EFFECTS OF MARITIME LOGISTICS ON PORT EFFICIENCY IN NIGERIA

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CERTIFICATION

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DEDICATION

I dedicate this work to God Almighty who made it possible to carry out this research, also to my beloved family members who contribute financially in one way or the other for success of this work.

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My immense gratitude goes to Almighty God, who has proved Himself faithful in my life, and throughout my academic year in the University, I give him all the glory. Also, my special appreciation goes to my supervisor, Dr. (Mr) I.C Nze, for supervising this thesis. His fatherly advice, correction, suggestion, constructive criticisms and encouragement contributed immensely top the quality of this work. The Almighty God will continue to bless him abundantly. Also, my profound gratitude goes to my co-mentor Prof. G.C.Emegharah and ,Prof. K.U. Nnadi, Dr. O.Donatus, Dr .B. Nwokedi for challenging me to complete this study and all your necessary support when I needed it most, and also making me realize that the completion of M.Sc is not the end of pursuit of knowledge but the awareness of ignorance and a start of acquisition of new knowledge. I remain eternally grateful.

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Abstract

The study analyzed the effects of maritime logistics on port efficiency in Nigeria. It used the Lagos Apapa port and Eastern port of Onne to investigate the effects of maritime logistics performance on port efficiency in Nigeria. The ex-post facto research design was used in which secondary data on the ship turnaround time, waiting time, time at berth and cargo dwell time prevailing in Lagos Apapa port and Onne port each year between 2007 and 2019 was obtained and used as proxies for maritime logistics performance and the cargo throughput performance and ship call handled by the port was used as indicators of productivity. The time expended per annum in port operations measured in man-hours and the average time vessels spent at berth annually in the ports between 2007 and 2019 were obtained and used as input to estimate the efficiency of the port in cargo handling relative to expended efforts in man-hours, the efficiency of the port in handling ship calls and the berth efficiency of the port. The augmented efficiency model was used to estimate the efficiency of the port as described above while the log-linear multiple regression analysis was used to estimate the effects of maritime logistics performance on the cargo handling efficiency, ship output efficiency and berth efficiency of the seaport. The test of hypotheses reveals that in all cases, there is a significant effect of maritime logistics performance on each of cargo handling/throughput efficiency, ship output efficiency and berth efficiency in both ports. The models showing the relationships and effects of maritime logistics on the various components of port efficiency in Onne are shown: *InEFFICARPUT = 1.366 - 0.072InSHTRTIME + 0.081InCARGODWELLTIME + 0.014InWAITINGTIME -0.16InBERTHTIME + e; InEFFISHTR = 0.007+ 0.109InSHTRTIME - 0.001InCARGODWELLTIME + 0.001InWAITINGTIME + 0.003InBERTHTIME + e; and InBERTHEFFICIENCY = 1.103+ 1.667InSHTRTIME + 0.193InCARGODWELLTIME + 0.264InWAITINGTIME - 5.706InBERTHTIME + e. For Lagos Apapa port, InBERTHEFFICIENCY = 23.320 + 0.252InSHTRTIME + 0.072InCARGODWELLTIME - 0.041InWAITINGTIME - 8.535InBERTHTIME + e; InEFFISHTR = 0.698+ 0.27InSHTRTIME + 0.031InCARGODWELLTIME -0.004InWAITINGTIME - 0.025InBERTHTIME + e.* It was recommended among other things that, port authorities and terminal operators must implement maritime logistics strategies to improve the maritime logistics performance indicators and subsequently improve port efficiency.
Keywords: Port-efficiency, maritime, logistics, port-performance, Nigeria

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Aylin (2016) views maritime logistics as a concept which involves the process of planning, implementing and managing the movement of goods and information involved in the ocean carriage of goods and trade through the seaports. It is a coinage from two words- ‘maritime, which is an English adjective usually employed in qualifying services, trade, operations, carrier and all forms of objects found in or within the proximity of the seas, ocean and rivers. Typical examples include expressions such maritime transport, maritime trade, maritime operations, etc; and ; ‘logistics’- which according to Aylin (2016) is the process of planning, organizing and executing the efficient transportation and storage of goods from the point of origin to the point of consumption with the goal being to meet customer requirements in a timely and cost-effective manner. The functions of logistics according to Aylin (2016) are identified to include but not limited to:

(i) Transportation

(ii) Warehousing and storage

(iii) Planning and organization of resources (time, labour, finance, equipment, etc,)

(iv) Optimizing and executing the use of vehicles, labour. time, retail locations and customers, planning and optimizing, yards, routes and shipment loading,

(v) inventory management,

(vi) Demand analysis and order processing, etc.

Studies by Dongping (2021) and Olapoju (2019) agree that the motivation supporting the development of logistics and its application in planning complex operations and processes is to improve the efficiency of operations and firms, in ensuring that limited input resources are employed to turnout greater outputs within available time and cost constraints. This implies also that logistics should be responsibly employed in limiting cost, time and risk associated with the implementation of complex operations and activities of firms employing it. This will ensure consumer/user satisfaction induced by time and cost saving as well as safety and security benefits.

The maritime industry/sector represents such a complex sector where the integration of logistics for performance improvement is inevitable. In the maritime industry, the complex nature of the maritime sub-sector requires the incorporation of the logistics functions and activity areas when addressing the numerous challenges and bottlenecks to efficiency in service delivery and port-user satisfaction in the sub-sector. For example, all maritime-related fields, such as ship ownership, chartering, shipping agencies, brokering, freight-forwarding, stevedoring, supply management, port operations, including others are separate operating units. However, they are integrated in the functions of port/maritime logistics (Nwokedi, Ndikom, Okoroji and Nwaorgu, 2021). According to Nwokedi *et al* (2021), Maritime logistics, similar to port logistics, is an integrated concept aimed at addressing all aspects of logistics and supply chain challenges associated with maritime transportation and the delivery of goods via the seaports, with focus on improving and/or maximizing efficiency of ports and maritime transport, bring about cost-effectiveness in port operations and use, limiting time of port service delivery, improving maritime safety and security services, improving quality of service quality, utility/customer satisfaction, associated with the use of maritime transport and seaports in the delivery of consignments by shippers and freight forwarders. The study adopts the definition of the concept of maritime logistics by Nwokedi *et al* (2021) as aforementioned. In the area of port operations as a shored-based operational aspect of maritime operations, the port logistics sector form an aspect of maritime logistics associated with the application of the logistics functions in port operations, management and administration to achieve the core goals of port authorities (cost effectiveness, time optimization, utility maximization and customer satisfaction, performance improvement, etc.) as mentioned above. Thus, we can identify core proxies that provides evidence of the performance of maritime logistics with regards to port operations to include variables such as ship-turnaround time in ports, cargo dwell time in ports, vessel waiting time, vessel time at berth, cost of port services, level of security and safety of cargo and personnel in ports (this can be determined using the cargo pilferage risk profile of ports and attacks on personnel while in port), level of congestion-induced-delay in ports, level of satisfaction and utility derivable from port services, and quality of service. Since these form the basic outputs and indicators of the performance of maritime logistics towards the realization of the goals of integration of maritime operations and logistics (maritime logistics) and implementation of logistical tools and processes in ports and maritime operations; they are accepted as metrics for the assessment of the performance of maritime logistics and the effects on port performance and efficiency (Nwokedi, *et al* 2021; Dongping, 2021; and Olapoju, 2019). The motivation for the implementation of maritime logistics is also to positively influence the above identified output variables or indicators and improve port productivity and efficiency.

Oxford advanced dictionary defines efficiency as the state or quality of being efficient, or able to accomplish something with the least waste of time and effort; competency in performance. It further views efficiency as the accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort. The effort in this context may take the form of input resources such as time worked by the labour force (man-hours), time worked by machinery and equipment employed (machine-hours), financial resources expended. According to Lee (2019), port efficiency indicates the relationship between port output/performance and the input resources employed in producing a given level of output and it is indicative of the capacity of a given port system to eliminate wastefulness by ensuring that limited input resources is employed to turnout large output. Port efficiency according to Nze, Ejem and Nze (2020) is the ability of a port system to limit waste of input resources by producing acceptable higher levels of output with limited and/or lower level of input resources such as time, labour, superstructure and finance.

Mathematically, efficiency of the maritime transport subsequent with regards to use of the ports (port efficiency) is expressed as the ratio of the useful output produced by the port to the level of input resources employed in producing it. Therefore port efficiency is defined as port output per unit of input, usually expressed as a percentage.

Since efficiency (***E***) is a function of output (O) and input (I), we write that: $E = \left(\frac{O}{I}\right)\left(\frac{100}{1}\right)$

We assert that the output performance of the maritime transport sector particularly the ports is generally measured in terms of the ship traffic handled in ports, the cargo throughput handled in ports, the container throughput handled, the revenue generated by the port, etc. Similarly, since labour-both human and machine labour are employed in the handling of the ships and cargo, time and labour measurable in man-hours and machine-hours represent input factors while the financial resources, the berths, superstructures, etc., also represent input resources towards the production of outputs by port authorities. The efficiency of the port can be assessed using the aforementioned input factors.

Basically, it is in the interest of this study to employ ship traffic performance, port revenue and cargo throughput handled in the ports as outputs and man-hours put into handling or working out these outputs as inputs, in order to determine the efficiency of the ports in the utilization of time as a major input over the years.

Furthermore, it is rightly believed that maritime logistics has effects in the level of productivity and efficiency of port operations in Nigeria, the identified outputs, indicators or proxies of maritime logistics performance such as ship-turnaround time, cargo-dwell time, vessel waiting time, vessel time at berth, port costs, level of safety and security of cargo and personnel in port, , will subsequently be used to assess the effects of maritime logistics on the productivity and efficiency of Nigerian ports over the years.

1.2 Problem Statement

Most empirical studies in the area of maritime logistics agree that the paramount motivation for the integration of logistics and maritime operations is the improvement of efficiency of maritime and port operations by the implementation of planning and organization and scientific management tools aimed at improving performance of the maritime sub-systems and consumer satisfaction. For example, studies by Dongping, (2021); Aylin, (2016) and Olapoju, (2019) agree that the implementation of the principles of maritime logistics in port operations should lead to improvement in variables of port operational indices such as: ship-turnaround time in ports, cargo dwell time in ports,vessel waiting time in port, average vessel time at berth, cost of port services (wharfage, ship-dues, berthage etc) ,cargo pilferage risk profile of ports (security), level of congestion-induced-delay in ports, level of satisfaction and utility derivable from port services, and quality of service which in turn should improve port efficiency by eliminating wastage of resources, time and effort (in man-hours or machine-hours) expended in port operations.

However, there is a problem in the employment and implementation of the principles and tools of professional maritime logistics practices in Nigerian ports, the ship-turnaround time, cargo dwell time, waiting time, time at berth, cargo pilferage risk profile, congestion related delays, cost of port services consumption, continues to rise while port efficiency seems to be stagnated over the years (Nwokedi *et al*, 2021; Olapoju, 2019). Despite the prevalence of the above identified challenges, not enough empirical studies have been able to investigate what constitute the trend of port efficiency in Nigerian ports relative to the problems of increasing ship-turnaround time, cargo dwell time, waiting time, time at berth, cargo pilferage risk profile, congestion-induced delay, increasing cost of port services, with a view to determining the effects of the identified outputs of implementation of maritime logistics on port efficiency. Moreover, available empirical literature has not been able to investigate using empirical data, how maritime logistics performance indicators such as ship turnaround time, vessels waiting time, cargo dwell time and average time vessels spend at berth being worked in Nigeria major ports affect the efficiency and productivity of the port. The expanded effect is that port operators and users are uncertain how the maritime logistics performance indicators identified above affect their effort aimed at improving port productivity in the ports. It is therefore important to empirically determine the relationship between maritime logistics performance outcomes and port efficiency in Nigeria in order that basis be developed based on empirical evidence for improvement in standards, principles and tools of professional maritime logistics practices in the seaport sector in Nigeria. This will in turn improve port efficiency and port-user satisfaction in Nigeria.

1.3 Aim and Objectives of the Study

The aim of the study is to analyze the effects of maritime logistics on port efficiency in Nigeria. The specific objectives of the study include:

i. To evaluate the efficiency of Nigerian ports in handling cargo cum vessel traffic relative to the expended efforts (in man-hours) and average time spent by vessels at berth in port operations over the years.

ii. To estimate the effects of maritime logistics performance on the efficiency of the port in cargo throughput productivity over the years.

iii. To determine the relationship depicting the effects of maritime logistics on the trend of port efficiency in handling ship calls in Nigeria.

iv. To establish the effects of maritime logistics on the berth efficiency of the port in Nigeria.

1.4 Research Questions

i. What is the efficiency of Nigerian ports in handling cargo cum vessel traffic relative to the expended efforts (in man-hours) and average time spent by vessels at berth in port operations over the years?

ii. What is the effect of maritime logistics on the efficiency of the port in cargo throughput productivity over the years?

iii. Is there a significant relationship between maritime logistics and port efficiency in handling ship calls in Nigeria?

iv. Is there a significant effect of maritime logistics on the berth efficiency of the port in Nigeria?

1.5 Hypotheses

H_{01}: The efficiency of Nigerian ports relative to the expended efforts (in man-hours) on port operations over the years is indeterminate.

H_{02}: There is no significant effect of maritime logistics on the efficiency of the port in cargo throughput productivity over the years

H_{03}: There is no significant relationship between maritime logistics and of port efficiency in handling ship calls in Nigeria.

H_{04}: There is no significant effect of maritime logistics on the berth efficiency of the port in Nigeria.

1.6 Justification of the Study

It is important to note that maritime and port operations significantly affect shipping and seaborne trade and influences costs, time, output, efficiency, safety and security risks associated with the use of maritime transport mode, in cargo handling and delivery, in the global logistics and supply chain sector. Thus a study of this kind focused on analyzing the effects of maritime logistics on port efficiency will have direct impacts of being used to improve and/or maximize the efficiency, cost-effectiveness, time, safety and security service, quality, utility/customer satisfaction, associated with the use of maritime transport and seaports in the delivery of consignments by shippers and freight forwarders. It is thus justified in that as shippers, freight forwarders, port and terminal operators benefit directly from the outcome of the study; the multiplier economic effects is enjoyed by the entire members of the public.. Similarly, shippers, port authorities, terminal operators and freight forwarders as major stakeholders and consumers of port services becomes very important beneficiaries of the outcome of the study while the efficiency and effectiveness of supply chain networks connected to Nigerian seaports can be improved with it. The study is equally important to students and researcher in academic and research institutions in this field of study, as a major reference research material for purposes of being used for further studies.

