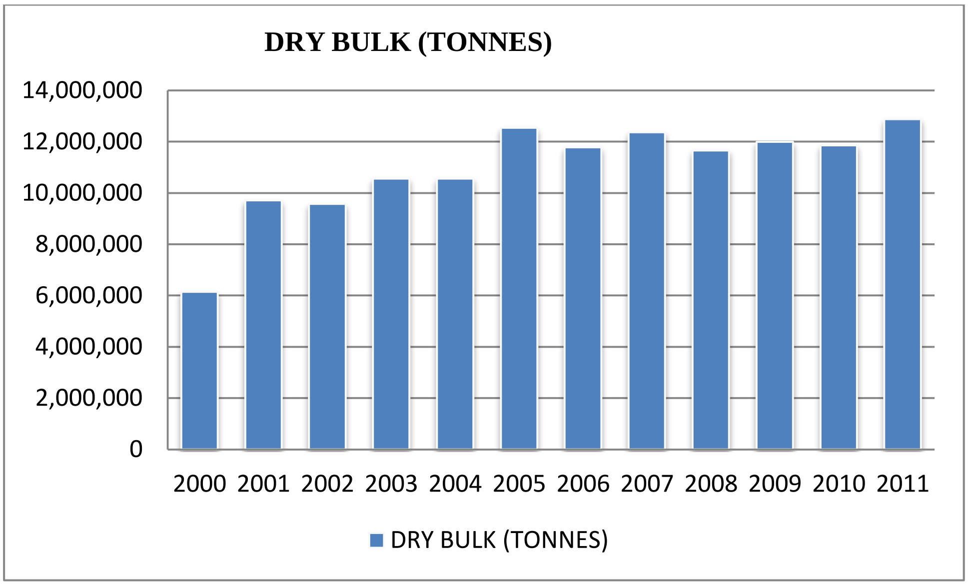


Figure 6.8: Pre- and post-concession DBC throughput

Source: Researcher's fieldwork (2012)

The general cargo throughput showed a remarkable increase after privatisation (Figure 6.9). As observed previously, ports in developing countries still handle a large volume of general cargo, because containerization has not taken foothold in those countries as in developed countries. Nigeria is no different, as general cargo still accounts for the largest volume in terms of throughput. General cargo accounts for the highest growth in throughput after concession.

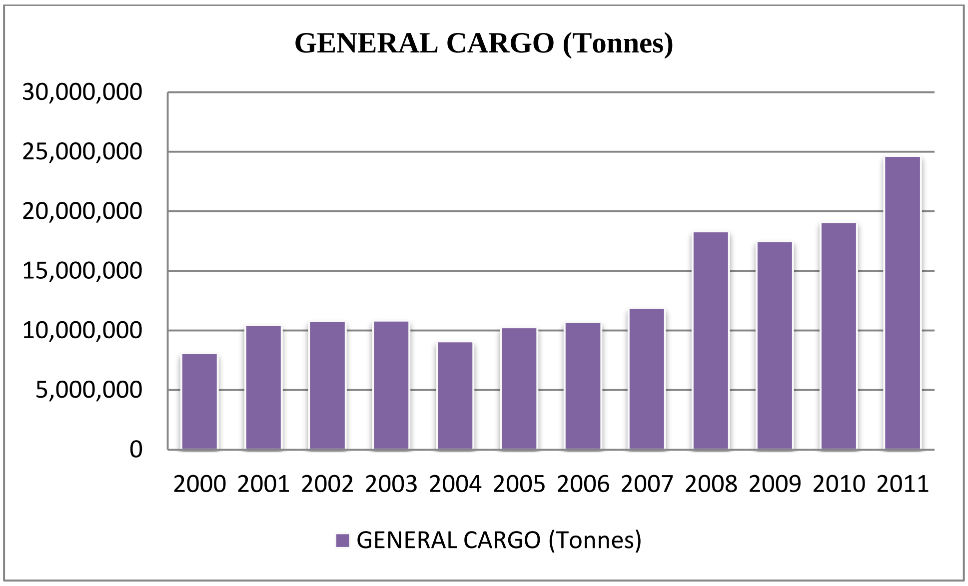


Figure 6.9: Pre- and post-concession GC throughput

Source: Researcher's fieldwork (2012)

6.8.2.2 Turnaround Time

There are a broad range of studies on the outcome of privatisation programmes, particularly in Europe and Asia, on port efficiency and the productivity of ports. However, the researcher came across only a single study (Ducruet & Merk, 2012) that examined container vessel turnaround times across the World. Though the study dwelt more on China, even that the survey only gave a snapshot, as it was based only on the average turnaround time (ATT) for the month of May. Despite that, the turnaround time is regarded as a key indicator of efficiency. Average turnaround time (ATT) is simply the average difference between departure and arrival dates of all ships calling at a port (or country), within one year (Ducruet & Merk, 2012). A review of the container vessels' turnaround times for 1996, 2006 and 2011, showed some surprising twists (Ibid). In 1996, ports with a high efficiency in terms of ATT were located in Western Europe, while the worst performing ports were in the former socialist countries (Cuba, Ukraine, the Baltic States, Poland, Russia, India, Vietnam, North Africa). In addition, Canada and Austria also ranked low, while Japan ranked highest among the countries handling large traffic volumes (Ducruet & Merk, 2012). In comparison to the Asian, European and American countries, African ports lagged behind.

A decade later (2006), the East-West dichotomy has faded away as former socialist countries have improved their rankings considerably, except for Cuba and Vietnam, while the efficiency of African ports has worsened. There were also noticeable, but gradual improvements, in Russia, Brazil, Canada and Turkey. In 2006, China was a major exception; it has the highest number of vessel calls but very low efficiency. The profile of China changed entirely in 2011; it has reached the first rank in terms of number of calls, with an ATT of 0.96 days, compared with 5.8 days in both 1996 and 2006. This change is remarkable compared to the more gradual change in some large countries and the stagnation of others (India, Indonesia and South Africa). China's performance is below Hong Kong (0.72 days), Taiwan (0.71 days) and South Korea (0.68 days). However, it performed better than Singapore (1.16 days) and the United States (1.02 days). On the other hand, Africa as a whole lags behind the World average; most of its ports exhibited very long ATT in 2011, with the exception of Morocco and Egypt. While the ports with the worst efficiency scores based on ATT are Kolkata (India), Mombasa (Kenya) and Algiers (Algeria); for the whole period under review, African ports consistently obtained low efficiency scores. The Nigerian container terminals are still below 1million TEUs per annum. They are not ranked among the busiest container ports. Despite that, the evaluation of the average turnaround time achievable at the ports is of paramount importance, as Nigerian ports are notorious for congestion.

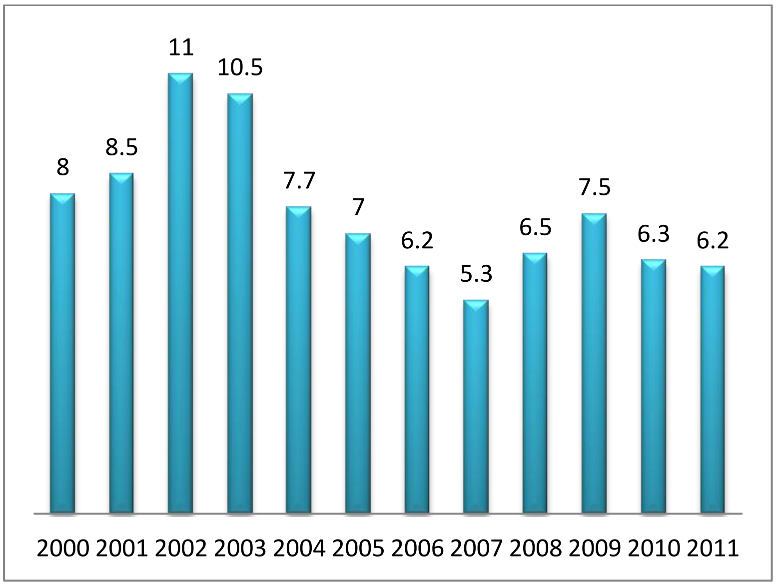


Figure 6.10: Pre- and post-concession average time efficiency of Nigerian ports

Source: Researcher's fieldwork (2012)

One of the primary objectives of the Nigerian port privatisation is to reduce the turnaround times of ship at the nation's ports, as the ATT of vessels was considered high in comparison with other neighbouring ports and constituted an obstacle to trade (Palsson & Leigland, 2007). Figure 6.10 shows the average yearly turnaround of different cargo vessels (Multipurpose, Container and RORO) in Nigerian ports, from 2000-2011. The average turnaround of multipurpose ports has gradually reduced from an all-time high of 11days in 2002 to 6.2 days in 2011. The lowest turnaround time of 5.3 days was recorded in 2007, a year after the private operators took over the operation of the terminals. Although there are some improvements, it is still considered very high. There are also diverse differences in ATT among the different ports in Nigeria. While the ports of Lagos (Apapa and TCIP) and Onne showed significant improvement after privatisation, the PH port's improvement was gradual, the Calabar port's improvement was fluctuating and the Warri port's efficiency deteriorated.

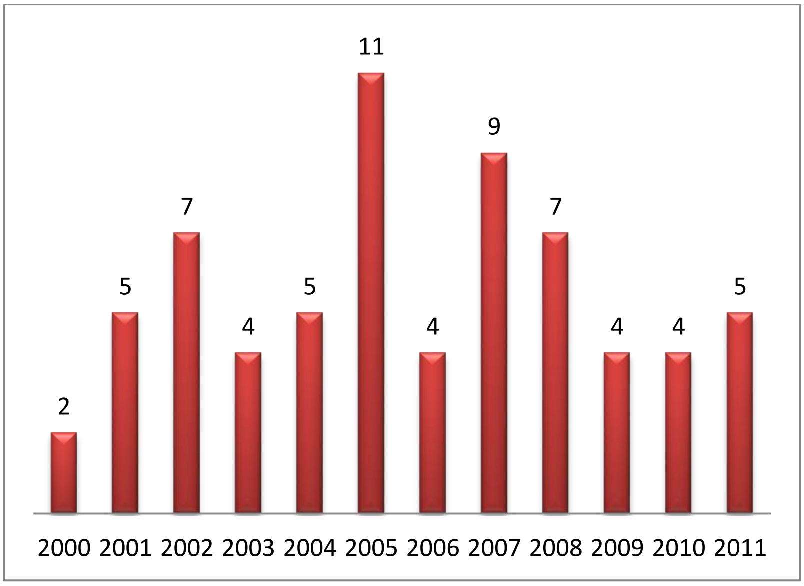


Figure 6.11: Pre- and post-concession time efficiency of container terminals

Source: Researcher's fieldwork (2012)

There is no remarkable improvement in the ATT of container vessels after privatisation (Figure 6.11). The best ATT achieved after privatisation is four days, while the highest is 9 days in 2007, which the APM terminal operator attributed to the constant breakdown of the equipment inherited from the NPA. When new and modern cranes were brought in, the ATT reduced to 4 days in 2009 and 2010 and then moved slightly higher to 5 days in 2011.

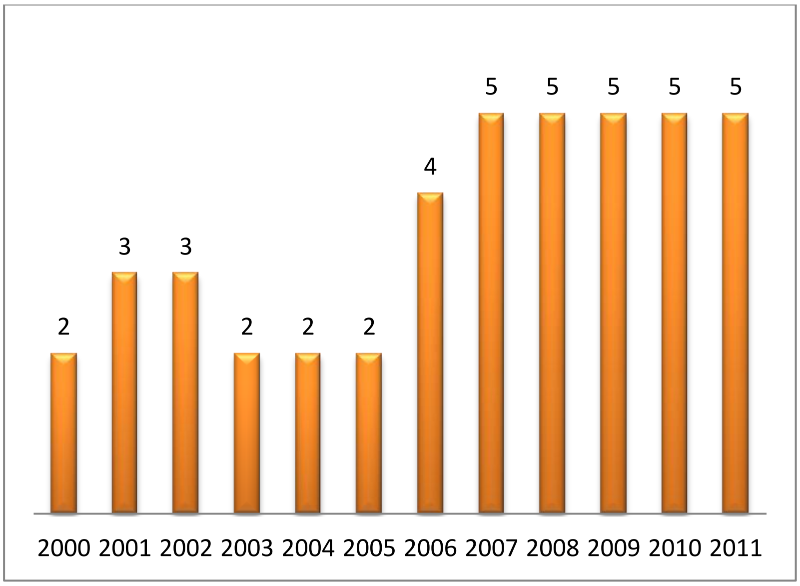


Figure 6.12: Pre- and post-concession time efficiency of RORO terminals

Source: Researcher's fieldwork (2012)

For the RORO terminals, the efficiency based on ATT decreased after privatisation (Figure 6.12). The lowest ATT achieved after privatisation was 4 days and the highest 5 days. For the pre-concession period, the lowest and highest were 2 and 3 days respectively. However, privatisation does not on its own improve the time efficiency of ports. Other approaches designed to improve ship-to-shore operations and other terminal services and functions need to be in place. Ship-to-shore operations can be enhanced by employing vessel queuing systems, the modernisation of equipment that can improve the speed of operations (double cycling, tandem and multiple lift cranes) and skilled manpower capable of achieving high crane productivity rates. Ship-to-shore operations are largely interlinked with other terminal operations, including yard equipment, terminal surface, storage capacity and terminal planning. These can constitute obstacles that affect the turnaround time of ships. Ship turnaround can be improved if the general conditions in the whole port area are favourable. It includes good intermodal connections with the hinterland within an integrated transport system, truck appointment systems at the gate, plus increased competition between different terminals and global terminal operators (Ducruet & Merk, 2012).

6.9 Chapter Summary

This chapter examined the relationships between ownership and efficiency, the level of competitiveness and efficiency and scale of production (port size) and efficiency, using both bivariate and multivariate analysis. In addition, the productivity change analysis was undertaken in this chapter. The result of the bivariate analysis showed an increase in efficiency after the adoption of the Landlord model (transfer of cargo handling operations to the private sector). While the multivariate analysis was performed on a projected efficiency model of Nigerian ports, assuming a relationship between a dependent variable efficiency and the predictor variables (production scale, ownership and competitiveness), using a two-stage log-transformed regression. The results indicated a statistically significant relationship between efficiency and ownership, as well as efficiency and port size represented by the scale of production and an insignificant relationship between the level of competition and efficiency. Therefore, the null hypothesis for port size and ownership was rejected and accepted for the degree of competition. In terms of the productivity change analysis, the results show that the total factor productivity of the Landlord model is higher than that of the Public port. However, the difference is not statistically significant at the 5% level. Likewise, the scale efficiency of the Landlord model is greater than that of the Public port, but statistically insignificant, while the technical efficiency change of Landlord and Public is equal (no change). On the other hand, the mean technological change of the Public port is higher than that of the Landlord port, but not statistically significant. The next chapter discusses the findings and the policy implications of this study.