1.7 Scope of the Study

Time Scope: The secondary (time series) data obtained from the Nigerian ports Authority (NPA), Onne, and used in the study covers a period of 15 years from 2007 to 2019. Onne port is used as the case study.

Theoretical scope: The formulated empirical models for predicting the yearly values of port efficiency based on the values of the outputs of maritime logistics – ship-turnaround time, cargo dwell time, vessel waiting time, and average time vessels spent at berth being worked in Nigeria. It did not extend to cargo safety and security, pilferage risks, cost of doing business in the port, which are also indicators of maritime logistics performance.

Geographical scope: The geographical scope of the study is the Nigerian maritime port sector. The secondary data cover the entirety of the Nigerian maritime port sector using Onne and Lagos Apapa seaports as the case study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

Under this section, the major concepts involved in the study were explained according to expert opinions available in empirical literature.

2.1.1. Concept of Maritime Logistics

The Council of Supply Chain Management Professionals (CSCMP, 2010) define logistics as: "the process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements".

This definition encompasses inbound, outbound, internal, and external movements of both human and material resources serving as input into production process as well as output from industrial operations for purposes of marketing and distribution to the consumers. Suffice it to be that logistics is responsible for the flow of materials through a supply chain via nodes such as seaports, rail freight stations, and other transportation terminals. Without logistics, it is impossible to achieve the movement and delivery of both raw materials and finished goods to the hub markets and customers in the last mile corridors of the supply chain networks (CSCMP, 2010). Thus, logistics as a concept, is an integral part of the production and distribution system, without which, it is impossible to achieve continuous flow of materials and finished goods inventory to and from the factories and service organizations. By implication, the global economies will plummet in the absence of implementation of effective logistics principles tools and tools in the management of organizational processes. When principles and scientific tools of logistics are applied in the maritime sub-sector of the global economy and in the facilitation and administration of seaborne trade via ports, land-based maritime operations, as well as offshore operations, it is termed maritime logistics. The motivation for maritime logistics is to enthrone efficiency and effectiveness in the discharge of maritime operations and maximize the utility derivable from consumption of port and maritime services.

Aylin (2016) views maritime logistics as a concept which involves the process of planning, implementing and managing the movement of goods and information involved in the ocean carriage of goods and trade through the seaports. It is a coinage from two words- ‘maritime, which is an English adjective usually employed in qualifying services, trade, operations, carrier and all forms of objects found in or within the proximity of the seas, ocean and rivers. Typical examples include expressions as such maritime transport, maritime trade, maritime operations, etc; and ; ‘logistics’- which according to Aylin (2016) is the process of planning, organizing and executing the efficient transportation and storage of goods from the point of origin to the point of consumption with the goal being to meet customer requirements in a timely and cost-effective manner. The functions of logistics according Aylin (2016) are identified to include but not limited to:

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(v) inventory management,

(vi) Demand analysis and order processing, etc.

Studies by Dongping (2021) and Olapoju (2019) agree that the motivation supporting the development of logistics and its application in planning complex operations and processes is to improve the efficiency of operations and firms, in ensuring that limited input resources are employed to turnout greater outputs. This implies also that logistics should be responsibly employed in limiting cost, time and risk associated with the implementation of complex operations and activities of firms employing it. This will ensure consumer/user satisfaction induced by time and cost saving as well as safety and security benefits.

The maritime industry/sector represents such a complex sector where the integration of logistics for performance improvement is inevitable. In the maritime industry, the complex nature of the maritime sub-sector requires the incorporation of the logistics functions and activity areas when addressing the numerous challenges and bottlenecks to efficiency in service delivery and port-user satisfaction in the sub-sector. For example, all maritime-related fields, such as ship ownership, chartering, shipping agencies, brokering, freight-forwarding, stevedoring, supply management, port operations, are separate operating units. However, they are integrated in the functions of port/maritime logistics (Nwokedi, Ndikom, Okoroji and Nwaorgu, 2021). According to Nwokedi *et al* (2021), Maritime logistics, similar to port logistics, is an integrated concept aimed at addressing all aspects of logistics and supply chain challenges associated with maritime transportation and the delivery of goods via the seaports, with focus on improving and/or maximizing efficiency of ports and maritime transport, bring about cost-effectiveness in port operations and use, limiting time of port service delivery, improving maritime safety and security services, improving quality of service quality, utility/customer satisfaction, associated with the use of maritime transport and seaports in the delivery of consignments by shippers and freight forwarders.

The study adopts the definition of the concept of maritime logistics by Nwokedi *et al* (2021) as aforementioned. In the area of port operations as a shored-based operational aspect of maritime operations, the port logistics sector form an aspect of maritime logistics associated with the application of the logistics functions in port operations, management and administration to achieve the core goals of port authorities (cost effectiveness, time optimization, utility maximization and customer satisfaction, performance improvement, etc.) as mentioned above. Thus, we can identify core proxies that provides evidence of the performance of maritime logistics with regards to port operations to include variables such as ship-turnaround time in ports, cargo dwell time in ports, cost of port services, level of security and safety of cargo and personnel in ports (this can be determined using the cargo pilferage risk profile of ports and attacks on personnel while in port), level of congestion-induced-delay in ports, level of satisfaction and utility derivable from port services, and quality of service. Since these form the basic indicators of the performance of maritime logistics towards the realization of the goals of integration of maritime operations and logistics (maritime logistics) and implementation of logistical tools and processes in ports and maritime operations; they are accepted as metrics for the assessment of the performance of maritime logistics and the effects on port performance and efficiency (Nwokedi, *et al* 2021; Dongping, 2021; and Olapoju, 2019). The motivation for the implementation of maritime logistics is also to positively influence the above identified goals/variables and improve port efficiency.

According to Tuna & Arabelen, (2013), "Maritime logistics is referred to as the process of planning, implementing and managing the movement of goods and information involved in the ocean carriage." Tuna & Arabelen, (2013), suggests that the main issue in maritime logistics lies in the concept of integration which has to occur in physical level (intermodal or multimodal), economic/strategic level (vertical integration, management structure) or organizational level (relationship based, people and process integration between organizations).

Tuna & Arabelen, (2013), identified three important actors in maritime logistics system:

(i) Shipping,

(ii) port/terminal operating, and;

(iii) Freight forwarding.

The main function of shipping is to move cargoes of shippers from one port to another. By adding logistics activities to the main function like collecting the cargoes in one point, informing the delivery position, helping customers who want special services, preparing bill of lading, container tracking, performing intermodal services and information flow the shipping service gets more close to the value added shipping logistics concept.

On the other hand, the main port/terminal operations are: loading ships, discharging ships and preparation of cargoes for final destination. In modern logistics system ports also contain value added services like warehousing, packaging, inland connections; repairing and assembly which make ports a cluster of organizations to fully become a link in supply chain (Tuna and Arabelen, 2013). The table-2.1 summarizes the functions of maritime logistics as proposed by Lee *et al*, (2012).

Table 2.1: Main Function and Supportive Activities of Maritime Logistics

	Shipping	**Port/Terminal operating**	**Freight forwarding**
Main function	Moving cargoes between ports	-Shipping reception -Loading/unloading cargoes -Stevedoring -Connecting to inland transportation	Booking vessels and preparing for requisite documents for ocean carriage and trade on behalf of shippers
Supportive logistics activities	-Documentation relating sea trade -Container tracking and information flow -Providing intermodal service	-Warehousing -Offering distribution center -Testing -Assembly -Repairing -Inland connections	-Inventory management -Packaging -Warehousing

Source: Lee et al (2012)

The definitions of the concept of maritime logistics examined previously indicate activities for which the maritime industry actors might be responsible. It is viewed that maritime logistics is not a concept that just shows the performed logistics activities like warehousing in addition to the main activities like shipping. It is a concept with broader philosophy which contains integration, coordination, value added customer services, lower costs, higher flexibility, reduced response time and higher quality (Lee *et al*, 2012).

2.1.2 Importance of Maritime Logistics Functions

(a) Transportation and Traffic Management

Transportation forms the operational main activity in the maritime logistics system. The very importance of transportation in maritime logistics made it that significant effort is always directed towards ensuring reduced cost of transportation as well as port charges and dues. This is mostly achieved through the adoption of the principles of economies of scale in which high volume of cargo is carried at one voyage to achieve lower per ton carriage cost. This is also a product of the application of logistics principles and planning (Aylin, 2016). Thus the ability to make a beneficial decision of whether to employ tramp or liner shipping requires the application of logistical tools. The table2.2 below compares the functions of maritime transportation and the concept of maritime logistics.

Table 2.2: Maritime logistics versus maritime transportation

	Maritime Transportation	**Maritime Logistics**
Concept .	The process of carrying and handling cargoes across the ocean	The process of planning, implementing and managing the movement of goods and information involved in ocean carriage
Focusing point	Maritime transportation emphasizes individual functions relating to sea transportation. Each function pursues its own aims or competitiveness.	Maritime logistics is concerned with not only individual functions relating to sea transportation, but also an effective logistics flow as a systematic entity of the logistics integration system.

Managerial function	Sea transportation activities: contracting, shipping, sea voyage, moving cargo, and loading/unloading.	Sea transportation activities: Contracting, shipping, sea voyage, moving cargo, and loading/unloading. Additional logistics services: Stripping/stuffing, storage, warehousing, offering a distribution center, quality control, testing, assembly, packaging, repacking, repairing, inland connection, and re-use

Sources: Aylin, (2016)**;** (Lee, *et al*., 2012)

As represented in the table above, while maritime transportation focuses on the individual functions relating to sea transportation, maritime logistics focuses on the effective and efficient cargo and information flow in the scope of logistics system. Maritime logistics is not only interested in sea transportation activities like shipping, loading and unloading but also in value added logistics activities like warehousing, packaging, repairing, stuffing, storage, etc. Maritime transport operators are accordingly encouraged to keep pace with other logistics functions as a central member of a global logistics integration system (Panayides & Song 2008). Traffic management and routing is a part of transportation sub-function of logistics. In maritime transportation routing depends on the type of shipping. Routes in liner shipping are predetermined, the loading and unloading ports are fixed and time schedules are certainly established

(b) Inventory Management

Inventory management concerns with trying to reduce the stock level and relating costs as low as possible. Song and Lee (2012) suggested that maritime managers who obtain significant customer information can constantly update on market demands. Later, they can forecast the market situation and that gives them a positive effect to coordinate their inventory management systems. Inventory planning has a critical role in customer service level. Service level can be measured as an order time, lead time, case fill rate, line fill rate, order fulfillment rate or any mix combination of these.

In the old times, both shipping companies and ports offered just basic logistics functions to their customers. Now days, the competition is getting larger each day, the new logistics services have been offered by shipping companies to gain a competitive advantage. Inventory management is a kindly new service for the ports to manage customer inventory and fulfill their orders. In maritime transportation most often occur in vertically integrated companies, where the same company controls all inventories as well as the fleet of ships transporting the products (Stalhane, Andersson, Christiansen, & Fagerholt, 2014). With using some information technologies ports should provide some inventory control activities such as; palletize racked-untracked option, lot and serial number control, cycle count review process and vendor managed inventory - wherever products are in transit from the port or moving to their final destination. Vendor managed inventory (VIM) is a stock management method that a supplier of products is responsible for optimizing the inventory held by a distributor. VIM agreements in which the supplier takes control of their tanks inventory levels, ensuring that adequate service levels are maintained. In maritime logistics, a fleet of ships transport multiple bulk goods from a set of production ports to a set of different customers; have their facilities (Giesen, Munoz, Silva & Leva, 2007).

On the other hand, inventory management also can be defined as controlling all contract affairs relating to rental, equipping and usage contracts for land areas, buildings, floating installations, as well as the clearing of contaminated sites and the removal of explosive ordinance on rented land areas which is located in the ports.

(c) Demand Forecasting

The forecast is a specific definition of what will be sold, when, and where (Bowersox, Closs, & Cooper, 2010). Forecasting remains as a critical capability for planning. It is important for maritime sector to plan the future to minimize the failure risks because of the volatile characteristic of the sector. Good planning starts with the appropriate demand forecasting.

Sustainability in logistics activities depends on efficient, effective and accurate demand forecasting. Like all other businesses, in maritime sector, demand forecasting acts as a decision support system. But the demand for shipping services isn't a self-sustained system. It should be considered as a part of general demand for other modes of transportation. With the capital intensive characteristics of maritime sector, demand forecasting is the basis of capacity calculation and investment decisions. Critical questions such as: which ship, which size, when to buy, are tried to be answered by shipping companies with the help of demand forecasting. Spot-chartering ships, time-chartering ships, sale and purchase, budget and strategic planning, make-or-buy, outsourcing are important decisions which are required to be forecasted. While searching the answers to these questions, the shipping companies and port authorities need past information and data sets.

In shipping sector there are different actors with different forecasting needs. Some of them are listed below:

Shipping companies: Depending on freight rates, new building and second hand prices shipping companies try to figure out the sale and purchase of ships decisions (Stopford, 2009). How second hand prices will develop, when to buy or sell ships are the basic questions of shipping companies that lead them to forecast demand before deciding.

Shipbuilders: Shipbuilders are concerned about the decisions like future demand for new ships, prices, currencies, subsidies and competition from other ship builders (Stopford, 2009).

Port authorities: Intense competition in port industry pushes port authorities to invest on advanced cargo handling facilities and to expand the port area. As a result, decisions about port development depend crucially on traffic forecasting to find out the volume of cargo in the future (Stopford, 2009).

(c) Cargo Handling

Cargo handling involves marshaling services (receive, store, assembly and sort the product in for delivery to a ship's berth) and stevedoring services (load and unload of products from ships). Unfortunately, this function is not easy, as aforementioned, the cargoes are differed based on three groupings.

In broad sense, there are two generic cargo groups; the general and the bulk cargoes. Based on that groups, also cargo handling equipment are classified as; general cargo equipment and bulk cargo equipment. Lifting and moving the cargo in batches or discrete units is called the general cargo. Dry-bulk cargo is the backbone of international sea trade. These bulk cargoes are handled at specialized terminals with special handling systems. Conveyors, pneumatic systems are some kinds of unloading systems for dry bulks.

Each type of cargo requires specialized equipment and berthing facilities (passenger berths, oil, coal, ore, grain, timber, roll-on/roll-off, containers, chemical and gas) (European Commission, 2013). Tyre cranes are commonly used in large ports for loading and unloading and hoisting bulk cargo. They can also take the task of renovating, dismantling and installing large port facilities. Portal cranes play vital role in bulk ports that would handle loads with heavy weight and high height, lifting, laying down and luffing often during the operating process (Liu et. al, 2015). Hammerhead crane was firstly designed to use in shipyards to support the battleship construction. The crane has an ability to lift up to 350 tons. So it is very useful for installing large pieces of ships. Unlike most cranes, Deck cranes placed on both ships and ports. They are used for handling operations or ship unloading and retrieval where no shore unloading facilities are available. Forklift is a small industrial vehicle which can be inserted under loads to lift and move them. In maritime logistics, it should be designed to stand up to the hard use and every day wear and tear of a marine environment.

Effective port handling minimizes transportation costs per unit carried, made possible by the steady increase in size of container ships. If shipping adds the functions of a material handling into its activities, generally in ports, it implies perfect coordination of calls by its various mother and feeder ships.

2.1.3 Concept of Port Logistics

The current global trend towards greater market concentration in shipping and port operations has been intensified, as has competition between container ports (Song & Lee, 2009). A port is composed of several terminals, or the terminals are components of a port. Seaports are the gate for foreign trade for the economies since they are the key point for the activities in maritime transportation. Moreover, they have become logistics based where many types of transportation are combined. These developments in functions of seaports lead to growing of ports` operating as an industry(Song & Lee, 2009). The costs of shipping depend also on the efficiency of the ports of call. Traditionally, ports are considered to act as an interface between ships and shore by providing shelter and berthing space, temporary storage and the provision of superstructure and infrastructure for cargo operation and movement within port (Song & Lee, 2009).

According to Song $ Lee (2009), The main activities of ports are as follows:

- **Pilotag:** This is a service provided by a pilot with local knowledge and skills which enable him to conduct the navigation and maneuvering of the vessel in and approaching the harbor.

- **Towage:** is a service provided by tug boats which move larger ships that either should not or cannot power themselves.

- **Cargo-handling**: involves the movement of cargo in and around a port. This includes marshalling services (the receipt, storage, assembly and sorting of cargo in preparation for delivery to a ship's berth) and stevedoring services (the loading of cargo onto and discharging cargo from ships).

Panayides and Song (2009) defined seaport terminal supply chain integration (TESCI) as the extent to which the terminal establishes systems and processes and undertakes functions relevant to becoming an integral part of the supply chain as opposed to being an isolated node that provides basic ship-shore operations. Because the ports are intersection points in the supply chain, port logistics is a two-way process. One logistics process is for the outgoing cargoes (exports) which move from the hinterland to destination and other logistics process is for the incoming cargoes (imports) which come from destination to the port hinterland. In this manner the inbound and outbound logistics activities change in both processes. In the case of outgoing cargo, inbound logistics composes of hinterland operations like truck and train operation, transshipment by transtainers (if the cargoes are container) and yard planning, and outbound logistics involves activities like berth and yard planning, crane assignment, and loading. In the case of incoming cargo, inbound logistics involves activities like berth assignment, yard planning, crane assignment, discharging, discharging sequencing, and stowage planning while outbound logistics composes of truck and train operations, transshipment of cargoes, yard planning and sequencing of trucks to be loaded. Also as an operation part of logistics, port logistics involves yard operations which involves export stocking, packaging, stuffing and redistribution within the yard in the case of outgoing cargoes, import stocking, packaging, redistribution within the yard and unsnuffing in the case of incoming cargoes (Song & Lee, 2009).

The maritime logistics activities' security also represents a critical variable in terms of competitiveness in the ports. In order to obtain secure ports, customs are willing to locate the container flows, through reducing of import/export documents and to permit the transportation of products to and from ports under bond or in a sealed container. Song & Lee (2009) suggested that, the security issue is directly related to the performance measurement of port logistics that all security conditions must be met and guaranteed in order for products to move unhindered within port.

2.1.4 Concept of Green Maritime Logistics

The environmental impacts of maritime operations as it relates to causation of climate change important factor to address when operating is not just the maritime transport mode, but in any modality in the transportation industry. The concept of green maritime logistics is a newly developed concept which seeks to ensure that maritime operations does not contribute significantly to the generation of toxic greenhouse gaseous emissions causing climate change and global warming. It is an attractive area whose importance increased recently. Psaraftis and Kontovas, (2009) noted that containerships are the largest maritime CO_2 emitters. The International Maritime Organization (IMO) is an agency that maintains a comprehensive regulatory framework for shipping which include safety, environmental concerns, legal matters, technical cooperation, maritime security and the efficiency of ships. The main responsibility addressed in green maritime logistics is to prevent and control marine pollution from shipping operations and maritime activities. The International Maritime Organization (IMO, 2012), observed that sea transportation accounts for about 4.8 % of global greenhouse gas (GHG) emissions with a total of 2031 million tons CO_2 in 2012. For making successful eco-friendly maritime operations, important decisions should take that based upon economic parameters and the environmental parameters that consider elimination of emissions. The main questions that try to find answers in maritime logistics include: estimation of emissions, impact of emissions on world climate and technological means to reduce emissions. To reduce maritime GHG emissions, it is important trying to optimize with respect to both environmental and traditional criteria. Psaraftis and Kontovas, (2010) analyzed that there are three ways to reduce GHG emissions; technical measures, market based instruments measures and logistics based options.

Technical measures are defined as use of more efficient options such as; eco-friendly fuels, energy saving engines, vehicle capacity, engine load, efficient propulsions, ship hulls. Emissions trading and carbon levy schemes are the categories of market based instruments. Reducing speed, optimizing route, planning fleet, changing the number of ships, degree of utilization, specific engine load are some example of logistics measurements. Lindstad (2012) stated that to increase the fleet size and mix, the emission per freight will minimize around 30%. Endresen et al., (2007) calculated CO_2 emission based on bunker consumption and emission factor. According to their formulation one ton of marine bunker produces 3.17 tons of carbon monoxide (CO), 0.02 tons of sulfur oxides (SO_2) and 0.057-0.087 tons of nitrogen oxides (NO). Also, heavy metals, dioxins, formaldehyde, ozone are the other particulate matters which affect both human health and environment. Environmental Protection Agency (EPA) is expected to double severe pollution by 2020. This effect is worth studying, especially for container vessels, which represented 4% of all maritime vessels but generated 20% of emissions from international shipping (Buhaug et al., 2009). Thus, green maritime logistics is a concept encompassing the numerous logistical principles and tools applied in the maritime transport sector to eliminate and/or reduce ship-based emissions and the impacts in the maritime industry globally.

2.1.4 Maritime Logistics in Nigeria

International trade is the exchange of goods and services among countries. Since consumption of goods must take place at the importing country's domain, these goods must cross international boundaries to land at the importing country's market, warehouse etc for consumption to take place. Therefore, international seaborne trade is the movement of goods and services from one country (Export) to another (importing country). Movement or carriage of the goods involved may be by air, road, rail or Sea. Movement of goods and passenger by water is known as maritime trade. The carrying equipment vessel or facility for maritime transport is the ship. Since the usage of ships to convey goods across international boundaries dominates other modes, shipping has come to be taken as international trade.

Maritime logistics is responsible for the planning and coordination of the flow of seaborne trade via ports in Nigeria across to and from the supply chain networks linked to the Nigeria international trade routes. Thus, the management of the ports in Nigeria as a maritime node for harnessing ship movement and flow of seaborne trade rest upon the implementation of standard principles of maritime logistics. The outcome of such planning, organization coordination and management of port operations achieved by the implementation of maritime logistics is seen in measurable variables/factors in the port such as: the ship turnaround time (STRT), cargo dwell time, cargo pilferage profile, port charges and costs, cargo examination procedure, port congestion induced delay, etc. thus the success and effectiveness of the implementation of maritime logistics in ports can be assessed on the basis of the above identified variables.

Ship Turnaround Time (STRT) as a port-related factor that influences the flow of shipping trade via the ports is defined as the total time that a vessel spends at a port from its arrival to departure. It encompasses the amount of time it takes the ship to be berthed in port on arrival, the time it takes her to discharge her cargo and take-up new cargo for the reverse journey if available, and leave the berth to embark on the exit or departure leg of the journey. The average ship turnaround time (ASTRT) is usually determined as the average difference between the date of departure and date of arrival of the vessels calling at a port, usually within one month of navigations. According to Nwokedi et al (2021), STRT is a major factor that influences port choice by ship owners and operators as it indicates the level of efficiency of use of port superstructures and cargo handling equipment. Thus, high ship turnaround time may imply longer period of stay in ports by vessels awaiting services with the attendant implications on the economy and finances of the affected ship-owners and operators. Higher STRT also increases the risk of delay in delivery of shipments and cargo to the shippers' warehouses in the hinterland markets, which could result to situation of stock-out and scarcity in the domestic markets, price inflation, shutdown, etc, among other negative economic implications. The strategic deployment of functional logistics tools and principles in the ports and maritime transport industry can help to overcome the risk of high ship turnaround time posed to the swift flow of shipping trade via the ports (Nwokedi *et al*, 2021).

Cargo dwell time (CDWT) as a port-related factor influencing the flow of shipping trade via the ports is the measure of the time that elapsed from the time the cargo arrives in the port to the time the goods leave the port premises after all permits and clearances have been secured for the cargo to leave the port to the shippers terminal and/or warehouse Longer days of cargo dwell time at the ports implies delays in the movement of the goods and an indication of the existence of congestion related delay within the port. Nigerian ports are noted to have the highest cargo dwell time in the West African sub-region and this is viewed as a serious factor that hampers efficient shipping trade flow through the ports and an indication that the port authority and terminal operators are yet to improve the utility and satisfaction of port users through the adoption and implementation of functional logistics strategies and approaches.

Cargo examination procedures and bottlenecks (CCEP). There is a challenge posed by the complexity of cargo examination procedures in most Nigerian ports. In most cases, too many agencies are involved in the examination even when it is not necessary. The varied dates of examination by the various agencies increases the cargo dwell time cost of examination, pilferage risks and the frustration faced by shippers and freight forwarders following the harrowing experiences in the cargo clearing process. There are up to 32 government agencies including the Nigerian Customs Service, all of which cause avoidable delays in the clearing of imported goods and consignments (Nwokedi et al 2021).

Port Charges and cost: It is suggested that in order to remove the bottlenecks associated with clearing of imported consignments and the flow of shipping trade in seaports, the number of government agencies directly involved in the examination and clearing of goods at the ports should be reduced to only those required for effective ship and cargo handling operations and national security (Ndikom, 2012). This is to reduce the duplicity of functions of the main agencies and payment of multiple charges by shippers. Port tariff and rates in Nigeria is also believed to be higher than those of other states within the West African sub-region. Poor states of port infrastructure and super structure, port congestion related delay, and high cargo pilferage risks are some more factors which are identified, to influence the flow of shipping trade in Nigerian ports as a result of the inability and delay of the port authorities and terminal operators in implementing maritime and port logistics approaches in seeking to address the dissatisfaction of port users as consumers of port services, with the quality of service rendered in the ports (Nwokedi et al, 2021).

As aforementioned, the identified factors influencing port operations arose, following the inability and delay in the implementation of the functional port and maritime logistics strategies in the Nigerian ports industry. Thus, port authorities over the years seem not to have seriously sorted to maximize the utility and satisfaction derivable to the port customers and users, from the consumption of port services. Cost of port services, time of doing business in port are witnessing continual increasing trend while customer satisfaction, port service quality is very low. It is important to note that these have implications on port efficiency which needs to be investigated in Nigeria

2.1.5 Concept of Port Efficiency

Oxford advanced dictionary defines efficiency as the state or quality of being efficient, or able to accomplish something with the least waste of time and effort; competency in performance. It further views efficiency as the accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort. The effort in this context may take the form of input resources such as time worked by the labour force (man-hours), time worked by machinery and equipment employed (machine-hours), financial resources expended, etc. According to Lee (2019), port efficiency indicates the relationship between port output/performance and the input resources employed in producing a given level of output and it is indicative of the capacity of a given port system to eliminate wastefulness by ensuring that limited input resources is employed to turnout large output. Port efficiency according to Nze, Ejem and Nze (2020) is the ability of a port system to limit waste of input resources by producing acceptable higher levels of output with limited and/or lower level of input resources such as time, labour, superstructure and finance.

Mathematically, efficiency of the maritime transport subsequent with regards to port efficiency is expressed as the ratio of the useful output produced by the port to the level of input resources employed in producing it. Therefore port efficiency is defined as port output per unit of input, usually expressed as a percentage.

Since efficiency (***E***) is a function of output (O) and input (I), we write that: $E = \left(\frac{O}{I}\right)\left(\frac{100}{1}\right)$

We assert that the output performance of the maritime transport sector particularly the ports is generally measured in terms of the ship traffic handled in ports, the cargo throughput handled in ports, the container throughput handled etc. Similarly, since labour the forms human and machine labour are employed in the handling of the ships and cargo, time and labour measurable in man-hours and machine-hours represent input factors while the financial resources, the berths, etc also represent input resources towards the production of outputs by port authorities.

Basically, it is in the interest of this study to employ ship traffic performance and cargo throughput handled in the ports as outputs and man-hours put into handling working out these output as well as the number of berths employed in handling them as inputs, in order to determine the efficiency of the ports over the years. Since it is rightly believed that maritime logistics has effects in the level of efficiency obtainable in the operations in the maritime port systems in Nigeria, the identified indicators of the performance of the implementation of maritime logistics in port operations such as ship-turnaround time in ports, cargo dwell time in ports, cost of port services, level of security and safety of cargo and personnel in ports (this can be determined using the cargo pilferage risk profile of ports and attacks on personnel while in port), will subsequently be used as proxies to assess the effects of maritime logistics on the efficiency of Nigerian ports over the years.