Chapter Seven: Research Findings, Policy Implication and Conclusions

7.1 Introduction

The research concerns the influence of the transfer of the ownership of port terminal operations from the public to the private sector, through concession contracts, on the performance of the Nigerian port industry. The performance of Nigeria ports was analysed from both efficiency and productivity perspectives. This chapter presents the findings from the analyses of both primary and secondary data collected from port users, the ports and terminals. In this chapter, the results of the research are discussed under three sub-headings based on different aspects of the research themes and for clarity. Thereafter, it draw conclusions and the policy implications of the results and highlights the contribution of this research to existing knowledge. Finally, the limitations of this research and the areas for further studies in Nigerian port privatisation will be highlighted.

7.2 Research Findings

Unlike previous studies that relied on container terminal operations worldwide to determine the impact of different ownership styles on port efficiency, this research is based on the activities of multipurpose ports. Additionally, it was observed from analyses of the literature, that most studies that are employing the DEA for performance evaluation use ports and terminals interchangeably. It contravenes the homogeneity assumption necessary for the DEA analysis. This research recognised that ports and terminals are distinct; therefore the analysis and benchmarking of ports was carried out on multipurpose ports in the same country for homogeneity. The efficiency measures were computed within the framework of the frontier function theory by adopting a non-parametric DEA. The frontier approach is consistent with the economic theory of optimising behaviour. It considers ports that operate on the frontier as efficient and interprets those that operate below the frontier as inefficient.

The DEA models adopted in this study allowed us to isolate the factors militating against the ability of the ports to achieve efficient operations. The possible reasons for inefficiency are classified into pure technical and scale efficiency. In terms of productivity change analyses, the study relied on the DEA-based Malmquist index, which decomposes the sources of productivity change into *catching-up* and *frontier shift* effects. The former captures overall technical efficiency change (EFFCH), while the latter captures technological change (TECHCH). Thereafter the EFFCH is further decomposed into pure technical efficiency change (PECH) and scale efficiency change (SECH).

The results of the port analyses using different DEA approaches (Intertemporal, Contemporaneous and Window) indicate that the efficiency differs from port to port and from year to year. The efficiency score from the DEA-BCC is greater than from the DEA-CCR, showing the presence of inefficiency due to a non-optimal scale of production. However, the efficiency gap experienced by the ports for the 12 years under study is more due to technical than scale efficiency. It is indicative of the mean technical and scale efficiency scores for the 12 years under study, which is 77.15% and 82.78% respectively. The most efficient port for the period is the Onne port with a mean efficiency of 97.5%, while the least efficient is the Warri port with an average efficiency of 53.5%. This finding is consistent with the Bv Haskoning of Netherlands (2001) study that precipitated the Nigerian ports' concession programme. The study indicated that the Onne port, which was the only port that adopted the Landlord model, as the most efficient port. It prompted the replication of the model in all the ports through the concession programme. However, the intriguing part of the findings of the research is in terms of benchmarks. The benchmark operation for all the ports to emulate is the PH port operations in 2004, which appeared 29 times as the reference operation for the inefficient ports. Although it is closely followed by the Onne port's operations in 2006, which appeared 28 times as a reference (Appendix 7.1). The results show that the PH port has performed well before concession. This supports the argument of this study that some of the ports would have been better off if left in the public domain. The low performance of the Warri port is attributed to the insecurity of the port's immediate hinterland. It led to most of the shipping lines deserting the port for fear of their crew members being kidnapped by Niger Delta militants, resulting in under-utilisation of the port's available resources. Most of the ports showed high variation in both technical and scale efficiency, as indicated by the mean standard deviations of 24.32 and 19.26 respectively. The yearly mean overall efficiency equally showed significant fluctuation; the highest mean efficiency score of 79.45% occurred in 2011, while the lowest efficiency score of 45.55% was recorded in 2000.

The efficiency estimates from the DEA-analysis suggest that the reason the Nigerian ports departed from the efficiency frontier for the period 2000-2011, were due to both technical and scale inefficiency. However, as the mean scale efficiency score is higher than the average technical efficiency index the overriding effect is attributable to technical inefficiency. Applying Farrell's estimated efficiency criterion, there is a 22.85% potential for improvement in pure technical efficiency of the average port in the sample. Pure technical inefficiency can be interpreted partly from motivational deficiency at both worker and managerial level. In other words, it is due to differences in the technical levels of ports. In an industry like ports, with long-lived infrastructure and highly specialised equipment, the coexistence of different levels of technology at any point in time is not an aberration. Therefore, for the Nigerian ports, all the DEA models indicate that the deviations from the best possible performance (the frontier) are mostly due to technical inefficiency, rather than scale. It implies that there is wastage in input, as technical efficiency is a measure of how well the port is allocating its resources to maximise its output generation.

On the other hand, the scale inefficiency of an average Nigerian port for the period 2000-2011 is 17.22%. Scale inefficiency is related to the excessive use of capital input (equipment) factors relative to labour input. The DEA measures have indicated the direction of improvements in scale efficiency values by the nature of returns to scale. The Lagos ports (Apapa and TCIP) are operating under increasing returns to scale, while the Eastern ports (Calabar, Onne, PH and Warri) are operating under decreasing returns to scale. The Lagos ports require an increase in cargo throughput and an improvement in turnaround time (outputs). The Eastern ports should reduce the quantity of inputs to operate at the optimum efficiency scale. In other words, the Eastern ports are underutilised.

This study examined the influence of port size on efficiency using intertemporal, contemporaneous and window analyses and the results indicate that no matter the DEA approach used, ports with larger production scales obtain higher efficiency scores. In other words, ports with larger production scales are more efficient than ports with smaller production scales. Larger ports have the requisite management skills to convert given inputs optimally to increase outputs, because they are technology leaders and have locational advantages. Therefore, the null hypothesis H0: There is no relationship between port size, and port efficiency, is rejected. This is evident from the average technical efficiency scores for the period under study. The ports with a high mean efficiency score of 90% and above are the big ports in terms of throughput (Onne, Apapa and PH). While the smaller ports (Calabar and Warri) have mean efficiency scores below 60%. This is in agreement with the results of the total productivity change analysis, which also showed that the change in the Nigerian ports' productivity after concession is driven by scale efficiency change.

A comparison of pre- and post-concession efficiency reveals that all the ports obtained higher efficiency scores after concession, except the PH port that has lower efficiency index. The operations of the Onne port after concession was considered 100%, albeit weakly efficient, as the operations in 2009-2011 are below optimal level as it still operates under DRS. The least efficient port is still the Warri port, which may be because most shippers are still reluctant to use the port as there is still skirmishes from the militants, despite the amnesty granted to them. It also shows that the ports in Lagos (Apapa and TCIP) improved tremendously after concession. While the ports in the Eastern zone either improved slightly (Onne port), or deteriorated in efficiency (Calabar, PH and Warri). The driver of this change is a change in scale efficiency. It suggests that the wholesale concession of the entire nation's ports, without recourse to the peculiarities of each port is not the best after all. That could be the reason why concessions in both developed and developing countries is a gradual process starting with container terminals, then other terminals. Even the British ports credited with the most advanced form of privatisation in the port industry, practice different governance models. It is only the 14 largest ports in terms of tonnage that are private ports, operated by three different companies and quoted on the British stock exchange. The trust ports have a different governance model; they have no known shareholders and are peculiar to British ports.

In summary, the analyses of the pre- and post-concession efficiency reveal that ports performed better after concession, as the mean overall technical, pure technical and scale efficiency are higher for the post-concession than the pre-concession period. However, this observation is not correct for all ports, as the Calabar and PH port performed better overall in the pre-concession than the post-concession period. While in theWarri port, it is only in terms of scale efficiency that the pre-concession is higher than the post-concession scale efficiency.

In terms of productivity change, the results obtained from the analyses of data show that total factor productivity increased after concession, but the increase is not statistically significant at both the 1% and 5% confidence levels. In addition, it indicated the source of efficiency change as being mainly scale rather than technical. This study also reveals the deterioration in technological change after concession. The results suggests that terminal operators have not brought the required investment in modern cargo handling equipment needed to improve the performance of the ports under study and to reduce turnaround time. On the other hand, a short run productivity change captured by the year-by-year MPI shows that the difference in the yearly efficiency of the ports is more due to pure technical than scale efficiency. It indicates that the focus of the terminal operators was on improving outputs through superior managerial processes, using existing inputs and technology. It is at variance with the primary objective of the concession of attracting private investment to the Nigerian port sector.

7.2.1 Summary of findings on the influence of ownership change on Nigerian ports performance.

The port concession programme has brought the six major Nigerian ports into the private domain. As Nigeria returned to democratic rule in 1999, the new dispensation is unsympathetic to public ownership. Many publicly owned companies, especially in the transport sector of which ports are a part, have been privatised. The primary objective of the port concession programme is to improve efficiency and reduce the cost of doing business in Nigerian ports. Plus, a reduction in the turnaround time of ships and cargo clearing time which among the highest in the World. However, there is no empirical basis considering Nigeria's geographical, socio-cultural and economic setting, for believing the superior performance of private ports. Nevertheless, Nigeria embarked on the most elaborate port privatisation exercise, dubbed the most ambitious port concession that has taken place worldwide.

However, the findings of this research suggest that the argument that the transfer of a port's terminal operations from the public to private sector improves the efficiency of the ports is right after all. The result of the preliminary analysis showed that the efficiency of Nigerian ports under the Landlord model is greater than the efficiency under the public sector. Even the efficiency of mixed ownership comprising of the two years' transitional period, is higher than that for public ownership. In addition, the findings of both the efficiency and productivity change analysis indicate an overwhelming influence of scale of production on efficiency. Plus, the competition level analysis shows the influence of intra-port competition after concession. Consequently, in order to determine which of the three factors (ownership, production scale and competition) is responsible for the improved operational performance of the ports understudy, a two-stage multivariate regression was undertaken. Firstly, on the factors that determine port size and secondly on the factors influencing port performance. The results, based on available data, show that the production scale captured by throughput volumes and ownership change are the primary determinants of Nigerian port performance.

Therefore, the following hypotheses are accepted:

- There is a relationship between the transfer of port terminal operations from public to the private sector and Nigerian ports' performance.
- There is a relationship between port size and port efficiency

While we reject the hypothesis:

- There is a relationship between port competition and port efficiency.

Although the delineation of ports into terminals as a result of the concession programme induced some intra-port competition, its influence is negligible in the presence of other factors affecting Nigerian ports' efficiency. On the contrary, inter-port competition does not exist in the Nigerian port industry due to non-completion of the second phase of the concession programme, which involves the unbundling of the NPA into four autonomous port authorities. As a result, the six ports understudy is non-autonomous and operate under a single national port administrative authority the NPA. Therefore, the conclusion that there is no relationship between port competition and efficiency drawn from this study should be interpreted with caution. As it may be a one-off thing due to the prevailing circumstance at the Nigerian port sector.

7.3 Policy Implications

The discussion of findings from this research reveals that the overall technical inefficiency of Nigerian ports after concession is primarily due to pure technical inefficiencies than scale inefficiencies. The lower pure technical efficiency compared to scale efficiency after concession, suggests that the inefficiency is due to the inability of the ports to meet target output (throughput and turnaround time). The results of the analysis shows that for the ports to be on the frontier, the throughput should be increased by 55.59%, and the turnaround time improved by 25.5% (Figure 5.1). Therefore, port managers should put in place management practices in tune with the market requirements of the various ports, in order to attract ships to the ports and reduce ship turnaround time by investing in modern cargo handling equipment. In addition, the study revealed that 25% of the ports achieved constant returns to scale (CRS), and another 25% of the ports operated at decreasing returns to scale (DRS). It implies that for ports with DRS, the percentage increase in output is below that of the input. While the other 50% of the ports that show increasing returns to scale (IRS), it mean that operations are greater than those of their CRS counterparts and should consider further expanding.

Globalisation coupled with the economic downturn experienced by the developed countries and instigated by the banking crisis of 2008, has paved the way for economic growth in the developing World, mainly in African countries. While the developed countries have been experiencing little or no growth and in some cases retardation after the crisis. The Nigerian economy has been growing at an annual rate of 7% since 2009 and has just overtaken South Africa as the largest economy in Africa. The emergency of Nigeria as the economic powerhouse of Africa entails growth in cargo shipment into the country. Nigerian ports have been at the forefront of the development as a net importer and the 11th largest exporter of crude oil. Demand has been expanding in many parts of the country and, as a result, most of the ports operate at IRS. Therefore, policies should be geared towards expanding the ports to enhance competitive advantage.

Although the study indicates that the concession programme on average has improved the performance of the Nigerian ports, this is not across the board as was revealed by the analysis of the pre- and post-concession port efficiency. While the ports in the Lagos zone improved in performance, the performance of ports in the Eastern region, except the Onne port deteriorated. It shows that the wholesale concession of all the national ports in one scoop is not the best after all, or the concessionaires in those ports are not performing as envisaged. The landlord, theNPA (as an independent regulator is not yet in place) should evaluate the activities of the terminal operators from time to time, in order to detect operators that are not performing, for the purpose of renegotiation. The ports of PH, Warri and Calabar fall under this category as the performance in the public sector outweighs the performance in the private sector. It should be considered during contract renegotiations if the trend persists, until the expiration of the contract.

Many inferences can be drawn from the use of systematic benchmarking through efficiency evaluations, as a tool for terminal operators to determine the efficiency of their terminals employed in this research. In contrast to piecemeal single performance indicators, global efficiency assessment methods using the DEA Panel data techniques offers port terminal operators overall assessment of the performance of the terminals, in comparison to others in the same circumstances. Benchmarking analysis is distinct from targets that are based on single terminal performance indicators. It allows local terminal operators to set priorities and to pursue improvements where resources are needed, in order to secure perceived gains. The findings from the DEA benchmark analyses can be used by port operators to allocate resources based on identified areas of need, so as to improve performance.

7.4 Achievement of Study Objectives

Objective 1: *To measure and examine the trend of efficiency of Nigerian seaports.*

To achieve the above objective a 12-year (2000-2011) panel data was collected from the statistics department of six Nigerian ports (Apapa, Calabar, Onne, PH, TCIP and Warri). Additionally from the headquarters of the Nigerian port authority (NPA) located in Lagos. The researcher collected data on annual throughput, mean yearly turnaround time, number of berths, the total number of equipment, the total number of staff employed by each port and the total storage capacity. The data were cleaned and summarised to fit the format required by the different DEA approaches (Intertemporal, contemporaneous and window) used in the analyses. The data were tested for positivity, homogeneity and isotonicity. The Pearson correlation between the variables was significant and positive, validating their use in a DEA analysis. The database and the descriptive of the variables used in the analyses are shown in appendix 5.1 and 5.2.

The analysis considers each port-year as a DMU to increase the number of data points and to improve the discriminatory power of the DEA. The efficiency scores for the different DEA approaches were computed for both the CRS (DEA-CCR) and the VRS (DEA-BCC) models. The overall (technical) efficiency score was obtained from the CRS model. While the VRS model gives the pure technical efficiency, the ratio of CCR and BCC efficiency scores (CCR/BCC) gives the scale efficiency. The results indicated high, but fluctuating efficiency levels. The operational efficiency of the ports is in terms of CCR, BCC and SE, Chapter 5 discusses the influence of port size on the efficiency of the ports and the implications.

Objective 2: *To evaluate the pre- and post-concession Nigerian ports efficiency.*

The study adopted an ex-post facto design (aka "causal-comparative") to achieve this objective, as the research is based on investigating the cause-effect of concession on operational performance of seaports. This relationship is examined by observing the post-concession state of affairs in the ports for the six years after concession (2006-2011) and also searching back six years before the concession (2000-2005) for plausible causal factors. This method is chosen as the researcher has no control over the variables of the pre- and post-concession periods, nor to be able to manipulate them because the concession programme is already in place. In this circumstance, to tease out the possible events that occurred in the past, the study attempts a reconstruction. It is done by using the operational variables of the ports before concession, to determine the level of efficiency for that period and the operational statistics after, to determine the state of affairs after concession. The study also solicited for the perceptions of port users on the influence of the concession programme on their operations, through semi-structured interviews. The result of the efficiency analyses revealed an increase in efficiency after concession, although, not across the board. The port users were of the view that the concession programme has significantly increased the cost of doing business at the ports. The driver of improved efficiency after concession is due to increase in throughput (scale efficiency). Section 5.4 of the thesis shows the results and discussions of this aspect of the research.

Objective 3: *To examine the overall performance of Nigerian ports from the productivity and efficiency change perspectives.*

Efficiency and productivity concepts are used in the literature to describe the performance of economic systems or DMUs and in this case ports. In achieving this objective, the study employed the theory of total factor productivity change by using the DEA-based Malmquist index (MPI). This technique gives sources of productivity change between periods, in this case pre-and post-concession. The pre- and post-concession multi-year total factor productivity change (TFPCH) of Nigerian seaports was obtained through this method. The TFPCH is decomposed into an efficiency change (EFFCH) component and technology change (TECHCH) component. The EFFCH further decomposes into the PECH and SECH. The results of the productivity change analyses indicated an increase in productivity and the source of this growth is EFFCH, rather than TECHCH. It is consistent with previous studies, as change in technology can only be observed in the medium to long term. A decomposition of the EFFCH shows that the increase in efficiency is more due to SECH than PECH. Likewise, the post-concession period showed increase in productivity change and the source is due to EFFCH as TECHCH deteriorated during the period. The source of increase in EFFCH during the post-concession period is SECH. Section 5.6 discusses the empirical results of TFPCH and the implications.

Objective 4: *To determine the competitiveness of the Nigerian seaports.*

For this objective, the level of competitiveness of the ports was computed based on market share. The pre- and post-concession market share of the ports and the HHI index were calculated based on the throughput levels. The analysis made use of the HHI technique based on market share of the ports, to determine the concentration index, which is an indication of the degree of competition. The main finding showed that the level of competition increased overall after concession. Though, it is most noticeable in the Apapa and PH ports (lower HHI index after concession), but overall the effect of competition on the performance is statistically insignificant at the 5% level.

Objective 5: *To determine the factors that influence Nigerian ports' performance.*

A theoretical model of operational performance was conceptualised in section 6.4, to achieve this objective. The model is used to resolve the complex relationship between production scales, port efficiency, port ownership and other exogenous variables in the model. The study assumed that the output can be endogenous in the relationship among variables. In the proposed model, port production and port efficiency are in a recursive path. Since port efficiency affects production scale and knowledge of previous port efficiency affects production level, creating a loop in the model. Two equations were proposed by the model:

one involving the determinants of throughput (production scale) and the second involving determinants of efficiency, so as to resolve the relationship between efficiency and production scale and performance of the ports. Thereafter, a two-stage OLS regression involving the logs of the factors that influence throughput and efficiency, as the two equations were non-linear. Firstly, with throughput as a dependent variable and the projected throughput derived from the first regression is employed in the second regression with efficiency as the dependent variable, in order to determine the significance of each factor. By so doing, the study was able to determine among these factors; production scale, level of competition and ownership change which are responsible for the improved performance of Nigerian ports after concession. The results of the analysis will enable policymakers to understand which factors are contributing to the overall performance of Nigerian ports and the areas to focus on for further improvements. The main finding is that competition plays an insignificant role in the operational efficiency of the Nigerian seaports, notwithstanding the delineation of ports into terminals through the concession programme. It is probably due to the inability of the government to implement the second phase of the concession programme, which involves the unbundling of the NPA into two autonomous port authorities to set the stage for inter-port competition.

7.5 Contribution to Knowledge

The findings of this research are of immense benefits to academia, policy makers and the NPA. The Nigerian port privatisation is a guinea-pig for studying the impact of wholesale concessions on the performance of national ports in Africa and indeed the whole World, due to the manner and speed in which the programme was executed. In the African context, it is the only country that has embraced the advanced form of the Landlord model of port administration and in Sub-Saharan Africa. The Nigerian port concession accounted for 55% of the private investment in ports in the sub-region, totalling $1.3billion as at 2008. Again in terms of trade, Nigeria occupies a strategic position in the sub-regional trade, as 70% of trade by volume meant for West and Central African are destined for Nigeria. Although Nigeria has undertaken an unprecented port reform, most of the studies on port reform, privatisation, ownership and efficiency are concentrated on Europe, Asia, North America and South America with very few from Africa and none for Nigeria. Hence, the need for this research titled: “Evaluation of Nigerian ports’ post-concession performance”. It was to ascertain the influence of port concession on the performance of the ports six years after the concession and to determine if the ports are on the path towards greater efficiency.

In addition, most of the literature on the effects of ownership change from the public to the private sector is based on European and Asian ports and mainly container terminals. No study has dealt with the effect of this change in ports in Sub-Saharan Africa, despite that, as at 2008; 42 concessions have taken place in the sub-region and 50% involves ports in Nigeria. Therefore, this study is a reference material for academia on the influence of increased private participation on the efficiency of the ports of a major player in the sub-region.

For the policy makers, it is a reference material on the evaluation of the first six years of the concession programme. Since it provides a holistic and independent view, based on empirical findings, on areas of inefficiency and weakness in the policy implementation and interventions required to improve performance. For instance, as the study revealed, there is limited competition six years into the implementation of the programme. Policy action should be geared towards unbundling the NPA and putting in place an independent regulator which can impose sanctions on anti-competitive behaviour by the terminal operators. For Sub-Saharan African sub-region policymakers, it is particularly important as a reference document for ports in the sub-region that have undertaken, or intending to undertake concessions, on the pitfalls and favourable outcomes of the programme.

For the landlord NPA, the study has identified the operators that are not making efficient use of the resources allocated and the efficient operators, as a benchmark for others to emulate. This information is particularly necessary for the NPA for the purpose of contract renegotiation and to apply sanctions where appropriate.

7.6 Limitations of the Research

There were several limitations encountered in conducting this research. First and foremost was an issue of collecting panel dataset going back 12 years in time, from an organisation without a database which proved an uphill task. Therefore, the data for this research was obtained from different sources (annual reports, abstracts of port statistics and the National Bureau of Statistics).

Since the data collected were not in conformity with the information required, transformations in the form of extrapolations from the available data were undertaken, in order to obtain consistent and compatible information necessary for the analyses. Extrapolation was first carried out on the post and pre-concession port nomenclature of ports. Before concession, reporting was based on 8 ports, as the container terminal in the Apapa port and the RORO terminal in the TCIP were regarded as separate ports. However after concession, the data reporting changed to a port basis for consistency and the researcher had to undertake some manipulation in order to bring the data for the two periods into the same format. For instance, prior to concession, the port input and output variables used in this study were reported on a port by port basis, but after concession, the reporting changed to a port authority basis.

As all the port authorities compared have multipurpose ports, the cargo volume was denoted in tonnes for uniformity. It is especially necessary for the benchmarking of the container terminals, as some of the terminal concessions for container operations do handle some other types of cargo. Therefore, to be fair in the comparison of the terminals, the container/cargo throughputs of the container terminals were captured in tonnes, not TEU. In addition, where there is a discrepancy in the value of variables obtained from different sources, the average of the value is taken as the figure used for this analysis. It was done in the throughput values and the number of equipment obtained from terminal operators and the port authorities. If all the information needed was available in a database, it would have been less cumbersome to manage and handle.

Another limitation is the small sample size involved in the study that restricted the number of variables employed for the DEA analyses. As a result, the DEA analysis produced high efficiency scores, especially in the BCC analysis. However, as the efficiency measures obtained from the DEA analysis are relative, as the number of years of operation increases, the relative efficiency of the ports may give a better result due to increase in the dataset. Nonetheless, the results obtained in this research gave a synopsis of the efficiency of operations of the Nigerian ports after concession.

7.7 Future Research on the Performance of Nigerian Ports

This study has attempted a comparison of pre- and post-concession efficiency and productivity change analysis, employing only physical measures and without recourse to cost information, due to lack of data. However, for a holistic view, if the information on price is available, a further research on pre- and post-concession efficiency analyses, can be undertaken, that will take into consideration allocative efficiency.

Furthermore, the present study did not put the consumer perspective into consideration. Future studies may use supply chain approach to benchmark the efficiency, so as to include the effectiveness perspective. Further studies on port terminal efficiency measurement, can be undertaken, using parametric and econometric methods as a control on the DEA methodology.

In addition, the APM terminal is now a dominant player in the container industry in the West African sub-region. It controls equity shares in nine terminals in eight West African countries, it controls two terminals in Nigeria (APMT, Apapa and WACT, Onne). While DP World is incharge of Dakar container terminal in Senegal. Therefore, the need for further studies on the effects of the transfer of container terminals from the public to global terminal operators, cannot be overemphasised. Especially, as it seems the sub-region is moving gradually from a public to a private monopoly that may not augur well for the efficiency and competitiveness of the ports.

7.8 Conclusions

This study set out to find the effects of privatising the Nigerian ports' operations through concession contracts on the performance of the ports and to identify the terminal operators that are making efficient use of the resources allocated to them. The literature review and discussions on the media, indicated gaps and the need to undertake this study. As most studies in port efficiency literature tilted towards Europe, Asia, the Americas, Australia and Oceania and there was barely anything on Africa. In terms of Nigeria, although there are some studies on the seaports, no study has evaluated the effects of the transfer of the port terminal operations from the public to the private sector on the performance of the ports six years after the implementation of the programme.

This research employed mainly quantitative techniques to evaluate the operational data of the different ports and terminals. The non-parametric DEA method was used for the analysis of efficiency, while the DEA based MPI was used for the productivity change analysis. Additionally, econometric techniques such as ANOVA, t-test and multivariate regression were employed for hypothesis testing, while the level of competitiveness was computed using concentration index.

Based on the empirical findings, the research was able to achieve the objectives. The main conclusion is that the port concession program has improved the efficiency of the ports through an increase in throughput levels. However, productivity has declined due to the deterioration in technological progress after concession. It suggests that the envisaged investment in ICT, tracking equipment and technologies, including modern cargo handling equipment by terminal operators, that will fast track port development in the Nigerian port sector and reduce turnaround time, has not materialised. Another salient finding is that competition is not a significant contributor to the Nigerian ports' performance, despite concession. In other words, concession, even without inducing intra-port competition, improves port operational performance by securing increased throughput through global alliances of GTOs.

The empirical findings and discussions have highlighted areas that policymakers need to consider in the further implementation of the concession programme and contract renegotiations. It has also spotlighted areas for further studies by other academics.

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Appendix

Appendix 1.1: Literature of DEA Applications in the port sector and the variables used

				Model parameters (Variables)	
Author	**Domain**	**Data**	**DMUs**	**Outputs**	**Inputs**
Roll and Hayuth (1993)	Entire world	Fictitious and cross-sectional, single period	20 ports	Container throughput, service level, User satisfaction, Ship calls	Size of labour force, Annual investment per port, The Uniformity of facilities and cargo
Poitras et al. (1996)	Australian and international	Cross-sectional	23 ports	TEU berth hour, Total number of containers handled per year	Mix of 20-foot and 40-foot containers, Average delays in commencing stevedoring, Difference between the berth time and gross working time, Number of containers lifted per quay crane hour, Number of gantry cranes, Frequency of ship calls, Average government port charges per container
Martinez-Budria et al. (1999)	Spain	Time series (1993-1997)	26 ports in five year span	Total cargo moved through the docks	Labour expenditures, Depreciation charges, Miscellaneous expenditures

Tongzon (2001)	Australia	Cross-sectional	16 ports	Cargo throughput, Ship working rate	Capital (number of berths, cranes, tugs), Labour(number of stevedore gangs), Land(size of terminal areas) Length of delay
Valentine and Gray (2001,2002)	Entire world	Cross-sectional	21 ports	Total tonnes throughput, Number of containers	Total length of berth, container berth length
Bonilla et al (2002	Spain	panel	23 ports	Throughput	Equipment
Itoh, 2002	Japan	Panel 1990-1999	8 major container	Throughput	Container terminal area, Number of berthed, Number of gantry cranes and labour
Barros (2003)	Portugal	Panel data	11 ports	Ships, Movement of freight, Gross gauge, Break-bulk cargo, Containerised freight, Solid bulk and liquid bulk	Labour (number of workers), Capital (book value of assets
Park and De (2004)	Korea	Cross-sectional	11ports	Productivity, Cargo throughput, Number of ship calls, profitability, Revenue,	Productivity, Berthing capacity, cargo-handling capacity, Profitability, Revenue, Cargo throughput, No. of ship calls, Marketability, Revenue, Overall efficiency, Berthing capacity,

				Marketability, Overall efficiency, Customer satisfaction	cargo handling capacity
Cullinane et al. (2004)	Worldwide	Time series (1992-1999)	25 ports	Throughput	Land factor Total quay length, terminal area Equipment factor Number of quay gantry cranes, yard gantry cranes, straddle carriers
Barros and Athanassiou (2004)	Greece and Portugal	Balanced panel data	6 ports	Ships, Movement of freight, Total cargo handled, Containers loaded and unloaded	Number of workers, Book value of assets
Cullinane et al.(2005)	Worldwide	Times series (1992-1999)	25 ports	Container throughput (TEU)	Terminal length, Terminal area, Quayside gantry, Yard gantry, Straddle carrier
Min and park (2005)	Korea	Time series	11 container terminals in four year span	Cargo throughput	Total length of quay, Number of cranes, Size of hard areas, Size of labour force
Wang and	Pan	Cross-sectional	104	Container throughput	Terminal length, Terminal area, Equipment

Cullinane, 2006	European		terminals	(TEU)	costs
Cullinane et al. (2006)	Worldwide	Cross-sectional	57	Container throughput (TEU)	Terminal length, Terminal area, No. of quayside gantry cranes, No. of yard gantry cranes, No. of straddle carriers
Rios and Macada (2006)	North America (Brazil, Argentina, Uruguay)	Time series (2002-2004)	23 terminals	TEUs handled, Average number of containers handled per hour per ship	Number of cranes, Number of berths, Number of employees, Terminal area
Barros (2006)	Italy	Balanced panel data (years 2003-2004)	24 ports	Liquid bulk, Dry bulk, Number of ships, Number of passengers, Number of containers with TEU, Number of containers with no TEU, Total sales	Number of personnel, Value of capital invested, Size of operating costs
Eraqi et al (2008)	Middle East and East	Panel data (2000-2005		Throughput (Tonnes), Ship calls	Berth length(m), storage area (m^2),Handling equipment

	Africa				
Wu et al (2010)	Worldwide	Cross-sectional data	77 major world container ports	Container throughput (TEU)	Capacity of handling equipment, No of berths, Terminal area& storage capacity
Ng and Lee (2007)	Malaysia	Cross-sectional data and Panel data	6 major Malaysia n container ports	Throughput and Number of ship calls	Total yard area, No. Of cranes, Total length of berth, No. Of quay cranes
De koster et al *(2009)*	World wide	Panel data	World major container terminals	Container throughput	Gantry cranes, quay length & yard area
Jiang & Li, 2009	North-East Asia	Cross-sectional	12 ports	Throughput (TEU)	Import/Export by Customs, GDP by regions, berth length, number of cranes
Barros et al (2010)	Angola, Mozambiqu e & Nigeria	Panel data (2004-2006)	23 ports	Total tonnes, Containers & No. Of ship calls	Berth depth, Total Area (m^2), No. Of cranes and No. Of employees.