2.2 Theoretical Review

Under this section, some of the theories explaining the subject matter involved in the study are discussed as shown below.

2.2.1 The Paradox Theory in Logistics and Supply Chain

A **paradox** according Lee (2012) is a logically self-contradictory statement or a statement that runs contrary to one's expectation. A paradox presents dual but opposing options or views. It is a statement that, despite apparently valid reasoning from true premises, leads to a seemingly self-contradictory or a logically unacceptable conclusion. A paradox usually involves contradictory-yet-interrelated elements that exist simultaneously and persist over time (Lee, 2012).

Although a commonly used term, “paradox” has so far been applied with a vague sense in logistics and supply chain research. The paradox has been developed in recent years in logistics research that calls for a renewed understanding for how to manage contradictions and tensions in logistics and supply chain decision making within an organization (Dameron and Torset, 2014). Smith and Lewis (2011) argue that organizational research in supply chain management has undergone three major development stages, where the earliest research generation opted for an answer to the question “Is A or B the most effective way?”, thus assuming that one organizational design is always superior to other alternatives. Thereafter the next generation of research, which was developed during the 1960s instead asked “Under what conditions is A or B the most effective way? This stream of literature has been labeled contingency theory and has been applied relatively often in logistics research during the years, perhaps most frequently). A third, paradox-based development stage focuses on tensions and conflicting goals inherent within and between elements in an organization or supply chain. The basis for this theoretical perspective was developed during the 1980s as a new means to capture and understand the underlying logic for effective organizations, particularly in times of rapid change (Evans et al., 2002; Graetz and Smith, 2009). Whereas some tensions could be resolved by simply choosing one of the two opposed arguments (an either/or choice referred to as a “dilemma”) others could be avoided by finding a solution that integrates the two sides (referred to as a “dialectic”) (Smith and Lewis, 2011). However, the proposition of the paradox theory is that, some tensions, hereby referred to as paradoxes, should not be resolved or avoided, instead they should be managed within the organization (Smith and Lewis, 2011). According to Smith and Lewis (2011), paradox theory does not advocate the search for an optimum “position” among the tensions (opposing views), or their settlement or avoidance. Rather, it advocates an act of balance of the tensions on a continuous basis in line with a turbulent environment. This is exactly the expected role of the implementation of maritime logisticic-finding a balance between the opposing variables of the maritime transport sector that ensures that consumers of maritime services maximize their utility while operators operate at acceptable levels of profit margin. In fact, such a perspective goes even further and does not only recognize the tensions, but also exploits and encourages the creativity and dynamism enhanced by the presence of tensions (Dameron and Torset, 2014; Smith &Lewis, 2011). Thus, tensions should be allowed to co-exist in the organization, as these tensions could be seen as an important driving force for innovation. Logistics is the innovation that balances organizational tensions for benefits to be earned from the opposing sides. Managing paradoxes – or coping as has been suggested as a better term for handling paradoxes in logistics and supply chain organizations .It requires a leadership that explores, rather than suppresses the tensions (Smith & Lewis, 2011). A first, major task for management becomes to make paradoxes explicit through "paradox cognition" (Smith and Lewis, 2011) as many paradoxes are latent until conditions such as scarcity of resources make them explicit to management.

Helpfully, Smith and Lewis (2011) identified four generic categories of paradoxes that are applicable particularly in supply chain management as a means to structure our analysis of paradoxes, and help to establish a "dualities-aware perspective". The four categories global logistics related paradoxes developed by Smith & Lewis include:

(1) Paradoxes of Learning,

(2) Belonging Paradoxes

(3) Organizing paradoxes, and;

(4) Performing Paradoxes.

1. **Learning paradoxes**: Learning paradoxes arise under efforts to adjust, renew, and change an organization, as they foster tensions between destroying past understandings to create new,

future practices (Smith and Lewis, 2011), i.e. historical experiences and knowhow is continuously challenged in the organization by new ideas and knowledge. Learning in a wide sense, including processes of knowledge creation and innovation is of fundamental importance for future success. For example, overall, the maritime transport industry has undergone major changes in recent years due to worldwide globalization and development in seaborne trade with increased competition and the resulting need for more rapid change and continuous learning. Of particular interest in the case companies is learning in the areas of new technology and emerging markets, and sustainability improvements. The learning paradoxes are, in these cases, particularly well framed in the act of balance between learning inside a collaborative, long term relationship, and at the same time the acquisition of new knowledge and innovation through new relationships (Smith and Lewis, 2011). Long-term relationships may facilitate development and trust-based inter-organizational learning, but at the same time too long relationships may jeopardize innovation and new thinking in the supply chain. From a paradox perspective, literature on global logistics and sourcing brings forward arguments for both sides of the coin. Whereas global sourcing articles based upon a supply chain management (SCM) tradition promote long term, stable relationships to be a facilitator of learning, innovation and development, other strategies may instead bring forward the advantages of new market constellations.

(2) **Belonging Paradoxes:** From a belonging perspective, the use of agents/intermediaries becomes an act of balance between encouraging them to plan and act as independent units on the one hand, and at the same time create a sense of common goals and values for the supply chain as a whole. In a global sourcing context for example, the need for a proper “belonging-balance” is mainly driven by the fact that worldwide supply chains include challenges related to cultural differences. A global supply chain, in comparison to a domestic one, naturally creates more tensions in buyer-supplier relationships as there are greater cultural and

regulatory differences that need to be tackled (Smith & Lewis, 2011). To function properly, a certain degree of freedom and local focus is needed in order to handle these cultural differences. On the other hand, cultural differences that are too great between e.g. a local purchasing office and the foreign headquarters may jeopardize effectiveness and efficiency in the supply chain. Examples from the cases an extension of the supply chain together with communication barriers (time differences and language) means that intermediaries such as local buying offices or regional operations managers play an important role in the case companies' supply chains. The use of these intermediaries is above all considered as a strategy to come closer to the suppliers, and create controllable and trust-based long term relationships. However, the intermediaries constitute a belonging paradox, as they are also seen as an extension of the supply chain that may hamper cultural understandings between headquarters and suppliers. To work as a united company, with one message and one strategy, communication and information sharing in the supply chain becomes more demanding, and innovative logistics principles can bridge this gap.

(3**) Organizing paradoxes**: Organizing paradoxes arise when structuring the organization, and include conflicts between attributes such as commitment, trust and creativity on the one hand, and efficiency, discipline and order on the other hand (Lewis, 2000). Typical paradoxes discussed are collaboration vs competition, empowerment vs direction, and control vs flexibility (Smith and Lewis, 2011). In a global logistics setting, organizing paradoxes have been acknowledged when discussing the design of the physical flow of goods from the sourcing region(s) (e.g. Asia) to the domestic markets (e.g. Europe or USA). Bygballe et al. (2012) outline four general retail supply chain structures from Asian suppliers to retail stores in Norway. These are (1) Deliveries between individual producers and retail stores, (2) Consolidation of shipments in the customer country, (3) Consolidation of shipments in the supplier country, and (4) Consolidation in both countries. Pros and cons in terms of e.g.

control and flexibility are presented based on these four structures, which clearly demonstrates the presence of tensions and conflicting goals between the different alternative structures. The organizing paradox is closely related to the degree of collaboration between the buyer and supplier, in which the advantages of close collaboration are compared against the advantages of having an arms-length, transaction-based relationship.

(4) **Performing paradoxes:** Performing paradoxes includes a discussion on “multiple and competing goals as stakeholders seek divergent organizational success” (Smith and Lewis, 2011). The performance of global sourcing in terms of costs, lead times and services, but also sustainability issues, has been a dominating theme in global logistics in the recent decade. In line with paradox theory, performance indicators such as costs, service, and lead times have been compared against each other and presented as trade-offs, dilemmas or similar (Smith & Lewis, 2011). There are at least three major classes of performing paradoxes discussed in the global sourcing literature:

(1) Supply chain costs versus price

(2) The total costs versus service aspects, including lead times, and

(3) Traditional logistics performance measurements of cost and service versus sustainability performance (e.g. CO_2- emissions or CSR-issues). First, starting with cost- and price related paradoxes, it is a well-known statement in existing global logistics and sourcing that not only price should be considered, but the total costs of purchasing. A long row of hidden costs (costs difficult to identify and/or quantify) and inflexibility costs (costs related to a company’s ability to cope with uncertainty) must be taken into consideration for a proper supply chain calculation (Bygballe et al., 2012). Second, in addition to the challenge of getting control of the total costs, the conflict between costs and service has for a long time been acknowledged as a key challenge for logistics in general (Bygballe et al., 2012).

Performance in terms of costs and service in the supply chain must be balanced. This balance not only concerns the buying company's organization, but also other members of the supply chain.

From the foregoing, it is important to state that a major role of implementation of maritime logistics in port operation is to address the numerous paradoxes faced by port operators, terminal operators, shippers, freight forwarders and other stakeholders in the sector. This is because, while the expectations of the port authority as the regulator differs and in some cases is conflicting with those of terminal operators and shippers, the expectations and targets of the freight forwarders is similarly different from those of terminal operators and, shippers and port authorities, giving rise to dualities of expectations and paradoxes. The implementation of maritime logistics should in line with the paradox theory, balance these tensions and dualities to the beneficial acceptance of the stakeholders in order to ensure port efficiency in Nigeria.

2.2.2: Transaction Cost Analysis (TCA) Theory

Transaction Cost Analysis (TCA) involves the study of trade prices to determine whether past trades were arranged at favourable prices—low prices for purchases and high prices for sales. At the heart of TCA is the difference between the costs of the transaction at the time the manager decided to execute it and the actual cost, including all operating charges—spreads commissions and fees. The resulting differential is called "slippage" (Festus & Xiaoming, 2010). Currency Management Automation solutions aim at both minimizing trading costs — by providing connectivity to best-price execution platforms— and providing the necessary data to conduct Transaction Cost Analysis. By implication, the postulation of TCA in supply chain management is that for prices to be favourable to the business organization, the trade transaction should have low prices for purchases and higher prices for sales (Festus & Xiaoming, 2010). It is often split into two parts – pre-trade and post-trade.

(i) Pre-trade

Pre-trade analysis is the process of taking known parameters of a planned trade and determining an execution strategy that will minimize the cost of transacting for a given level of acceptable risk. It is not possible to reduce both projected risk and cost past a certain efficient frontier, since reducing risk tolerance requires limiting market exposure and thus trading faster. In this situation, market impact cost is much greater than for trades that accept greater risk and are executed more slowly (Festus & Xiaoming, 2010).

(ii) Post-trade

The post-trade process involves first recording the data from previous trading periods, including trade timing, arrival price, average execution price, and relevant details about market movement. These data are then measured and compared to several benchmarks, such as the volume-weighted average price (VWAP), time-weighted average price (TWAP), participation-weighted average price (PWP), or a variety of other measures. Implementation shortfall is a commonly targeted benchmark, which is the sum of all explicit and implicit costs. After measurement, costs must be attributed to their underlying causes. Finally, this analysis is used to evaluate performance and monitor future transactions (Festus & Xiaoming, 2010).

The final stage of transaction cost analysis involves combining the results of the measurement and attribution to evaluate each agent. This is often done through periodic reports detailing important statistics as well as graphics to help visualize trends in the data. Transaction cost analysis providers will often include regular consulting to help draw conclusions from the data, establish goals to improve performance, and monitor future trading to determine the impact of any changes (Festus & Xiaoming, 2010).

The implications of the transaction cost analysis theory in maritime logistics and port efficiency is the the port users (shippers and ship-owners) employ the theory in analyzing the pre and post implications of port costs on their overall trading costs. This has implications too on port choice and port efficiency. Thus, the theory supports the use of port prices and or costs borne by port users for consumption of port services as an output of maritime logistics whose effects on port efficiency needs to be investigated.

2.2.3 Network Perspective (NP) Theory

This is a theory that gives relationship and explanations on all the networks which are available to facilitate connections between all levels in supply chain management. The network theory is one of the grand theories for purchasing and supply management which have been introduced during the last decades. Mainly the network theory is considered to describe the relationships in which companies, suppliers, customers or buyer are engaged. The theory was first introduced during the 1970s and the 1980s and developed from the focus on relationships between just two entities, or strategic alliances, towards an approach which entails multiple relationships between different counterparts throughout the supply chain. Chang, Chiang & Pai (2012) further state that the supply chain network is a complicated network model, and its specific context depends on the relationships among the network members (Chang, Chiang, & Pai, 2012). The term network refers to two or more organizations involved in long- term relationships (Chang, Chiang, & Pai, 2012). Moreover, networks are seen as beneficial for every company embedded through the investments and actions of the other counterparts involved in the process. Furthermore, it was found that there are several underlying assumptions, as for instance that a central position of companies within a network could lead to competitive advantage, or that companies share information and knowledge with their partners. Moreover, in terms of the contribution to purchasing it can be said that the theory is applicable to the most important decision points (Chang, Chiang, & Pai, 2012). The theory helps with the demand planning through the simplification of the resource allocation reached through the settlement of strategic long-term partnerships. Moreover, companies embedded in a network have the ability to choose from a greater set of suppliers and through this can even ensure the supply of critical commodities. Furthermore, the relationships among companies are assumed to be trustworthy and thus contribute to the value addition on both sides and further simplify the decision about the selection of the supply strategy. Lastly, the network theory contributes to the fourth decision point, namely the negotiation, since companies in networks aim to engage in long-term contracts through which strong partnerships develop (Chang, Chiang, & Pai, 2012).