Pjevčević et al. (2012)	Serbia	Panel data (2001-2008)	5 ports	Annual Throughput	Total area of warehouse, quay length, number of cranes and port throughput
Caldeirinha and Felicio, 2011	Iberia		22 EU container terminals	Annual TEU	Size of terminal, quay size, and number of cranes
Herrera et al (2008)	Worldwide		86 container terminals	Annual TEU	Terminal area, Ship-to-shore gantries, the number of quay, yard and mobile gantries & number of tractors and trailers.
Munisamy et al. (2011)	Latin America	Panel data (2000-2008)	30 ports	Throughput	Berth length, Terminal area, Total number of quay equipment, Total number of yard equipment, total number of general equipment and total number of sophisticated equipment.
Shu-Wan Hung et al (2010)	Asia-pacific-region	Cross-sectional	31 container terminals	Container Throughput	Terminal area, ship-shore container gantry, number of berths, & terminal length.
Cullinane & Wang (2010)	Worldwide	Panel data 1992-1999	25 container terminals	Throughput	Terminal area, terminal length, quayside gantry, yard side gantry and straddle carrier
So et al (2007)	North-east	Cross-section	19	Throughput TEU	Number of quay, yard equipment, total berth

	Asia		container		length and terminal area
Li & Liu (2009)	China	Cross-section 2008	8 Ports	Per-share earnings, input of main business & profit after tax	Net asset, Net-asset per share, cost of main business and number of staff
Rajasekar et al (2014)	India	Panel data 1993-2011	7 major ports	Throughput & total traffic	Number of berth, berth length, No of equipment and number of employees
Kasypi Moktar, 2013	Malaysia	Panel data 2003-2010	6 major container	Throughput	Total terminal area, Maximum draft, Berth length, Quay crane index, Yard stacking index, Vehicles and number of gate lanes.

Appendix 1.2: Newspaper Articles on Nigerian Ports Concession

S/N	Article title	Newspaper Name & Date of Publication	Website
1	Harnessing gains of new seaports reform	Nigeria Leadership, 16/10/2011	http://allafrica.com/stories/201110160008.html
2	Nigeria: Agents grumble over delay at Onne seaport	Nigeria Vanguard, 11/07/12	http://allafrica.com/stories/201207110393.html
3	Reduction of multiple charges, panacea for cargo diversion	National Mirror, 05/07/2013	http://nationalmirroronline.net/new/reduction-of-multiple-port-charges-panacea-to-cargo-diversion/
4	Groans over port charges	PM News 10/09/2012	http://pmnewsnigeria.com/2012/09/10/groans-over-port-charges/
5	House Representative members to investigate concessionaires of Nigerian seaports	Daily News Watch, Nigeria, 08/11/2013	http://www.mydailynewswatchng.com/2013/11/08/reps-investigate-concessionaires-nigerian-seaports/
6	The Battle for Eastern ports	16/03/2012	http://www.marineandpetroleum.com/content/battle-eastern-ports
7	Why Eastern ports are Under-utilised	16/03/2012	http://www.thisdaylive.com/articles/-why-eastern-ports-are-under-utilised-/111573/
8	NPA and the competition for hub port status	Nig. Daily independent 01/12/2012	http://dailyindependentnig.com/2012/12/npa-and-the-competition-for-hub-port-status/
9	Why ports are not Working-ICPC	Vanguard, 15/12/2013	http://www.vanguardngr.com/2013/12/ports-working-icpc/

10	Africa celebrates Nigeria over port reform	Vanguard 29/12/2010	http://www.vanguardngr.com/2010/12/africa-celebrates-nigeria-over-port-reforms/
11	Maritime fraud: How terminal operators, shipping agencies defraud importers	20/01/2014	http://sunnewsonline.com/new/business/maritime-fraud-terminal-operators-shipping-agencies-defraud-importers/
12	Terminal Operators decry Cost of doing Business in Nigerian ports	thisday, 26/07/2013	http://www.thisdaylive.com/articles/terminal-operators-decry-cost-of-doing-business-in-nigerian-ports/154406/
13	Has Concession of ports helped Nigeria?	Financial intelligence, 21/01/2013	http://www.myfinancialintelligence.com/transport/has-concessioned-ports-helped-nigeria/2013-01-21
14	Why ports aren't making profits despite concession	Daily Trust 8/10/2012	http://allafrica.com/stories/201210070345.html
15	Port reform: The gains, the expectations	Daily champion 19/07/2013	http://championonlinenews.com/index.php?option=com_k2&view=item&id=8816:port-reform-the-gains-the-expectations&Itemid=221&lang=en
16	The gains and challenges of port concession in Nigeria	businessday19/02/2014	http://businessdayonline.com/2014/02/the-gains-and-challenges-of-port-concession-in-nigeria/
17	Ports concession in Nigeria is a success story	Ships and ports 19/07/2013	http://www.shipsandports.com.ng/2013/news/Ports_concession_in_Nigeria_is_a_success_story.php
18	Container Transfer, Ships allocation blamed for Lagos ports' congestion	Thisday newspaper 13/09/2013	http://allafrica.com/stories/201309130464.html
19	Reps to investigate concessionaires of	Daily News watch 08/11/2013	http://www.mydailynewswatchng.com/2013/11/08/reps-investigate-concessionaires-nigerian-seapor

	Nigerian ports		
20	Fed Government blamed for corruption in ports	Nigeriaintel.com 14/08/2013	http://www.nigeriaintel.com/2013/08/14/fed-govt-blamed-for-corruption-in-ports/
21	Concessionaires plan to hike port charges	Nigeria daily independent October, 2013	http://dailyindependentnig.com/2013/10/concessionaires-plan-to-hike-port-charges/
22	Seaports Concession	Conduit to Cede or Chide NPA, March, 2008	http://nigeriaworld.com/articles/2008/mar/254.html

Appendix 5.1: Nigerian port level analysis data (2000-2011)

PORTS	Thrup	TAT	NOB	NOE	NOS	STC
APAPA 2000	11,008	13	26	183	3991	617.5
APAPA 2001	13,898	15	26	110	3943	617.5
APAPA 2002	14,306	23	26	102	4103	617.5
APAPA 2003	14,579	21	26	88	3592	717.9
APAPA 2004	15,152	21	26	92	3,747	720.4
APAPA 2005	16,931	14	26	123	3,022	720.4
APAPA 2006	15,113	9	27	120	893	720.4
APAPA 2007	18,567	9	27	100	1182	720.4
APAPA 2008	20,309	10	28	80	1269	720.4
APAPA 2009	21,119	9	28	86	1391	720.4
APAPA 2010	22,005	7	28	91	1489	720.4
APAPA 2011	23,365	8	29	95	1487	720.4
CAL 2000	306	3	12	69	583	131
CAL 2001	325	6	12	53	566	131
CAL2002	400	6	12	29	595	131
CAL 2003	481	5	12	30	597	131.3
CAL 2004	753	5	12	13	570	131.3
CAL 2005	858	2	12	15	499	131.3
CAL 2006	777	3	12	15	459	131.3
CAL 2007	1,042	2	12	18	275	131.3
CAL 2008	1,165	4	12	18	220	131.3
CAL 2009	1,699	4	12	20	431	131.3
CAL 2010	1,588	3	12	20	219	131.3
CAL 2011	1,880	4	12	21	369	131.3
ONNE 2000	7,166	4	6	43	1876	151
ONNE2001	9,056	4	6	45	1,775	151
ONNE 2002	10,182	8	6	45	1,853	151
ONNE 2003	11,995	3	6	48	1690	270.8
ONNE 2004	13,688	3	6	46	1,185	271

ONNE 2005	13,809	3	6	46	1,146	270.8
ONNE 2006	15,820	2	6	40	1747	270.8
ONNE 2007	21,559	2	7	45	2157	979
ONNE 2008	21,419	5	7	48	2593	979
ONNE 2009	17,462	5	7	48	2894	979
ONNE 2010	23,302	3	10	55	3364	979
ONNE 2011	26,217	4	10	250	3364	979
PH 2000	4,684	11	8	77	1252	81
PH 2001	5,690	12	8	36	1,243	81
PH 2002	5,302	14	8	17	1,286	81
PH 2003	4,845	17	8	16	1249	83.4
PH 2004	4,964	17	11	31	1,096	83
PH 2005	5,347	13	11	20	929	83.4
PH 2006	5,580	12	11	23	291	83.4
PH 2007	4,879	10	11	25	504	83.4
PH 2008	4,885	10	11	21	631	83.4
PH 2009	5,185	11	11	28	870	83.4
PH 2010	5,797	9	11	22	936	83.4
PH 2011	7,464	10	11	27	1157	83.4
TCIP 2000	3,938	12	16	147	1976	376
TCIP 2001	5,116	10	16	78	1,979	376
TCIP 2002	4,755	11	16	71	2,196	376
TCIP 2003	5,293	9	16	104	2398	376
TCIP 2004	4,694	8	16	119	2,126	383
TCIP 2005	5,461	7	16	118	1,772	383
TCIP 2006	7,400	4	18	105	1106	383
TCIP 2007	10,003	4	18	113	1155	395.2
TCIP 2008	13,413	4	18	122	1376	395.2
TCIP 2009	14,099	7	18	120	1550	404
TCIP 2010	13,076	5	18	99	1678	404
TCIP 2011	15,371	5	18	119	1678	404
WARRI 2000	1,837	6	20	79	1216	301

WARRI 2001	1,855	6	20	33	1,214	301
WARRI 2002	2,043	6	20	25	1,206	301
WARRI 2003	1,886	8	20	19	1169	301
WARRI 2004	1,566	8	20	15	1092	301
WARRI 2005	2,223	6	20	38	942	301
WARRI 2006	1,461	7	23	25	836	301
WARRI 2007	1,516	6	23	35	644	301
WARRI 2008	4,002	7	23	28	685	301
WARRI 2009	7,345	9	23	30	815	301
WARRI 2010	9,142	8	23	37	829	301
WARRI 2011	8,467	7	23	32	840	301

- *THRP('000Tonnes)=Throughput in thousand tonnes,*
- *TAT(Days)=Yearly average turnaround time in days,*
- *NOB(Units)=Total number of berths in units,*
- *NOE(Units)=Total number of equipment in units,*
- *NOS(Units)=Total number of staff in units,*
- *STC ('000Tonnes) =Storage capacity in thousand tonnes*

Appendix 5.2: Descriptive statistics of input and output variables

YEAR	DESCRIPS	THRUP('000tonnes)	TAT(units)	NOB(units)	NOE(units)	NOS(units)	STC('000tonnes)
2000	Mean	4823.2	8.17	14.67	99.67	1815.67	276.25
	STDEV	3843.6	4.36	7.55	53.44	1179.68	200.96
	Kurtosis	0.1	-2.63	-0.88	-0.68	2.76	0.53
	Skewness	0.7	-0.10	0.45	0.89	1.4675	1.05
	Minimum	306.0	3	6	43	583	81
	Maximum	11008	13	26	183	3991	617.5
2001	Mean	5990	8.83	14.67	59.17	1786.67	276.3
	STDEV	4939.3	4.22	7.55	29.66	1166.23	200.92
	Kurtosis	0.009	-1.32	-0.88	0.625	2.85	0.54
	Skewness	0.7	0.44	0.45	1.203	1.49	1.05
	Minimum	325	4	6	33	566	81
	Maximum	13898	15	26	110	3,943	617.5
2002	Mean	6164.7	11.33	14.67	48.17	1873.17	276.3
	STDEV	5203.3	6.50	7.55	32.57	1224.78	200.92
	Kurtosis	-0.5	1.71	-0.88	-0.01	2.37	0.54
	Skewness	0.7	1.38	0.45	1.03	1.39	1.05
	Minimum	400	6	6	17	595	81
	Maximum	14306	23	26	102	4,103	617.5
2003	Mean	6513.2	10.5	14.67	50.83	1782.5	313.4
	STDEV	5606.7	7.04	7.55	37.09	1070.34	226.08
	Kurtosis	-1.3	-1.09	-0.88	-1.59	0.72	1.97
	Skewness	0.6	0.71	0.45	0.69	1.01	1.25
	Minimum	481	3	6	16	597	83.4
	Maximum	14579	21	26	104	3592	717.9
2004	Mean	6802.8	10.33	15.17	52.67	1636	314.98
	STDEV	6147.8	7.09	7.11	43.48	1150.97	227.38
	Kurtosis	-1.7	-1.07	-0.29	-1.07	2.29	1.88
	Skewness	0.7	0.79	0.43	0.83	1.56	1.23

	Minimum	753	3	6	13	570	83.4
	Maximum	15152	21	26	119	3747	720.4
2005	Mean	7438.2	7.5	15.17	60	1385	314.98
	STDEV	6472.7	5.01	7.11	48.25	902.87	227.38
	Kurtosis	-1.3	-1.77	-0.29	-1.86	2.08	1.88
	Skewness	0.7	0.43	0.43	0.74	1.45	1.23
	Minimum	858	2	6	15	499	83.4
	Maximum	16931	14	26	123	3022	720.4
2006	Mean	7691.9	6.17	16.17	54.67	888.67	314.98
	STDEV	6516.6	3.87	7.94	45.77	515.48	227.38
	Kurtosis	-1.9	-1.10	-1.37	-1.63	0.76	1.88
	Skewness	0.4	0.56	0.20	0.89	0.77	1.23
	Minimum	777	2	6	15	291	83.4
	Maximum	15820.4	12	27	120	1747	720.4
2007	Mean	9594.4	5.5	16.33	56	986.17	435.05
	STDEV	8769	3.45	7.69	40.38	677.20	350.08
	Kurtosis	-1.9	-1.97	-1.50	-1.64	1.09	-0.74
	Skewness	0.5	0.33	0.31	0.80	1.07	0.77
	Minimum	1042	2	7	18	275	83.4
	Maximum	21559	10	27	113	2157	979
2008	Mean	10865.6	6.67	16.5	52.83	1129	435.05
	STDEV	8763.7	2.80	7.97	40.96	836.10	350.08
	Kurtosis	-2.4	-2.23	-1.26	0.29	1.46	-0.74
	Skewness	0.3	0.43	0.41	1.14	1.13	0.77
	Minimum	1165	4	7	18	220	83.4
	Maximum	21419	10	28	122	2593	979
2009	Mean	11151.6	7.50	16.50	55.33	1,325.17	436.52
	STDEV	7580.2	2.66	7.97	39.53	869.84	349.90
	Kurtosis	-1.8	- 1.40	- 1.26	- 0.26	2.08	- 0.75
	Skewness	0.1	- 0.14	0.41	1.06	1.34	0.75
	Minimum	1699	4	7	20	431	83.4

	Maximum	21119	11	28	120	2894	979
2010	Mean	12485.1	5.83	17	54	1419.17	436.52
	STDEV	8747.9	2.56	7.32	34.25	1084.10	349.90
	Kurtosis	-1.7	-2.13	-1.31	-1.95	2.14	-0.75
	Skewness	0.2	-0.05	0.66	0.48	1.25	0.75
	Minimum	1588	3	10	20	219	83.4
	Maximum	23302	9	28	99	3364	979
2011	Mean	13794.1	6.33	17.17	90.67	1,482.50	436.52
	STDEV	9579.2	2.42	7.63	87.81	1,033.14	349.90
	Kurtosis	-1.7	-1.14	-0.96	1.95	2.51	-0.75
	Skewness	0.2	0.56	0.75	1.45	1.36	0.75
	Minimum	1880	4	10	21	369	83.4
	Maximum	26217	10	29	250	3364	979

- *THRP(‘000Tonnes)=Throughput in thousand tonnes,*
- *TAT(Days)=Yearly average turnaround time in days,*
- *NOB(Units)=Total number of berths in units,*
- *NOE(Units)=Total number of equipment in units,*
- *NOS(Units)=Total number of staff in units,*
- *STC (‘000Tonnes) =Storage capacity in thousand tonnes.*

Appendix 5.3: Descriptive analysis of the variables

The main objective of the descriptive statistics is to understand the behaviour of the variables that are employed for the analysis. By observing the value of mean, median, maximum and minimum values, standard deviation, skewness and kurtosis the statistical behaviour of the variables will be ascertained (appendix 5.2). The relatively high value of standard deviation is an indication of high dispersion among the data in the sample. In other words, the finding shows that all the 72 port-years in the sample have large dispersion in the throughput level, turnaround time, number of berths, total number of equipment, total number of staff and storage capacity across the period under review. All the data show positive skewness while throughput, turnaround time and the total number of equipment are moderately skewed; whereas the total number of staff and total storage capacity are highly skewed (appendix 5.2). The absolute value of kurtosis for all the variables is less than 3 indicating a platykurtic distribution. A platykurtic distribution in terms of shape exhibits a more flattened peak around the mean and longer tails.

Appendix 5.2 shows the changes in the input resources (infrastructure) and the outputs for the year before the concession 2005 and the 6th year (2011) after concession. It can be observed that, six years after the transfer of port operation from public to private hands, the mean throughput value which was 7,438,210metric tonnes in 2005 has increased to 13,794,080 in 2011. This represents an increase of 85.45%. The average turnaround time has reduced from 7.5 to 6.33 days indicating an improvement of 15.56%. The input resources also witnessed an upward trend after concession. The average number of berths increased from 15.17 to 17.17 an increase of 13.19%. The increase is due to construction of new berths by terminal operators that their concession is based on build, operate and transfer. The terminal operators have also brought new equipment as the average total number of equipment in use at the ports under consideration shot up from 60 to 90.67 an increase of 51.11%. The mean storage capacity increased from 314.98 thousand metric of cargo storage capacity to 436.52 thousand metric tonnes an improvement of 38.58%. Likewise the mean staff strength of the six ports increased from 1385 in 2005 to 1483 in 2011 an increase of 7.04. This should not be a basis for justifying that private participation increases employment because the 2005 figure is the figure after the massive retrenchment by NPA that paved way for the takeover of the terminals by the private operators in 2006. This figure only signifies that six years after the private sector took over the operational function of Nigerian seaports the mean staff strength has increased by 7.04%. However, this increment falls short of the total number of staff of 9816 employed by the six ports before the massive retrenchment of 2004 which paved way for the concession programme.

Appendix 5.4: Port level Inter-temporal Analysis technical efficiency scores, RTS, Actual/Target Input and Output variables

Port-Year	Score	RTS	Actual Throughput	Actual Turnaround	Actual No. of Berths	Actual No. of Equips	Actual No. of Staff	Actual Capacity	Target Throughput	Target Turnaround	Target No. of Berths	Target No. of Equips	Target No. of Staff	Target Capacity
APAPA 2000	68.38	1	11008	13	26	183	3991	617.5	16098.27	19.01	26	96.91	3322.143	617.5
APAPA 2001	83.76	1	13898	15	26	110	3943	617.5	16593.52	17.91	26	95.51	3106.372	617.5
APAPA 2002	100	1	14306	23	26	102	4103	617.5	14306	23	26	102	4103	617.5
APAPA 2003	100	1	14579	21	26	88	3592	717.9	14579	21	26	88	3592	717.9
APAPA 2004	100	1	15152	21	26	92	3747	720.4	15152	21	26	92	3747	720.4
APAPA 2005	89.92	1	16931	14	26	123	3022	720.4	18829.65	15.57	25.83	111.6	3022	687.76
APAPA 2006	100	1	15113	9	27	120	893	720.4	15113	9	27	120	893	720.4
APAPA 2007	97.49	1	18567	9	27	100	1182	720.4	19044.50	9.23	27	91.38	1182	680.45
APAPA 2008	100	0	20309	10	28	80	1269	720.4	20309	10	28	80	1269	720.4
APAPA 2009	98.17	1	21119	9	28	86	1391	720.4	21512.28	9.17	28	86	1391	720.4
APAPA 2010	96.21	1	22005	7	28	91	1489	720.4	22872.23	7.81	27.61	91	1489	720.4
APAPA 2011	100	0	23365	8	29	95	1487	720.4	23365	8	29	95	1487	720.4
CAL 2000	21.72	1	306	3	12	69	583	131	5356.56	13.81	11	25.90	583	83.25
CAL 2001	43.77	1	325	6	12	53	566	131	5369.57	13.71	11	25.73	566	83.26
CAL 2002	43.20	1	400	6	12	29	595	131	5347.37	13.89	11	26.02	595	83.25
CAL 2003	35.97	1	481	5	12	30	597	131.3	5345.84	13.90	11	26.04	597	83.25
CAL 2004	100	-1	753	5	12	13	570	131.3	753	5	12	13	570	131.3
CAL 2005	54.52	-1	858	2	12	15	499	131.3	1573.87	6.08	11.84	15	499	123.45
CAL 2006	65.10	-1	777	3	12	15	459	131.3	1193.54	5.22	11.93	15	459	128.00
CAL 2007	61.73	-1	1042	2	12	18	275	131.3	1687.96	5.18	11.87	18	275	125.04
CAL 2008	100	-1	1165	4	12	18	220	131.3	1165	4	12	18	220	131.3
CAL 2009	39.26	-1	1699	4	12	20	431	131.3	4327.06	10.63	11.03	20	431	95.29
CAL 2010	100	-1	1588	3	12	20	219	131.3	1588	3	12	20	219	131.3
CAL 2011	40.07	-1	1880	4	12	21	369	131.3	4691.56	10.89	11.09	21	369	92.00

ONNE 2000	100	-1	7166	4	6	43	1876	151	7166	4	6	43	1876	151
ONNE 2002	100	0	10182	8	6	45	1853	151	10182	8	6	45	1853	151
ONNE 2003	84.40	-1	11995	3	6	48	1690	270.8	14212.84	3.55	6	42.00	1690	242.48
ONNE 2004	98.88	-1	13688	3	6	46	1185	271	13843.47	3.03	6	45.71	1185	268.88
ONNE 2005	100	0	13809	3	6	46	1146	270.8	13809	3	6	46	1146	270.8
ONNE 2006	100	0	15820	2	6	40	1747	270.8	15820	2	6	40	1747	270.8
ONNE 2007	100	0	21559	2	7	45	2157	979	21559	2	7	45	2157	979
ONNE 2008	100	0	21419	5	7	48	2593	979	21419	5	7	48	2593	979
ONNE 2009	87.11	-1	17462	5	7	48	2894	979	20046.78	5.74	7	46.27	2490.17	893.96
ONNE 2010	100	1	23302	3	10	55	3364	979	23302	3	10	55	3364	979
ONNE 2011	100	1	26217	4	10	250	3364	979	26217	4	10	250	3364	979
ONNE2001	100	-1	9056	4	6	45	1775	151	9056	4	6	45	1775	151
PH 2000	88.58	-1	4684	11	8	77	1252	81	5608.79	12.42	8	32.02	1252	81
PH 2001	100	-1	5690	12	8	36	1243	81	5690	12	8	36	1243	81
PH 2002	100	0	5302	14	8	17	1286	81	5302	14	8	17	1286	81
PH 2003	100	0	4845	17	8	16	1249	83.4	4845	17	8	16	1249	83.4
PH 2004	100	0	4964	17	11	31	1096	83	4964	17	11	31	1096	83
PH 2005	95.97	1	5347	13	11	20	929	83.4	5571.27	13.55	9.34	20	929	83.4
PH 2006	100	0	5580	12	11	23	291	83.4	5580	12	11	23	291	83.4
PH 2007	83.17	1	4879	10	11	25	504	83.4	5866.27	12.02	11.00	24.31	504	83.4
PH 2008	88.69	-1	4885	10	11	21	631	83.4	5507.65	12.66	9.98	21	631	83.4
PH 2009	85.35	1	5185	11	11	28	870	83.4	6074.95	12.89	11.00	27.07	870	83.4
PH 2010	95.21	-1	5797	9	11	22	936	83.4	6088.80	12.11	9.83	22	936	83.4
PH 2011	100	0	7464	10	11	27	1157	83.4	7464	10	11	27	1157	83.4
TCIP 2000	63.98	1	3938	12	16	147	1976	376	7697.94	18.76	15.39	51.78	1976	239.42
TCIP 2001	55.97	1	5116	10	16	78	1979	376	9139.84	17.87	16	50.98	1979	297.89
TCIP 2002	57.43	1	4755	11	16	71	2196	376	8304.48	19.16	16	54.56	2196	275.06
TCIP 2003	50.18	1	5293	9	16	104	2398	376	10547.25	17.93	16	64.71	2398	371.15
TCIP 2004	45.87	1	4694	8	16	119	2126	383	10233.79	17.44	16	55.38	2126	347.35
TCIP 2005	46.57	1	5461	7	16	118	1772	383	11727.15	15.03	16	59.74	1772	383
TCIP 2006	49.10	1	7400	4	18	105	1106	383	15072.69	8.15	17.14	55.95	1106	383

TCIP 2007	63.20	1	10003	4	18	113	1155	395.2	15828.35	6.33	15.02	58.64	1155	395.2
TCIP 2008	80.08	1	13413	4	18	122	1376	395.2	16749.56	5.00	13.60	57.38	1376	395.2
TCIP 2009	87.13	1	14099	7	18	120	1550	404	16181.99	8.03	16.37	59.69	1485.28	404
TCIP 2010	77.48	1	13076	5	18	99	1678	404	16877.58	6.45	15.05	58.43	1553.86	404
TCIP 2011	89.11	1	15371	5	18	119	1678	404	17248.54	5.61	14.34	57.76	1590.43	404
WARRI 2000	34.80	1	1837	6	20	79	1216	301	5336.81	17.24	11.60	33.83	1216	104.33
WARRI 2001	34.85	1	1855	6	20	33	1214	301	5322.11	17.21	11.46	33	1214	104.52
WARRI 2002	35.96	1	2043	6	20	25	1206	301	5681.75	16.69	10.16	25	1206	117.17
WARRI 2003	47.84	1	1886	8	20	19	1169	301	4906.66	16.72	8.69	19	1169	83.33
WARRI 2004	61.54	-1	1566	8	20	15	1092	301	3481	13	9.33	15	1022.67	99.37
WARRI 2005	38.30	1	2223	6	20	38	942	301	5804.44	15.67	11.79	31.68	942	112.84
WARRI 2006	46.09	1	1461	7	23	25	836	301	5162.56	15.19	10.38	25	836	83.23
WARRI 2007	42.28	1	1516	6	23	35	644	301	5309.88	14.19	11	26.51	644	83.22
WARRI 2008	54.40	1	4002	7	23	28	685	301	7355.99	12.87	12.04	28	685	172.52
WARRI 2009	80.60	1	7345	9	23	30	815	301	9113.01	11.17	11.35	30	815	272.20
WARRI 2010	83.88	1	9142	8	23	37	829	301	10899.27	9.54	12.92	37	829	301
WARRI 2011	81.24	1	8467	7	23	32	840	301	10421.78	8.62	9.95	32	840	301

RTS= Returns to scale, 1=Increasing returns to scale (IRS) -1=Decreasing Returns to scale (DRS), 0= Constant returns to scale (CRS), Target Output (throughput) = the volume that needed to be produced for the DMU to be on the efficient frontier, Actual Output=the volume produced, Target inputs=quantum of inputs that ought to be employed for the DMU to be on the efficient frontier, Actual inputs=the actual resources used.