2.2.4 The GSIM model by Francois and Hall

The GSIM model was according to the works of Francois and Hall (2003), the GSIM model approaches a partial equilibrium analysis on the effect of changes in trade policy, which relates to changes in tariff measures, on global, regional and national trade flows. The model can be used to estimate the shifting of trade patterns in the world when changing a specific trade condition. In order to estimate the change from the initial condition to the future condition when the change of trade policy has been applied, Francois and Hall (2003) use an ad valorem tariff, which includes not just the real tariff imposed for a specific commodity, but also Non-Tariff Barriers (Berden et al, 2009). The Ad valorem tariff from the GSIM model captures all the Non-Tariff Barriers (NTBs) that bilateral trade encounters. Those barriers include difficulties such as paperwork, quotas, hard regulations and requirements that limit trade. On these barriers we can include trade sanctions as an additional Non-Tariff

Barrier. As reported by Berden et al (2009), the GSIM model helps to measure the outcomes of a free trade agreement between the US and the EU on trade and investment. They capture the shifting of trade and the benefits or losses that a free trade agreement brings to a bilateral trade relationship. It enables the effects of bilateral trade on imports and exports and variations in trade to be obtained.

Thus, effective implementation of professional logistics principles can be employed to achieve desired shift in trade flows. Such shift in trade flows in favour of a given port will improve the performance and efficiency of the port while that of the port that faced decline in demand occasioned by the shift in trade will be negatively impacted.

2.3 Empirical Review

Various empirical studies have being able to examine the issues of port efficiency. Others have also dwelt on exploratory research on the concept and impacts of maritime and port logistics in exclusion of how it has impacted port efficiency.

For example, Nze, Ejem and Nze (2020) carried out a study on 'Benchmarking technical efficiency of Nigerian seaports' using ex-post facto research design and employed Data Envelopment Analysis (DEA) optimization tool as a method of analysis. The study used secondary data on ship traffic, vehicle traffic, berth efficiency, turnaround time as input variables and average cargo throughput as output variable to compare the pre and post efficiency of Nigerian ports of Tin-can Island, Apapa, Delta port (Warri), Onne and Calabar ports. The study found that the year 2014 was the most efficient year of the 36 year period covered by the study. It also found that the Tin can Island port was technically efficient in the operation years of 1980, 1981, 1985, 1997, 1998, 2009, 2013, 2014 and 2015 with efficiency score of 1.0. The study notes that in the post concession years, port was technically inefficient in 2006, 2007, 2008, 2010, 2011 and 2012 (Nze, et al, 2020).

Dayananda & Dwarakish (2018) carried out a study titled: ‘Measuring port performance and productivity’. The study aimed to determine the relationship between the satisfaction obtained by the shippers and the level of port performance achieved and how this impacts port efficiency. It the opinion of Dayananda *et al* (2018) the ports have to offer very satisfactory services to vessel operators and at the same time managed to provide optimal infrastructure based on the expected vessel type and cargo to be handled. The port performance thus requires a set of measures related to vessels stay at port, rate of loading/ unloading the cargo and quality storage/inland transport. The result of the study indicates that there exists a strong interrelationship between these set of measures and various port performance indicators. The paper established a significant relationship between the various observed performance parameters and the total cargo traffic handled in ports. The result shows that the number of vessels handled and the output per hook per shift have a strong positive correlation of 0.975 and 0.967 respectively. The idling time at berth has strong negative correlation of -0.934 (Dayananda & Dwarakish, 2018).

Chairullah, Heti, Eva, & Tridoyo (2021) examined the impact of maritime logistics on archipelagic economic development in eastern Indonesia. The aim of the paper was to establish the performance of local ports and maritime logistics impact on the small island economy in East Indonesia, especially in the North Maluku Province. The research used the survey method and the Stochastic Frontier Analysis to measure each local port’s performance in which Gross Regional Domestic Product (GRDP) per capita constitutes the output variable. While GRDP, number of cargo throughput, number of port labor, inland connection, loading and unloading tariff, and sea freight cost are input variables. The results show that the loading and unloading tariffs and sea transportation costs harm the GRDP per capita of the respective small island districts (Chairullah, Heti, Eva, & Tridoyo, 2021). Other findings suggest that the port of Morotai, Central Halmahera, North Halmahera, and Ternate have a higher level of technical efficiency than those in East Halmahera, South Halmahera, Sula, and Tidore. Low port efficiency can disrupt the distribution of goods between islands, resulting in higher logistics costs (Chairullah, Heti, Eva, & Tridoyo, 2021).

Nwokedi, Ndikom, Okoroji and Nwaorgu (2021) determined the determinant port-related factors affecting the flow of shipping trade and logistics in Nigerian ports. The study notes that current port management trends in Nigeria suggests existence of numerous inefficiency challenges reflected in long ship turnaround time, increasing trend of cargo dwell time, high cargo pilferage risk rate, poor condition of port infrastructure and superstructure, multiple charges and government agencies, cumbersome cargo clearance & examination procedures, port congestion related delays particularly in Apapa and Onne ports (Nwokedi, Ndikom, Okoroji and Nwaorgu, 2021). The study objective was to identify the decisive port-related factors constraining the flow of shipping trade in Nigerian ports using a survey to obtain data on the influence of the identified factors on the flow of shipping trade in Nigerian ports. The Principal Component Analysis (PCA) was used to analyze the data obtained. The results indicate that high cargo pilferage risk profile, long ship turnaround time and increasing trend of cargo dwell time constitute the significant port-related factors constraining the flow of shipping in Nigerian ports. It concluded that terminal operators should prioritize solutions to the problems of high cargo pilferage risk profile, long ship turnaround time and increasing cargo dwell time, which constitute the major constraints to the flow of shipping trade (Nwokedi, Ndikom, Okoroji and Nwaorgu, 2021).

2.3.1 Literature Gap

From the foregoing, it is important to note that few empirical studies have been able to x-ray the important issues of port productivity, efficiency and the relatedness to maritime/port logistics. However, there exist several identified gaps in this study area that have not being examined by available empirical studies. For example, studies by Nwokedi et al (2021) and Chairullah, Heti, Eva, & Tridoyo (2021) agree that the output of maritime/port logistics should be resultant improvement in ship-turnaround time, cargo dwell time, cargo security and safety, reduction in congestion induced delay, and port-user satisfaction. Nze *et al* (2020) also was able to establish and benchmark the efficiency of the Nigerian ports over a 36 year period using DEA. However, no empirical studies have been able to:

(1) Evaluate the efficiency of Nigerian ports relative to the expended efforts (in man-hours) in port operations and time at berth over the years.

(2) Estimate the effects of maritime logistics performance on port efficiency in cargo handling in Nigerian ports over the years

(3) Determine the relationship depicting the effects of maritime logistics on the trend of port efficiency in handling ship calls in Nigeria.

(4) Establish the effect of maritime logistics performance on berth efficiency of the ports over the years.

The above literature gaps were identified in line with the objectives of the study and this current study seeks to bridge the gap in knowledge reflected in the gaps in literature.

CHAPTER THREE

METHODOLOGY

In this chapter, the methods and procedures that were employed in dealing with the research questions in order to realize the objectives of the study were discussed. Research methodology is a way and process used in carrying out a research including theoretical assumptions upon which the research is based and the implications of these for the method(s) adopted. The study employed secondary data in the study and the use of statistics and Log linear regression models in establishing the relationship between maritime logistics and various components of port efficiency in Lagos Apapa port complex and Onne port. It also used the port efficiency function to estimate the efficiency of the Lagos Apapa Port complex and Onne port relative to the effort in man-hours expended in generating the cargo outputs, ship outputs and berth outputs over the period covered in the study. This chapter also examined in details the methods and sources of data, research design, methods of data analysis and test of hypotheses, among others.

3.1 Description of the Study Area

The study area of the research is the Nigerian maritime logistics sub-sector with particular focus on the Nigerian seaport industry. The Nigerian Ports Authority (NPA, 2019) reported that the Lagos Port complex and Onne port handle between 65% and 70% of total volume of vessel and seaborne trade that come to Nigeria. Thus, the Lagos Apapa port complex and Onne Port Complex carry significant volume of vessel and cargo traffic handled in port in Nigeria and therefore dominates port affairs in Nigeria. This is the reason this study adopted and used the Lagos Apapa port complex and Onne port in this study. Both ports are the major ports in the West and Central African sub-regions and operate on 24hours service time nonstop and host to the major container terminals and West African Container Terminal (WACT) and other terminal operators. Therefore the study area of the research is the

Nigerian port industry and maritime logistics sector with focus on the performance and productivity of Lagos Apapa port complex and Onne port upon which the efficiency of the port was determined.

3.2 Research Design

The study is designed to assess the effects of maritime logistics on port efficiency in Nigeria. The adopted ex-post facto research designs in which time series data on outcomes of implementation of maritime logistics in Lagos Apapa port and Onne port which include: ship-turnaround time, cargo dwell time, waiting time, time at berth of the port between 2007 and 2019 were obtained from the Nigerian ports authority (NPA) and used as independent variables to determine the relationship between maritime logistics and port efficiency. The cargo throughput and ship traffic size of the port over the same period was also obtained from the NPA and used as port output variables to determine the efficiency of the port over the period. Having earlier identified the objectives and research questions to be addressed by the study, the influence of maritime logistics on port efficiency in Nigeria was determined.

3.3 Sources of Data

This research relied upon both secondary sources of data for the study. Secondary data constitute data generated from secondary means such as Nigerian Ports Authority annual reports, Shipper Council annual Reports and Statistical publication, and data bases of related maritime organizations, etc. The secondary data of both the dependent and independent variables were obtained from the Nigerian Ports Authority (NPA), Lagos and Onne branches

3.4 Method of Data Analysis

Under this section, the various methods employed in analyzing the secondary data obtained in order to achieve the objectives of the study and arrive at a good conclusion were discussed. The methods used to analyze the data obtained include: (i) the port efficiency function (ii) Log-linear multiple regression analysis.

3.4.1: Port Efficiency Function

Mathematically, the efficiency function expresses efficiency as the ratio of the useful output produced to the level of input resources expended in producing it.

That is; efficiency (***E***) is a function of output (O) and input (I), we write that:

$$E = \left(\frac{O}{I}\right)\left(\frac{100}{1}\right) \qquad \text{(i)}$$

Port efficiency ($\boldsymbol{E_p}$) is thus a function of the ratio of the output or performance of the port to the input resources or effort expended in producing the output.

That is: $\boldsymbol{E_p} = \left(\frac{O}{I}\right)\left(\frac{100}{1}\right) \qquad (2)$

It is important to note that the output of the ports is usually expressed in terms of the cargo throughput ($\boldsymbol{CARPUT_t}$), container throughput($\boldsymbol{CONPUT_t}$), ship-traffic size ($\boldsymbol{SHIPTS_t}$), port revenue ($\boldsymbol{PORREV_t}$), vehicle throughput ($\boldsymbol{VEHPUT_t}$), etc produced and/or handled over a given period of time, for example one year period.

Similarly, port input resources constitute financial resources and expenditure ($\boldsymbol{FINEXP_t}$) as cost put into the production of port services, equipment and infrastructure (superstructure and infrastructure); man-hours of port labour expended as effort in producing the output ($\boldsymbol{EFFORT}_t$), machine-hours expended as effort in producing the output, Time expended at berth in working on ship (***BERTHTIME***), number of berths engaged in producing the output, etc.

However, since it takes human operators to operate the machines and equipment, run and manage the berths, financial resources and other inputs into port operations as the human labour expend energy over time in carrying out these operations; it implies that the most generalized form of input that form the best choice of input to be used in the study to evaluate port efficiency is the effort (***EFFORT***$_t$) in (man-hours) expended in producing the outputs.

Therefore to evaluate port efficiency, we modified the port efficiency function as follows:

Port efficiency =

$$E_p = \left(\frac{CARPUTt}{EFFORTt}\right)\left(\frac{100}{(1)}\right) \quad (3),$$

for cargo handling efficiency) or throughput efficiency.

Where: $\boldsymbol{CARPUT_t}$ = cargo throughput handled by the port each year over the period between 2007 and 2019 measured in tons.

$\boldsymbol{EFFORT_t}$ = aggregate effort in man-hours expended in producing the output in the form of cargo throughput each year over the period covered in the study.

Similarly for container throughput, ship traffic size and port revenue, we have:

Port efficiency =

$$E_p = \left(\frac{\boldsymbol{SHIPTRt}}{EFFORTt}\right)\left(\frac{100}{(1)}\right) \quad (4),$$

for ship output efficiency

Berth Efficiency =

$$E_p = \left(\frac{\boldsymbol{SHPTR}}{BERTHTIME}\right)\left(\frac{100}{(1)}\right) \quad (5),$$

berth efficiency

Using the port efficiency function described above, we used the Natural log function to convert all input and output variables into common units as shown:

Port efficiency =

$$E_p = EFFICARPUT = \left(\frac{LogCARPUTt}{Log\ EFFORTt}\right)\left(\frac{100}{(1)}\right) \qquad (6)$$

(for cargo handling efficiency)

Port efficiency = $E_p = EFFISHPTR = \left(\frac{\boldsymbol{Log\ SHIPTRt}}{Log\ EFFORTt}\right)\left(\frac{100}{(1)}\right)$ (7)

for ship output efficiency

Berth Efficiency = $E_p = BERTHEFFICIENCY = \left(\frac{\boldsymbol{LogSHPTR}}{LogBERTHTIME}\right)\left(\frac{100}{(1)}\right)$ (8)

berth efficiency .

The efficiency of the Lagos Apapa port and Onne port over the period covered in the study was determined using the above efficiency functions..

3.4.3 Log-Linear Regression Analysis Method

Regression analysis is a statistical investigation of the relationship between a dependent variable Y and one or more independent variable (s) X or Xs, and the use of the modelled relationship to predict, control or optimize the value of the dependent variable Y (Ugwu, 2003). The relationship is formulated in an equation to express the value of Y in terms of the corresponding values of X or the Xs and to enable future values of Y to be predicted in terms of the observed values of X to be controlled or optimized by manipulating the values of X or the Xs. The independent variables Xs are called explanatory variables or controlled variables while the dependent variables Y is also called response variable. Though, we have so many types of regression analysis; multiple log-linear regression analysis was for this work.

3.5.1.1 Multiple Log-Linear Regression Analysis

This shows the relationship between two or more variables; dependent variables (Y) and more than a single independent variable (X_1 --- X_n) which is expressed mathematically as

$Log Y_t = \beta_0 + \beta_1 Log X_1$ --------+ $\beta_n Log X_n + e$

Where e= random error term.