Appendix 5.5: Nigerian ports reference peers (benchmarks), Input/output slacks for inefficient port-year operations

Port-Year	Score	Refs	Peers	Slacks Throughput	Slacks Turnaround Time	Slacks No. of Berths	Slacks No. of Equips.	Slacks No. of Staff	Slacks Capacity
APAPA 2000	68.38	0	4	0	0	0	34.4%	16.3%	0
APAPA 2001	83.76	0	4	0	0	0	5.8%	20.4%	0
APAPA 2002	100	13	0	0	0	0	0	0	0
APAPA 2003	100	3	0	0	0	0	0	0	0
APAPA 2004	100	1	0	0	0	0	0	0	0
APAPA 2005	89.92	0	3	0	0	0	0	0	0
APAPA 2006	100	2	0	0	0	0	0	0	0
APAPA 2007	97.49	0	4	0	4.2%	1.8%	10.0%	0	5.8%
APAPA 2008	100	13	0	0	0	0	0	0	0
APAPA 2009	98.17	0	6	0	0	0	0	0.3%	0
APAPA 2010	96.21	0	4	0	2.3%	1.3%	0	0	0
APAPA 2011	100	15	0	0	0	0	0	0	0
CAL 2000	21.72	0	2	15.1%	0	3%	17.2%	0	5%
CAL 2001	43.77	0	2	17.6%	0	3%	10.9%	0	5%
CAL 2002	43.20	0	2	16.9%	0	3%	1.2%	0	5%
CAL 2003	35.97	0	2	15.3%	0	3%	1.6%	0	5%
CAL 2004	100	7	0	0	0	0	0	0	0
CAL 2005	54.52	0	3	0	0	0	0	0	0
CAL 2006	65.10	0	3	0	0	0	0	0	0
CAL 2007	61.73	0	3	0	9.0%	0.8%	0	0	0.4%
CAL 2008	100	4	0	0	0	0	0	0	0
CAL 2009	39.26	0	3	0	1.5%	3.5%	0	0	2.1%
CAL 2010	100	1	0	0	0	0	0	0	0
CAL 2011	40.07	0	3	0	0	0	0	0	0

ONNE 2000	100	1	0	0	0	0	0	0	0
ONNE2001	100	1	0	0	0	0	0	0	0
ONNE 2002	100	4	0	0	0	0	2.4%	0.0000	2.9%
ONNE 2003	84.40	0	3	0	0	0	0.1%	0.0000	0.2%
ONNE 2004	98.88	0	3	0	0	0	0	0	0
ONNE 2005	100	7	0	0	0	0	0	0	0
ONNE 2006	100	18	0	0	0	0	0	0	0
ONNE 2007	100	7	0	0	0	0	0	0	0
ONNE 2008	100	3	0	0	0	0	0.7%	9.8%	8.7%
ONNE 2009	87.11	0	3	0	0	0	0	0	0
ONNE 2010	100	1	0	0	0	0	0	0	0
ONNE 2011	100	6	0	0	0	0	0	0	0
PH 2000	88.58	0	2	1.2%	0	0	18.0%	0	0
PH 2001	100	2	0	0	0	0	0	0	0
PH 2002	100	5	0	0	0	0	0	0	0
PH 2003	100	19	0	0	0	0	0	0	0
PH 2004	100	23	0	0	0	0	0	0	0
PH 2005	95.97	0	5	0	0	5.7%	0	0	0
PH 2006	100	27	0	0	0	0	0	0	0
PH 2007	83.17	0	4	0	0	0.0000	0.28%	0	0
PH 2008	88.69	0	4	0	6.0%	3.53%	0	0	0
PH 2009	85.35	0	4	0	0	0.01%	0.4%	0	0
PH 2010	95.21	0	4	0	11.6%	4.02%	0	0	0
PH 2011	100	5	0	0	0	0	0	0	0
TCIP 2000	63.98	0	2	0	0	15.2%	45.7%	21.3%	27.7%
TCIP 2001	55.97	0	4	0	0	5.7%	14.9%	20.7%	17.1%
TCIP 2002	57.43	0	3	0	0	9.6%	13.5%	26.3%	21.5%
TCIP 2003	50.18	0	4	0	0	2.1%	24.1%	30.6%	13.1%
TCIP 2004	45.87	0	4	0	0	2.1%	30.2%	24.0%	13.9%
TCIP 2005	46.57	0	5	0	0	0	30.5%	12.5%	4.4%

TCIP 2006	49.10	0	4	0	0	3.0%	19.6%	0	0
TCIP 2007	63.20	0	4	0	0	10.3%	21.7%	0	0
TCIP 2008	80.08	0	4	0	0	15.2%	25.8%	0	0
TCIP 2009	87.13	0	3	0	0	5.6%	24.1%	1.6%	0
TCIP 2010	77.48	0	3	0	0	10.2%	16.2%	3.0%	0
TCIP 2011	89.11	0	3	0	0	12.6%	24.5%	2.1%	0
WARRI 2000	34.80	0	2	0	0	30.2%	18.9%	2.9%	21.4%
WARRI 2001	34.85	0	4	0	0	30.1%	0.5%	2.8%	21.2%
WARRI 2002	35.96	0	4	0	0	33.9%	0	0.4%	19.0%
WARRI 2003	47.84	0	3	3.7%	0	39.0%	0	0	22.2%
WARRI 2004	61.54	0	2	0	0	0	0	0	0
WARRI 2005	38.30	0	3	0	0	28.3%	2.5%	0	19.2%
WARRI 2006	46.09	0	3	7.6%	0	43.5%	0	0	22.2%
WARRI 2007	42.28	0	2	6.6%	0	41.4%	3.4%	0	22.2%
WARRI 2008	54.40	0	4	0	0	37.8%	0	0	13.1%
WARRI 2009	80.60	0	4	0	0	40.2%	0	0	2.9%
WARRI 2010	83.88	0	5	0	0	34.7%	0	0	0
WARRI 2011	81.24	0	5	0	0	45.0%	0	0	0

Slacks= Percentage Adjustments to be made each input/output variable of inefficient and weakly efficient DMU to be on the frontier

Appendix 5.6: Port overall (CCR), technical (BCC), scale (SE) and super-efficiency scores and return to scale

			Yearly efficiency in percentages (100= "efficient")		
PORT-YEAR	CCR	BCC	SE	Super-efficiency score	RTS
APAPA 2000	35.2	68.4	51.5		IRS
APAPA 2001	42.7	83.8	51		IRS
APAPA 2002	53.4	100	53.4		IRS
APAPA 2003	54.7	100	54.7		IRS
APAPA 2004	54.5	100	54.5		IRS
APAPA 2005	52	89.9	57.8		IRS
APAPA 2006	95.4	100	95.4		IRS
APAPA 2007	96.1	97.5	98.6		IRS
APAPA 2008	100	100	100	100.3	CRS
APAPA 2009	97	98.2	98.8		IRS
APAPA 2010	95.9	96.2	99.7		IRS
APAPA 2011	100	100	100	102.2	CRS
CALABAR 2000	19.7	21.7	90.8		IRS
CALABAR 2001	39.8	43.8	90.9		IRS
CALABAR 2002	39.2	43.2	90.7		IRS
CALABAR 2003	32.6	36	90.6		IRS
CALABAR 2004	49.3	100	49.3		DRS
CALABAR 2005	20.8	54.5	38.2		DRS
CALABAR 2006	29.8	65.1	45.8		DRS
CALABAR 2007	22.4	61.7	36.3		DRS
CALABAR 2008	44.1	100	44.1		DRS
CALABAR 2009	33.8	39.3	86		DRS
CALABAR 2010	37.8	100	37.8		DRS
CALABAR 2011	35.3	40.1	88		DRS
ONNE 2000	70.8	100	70.8		DRS

ONNE2001	89.5	100	89.5		IRS
ONNE 2002	100	100	100	112.9	CRS
ONNE 2003	83.5	84.4	98.9		DRS
ONNE 2004	98.8	98.9	99.9		DRS
ONNE 2005	100	100	100	121.6	CRS
ONNE 2006	100	100	100	127	CRS
ONNE 2007	100	100	100	115.1	CRS
ONNE 2008	100	100	100	115.8	CRS
ONNE 2009	86.9	87.1	99.8		IRS
ONNE 2010	92.9	100	92.9		IRS
ONNE 2011	91.1	100	91.1		DRS
PH 2000	84.8	88.6	95.7		DRS
PH 2001	99.5	100	99.5		DRS
PH 2002	100	100	100	103	CRS
PH 2003	100	100	100	129	CRS
PH 2004	100	100	100	105.3	CRS
PH 2005	96	96	100		IRS
PH 2006	100	100	100	207*	CRS
PH 2007	83.2	83.2	100		IRS
PH 2008	86.9	88.7	98.0		DRS
PH 2009	85.3	85.4	99.9		IRS
PH 2010	92	95.2	96.6		DRS
PH 2011	100	100	100	133.1	CRS
TCIP 2000	40.8	64	63.8		IRS
TCIP 2001	39.1	56	69.8		IRS
TCIP 2002	38.7	57.4	67.4		IRS
TCIP 2003	34	50.2	67.7		IRS
TCIP 2004	32	45.9	69.7		IRS
TCIP 2005	34.2	46.6	73.4		IRS
TCIP 2006	45.6	49.1	92.9		IRS
TCIP 2007	59.6	63.2	94.3		IRS

TCIP 2008	70.3	80.1	87.8		IRS
TCIP 2009	67.5	87.1	77.5		IRS
TCIP 2010	59.4	77.5	76.6		IRS
TCIP 2011	69.8	89.1	78.3		IRS
WARRI 2000	22	34.8	63.2		IRS
WARRI 2001	25.2	34.9	72.2		IRS
WARRI 2002	29.6	36	82.2		IRS
WARRI 2003	45.5	47.8	95.2		IRS
WARRI 2004	52.3	61.5	85.0		DRS
WARRI2005	25.4	38.3	66.3		DRS
WARRI 2006	40.4	46.1	87.6		DRS
WARRI 2007	30.1	42.3	71.2		DRS
WARRI 2008	50.1	54.4	92.1		DRS
WARRI 2009	76.1	80.6	94.4		DRS
WARRI 2010	80.8	83.9	96.3		DRS
WARRI 2011	80.5	81.2	99.1		DRS
MEAN	64.88	77.15	82.78		
STDEV	28.24	24.32	19.26		
CORREL(CCR&BCC)	0.825				

- *CCR=efficiency scores from DEA constant returns to scale model,*
- *BCC=efficiency scores from variable returns to scale model,*
- *SE=Scale efficiency ratio of CCR and BCC,*
- *RTS=Returns to scale characteristics,*
- *CRS=Constant returns to scale,*
- *IRS=Increasing returns to scale,*
- *DRS=Decreasing returns to scale.*
- *GREEN Colour= Overall efficient(both technical and scale)*
- *YELLOW Colour=Only technically efficient*
- *BLUE Colour = Most efficient port-year operation*

Appendix 5.7: Nigerian ports DEA-BCC Window efficiency scores (2000-2011)

PORTS	**DEA BCC EFFICIENCY SCORES IN PERCENTAGES (100= "EFFICIENT")**														
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	MEAN	STD	VAR
APAPA 2000-2002	78.10	99.2	100										92.43	12.4	154.2
2001-2003		97.5	100	100									99.2	1.4	2.1
2002-2004			100	100	100								100	0	0
2003-2005				100	100	100							100	0	0
2004-2006					100	100	100						100	0	0
2005-2007						100	100	100					100	0	0
2006-2008							100	97.5	100				99.2	1.4	2.1
2007-2009								99.2	100	100			99.7	0.5	0.21
2008-2010									100	100	100		100.00	0	0
2009-2011										100	97.6	100	99.2	1.4	1.92
TOTAL MEAN	78.1	98.4	100	100	100	100	100	98.9	100	100	98.8	100	99.0	3.8	16.1
CL RANGE		1.7	0	0	0		0	1.7	0	0	2.4				
CAL 2000-2002	66.6	100	100										88.87	19.3	371.9
2001-2003		100	100	100									100	0	0
2002-2004			100	84.4	100								94.8	9.0	81.1
2003-2005				89	100	100							96.3	6.4	40.3
2004-2006					100	58.8	100						86.3	23.8	565.8
2005-2007						100	100	100					100	0	0

2006-2008							64.9	100	100				88.3	20.3	410.7
2007-2009								89.4	100	55.1			81.5	23.5	550.8
2008-2010									100	56.5	100		85.5	25.1	630.8
2009-2011										100	100	89	96.3	6.4	40.33
TOTAL MEAN	66.6	100	100	91.1	100	86.3	88.3	96.5	100	70.5	100	89	91.79	10.0	225.1
CL RANGE		0	0	15.6	0	41.2	35.1	10.6	0	44.9	0				
ONNE 2000-2002	100	100	100										100	0	0
2001-2003		100	100	100									100	0	0
2002-2004			100	100	89.3								96.4	6.2	38.2
2003-2005				100	100	100							100	0	0
2004-2006					100	100	100						100	0	0
2005-2007						100	100	100					100	0	0
2006-2008							100	100	100				100	0	0
2007-2009								100	100	100			100	0	0
2008-2010									100	100	100		100	0	0
2009-2011										100	100	100	100	0	0
TOTAL MEAN	100	100	100	100	96.4	100	100	100	100	100	100	100	99.6	2.0	3.8
CL RANGE		0	0	0	10.7	0	0	0	0	0	0				
PH 2000-2002	88.6	100	100										96.2	6.6	43.3
2001-2003		100	100	100									100	0	0
2002-2004			100	100	100								100	0	0
2003-2005				100	100	100							100	0	0
2004-2006					100	100	100						100	0	0

2005-2007						100	100	87.4					95.8	7.3	52.9
2006-2008							100	87.4	100				95.8	7.3	52.9
2007-2009								100	100	100			100	0	0
2008-2010									100	100	100		100	0	0
2009-2011										100	100	100	100	0	0
TOTAL MEAN	88.6	100	100	100	100	100	100	91.6	100	100	100	100	98.78	3.4	13.89
CL RANGE		0	0	0	0	0	0	12.6	0	0	0				
TCIP 2000-2002	74.1	65.1	65.1										68.1	5.2	27
2001-2003		60.3	58.2	52.4									57.0	4.1	16.7
2002-2004			57.4	51.3	47.5								52.1	5.0	24.9
2003-2005				51.9	47.4	51.5							50.3	2.5	6.2
2004-2006					47.5	50.1	56.8						51.5	4.8	23.0
2005-2007						54.4	53.4	68					58.6	8.2	66.5
2006-2008							51.7	67.9	84.6				68.1	16.5	270.6
2007-2009								76.9	99	100			92.0	13.1	170.5
2008-2010									98.4	100	93.7		97.4	3.3	10.7
2009-2011										92.5	85.5	100	92.7	7.3	52.6
TOTAL MEAN	74.1	62.7	60.2	51.9	47.5	52	54.0	70.9	94	97.5	89.6	100	68.8	4.5	365.9
CL RANGE		4.8	7.7	0.8	0.1	4.3	5.1	9	14.4	7.5	8.2				
WARR1 2000-2002	45.4	45.5	45.8										45.6	0.2	0.04
2001-2003		38.7	41.5	51									43.7	6.4	41.56
2002-2004			37	49.5	61.5								49.3	12.3	150.1
2003-2005				49.1	61.5	44.9							51.8	8.6	74.5

2004-2006					100	38.5	48.9						62.5	32.9	1084
2005-2007						46.1	54.5	47.8					49.5	4.4	19.7
2006-2008							58.3	50	59.1				55.8	5.0	25.4
2007-2009								57.8	68.1	93.7			73.2	18.5	341.7
2008-2010									69.5	95	99.3		87.9	16.1	259.5
2009-2011										100	100	100	100	0	0
TOTAL MEAN	45.4	42.1	41.4	49.9	74.3	43.2	53.9	51.9	65.6	96.2	99.7	100	61.9	10.0	479.6
CL RANGE		6.8	8.8	1.9	38.5	7.6	9.4	10	10.4	6.3	0.7				

CL= Column range

Appendix 5.8: Nigerian ports DEA-CCR Window efficiency scores (2000-2011)

PORTS	**DEA-CCR EFFICIENCY SCORES IN PERCENTAGES (100%="EFFICIENT")**												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	MEAN	STDEV
APAPA 2000-2002	53.2	67	71.8										64	
2001-2003		60.1	66.1	74.5									66.9	
2002-2004			54.6	59.7	58.6								57.6	
2003-2005				57.9	57	60.5							58.5	
2004-2006					64	53.8	96.6						71.5	
2005-2007						100	100	100					100	
2006-2008							100	97.5	100				99.2	
2007-2009								98.2	100	100			99.4	
2008-2010									100	100	100		100	
2009-2011										100	96.3	100	98.8	
TOTAL MEAN	53.2	63.6	64.2	64.0	59.9	71.4	98.9	98.6	100	100	98.2	100	81.4	19.5
CL RANGE		6.9	17.2	16.6	7	46.2	3.4	2.5	0	0	3.7			
CAL 2000-2002	47.3	97.4	92.6										79.1	
2001-2003		77.9	74.1	61.5									71.2	
2002-2004			65	54	59.1								59.4	
2003-2005				54	59.1	29.2							47.4	
2004-2006					60.1	22.2	33.9						38.7	
2005-2007						68.3	99.2	78.4					82.0	
2006-2008							83.3	55.4	100				79.6	
2007-2009								51	100	100			83.7	
2008-2010									100	56.3	88.8		81.7	
2009-2011										72	100	82.8	84.9	
TOTAL MEAN	47.3	87.7	77.2	56.5	59.4	39.9	72.1	61.6	100	76.1	94.4	82.8	70.8	22.7

CL RANGE		19.5	27.6	7.5	1	46.1	65.3	27.4	0	43.7	11.2			
ONNE 2000-2002	73.1	100	92.8										88.6	
2001-2003		91.6	100	100									97.2	
2002-2004			100	89.3	100								96.4	
2003-2005				89.3	99.3	100							96.2	
2004-2006					99.3	100	100						99.8	
2005-2007						100	100	100					100	
2006-2008							100	100	100				100	
2007-2009								100	100	94.1			98.03	
2008-2010									100	94.1	100		98.03	
2009-2011										100	100	100	100	
TOTAL MEAN	73.1	95.8	100	92.9	99.5	100	100	100	100	96.1	100	100	97.43	5.7
CL RANGE		8.4	7.2	10.7	0.7	0	0	0	0	5.9	0			
PH 2000-2002	85.8	100	100										95.3	
2001-2003		100	100	100									100	
2002-2004			100	100	100								100	
2003-2005				100	100	100							100	
2004-2006					100	100	100						100	
2005-2007						100	100	82.4					94.1	
2006-2008							100	83.7	93.5				92.4	
2007-2009								100	100	100			100	
2008-2010									100	100	100		100	
2009-2011										100	100	100	100	
TOTAL MEAN	85.8	100	100	100	100	100	100	88.7	97.8	100	100	100	98.18	5.0
CL RANGE		0	0	0	0	0	0	17.6	6.5	0	0			
TCIP 2000-2002	55.8	55.4	49.3										53.5	
2001-2003		52.2	46.5	42.6									47.1	
2002-2004			40.5	35.2	34.1								36.6	

2003-2005				34.9	33.8	39.2							35.97	
2004-2006					36.9	36.5	46.3						39.9	
2005-2007						91.5	68.4	75.2					78.4	
2006-2008							49.8	65.4	79.2				64.8	
2007-2009								76.7	99	100			91.9	
2008-2010									98.2	100	92		96.7	
2009-2011										91.5	83.1	97.7	90.8	
TOTAL MEAN	55.8	53.8	45.4	37.6	34.9	55.7	54.8	72.4	92.1	97.2	87.6	97.7	63.6	24.6
CL RANGE		3.2	8.8	7.7	3.1	55	22.1	4.3	13.2	8.5	8.9			
WARR1 2000-2002	45.3	45.4	45.7										45.5	
2001-2003		37.9	40.2	50.3									42.8	
2002-2004			36.5	48.8	53.4								46.2	
2003-2005				48.8	53.4	44							48.7	
2004-2006					82.1	27.8	46.6						52.2	
2005-2007						27.8	46.6	31.5					35.3	
2006-2008							53.7	32.9	53.2				46.6	
2007-2009								47	63.7	93.1			67.9	
2008-2010									68	94.4	95.5		86.0	
2009-2011										100	100	100	100	
TOTAL MEAN	45.3	41.7	40.8	49.3	63.0	33.2	49.0	37.1	61.6	95.8	97.8	100	57.1	24.6
CL RANGE		17.5	12.8	1.5	28.7	56	72.2	19.6	32	5.6	4.5			

Appendix 5.9: Pre-concession DEA-CCR & BCC efficiency scores and returns to scale

PORT-YEAR	PRE-CCR	PRE-BCC	SE	RTS
APAPA 2000	36.1	72.6	49.72	IRS
APAPA 2001	44.3	90.4	49	IRS
APAPA 2002	54	100	54	IRS
APAPA 2003	57.9	100	57.90	IRS
APAPA 2004	57	100	57	IRS
APAPA 2005	60.5	100	60.50	IRS
CALABAR 2000	33.2	48.4	68.60	CRS
CALABAR 2001	68.3	100	68.30	DRS
CALABAR 2002	65	100	65	DRS
CALABAR 2003	54	82.5	65.45	DRS
CALABAR 2004	59.1	100	59.10	DRS
CALABAR 2005	29.2	100	29.20	DRS
ONNE 2000	71.9	100	71.90	DRS
ONNE 2001	90.4	100	90	DRS
ONNE 2002	100	100.0	100	CRS
ONNE 2003	88.7	88.7	100	CRS
ONNE 2004	99.2	99	100	CRS
ONNE 2005	100	100	100	CRS
PH 2000	85.1	88.6	96.05	DRS
PH 2001	100	100	100	CRS
PH 2002	100	100	100	CRS
PH 2003	100	100	100	CRS
PH 2004	100	100	100	CRS
PH 2005	100	100	100	CRS
TCIP 2000	43.4	64	67.81	IRS
TCIP 2001	42	57.2	73.43	IRS
TCIP 2002	40.3	57.4	70.21	IRS
TCIP 2003	34.9	51.3	68.03	IRS
TCIP 2004	33.8	47.4	71.31	IRS

TCIP 2005	39.2	51.5	76.12	IRS
WARRI 2000	32.2	34.8	92.53	IRS
WARRI 2001	32.4	34.9	92.84	IRS
WARRI 2002	34.8	36.9	94.31	IRS
WARRI 2003	48.8	49.1	99.39	DRS
WARRI 2004	53.4	61.5	86.83	DRS
WARRI2005	44	44.7	98.43	DRS
MEAN	62.0	79.5	78.7	
STDEV	25.33	24.12	19.33	
CORREL	0.72			

Appendix 5.10: Post-concession Overall, pure technical, scale efficiency scores and returns to scale

PORT-YEAR	POST-CCR	POST-BCC	SE	RTS
APAPA 2006	95.4	100	95.4	IRS
APAPA 2007	96.1	97.5	98.6	IRS
APAPA 2008	100	100	100	CRS
APAPA 2009	97.1	98.4	98.7	IRS
APAPA 2010	96.0	96.2	99.8	IRS
APAPA 2011	100	100	100	CRS
CALABAR 2006	38.3	100	38.3	DRS
CALABAR 2007	22.5	64.9	34.7	DRS
CALABAR 2008	44.1	100	44.1	DRS
CALABAR 2009	38.3	46	83.3	DRS
CALABAR 2010	37.8	100	37.8	DRS
CALABAR 2011	36.7	42.3	86.8	DRS
ONNE 2006	100	100	100	CRS
ONNE 2007	91.1	100	91.1	CRS
ONNE 2008	100	100	100	CRS
ONNE 2009	100	100	100	DRS
ONNE 2010	92.8	100	92.8	IRS
ONNE 2011	93.4	100	93.4	IRS
PH 2006	100.0	100	100	CRS
PH 2007	84.7	84.7	100	CRS
PH 2008	93.7	100	93.7	DRS
PH 2009	92.1	92.1	100	CRS
PH 2010	97.4	100	97.4	DRS
PH 2011	100	100	100	CRS
TCIP 2006	48.3	49.1	98.4	IRS
TCIP 2007	63.5	64.3	98.8	IRS
TCIP 2008	77.5	81	95.7	IRS
TCIP 2009	75.8	88.7	85.5	IRS
TCIP 2010	67.1	78.1	85.9	IRS
TCIP 2011	78.8	89.6	87.9	IRS

WARRI 2006	53.7	58.3	92.1	IRS
WARRI 2007	32.9	50	65.8	IRS
WARRI 2008	53.2	59.1	90.0	IRS
WARRI 2009	78.5	83.2	94.4	IRS
WARRI 2010	80.8	83.9	96.3	IRS
WARRI 2011	80.5	81.4	98.9	IRS
MEAN	76.1	85.8	88.2	
STDEV	24.63	18.73	19.06	
CORREL	0.72			

Appendix 6.1: Port-year DEA-efficiency scores of ownership types

	DEA EFFICIENCY SCORES				
	OWNERSHIP TYPE				
PORT-YEAR	PUBLIC	PORT-YEAR	MIXED	PORT-YEAR	LANDLORD
APAPA 2000	74.40%	APAPA 2006	100.00%	APAPA 2008	100.00%
APAPA 2001	93.20%	CALABAR 2006	100.00%	APAPA 2009	98.40%
APAPA 2002	100.00%	CALABAR 2007	100.00%	APAPA 2010	96.70%
APAPA 2003	100.00%	PH 2006	100.00%	APAPA 2011	100.00%
APAPA 2004	100.00%	TCIP 2006	75.90%	CALABAR 2008	100.00%
APAPA 2005	100.00%	WARRI 2006	58.30%	CALABAR 2009	56.50%
CALABAR 2000	48.40%	WARRI 2007	50.00%	CALABAR 2010	100.00%
CALABAR 2001	100.00%			CALABAR 2011	68.20%
CALABAR 2002	100.00%			ONNE 2008	100.00%
CALABAR 2003	82.50%			ONNE 2009	100.00%
CALABAR 2004	100.00%			ONNE 2010	100.00%
CALABAR 2005	100.00%			ONNE 2011	100.00%
PH 2000	88.60%			PH 2008	100.00%
PH 2001	100.00%			PH 2009	100.00%
PH 2002	100.00%			PH 2010	100.00%
PH 2003	100.00%			PH 2011	100.00%
PH 2004	100.00%			TCIP 2008	91.10%
PH 2005	100.00%			TCIP 2009	92.50%
TCIP 2000	64.00%			TCIP 2010	85.50%
TCIP 2001	57.40%			TCIP 2011	100.00%
TCIP 2002	57.40%			WARRI 2008	69.50%
TCIP 2003	53.40%			WARRI 2009	94.80%
TCIP 2004	47.70%			WARRI 2010	98.60%
TCIP 2005	56.10%			WARRI 2011	100.00%
WARRI 2000	34.80%				
WARRI 2001	34.90%				
WARRI 2002	37.50%				
WARRI 2003	49.10%				
WARRI 2004	61.50%				
WARRI 2005	44.70%				
MEAN	76.19%		0.83457		93.83%
STDEV	0.249649096		0.22		0.1199051
Std Error	0.04557948		0.08315		0.0244755

Appendix 6.2: Comparison of port efficiency score of different ownership styles

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PUBLIC	30	22.856	0.761867	0.062325		
MIXED OWNERSHIP	7	5.842	0.834571	0.048401		
LANDLORD	24	22.518	0.93825	0.014377		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.415014876	2	0.207507	4.95592	0.010304	3.155932
Within Groups	2.428495681	58	0.041871			
Total	2.843510557	60				

Appendix 6.3: Bivariate analysis of public and mixed ownership efficiency scores

t-Test: Two-Sample Assuming Unequal Variances		
	PUBLIC	*MIXED OWNERSHIP*
Mean	0.761866667	0.834571429
Variance	0.062324671	0.048400619
Observations	30	7
Hypothesized Mean Diffe	0	
df	10	
t Stat	-0.766722152	
P(T<=t) one-tail	0.230481967	
t Critical one-tail	1.812461102	
P(T<=t) two-tail	0.460963934	
t Critical two-tail	2.228138842	

Appendix 6.4: Bivariate analysis of mixed and landlord ownership efficiency scores

t-Test: Two-Sample Assuming Unequal Variances		
	MIXED OWNERSHIP	*LANDLORD*
Mean	0.834571429	0.93825
Variance	0.048400619	0.014377239
Observations	7	24
Hypothesized Mean Difference	0	
df	7	
t Stat	-1.196106923	
P(T<=t) one-tail	0.135296736	
t Critical one-tail	1.894578604	
P(T<=t) two-tail	0.270593472	
t Critical two-tail	2.364624251	

Appendix 6.5: Ownership and sources of efficiency analysis

PORT-YEAR	PMPI	PTECHCH	PPECH	PSECH	PORT-YEAR	LMPI	LTECHCH	LPECH	LSECH
APAPA2002-2003	1.1319	0.9573	1	0.9573	APAPA2008-2009	0.9655	0.9655	1	0.9655
APAPA2003-2004	1.0028	1.0028	1	1.0028	APAPA2009-2010	0.9686	0.9686	1	0.9686
APAPA2004-2005	1.1404	1.1404	1	1.1404	APAPA2010-2011	1.0491	1.0491	1	1.0491
CALABAR2002-2003	0.8305	1.2503	1	1.2503	CALABAR2008-2009	0.5362	0.7305	1	0.7305
CALABAR2003-2004	1.1664	1.0233	1	1.0233	CALABAR2009-2010	1.3383	0.9824	1	0.9824
CALABAR2004-2005	0.5079	1.1924	1	1.1924	CALABAR2010-2011	0.8503	0.8503	1	0.8503
PH2002-2003	1.0701	1.0701	1	1.0701	PH2008-2009	0.9334	0.9334	1	0.9334
PH2003-2004	0.7756	0.7756	1	0.7756	PH2009-2010	1.0185	1.0185	1	1.0185
PH2004-2005	1.1226	1.1226	1	1.1226	PH2010-2011	1.0765	1.0765	1	1.0765
TCIP2002-2003	1.0251	0.9602	0.8871	1.082403	TCIP2008-2009	1.0546	1.0546	1	1.0546
TCIP2003-2004	0.9355	0.9825	0.9729	1.009867	TCIP2009-2010	0.9395	0.9558	1	0.9558
TCIP2004-2005	1.1918	1.1073	1.0562	1.048381	TCIP2010-2011	1.1593	1.1395	1	1.1395
WARRI2002-2003	1.2662	1.1509	1.1226	1.025209	WARRI2008-2009	1.3252	0.9012	1.4286	0.630827
WARRI2003-2004	1.1645	0.602	1.941	0.310149	WARRI2009-2010	0.9694	0.9694	1	0.9694
WARRI2004-2005	0.5452	1.1648	0.4613	2.525038	WARRI2010-2011	0.9657	0.9657	1	0.9657