For such, log-linear estimation method can be used to estimate the coefficients- β_0, and β_1, , and normal hypotheses testing method using t-test and f-test similar to OLS estimation holds valid.

Using the multiple log-linear regression model approach the effects of maritime logistics on port efficiency in Nigeria was determined. The effects of the outcomes of the implementation of maritime logistics in Nigerian ports- ship-turnaround time (***$SHPTRT_t$***), cargo dwell time (***CARDWT***t), cargo pilferage risk profile (***$CARPIL_t$***), ship-dues (***$SHPDUES_t$***), cargo rates (***$CARATES_t$***) (port charges) on port efficiency (***E_p***) in Nigeria was determined.

The relationship between the port efficiency and maritime logistics was investigated using port efficiency as a dependent variable; since it is a normal view that the implementation of maritime logistics in ports should influence port efficiency. Therefore, port efficiency is a dependent variable on maritime logistics.

$EFFICARPUT = \beta_0 + \beta_1 LogSHPTRT_t + \beta_2 LOGCARDWT_t + \beta_3 LogWAITINGTIME + \beta_4 LogBERTHTIME + \mathcal{E}$ ---------------------------- (9) for cargo handling efficiency

$EFFISHIPTR = \beta_0 + \beta_1 LogSHPTRT_t + \beta_2 LogCARDWT_t + \beta_3 LogWAITINGTIME + \beta_4 LogBERTHTIME + \mathcal{E}$ ---------------------------- (10) for berth efficiency/ship handling efficiency at berth.

$$\boldsymbol{BERTHEFFICIENCY = \beta_0 + \beta_1 LogSHPTRT_t + \beta_2 LogCARDWT_t + \beta_3 LogWAITINGTIME + \beta_4 LogBERTHTIME + \mathcal{E}}$$ ----------------------------- (11) for berth efficiency

Normal hypotheses testing methods for OLS estimation using t-test and f-test was used to determine the significances of the effects of implementation of maritime logistics on port efficiency in Nigeria.

CHAPTER FOUR

RESULTS AND DISCUSSION OF FINDINGS

4.1 Data Presentation

In this section, the data collected from the Nigerian ports authority and used for the study was presented as shown in the various tables below:

Table4.1: Cargo Throughput and Ship Traffic Productivity of Onne Port, Aggregate Effort in Man-hours Expended by the Port and Number of Days at Berth Vessels are worked.

Year	Cargo throughput (Tons)	Ship traffic	Effort (Man-hours)	At Berth(Days)
2007	21171019	733	8760	4.80
2008	22089920	712	8760	4.26
2009	17480233	686	8760	3.39
2010	23345586	769	8760	3.58
2011	26229884	885	8760	4.6
2012	27,580,642	859	8760	3.27
2013	24,773,387	823	8760	2.27
2014	27,964,251	847	8760	2.04
2015	26,314,828	741	8760	2.60
2016	23,896,730	659	8760	2.10
2017	25,836,246	671	8760	2.30
2018	29,498,840	695	8760	3.30
2019	28,400,124	717	8760	2.40

Source: NPA Statistical Report of Onne Port, 2009, 2013, 2016 & 2019

The table above provides evidence of the productivity or output of Onne port in terms of the cargo throughput and ship traffic handled in port between 2007 and 2019 covering a period of 13 years. Cargo throughput and ship traffic handled by ports the represent the output of the port over the period upon which the efficiency of the port can be assessed relative to the input materials expended in achieving these output. The aggregate effort in man-hours representing the time per annum expended by the seaport and over which the port recorded the cargo throughput and ship traffic outputs was also identified in table-4.1. The average time per annum expended by the gang at berth in working on each vessel that called at the berths is also given in days in the above table. Both the aggregate time expended in handling cargo and ship in the port and the time used at berth represent inputs and efforts expended by the ports in achieving the levels of outputs between 2007 and 2019 as shown in table-4.1 above. The above table of port output and input resources was used for further analysis to estimate the efficiency of the port in producing these levels of output. However, in order to ensure that all variables assume common units, a Natural Log transformation of the all the figures of each variable in the table-4.1 were implemented in Table-4.3. It was this natural Log transformed data that was used for further analysis in order to obtain a more accurate result.

Table4.2: Maritime/Port Logistics Performance Indicators of Onne Port (2007-2019)

s/n	year	Cargo dwell time (Days)	Ship turnaround time	Awaiting Berth(Days)	At Berth(Days)
1	2007	11	6.55	2.60	4.80
2	2008	10	5.76	1.05	4.26
3	2009	12	4.50	0.36	3.39
4	2010	13	4.84	1.01	3.58
5	2011	12	4.05	1.95	4.6
6	2012	11	2.5	1.11	3.27
7	2013	15	2.6	1.21	2.27
8	2014	14	2.70	1.71	2.04
9	2015	11	2.59	2.00	2.60
10	2016	15	2.39	1.95	2.10
11	2017	13	2.47	2.2	2.30
12	2018	15	3.70	1.86	3.30
13	2019	14	2.00	1.90	2.40

Source: Nigeria Ports Authority (NPA) Onne, Statistical Report, various editions.

Table-4.2 above shows the indicators of maritime logistics performance in Onne port. Part of the core objectives of implementing logistics function in the port and maritime sector (maritime/port logistics) is to optimize port and maritime sector productivity and by achieving cost and time reductions in port and maritime operations. Thus table-4.2 above shows the cargo dwell time (in days), ship turnaround time (in days), average time (in days) spent by vessels at farewell buoys awaiting berths, average time spent by vessels at berth being worked (loading or discharging). These are outcomes of implementation of maritime logistics and indicators of maritime/port logistics performance. The variables in table4.2 form the dependent variables used to estimate the effects of maritime logistics performance on port productivity and efficiency of Onne port between 2007 and 2019. Before being used for further analysis, it was transformed using the Natural Log model.

Table-4.3: Natural Log transformation of Table-4.1

Year	InEFFORT	InCARPUT	InSHTR	InBERTHDAYS
2007	9.08	16.87	6.60	1.57
2008	9.08	16.91	6.57	1.45
2009	9.08	16.68	6.53	1.22
2010	9.08	16.97	6.65	1.28
2011	9.08	17.08	6.79	1.53
2012	9.08	17.13	6.76	1.19
2013	9.08	17.03	6.71	0.82
2014	9.08	17.15	6.74	0.71
2015	9.08	17.09	6.61	0.96
2016	9.08	16.99	6.49	0.74
2017	9.08	17.07	6.51	0.83
2018	9.08	17.20	6.54	1.19
2019	9.08	17.16	6.58	0.88

Source: Authors calculation

The table above shows the natural Log (Ln) transformation of the content of the table-4.1 in order to convert all the variables into common units of natural Log for determining the efficiency of the port in producing output and estimating the effects of maritime logistics performance on the efficiency of the port. Similarly, Table-4.2 was also transformed into natural Log units as shown in table-4.4 below

Table-4.4: Natural Log transformation of Table-4.2

Year	InSHTRTIME	InCARGODWELLTIME	InWAITINGTIME	InBERTHDAYS
2007	1.88	2.40	.96	1.57
2008	1.75	2.30	.05	1.45
2009	1.50	2.48	-1.02	1.22
2010	1.58	2.56	.01	1.28
2011	1.40	2.48	.67	1.53
2012	.92	2.40	.10	1.19
2013	.96	2.71	.19	0.82
2014	.99	2.64	.54	0.71
2015	.95	2.40	.69	0.96
2016	.87	2.71	.67	0.74
2017	.90	2.56	.79	0.83
2018	1.31	2.71	.62	1.19
2019	.69	2.64	.64	0.88

Source: Authors calculation

Table-4.4 shows the natural Log transformation of table-4.2 which provides evidence of the maritime/port logistics performance of indicators of Onne port, Nigeria. The content of table-4.4 was used as the explanatory variables to investigate the effects of maritime logistics performance of Onne seaport on port productivity and efficiency in the port as discussed in the subsequent sections of the work.

Table4.5: Cargo Throughput and Ship Traffic Productivity of Lagos Apapa Port Complex, Aggregate Effort in Man-hours Expended by the Port and Number of Days at Berth Vessels are worked.

Year	Cargo throughput (Tons)	Ship traffic	Effort (Man-hours)	At Berth(Days)
2007	15223340	1359	8760	3.39
2008	14813072	1343	8760	3.58
2009	17427096	1376	8760	4.60
2010	18914876	1351	8760	4.27
2011	18159707	1376	8760	4.27
2012	22808353	1359	8760	4.04
2013	21065520	1452	8760	4.2
2014	21730426	1545	8760	4.3
2015	22931321	1587	8760	4.6
2016	21892629	1563	8760	4.1
2017	23,909,238	1387	8760	4.3
2018	22,911,063	1640	8760	4.3
2019	23904210	1852	8760	4.23

Source: NPA Statistical Report of Onne Port, 2009, 2013, 2016 & 2019

Table4.5 above shows the data collected from the Nigerian ports authority (NPA), Lagos Apapa port complex indicating the cargo throughput, ship traffic, aggregate effort and time spent at berths being worked by ships that called to the port. The data covered a period of 13 years from 2007 to 2019.

Table-4.6: Maritime Logistics Performance of Lagos Apapa port complex

Year	SHTRTIME	CARGODWELLTIME	AWAITINGTIME
2007	3.75	15	0.36
2008	4.59	19	1.01
2009	6.55	18	1.95
2010	5.38	20	1.11
2011	5.48	17	1.21
2012	7.1	16	1.71
2013	8.2	19	0.87
2014	7.9	20	0.51
2015	7.2	21	0.62
2016	7.5	19	0.61
2017	7.53	23	1.4
2018	8.3	21	1.6
2019	7.8	22	1.5

Source: Nigerian Ports Authority, Apapa

Table 4.6 above similarly shows the ship turnaround time (SHTRIME), cargo dwell time (CARGODWELLTIME), and the average time spent by vessel awaiting berth (AWAITINGTIME) in Apapa Port, all indicating the maritime logistics performance of the Lagos port complex, Apapa over the 13 years between 2007 and 2019 covered in the study. The natural log transformation of the dataset set collected for the Lagos Apapa port complex is shown in subsequent tables below.

Table-4.7: Natural Log Transformation of table4.5

Year	InCARPUT	InSHTR	InEffort	InBerthDays
2007	16.54	7.21	9.08	1.22
2008	16.51	7.20	9.08	1.28
2009	16.67	7.23	9.08	1.53
2010	16.76	7.21	9.08	1.45
2011	16.71	7.23	9.08	1.45
2012	16.94	7.21	9.08	1.46
2013	16.86	7.28	9.08	1.53
2014	16.89	7.34	9.08	1.41
2015	16.95	7.37	9.08	1.46
2016	16.90	7.35	9.08	1.46
2017	16.99	7.23	9.08	1.44
2018	16.95	7.40	9.08	1.45
2019	16.99	7.52	9.08	1.53

Source: Authors Calculation.

Table 4.7 above shows the natural log transformation of productivity indicators of the Lagos Apapa port complex to make amenable for use in the determination of port efficiency and the impact of maritime logistics on port efficiency in Lagos Apapa port complex, Nigeria between 2007 and 2019.

Table-4.8: Natural Transformation of Maritime Logistics Performance of Lagos Apapa port complex

Year	InSTRT	InDWELLTIME	InAWAITINGTIME
2007	1.32	2.71	-1.02
2008	1.52	2.94	0.01
2009	1.88	2.89	0.67
2010	1.68	2.83	0.19
2011	1.70	3.00	0.10
2012	1.96	2.77	0.54
2013	2.10	2.94	-0.14
2014	2,07	3.00	-0.67
2015	1.97	3.04	-0.48
2016	2.01	2.94	-0.49
2017	2.02	3.14	0.34
2018	2.12	3.04	0.47
2019	2.05	3.09	0.41

Source: Authors calculation

Table 4.8 above shows the natural log transformation of the maritime logistics performance indicators of the Lagos Apapa port complex to make amenable for use in the determination of port efficiency and the impact of maritime logistics on port efficiency in Lagos Apapa port complex, Nigeria between 2007 and 2019. The statistics of Ship turnaround time, cargo dwell time and average time vessel spent in the port awaiting berth from 2007 to 2019 were transformed into natural log equivalents.

4.2: Results and Discussion of Findings

Table-4.9: Descriptive Statistics of Port Productivity Indicators, Port Efficiency and Maritime Logistics Performance Indicators

Variable	N	Range	Minimum	Maximum	Sum
CARPUT	13	12018607.00	17480233.00	29498840.00	324581690.00
SHPTRFIC	13	226.00	659.00	885.00	9797.00
EFFORT	13	.00	8760.00	8760.00	113880.00
EFFICARPUT	13	.06	1.84	1.89	24.38
BERTHDAYS	13	2.76	2.04	4.80	40.91
EFFISHTR	13	.03	.71	.75	9.48
CARGODWELLTIME	13	5.00	10.00	15.00	166.00
SHPTURNTIME	13	4.55	2.00	6.55	46.65
AWAITINGTIME	13	2.24	.36	2.60	20.91
Valid N (listwise)	13				

Descriptive Statistics

	Mean	Std. Deviation	Variance
CARPUT	24967822.3077	3352316.82070	11238028066361.900
SHPTRFIC	753.6154	76.14738	5798.423
EFFORT	8760.0000	.00000	.000
EFFICARPUT	1.8753	.01584	.000
BERTHDAYS	3.1469	2.8601	1.345
EFFISHTR	.7293	.01093	.000
CARGODWELLTIME	12.7692	1.73944	3.026
SHPTURNTIME	3.5885	1.45108	2.106
AWAITINGTIME	1.6085	.61334	.376
Valid N (listwise)			

Source: Author's calculation

The descriptive statistics result in table 4.9 shows that the average cargo throughput productivity of Onne port per annum between 2007 and 2019 is 24967822.31 with a standard deviation of 3352316.820. The maximum and minimum cargo throughput output of the port was 29498840.00 and 17480233.00 in the years 2018 and 2009 respectively. It also shows that the aggregate cargo throughput productivity of the port over the 13 years period is 32481690.00. In a similar manner, the average ship traffic productivity of the port per annum between 2007 and 2019 is 753.615 vessels with a standard deviation of 76.15. The maximum and minimum ship traffic productivity was achieved as 885.00 and 659.00 in the years 2011 and 2016 respectively; giving a range of 226.0 vessels. The aggregate ship traffic productivity of the port over the period is 9797.00 vessels. The aggregate effort (man-hours) expended by all sections of port operations in achieving the outputs between 2007 and 2019 is 113880.00 man-hours, and an average of 8760 man-hours per annum. This translates to a mean of about 2850.20 Tons of cargo worked by the port per man-hour (2850.20 ton/hour) in all sections in onne port and about 0.087vessels worked per hour in port over the period covered in the study. The average mean number of days vessels spent at berths in Onne port over the period being worked is 3.1469 days with a standard deviation of 2.6801. The maximum and minimum days spent by vessels at berths being worked over the period is 4.80 days and 2.04 days respectively in years 2007 and 2014. Ship turnaround time, cargo dwell time, and vessel average time of awaiting berth; which are indicators of maritime logistics performance have respective mean scores of 3.5885 days, 12.7692 days and 1.60 days with respective standard deviations of 1.4512, 1.7394 and 0.61334.