Appendix 6.6: comparison of change in total factor productivity of public and landlord ports

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PMPI	15	14.8765	0.991766667	0.053666		
LMPI	15	15.1501	1.010006667	0.036112		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.002495232	1	0.002495232	0.055587	0.815329	4.195972
Within Groups	1.256894063	28	0.044889074			
Total	1.259389295	29				

t-Test: Paired Two Sample for Means		
	PMPI	*LMPI*
Mean	0.991766667	1.010007
Variance	0.053666127	0.036112
Observations	15	15
Pearson Correlation	0.560726258	
Hypothesized Mean Difference	0	
df	14	
t Stat	-0.35142463	
P(T<=t) one-tail	0.365251291	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.730502582	
t Critical two-tail	2.144786681	

Appendix 6.7: Comparison of technological change of public and landlord ports

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PTECHCH	15	15.5025	1.0335	0.028354131		
LTECHCH	15	14.561	0.97073333	0.009570604		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.029547	1	0.02954741	1.558213032	0.222265	4.195972
Within Groups	0.530946	28	0.01896237			
Total	0.560494	29				

t-Test: Paired Two Sample for Means		
	PTECHCH	LTECHCH
Mean	1.0335	0.970733333
Variance	0.02835413	0.009570604
Observations	15	15
Pearson Correlation	-0.2945824	
Hypothesized Mean Difference	0	
df	14	
t Stat	1.11386784	
P(T<=t) one-tail	0.14204716	
t Critical one-tail	1.76131012	
P(T<=t) two-tail	0.28409433	
t Critical two-tail	2.14478668	

Appendix 6.8: Comparison of technical efficiency change of public and landlord ports

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PPECH	15	15.4411	1.02940667	0.085312674		
LPECH	15	15.4286	1.02857333	0.012246531		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.21E-06	1	5.2083E-06	0.000106773	0.991829	4.195972
Within Groups	1.365829	28	0.0487796			
Total	1.365834	29				

t-Test: Paired Two Sample for Means		
	PPECH	LPECH
Mean	1.02940667	1.028573333
Variance	0.08531267	0.012246531
Observations	15	15
Pearson Correlation	0.08826645	
Hypothesized Mean Difference	0	
df	14	
t Stat	0.01064921	
P(T<=t) one-tail	0.49582679	
t Critical one-tail	1.76131012	
P(T<=t) two-tail	0.99165358	
t Critical two-tail	2.14478668	

Appendix 6.9: Comparison of scale efficiency change of public and landlord ports

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
PSECH	15	15.84994835	1.056663223	0.431431
LSECH	15	14.29062738	0.952708492	0.01713

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.081049396	1	0.081049396	0.361375	0.552579	4.195972
Within Groups	6.279852632	28	0.224280451			
Total	6.360902028	29				

t-Test: Paired Two Sample for Means

	PSECH	*LSECH*
Mean	1.056663223	0.952708492
Variance	0.431431174	0.017129729
Observations	15	15
Pearson Correlation	0.183337928	
Hypothesized Mean Difference	0	
df	14	
t Stat	0.623449941	
P(T<=t) one-tail	0.271506672	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.543013344	
t Critical two-tail	2.144786681	

Appendix 6.10: Throughput determinants data in Log form

PORT-YEAR	LNTHRPUT	LNEFF	LNDEP	LNCALLS	SEC	24HRS	LNPCTR
APAPA 2000	9.306	3.561	2.351	7.159	0	0	15.873
APAPA 2001	9.540	3.754	2.351	7.252	0	0	15.899
APAPA 2002	9.568	3.978	2.351	6.861	0	0	15.924
APAPA 2003	9.587	4.002	2.351	6.797	0	0	15.949
APAPA 2004	9.626	3.998	2.351	7.227	0	0	15.975
APAPA 2005	9.737	3.951	2.351	6.862	0	0	16.000

APAPA 2006	9.623	4.558	2.351	7.028	0	0	16.025
APAPA 2007	9.829	4.565	2.442	7.215	0	0	16.047
APAPA 2008	9.919	4.605	2.526	7.281	0	0	16.069
APAPA 2009	9.958	4.575	2.526	7.343	0	0	16.091
APAPA 2010	9.999	4.563	2.603	7.370	0	1	16.112
APAPA 2011	10.059	4.605	2.603	7.374	0	1	16.134
CAL 2000	5.724	2.981	2.197	5.333	0	0	14.725
CAL 2001	5.784	3.684	2.197	5.037	0	0	14.750
CAL 2002	5.991	3.669	2.197	4.691	0	0	14.775
CAL 2003	6.176	3.484	2.197	5.094	0	0	14.800
CAL 2004	6.624	3.898	2.197	5.361	0	0	14.826
CAL 2005	6.755	3.035	2.197	5.620	0	0	14.851
CAL 2006	6.655	3.395	2.197	5.771	0	0	14.876
CAL 2007	6.949	3.109	2.197	5.505	0	0	14.898
CAL 2008	7.060	3.786	2.197	5.861	0	0	14.920
CAL 2009	7.438	3.520	2.197	5.771	0	0	14.942
CAL 2010	7.370	3.632	2.398	5.283	0	0	14.963
CAL 2011	7.539	3.564	2.398	5.187	0	0	14.985
ONNE 2000	8.877	4.260	2.380	5.497	1	0	15.309
ONNE 2001	9.111	4.494	2.380	6.157	1	0	15.335
ONNE 2002	9.228	4.605	2.380	6.192	1	0	15.360
ONNE 2003	9.392	4.425	2.380	5.889	1	0	15.385
ONNE 2004	9.524	4.593	2.351	5.966	1	0	15.411
ONNE 2005	9.533	4.605	2.351	6.047	1	0	15.436
ONNE 2006	9.669	4.605	2.526	6.529	1	0	15.461
ONNE 2007	9.979	4.605	2.526	6.597	1	0	15.483

ONNE 2008	9.972	4.605	2.526	6.568	1	0	15.505
ONNE 2009	9.768	4.465	2.526	6.531	1	0	15.527
ONNE 2010	10.056	4.532	2.526	6.645	0	1	15.548
ONNE 2011	10.174	4.512	2.526	6.786	0	1	15.570
PH 2000	8.452	4.440	1.977	6.258	1	0	15.309
PH 2001	8.646	4.600	2.069	6.248	1	0	15.335
PH 2002	8.576	4.605	2.069	6.207	1	0	15.360
PH 2003	8.486	4.605	2.069	6.205	1	0	15.385
PH 2004	8.510	4.605	2.069	6.014	1	0	15.411
PH 2005	8.584	4.564	2.197	5.476	1	0	15.436
PH 2006	8.627	4.605	2.197	6.120	1	0	15.461
PH 2007	8.493	4.421	2.197	6.120	1	0	15.483
PH 2008	8.494	4.465	2.197	6.176	1	0	15.505
PH 2009	8.554	4.446	2.197	6.129	1	0	15.527
PH 2010	8.665	4.522	2.197	6.178	0	0	15.548
PH 2011	8.918	4.605	2.197	6.370	0	0	15.570
TCIP 2000	8.278	3.709	2.442	6.506	0	0	15.873
TCIP 2001	8.540	3.666	2.442	6.561	0	0	15.899
TCIP 2002	8.467	3.656	2.442	6.504	0	0	15.924
TCIP 2003	8.574	3.526	2.442	6.724	0	0	15.949
TCIP 2004	8.454	3.466	2.442	6.545	0	0	15.975
TCIP 2005	8.605	3.532	2.442	6.205	0	0	16.000
TCIP 2006	8.909	3.820	2.398	6.737	0	0	16.025
TCIP 2007	9.211	4.088	2.398	7.184	0	0	16.047
TCIP 2008	9.504	4.253	2.398	7.184	0	0	16.069
TCIP 2009	9.554	4.212	2.485	7.236	0	0	16.091

TCIP 2010	9.479	4.084	2.485	7.316	0	1	16.112
TCIP 2011	9.640	4.246	2.485	7.395	0	1	16.134
WARRI 2000	7.516	3.091	2.140	5.727	1	0	15.074
WARRI 2001	7.526	3.227	2.140	6.038	1	0	15.100
WARRI 2002	7.622	3.388	2.140	5.953	1	0	15.125
WARRI 2003	7.542	3.818	2.140	5.756	1	0	15.150
WARRI 2004	7.356	3.957	2.140	5.697	1	0	15.175
WARRI2005	7.707	3.235	2.140	5.889	1	0	15.201
WARRI 2006	7.287	3.699	2.197	5.549	1	0	15.226
WARRI 2007	7.324	3.405	2.197	5.606	1	0	15.248
WARRI 2008	8.295	3.914	2.197	5.733	1	0	15.270
WARRI 2009	8.902	4.332	2.197	5.771	1	0	15.291
WARRI 2010	9.121	4.392	2.197	5.832	1	0	15.313
WARRI 2011	9.044	4.388	2.197	5.892	1	0	15.335

Appendix 6.11: First- Stage Regression with throughput Analysis

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.969642801
R Square	0.940207161
Adjusted R Square	0.934687822
Standard Error	0.294048317
Observations	72

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	88.37412583	14.72902097	170.34778	8.9336E-38
Residual	65	5.620186839	0.086464413		
Total	71	93.99431267			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-9.690506686	2.506327534	-3.866416722	0.0002579	-14.6959884	-4.68503	-14.695988	-4.685025
LNEFF	0.60998141	0.059708425	10.21600234	3.782E-15	0.49073545	0.729227	0.49073545	0.72922737
LNDEP	1.889004171	0.335949942	5.622873936	4.26E-07	1.21806581	2.559943	1.21806581	2.55994253
LNCALLS	0.489796157	0.139554405	3.509714776	0.0008202	0.21108677	0.768506	0.21108677	0.76850555
SEC	0.390373467	0.097160591	4.017816927	0.000155	0.19633037	0.584417	0.19633037	0.58441656
24HRS	-0.013666384	0.147906996	-0.092398494	0.9266656	-0.30905705	0.281724	-0.309057	0.28172428
LNPCTR	0.540483227	0.214887714	2.515189062	0.0143787	0.11132283	0.969644	0.11132283	0.96964362

Appendix 6.12: Data on determinants of Nigerian ports efficiency

PORT-YEAR	LNEFF	LNTHRPUT	COM	OWN
APAPA 2000	3.561	8.891	0.160	0
APAPA 2001	3.754	9.119	0.160	0
APAPA 2002	3.978	9.017	0.160	0
APAPA 2003	4.002	9.002	0.160	0
APAPA 2004	3.998	9.325	0.160	0
APAPA 2005	3.951	9.037	0.160	0
APAPA 2006	4.558	9.631	0.159	1
APAPA 2007	4.565	9.974	0.159	1
APAPA 2008	4.605	10.238	0.158	1
APAPA 2009	4.575	10.272	0.158	1
APAPA 2010	4.563	10.397	0.156	1
APAPA 2011	4.605	10.443	0.155	1
CALABAR 2000	2.981	6.198	0.021	0
CALABAR 2001	3.684	6.529	0.018	0
CALABAR 2002	3.669	6.280	0.021	0
CALABAR 2003	3.484	6.446	0.024	0
CALABAR 2004	3.898	6.967	0.032	0
CALABAR 2005	3.035	6.515	0.033	0
CALABAR 2006	3.395	6.911	0.030	1
CALABAR 2007	3.109	6.512	0.032	1
CALABAR 2008	3.786	7.296	0.031	1
CALABAR 2009	3.520	7.041	0.041	1
CALABAR 2010	3.632	7.201	0.035	1
CALABAR 2011	3.564	7.091	0.037	1

ONNE 2000	4.260	8.543	0.150	1
ONNE 2001	4.494	9.214	0.151	1
ONNE 2002	4.605	9.337	0.154	1
ONNE 2003	4.425	8.993	0.157	1
ONNE 2004	4.593	9.131	0.159	1
ONNE 2005	4.605	9.212	0.158	1
ONNE 2006	4.605	9.941	0.159	1
ONNE 2007	4.605	10.001	0.160	1
ONNE 2008	4.605	9.992	0.159	1
ONNE 2009	4.465	9.870	0.152	1
ONNE 2010	4.532	9.389	0.158	1
ONNE 2011	4.512	9.488	0.158	1
PH 2000	4.440	8.391	0.128	0
PH 2001	4.600	8.712	0.127	0
PH 2002	4.605	8.699	0.121	0
PH 2003	4.605	8.711	0.112	0
PH 2004	4.605	8.585	0.111	0
PH 2005	4.564	8.444	0.110	0
PH 2006	4.605	8.956	0.111	1
PH 2007	4.421	8.828	0.091	1
PH 2008	4.465	8.913	0.084	1
PH 2009	4.446	8.876	0.086	1
PH 2010	4.522	8.413	0.086	1
PH 2011	4.605	8.628	0.094	1
TCIP 2000	3.709	8.718	0.118	0
TCIP 2001	3.666	8.739	0.121	0

TCIP 2002	3.656	8.703	0.115	0
TCIP 2003	3.526	8.778	0.118	0
TCIP 2004	3.466	8.616	0.108	0
TCIP 2005	3.532	8.431	0.112	0
TCIP 2006	3.820	8.957	0.127	1
TCIP 2007	4.088	9.497	0.132	1
TCIP 2008	4.253	9.633	0.141	1
TCIP 2009	4.212	9.834	0.143	1
TCIP 2010	4.084	9.749	0.132	1
TCIP 2011	4.246	9.940	0.136	1
WARRI 2000	3.091	7.200	0.076	0
WARRI 2001	3.227	7.543	0.066	0
WARRI 2002	3.388	7.616	0.069	0
WARRI 2003	3.818	7.812	0.064	0
WARRI 2004	3.957	7.888	0.054	0
WARRI2005	3.235	7.493	0.065	0
WARRI 2006	3.699	7.730	0.047	1
WARRI 2007	3.405	7.560	0.042	1
WARRI 2008	3.914	8.050	0.074	1
WARRI 2009	4.332	8.406	0.105	1
WARRI 2010	4.392	8.507	0.111	1
WARRI 2011	4.388	8.559	0.101	1

Appendix 6.13: Second-Stage regression efficiency Model

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.8909903							
R Square	0.7938637							
Adjusted R Squar	0.7847694							
Standard Error	0.4030676							
Observations	72							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	3	42.54575004	14.18192	87.29293	2.8554E-23			
Residual	68	11.0475191	0.162464					
Total	71	53.59326914						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.1026507	1.62283847	-0.06325	0.94975	-3.34097445	3.135673	-3.3409744	3.13567297
LNTHRPUT	0.4256784	0.188714842	2.25567	0.027312	0.049103787	0.802253	0.04910379	0.80225298
LNCOM	0.0847491	0.088220278	0.960654	0.34013	-0.09129168	0.26079	-0.0912917	0.26078996
OWN	0.4033311	0.112163374	3.595925	0.000608	0.17951256	0.62715	0.17951256	0.62714961

Appendix 8.1: Nigerian ports Inter-temporal analysis VRS reference efficiency benchmarks