Table-4.10: Efficiency of Onne Port in Cargo Throughput Output and Ship Traffic Handled Relative to the Aggregate Effort (in Man-hours) Expended in all Sections of the Port and Ship Time at Berths (days) over the Years

Year	EFFICARPUT	EFFISHTR	BERTHEFFICIENCY
2007	1.86	0.73	4.20
2008	1.86	0.72	4.53
2009	1.84	0.72	5.35
2010	1.87	0.73	5.20
2011	1.88	0.75	4.44
2012	1.89	0.74	5.68
2013	1.88	0.74	8.18
2014	1.89	0.74	9.49
2015	1.88	0.73	6.85
2016	1.87	0.71	8.77
2017	1.88	0.72	7.84
2018	1.89	0.72	5.47
2019	1.89	0.72	7.47
Average efficiency	1.8753	0.73	6.009

Source: Author's calculation

The table 4.10 above shows the result of the efficiency of Onne port in the generation of cargo throughput (Cargo throughput efficiency-EFFICARPUT) and ship traffic handled (efficiency in ship output-EFFISHTR)) relative to the aggregate port time expended and average vessel time spent at berth being worked. The efficiency of the port in handling ship at berth relative to the time at berth being worked (in days) is referred to as berth efficiency measured by the ration of ship traffic produced/handled by the port to the average time spent at berth.

The result indicates that between 2007 and 2019, Onne port achieved mean efficiency level of 1.8753 (187%) in cargo throughput output of the port relative to the aggregate effort (time in man-hours) expended by the port. In the years 2010, 2011, 2012, 2013, 2014, 2015, 2016 2017, 2018, and 2019, the port was more efficient in the use of port time in generating higher cargo throughput output than it was in 2007, 2008 and 2009 because at the respective efficiency levels, the cargo throughput output of the port was greater or equal to the prevailing average cargo throughput of 24967822.31 tons over the period. Even though the same quantum of man-hours was expended in 2007, 2009 and 2009; lesser cargo throughput was achieved by the port in those years in comparison to the remainder years where cargo throughput efficiency of the port in the utilization of port-time (man-hours) was higher. The port was most efficient in the use of port-time in handling cargo in the years 2018 with maximum output but was least efficient in the cargo handling in 2009 with a minimum output generated relative to equal effort (port-time) expended over the period. The implication is that even when equal man-hours is expended over a given period of time by a port, efficiency in the handling of cargo and generation of output may not be equal. Thus the efficiency of a port in turning out output relative to expended effort may be influenced by other factors such as availability and condition of infrastructure and superstructure, professional know-how, maintainability issues, etc.

Similarly, the efficiency level of Onne port ship output relative to the aggregate quantum of time-effort (in man-hours) expended by the port authority over the entire period of stay of each vessel in the port is an average of 0.729(73%) per annum between 2007 and 2019. The result indicates that the port achieved the highest level of efficiency in ship output in the year 2011 where it had an efficiency level of 75% (0.75); indicating that more vessels were worked in 2011 within the same unit of effort (port-time in man-hours) expended like the other years. This suggests optimal use of port-time in turning out higher level of ship output. The port recorded the least level of efficiency 71% (0.71) in the year 2016 when it's per unit effort expended yielded the least ship output. When compared with the average ship output efficiency of the port over the period; years 2008, 2009, 2016, 2017, 2018 and 2019 operated at less efficiency levels than the average 0f 73%. The implication is that efforts (man-hours) expended by the ports yielded less ship outputs that the prevailing average of 753.6 vessels perineum over the period.

Furthermore, the berth efficiency of the Onne port which measures the efficiency of the berth in turning out output within the limits of the average time vessels spend at berths, being worked in the port; shows an average score of 6.01(601%). This indicates that on the average, the Onne port has a high level of berth efficiency showing that per unit time in days expended working on vessels at berth yield very higher output-about 601% for expended effort. However, in years 2013, 2014, 2015, 2016, 2017, and 2019, the port operated in berth efficiency levels higher than the average while in years 2007, 2008, 2009, 2010, 2011, and 2018, the port had high level of berth efficiencies which were however less than the prevailing average over the period. The highest berth efficiency of 9.49 (949%) was recorded in the port in the 2015 while the least berth efficiency in the use of port-time expended in turning out ship output 4.20(420%) was recorded in 2007. These results corroborates the findings of Nze, Ejem and Nze (2020), and Dere , Omoke, Ojukunle and Nwagbo (2021) using Data Envelopment Analysis (DEA). The result of the efficiency of Onne port above was further used as the dependent variables in assessing the effects of maritime logistics performance on the efficiency of Onne port as shown in subsequent tables below.

Table-4.11: Effect of Maritime Logistics on Onne port Efficiency in Cargo throughput Output

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.836[a]	.699	.549	.01011	1.813

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.002	4	.000	4.654	.031[b]
	Residual	.001	8	.000		
	Total	.003	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.366	.214		6.393	.000
	InSHPTRTIME	-.072	.030	.478	2.426	.041
	InCARGODWELLTIME	.018	.028	.165	.633	.544
	InWAITINGTIME	.014	.006	.498	2.521	.036
	InBERTHTIME	-.016	.013	-.326	-1.252	.246

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.8457	1.8945	1.8754	.01260	13
Residual	-.01223	.01528	.00000	.00826	13
Std. Predicted Value	-2.356	1.519	.000	1.000	13
Std. Residual	-1.209	1.510	.000	.816	13

a. Dependent Variable: EFFICARPUT

Source: Authors Calculation

The result shown in Table-4.11 above indicates the coefficient of correlation R which measures the degree of correlation between maritime logistics performance and cargo throughput efficiency of Onne port is 0.836. This implies the existence of about 84% correlation between maritime logistics performance in Onne port and port efficiency in the cargo throughput productivity.

The model showing the relationship depicting the effects of maritime logistics performance measured by ship turnaround time, cargo dwell time, vessel waiting time and vessel time at berth on the efficiency of Onne port in cargo throughput productivity between 2007 and 2019 is:

InEFFICARPUT = 1.366 - 0.072InSHTRTIME + 0.018InCARGODWELLTIME + 0.014InWAITINGTIME -0.16InBERTHTIME + e

This implies that a unit annual increase in ship turnaround time in the port decreases port efficiency with regards to cargo throughput productivity by 0.072 units while a unit increases in cargo dwell time increases port efficiency in cargo throughput output by 0.018 units. Similarly, a unit increase in vessel waiting time before being called to berth increases port efficiency by 0.014 units while a unit increase in the average time spent by vessels at berth being worked decreases efficiency of the port in cargo handling by 0.16 units. The implication is that increasing ship turnaround time and vessel time at berth decreases the efficiency of the port in cargo handling while reverse is the case for increasing cargo dwell time and time awaiting berth. This finding is contrary to the general believe that increasing cargo dwell time and vessel waiting time would lead to deceasing port efficiency in cargo throughput output.

The coefficient of determination R^2 which measures the explanatory power of the model is 0.699. This indicates that about 70% variation in the efficiency of Onne port in cargo throughput output is explained by maritime logistics performance of the port. The relationship between ship output efficiency of the port relative to the aggregate time spent in port and the maritime logistics performance of the port is presented and discussed in table-4.12 below.

Table-4.12: Relationship between Efficiency of Onne Port in Handling Ship Calls (ship output) and Maritime Logistics Performance in the Port

Descriptive Statistics

	Mean	Std. Deviation	N
EFFISHTR	.7285	.01144	13
InSHPTRTIME	6.6215	.09999	13
InCARGODWELLTIME	2.5377	.13875	13
InWAITINGTIME	.3777	.51960	13
InBERTHTIME	1.1054	.30165	13

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.968[a]	.937	.906	.00350	3.162

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.001	4	.000	29.973	.000[b]
	Residual	.000	8	.000		
	Total	.002	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.007	.074		.100	.923
	InSHPTRTIME	.109	.010	.950	10.566	.000
	InCARGODWELLTIME	-.001	.010	-.008	-.065	.949
	InWAITINGTIME	.001	.002	.058	.640	.540
	InBERTHTIME	.003	.004	.071	.601	.565

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.7134	.7483	.7285	.01107	13
Residual	-.00361	.00389	.00000	.00286	13
Std. Predicted Value	-1.356	1.793	.000	1.000	13
Std. Residual	-1.030	1.110	.000	.816	13

a. Dependent Variable: EFFISHTR

Source: Author's calculation

Table-4.12 above shows the relationship that depicts the effects of maritime logistics performance on the ship output efficiency of the port. The ship output efficiency of the port represent the ratio of the total ships handled in the port to the aggregate time expended by the port in handling it over a given time period expressed as a percentage. The table-4.12 shows that the coefficient of correlation R between the ship output efficiency of the port and maritime logistics performance between 2007 and 2019 is 0.968 which indicates about 97% positive correlation between the efficiency of the port in handling ship calls and the maritime logistics performance. The model showing the effect of maritime logistics performance measured by ship turnaround time, cargo dwell time, vessel waiting time and vessel time at berth on the efficiency of Onne port in cargo ship output productivity between 2007 and 2019 is:

InEFFISHTR = 0.007+ 0.109InSHTRTIME - 0.001InCARGODWELLTIME + 0.001InWAITINGTIME + 0.003InBERTHTIME + e

This implies that a unit annual increase in ship turnaround time in the port increases port efficiency with regards to ship output productivity (number of ship calls handled) by 0.109 units while a unit increase in cargo dwell time decreases port efficiency in ship output by 0.001 units. Similarly, a unit increase in vessel waiting time before being called to berth increases port efficiency by 0.001 units while a unit increase in the average time spent by vessels at berth being worked increases efficiency of the port in handling of ship calls by 0.003 units. By implication, increasing ship turnaround time, vessel waiting time and vessel time at berth increases the efficiency of the port in ship handling while reverse is the case for increasing cargo dwell time in the port.

The coefficient of determination R^2 which measures the explanatory power of the model is 0.937. This indicates that about 94% variation in the efficiency of Onne port in ship calls handled in the port is explained by maritime logistics performance of the port. The relationship between berth efficiency of the port and the maritime logistics performance of the port is presented and discussed in table-4.9 below.

Table-4.13: Relationship between Berth Efficiency of Onne Port in Handling Ship Calls and Maritime Logistics Performance in the Port

	Mean	Std. Deviation	N
BERTHEFFICIENCY	6.4208	1.77607	13
InSHPTRTIME	6.6215	.09999	13
InCARGODWELLTIME	2.5377	.13875	13
InWAITINGTIME	.3777	.51960	13
InBERTHTIME	1.1054	.30165	13

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.983[a]	.966	.948	.40306	2.218

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	36.553	4	9.138	56.250	.000[b]
	Residual	1.300	8	.162		
	Total	37.853	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.103	8.513		.130	.900
	InSHPTRTIME	1.667	1.183	.094	1.409	.196
	InCARGODWELLTIME	.193	1.126	.015	.171	.868
	InWAITINGTIME	.264	.228	.077	1.155	.282
	InBERTHTIME	-5.706	.517	-.969	-11.028	.000

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.8609	8.9368	6.4208	1.74531	13
Residual	-.43695	.55324	.00000	.32910	13
Std. Predicted Value	-1.467	1.442	.000	1.000	13
Std. Residual	-1.084	1.373	.000	.816	13

a. Dependent Variable: BERTHEFFICIENCY

Source: Authors calculation

Table-4.13 above shows the relationship that depicts the effects of maritime logistics performance on the berth efficiency of Onne port. The berth efficiency of the port represents the ratio of the total ships handled in the berths to the average time the vessels were at berth being worked. The table-4.13 shows that the coefficient of correlation R between the berth efficiency of the port and maritime logistics performance between 2007 and 2019 is 0.983 which indicates about 98% positive correlation between the berth efficiency of the port in handling ship calls and the maritime logistics performance. The model showing the effect of maritime logistics performance measured by ship turnaround time, cargo dwell time, vessel waiting time and vessel time at berth on the berth efficiency of Onne port in ship handling between 2007 and 2019 is:

InBERTHEFFICIENCY = 1.103+ 1.667InSHTRTIME + 0.193InCARGODWELLTIME + 0.264InWAITINGTIME -5.706InBERTHTIME + e

This implies that a unit annual increase in ship turnaround time in the port increases berth efficiency with regards to ship output productivity (number of ship calls handled) by 1.667 units while a unit increase in cargo dwell time also increases berth efficiency in the port by 0.193 units. Similarly, a unit increase in vessel waiting time increases berth efficiency in the port by 0.264 units while a unit increase in the average time spent by vessels at berth being worked decreases berth efficiency of the port in handling of ship calls by 5.706 units. By implication, increasing ship turnaround time, vessel waiting time and cargo dwell time increases berth efficiency of the port in ship handling while increasing vessel time at berth decreases berth efficiency in the port.

The coefficient of determination R^2 which measures the explanatory power of the model is 0.966. This indicates that about 97% variation in the berth efficiency of Onne port in handling ship calls is explained by maritime logistics performance of the port.

Table4.14: Descriptive Statistics of the productivity indicators and maritime logistics performance of Lagos Apapa Port complex between 2007 and 2019

	N	Range	Minimum	Maximum	Sum
	Statistic	Statistic	Statistic	Statistic	Statistic
THRPUT	13	9096166.00	14813072.00	23909238.00	499690851.00
SHTR	13	509.00	1343.00	1852.00	19190.00
STRT	13	4.55	3.75	8.30	87.28
EFFORT	13	.00	8760.00	8760.00	113880.00
ATBERTH	13	1.21	3.39	4.60	54.18
AWAITIBERTH	13	1.59	.36	1.95	14.46
DWELLTIME	13	8.00	15.00	23.00	250.00
Valid N (listwise)	13				

Descriptive Statistics

	Mean		Std. Deviation
	Statistic	Std. Error	Statistic
THRPUT	38437757.7692	882900.31301	3183342.34969
SHTR	1476.1538	42.52538	153.32745
STRT	6.7138	.40513	1.46072
EFFORT	8760.0000	.00000	.00000
ATBERTH	4.1677	.09552	.34439
AWAITIBERTH	1.1123	.13941	.50266
DWELLTIME	19.2308	.64205	2.31495
Valid N (listwise)			

Source: Authors calculation

The descriptive statistics result in table- 4.14 shows that the average cargo throughput productivity of Lagos Apapa port per annum between 2007 and 2019 is 38437757.7692 with a standard deviation of 3183342.35. It also shows that the aggregate cargo throughput productivity of the port over the 13 years period is 499690851.00. In a similar manner, the average ship traffic productivity of the port per annum between 2007 and 2019 is 1476.1538 vessels with a standard deviation of 153.32745. The maximum and minimum ship traffic productivity was achieved as 1852 and 1343 in the years 2019 and 2008 respectively; giving a range of 509.00 vessels. The aggregate ship traffic productivity of the port over the period is 19190.00 vessels. The aggregate effort (man-hours) expended by all sections of port operations in achieving the outputs between 2007 and 2019 is 113880.00 man-hours, and an average of

8760man-hours per annum. The average mean number of days vessels spent at berths in Lagos Apapa port over the period being worked is 4.1677days with a standard deviation of 0.34439. The maximum and minimum days spent by vessels at berths being worked over the period is 4.60 days and 3.39 days respectively in years 2009 and 2007. Ship turnaround time, cargo dwell time, and vessel average time of awaiting berth; which are all indicators of maritime logistics performance have respective mean scores of 6.7138 days, 19.2303 days and 1.1123 days with respective standard deviations of 1.46072, 2.315 and .50266.

Table-4.15: Efficiency of Lagos Apapa Port Complex in Cargo Throughput Output and Ship Traffic Handled Relative to the Aggregate Effort (in Man-hours) Expended in all Sections of the Port and Ship Time at Berths (days) over the Years

YEAR	EFFCARPUT	EFFSHTR	BERTHEFICIENCY
2007	1.82	0.79	13.55
2008	1.82	0.79	12.95
2009	1.94	0.80	10.93
2010	1.85	0.79	11.54
2011	1.84	0.80	11.51
2012	1.87	0.79	12.13
2013	1.86	0.80	11.75
2014	1.96	0.81	11.58
2015	1.89	0.81	11.11
2016	1.86	0.81	11.98
2017	1.87	0.80	11.65
2018	1.87	0.82	11.62
2019	1.98	0.83	11.78
Average	1.89	0.80	11.85

The shows the result of the efficiency of Lagos Apapa port complex in the generation of cargo throughput (Cargo throughput efficiency-EFFICARPUT) and ship traffic handled (efficiency in ship output-EFFISHTR)) relative to the aggregate port time expended and average vessel time spent at berth being worked. The efficiency of the port in handling ship at berth relative to the time at berth being worked (in days) is referred to as berth efficiency measured by the ratio of ship traffic produced/handled by the port to the average time spent at berth.

The result indicates that between 2007 and 2019, Lagos Apapa port achieved mean efficiency level of 1.85(189%) in cargo throughput output of the port relative to the aggregate effort (time in man-hours) expended by the port. In the years 2009, 2014, and 2019, the port was more efficient in the use of port time in generating higher cargo throughput output than it was in other years because at the respective efficiency levels, the efficiency of the port in cargo throughput output was greater than the prevailing average of 1.89 (189%) over the period. Even though the same quantum of man-hours was expended in other years, the efficiency of the port in cargo handling was less than the prevailing average rate determined for the port over the period. The port was most efficient in the use of port-time for generation of cargo throughput output in the years 2019 with maximum cargo output but was least efficient in the cargo output in 2007 and 2008. The implication is that even when equal man-hours are expended over a given period of time by the port, efficiency in the handling of cargo and generation of output may not be equal. Thus the efficiency of a port in turning out output relative to expended effort may be influenced by other factors such as availability and conditions of infrastructure and superstructure, professional know-how, maintainability issues.

Similarly, the efficiency level of Lagos Apapa port complex ship output relative to the aggregate quantum of time-effort (in man-hours) expended by the port authority over the entire period of stay of each vessel in the port is an average of 0.80 (80%) per annum between 2007 and 2019. The result indicates that the port achieved the highest level of efficiency in ship output in the year 2019 where it had an efficiency level of 83%(0.83); indicating that more vessels were worked in 2019 within the same unit of effort (port-time in man-hours) expended like in the other years. This suggests optimal use of port-time in turning out higher level of ship output. The port recorded the least level of efficiency 79% (0.79) in the years 2007, 2008, 2010 and 2012. When compared with the average ship output efficiency of the port over the period; years 2019 operated at efficiency levels higher than the average of 80%. The implication is that efforts (man-hours) expended by the ports yielded greater ship outputs than the prevailing average of 1476.1538vessels per annum over the period.

Furthermore, the berth efficiency of the Lagos Apapa port which measures the efficiency of the berth in turning out output within the limits of the average time vessels spend at berths, being worked in the port; shows an average score of 11.85 (1185%). This indicates that on the average, the Lagos Apapa port has a high level of berth efficiency showing that per unit time in days expended working on vessels at berth yield very higher output-about 1185% for expended effort. However, in years 2007, 2008, 2012, and 2016, the port operated at berth efficiency levels higher than the average while in the other years, the port though had high level of berth efficiency, but each was lower that the prevailing average 0f 11.85 over the period. The highest berth efficiency of 13.55 (1355%) was recorded in the port in the year 2007 while the least berth efficiency in the use of port-time expended in turning out ship output 10.93 (1093%) was recorded in 2009. These results corroborates the findings of Nze, Ejem and Nze (2020), and Dere , Omoke, Ojukunle and Nwagbo (2021) using Data Envelopment Analysis (DEA). The result of the efficiency of Lagos Apapa port complex above was further used as the dependent variables in assessing the effects of maritime logistics performance on the efficiency of Lagos Appapa port as shown in subsequent tables below.

Table-4.16: Effect of Maritime Logistics on Lagos Apapa port Efficiency in Cargo throughput Output

	Mean	Std. Deviation	N
EFFCARPUT	1.8529	.01829	13
InSTRT	1.8783	.24722	13
InATBERTH	1.4240	.08695	13
InAWAITIBERTH	-.0066	.52190	13
InDWELLTIME	2.9496	.12371	13

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.896[a]	.803	.704	.00994	2.075

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.003	4	.001	8.146	.006[b]
	Residual	.001	8	.000		
	Total	.004	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.697	.083		20.524	.000
	InSTRT	.064	.018	.871	3.562	.007
	InATBERTH	-.008	.051	-.039	-.162	.875
	InAWAITIBERTH	-.002	.006	-.054	-.310	.765
	InDWELLTIME	.016	.030	.107	.534	.608

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.8168	1.8686	1.8529	.01639	13
Residual	-.01323	.01177	.00000	.00812	13
Std. Predicted Value	-2.204	.956	.000	1.000	13
Std. Residual	-1.330	1.184	.000	.816	13

a. Dependent Variable: EFFCARPUT

Table-4.16 above shows the relationship that depicts the effects of maritime logistics performance on the cargo handling efficiency of the Lagos Apapa port. The cargo handling efficiency of the port represent the ratio of the total cargo handled in the port to the aggregate time or effort expended by the port in handling it over a given time period expressed as a percentage. The table-4.17 shows that the coefficient of correlation R between the cargo handling efficiency of the port and maritime logistics performance between 2007 and 2019 is 0.896 which indicates about 90% positive correlation between the efficiency of the port in cargo handling and the maritime logistics performance. The model showing the effect of maritime logistics performance measured by ship turnaround time, cargo dwell time, vessel waiting time and vessel time at berth on the cargo handling efficiency of Lagos Apapa port complex between 2007 and 2019 is:

InEFFICAPUT = 1.697+ 0.064InSHTRTIME + 0.016InCARGODWELLTIME - 0.002InWAITINGTIME - 0.008InBERTHTIME + e

This implies that a unit annual increase in ship turnaround time in the port increases port efficiency with regards to cargo handling productivity by 0.064 units while a unit increase in cargo dwell time also increases Lagos Apapa port efficiency in cargo handling by 0.016 units. Similarly, a unit increase in vessel waiting time before being called to berth decreases Lagos Apapa port cargo handling efficiency by 0.002 units while a unit increase in the average time spent by vessels at berth being worked decreases cargo handling efficiency of the port by 0.008 units. By implication, increasing ship turnaround time, and cargo dwell time in Lagos Apapa port increases the cargo handling efficiency of the port while reverse is the case for increasing vessel waiting time and time spent by vessels being worked at berths.

The coefficient of determination R^2 which measures the explanatory power of the model is 0.803. This indicates that about 80% variation in the cargo handling efficiency of Lagos Apapa port is explained by maritime logistics performance of the port.

Table-4.17: Relationship between Efficiency of Lagos Apapa Port in Handling Ship Calls (ship output) and Maritime Logistics Performance in the Port

	Mean	Std. Deviation	N
EFFSHTR	.8033	.01089	13
InSTRT	1.8783	.24722	13
InATBERTH	1.4240	.08695	13
InAWAITIBERTH	-.0066	.52190	13
InDWELLTIME	2.9496	.12371	13

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.806[a]	.649	.248	.00944	1.436

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.001	4	.000	16.990	.002[b]
1	Residual	.001	8	.000		
	Total	.001	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	.698	.079		8.884	.000
	InSTRT	.027	.017	.607	2.556	.016
1	InATBERTH	-.025	.048	-.203	-.526	.613
	InAWAITIBERTH	-.004	.006	-.201	-.724	.490
	InDWELLTIME	.031	.028	.353	1.101	.303

a. Dependent Variable: EFFSHTR

Table-4.17 above shows the relationship that depicts the effects of maritime logistics performance on the ship output efficiency of the Lagos Apapa port. The ship output efficiency of the port represent the ratio of the total ships handled in the port to the aggregate time expended by the port in handling it over a given time period expressed as a percentage. The table-4.16 shows that the coefficient of correlation R between the ship output efficiency of the port and maritime logistics performance between 2007 and 2019 is 0.806 which indicates about 81% positive correlation between the efficiency of the port in handling ship calls and the maritime logistics performance. The model showing the effect of maritime logistics performance measured by ship turnaround time, cargo dwell time, vessel waiting time and vessel time at berth on the efficiency of Lagos Apapa port complex in ship output productivity between 2007 and 2019 is:

InEFFISHTR = 0.698+ 0.27InSHTRTIME + 0.031InCARGODWELLTIME - 0.004InWAITINGTIME - 0.025InBERTHTIME + e

This implies that a unit annual increase in ship turnaround time in the port increases port efficiency with regards to ship output productivity (number of ship calls handled) by 0.27

units while a unit increase in cargo dwell time also increases Lagos Apapa port efficiency in ship output by 0.031 units. Similarly, a unit increase in vessel waiting time before being called to berth decreases Lagos Apapa port efficiency in ship handling by 0.004 units while a unit increase in the average time spent by vessels at berth being worked decreases efficiency of the port in handling of ship calls by 0.025 units. By implication, increasing ship turnaround time, and cargo dwell time in Lagos Apapa port increases the efficiency of the port in ship handling while reverse is the case for increasing waiting time and time spent by vessels being worked at berths.

The coefficient of determination R^2 which measures the explanatory power of the model is 0.649. This indicates that about 65% variation in the efficiency of Lagos Apapa port in ship calls handled in the port is explained by maritime logistics performance of the port. The relationship between berth efficiency of the port and the maritime logistics performance of the port is presented and discussed in table-4.18 below.

Table-4.18: Relationship between Berth Efficiency of Lagos Apapa Port in Handling Ship Calls and Maritime Logistics Performance in the Port

	Mean	Std. Deviation	N
BERTHEFFIC	11.8519	.70555	13
InSTRT	1.8783	.24722	13
InATBERTH	1.4240	.08695	13
InAWAITIBERTH	-.0066	.52190	13
InDWELLTIME	2.9496	.12371	13

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.997[a]	.993	.990	.07012	2.477

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.934	4	1.484	301.697	.000[b]
	Residual	.039	8	.005		
	Total	5.974	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	23.320	.583		40.001	.000
	InSTRT	.252	.128	.088	1.971	.084
	InATBERTH	-8.535	.359	-1.052	-23.752	.000
	InAWAITIBERTH	-.041	.043	-.030	-.951	.369
	InDWELLTIME	.072	.210	.013	.345	.739

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	10.9491	13.4700	11.8519	.70322	13
Residual	-.08416	.07680	.00000	.05726	13
Std. Predicted Value	-1.284	2.301	.000	1.000	13
Std. Residual	-1.200	1.095	.000	.816	13

a. Dependent Variable: BERTHEFFIC

Table-4.18 above shows the relationship that depicts the effects of maritime logistics performance on the berth efficiency of Lagos Apapa port. The berth efficiency of the port represents the ratio of the total ships handled in the berths to the average time the vessels were at berth being worked. The table-4.18 shows that the coefficient of correlation R between the berth efficiency of the Lagos Apapa port and maritime logistics performance between 2007 and 2019 is 0.997 which indicates about 100% positive correlation between the berth efficiency of the port in handling ship calls and the maritime logistics performance. The model showing the effect of maritime logistics performance measured by ship turnaround time, cargo dwell time, vessel waiting time and vessel time at berth on the berth efficiency of Lagos Apapa port in ship handling between 2007 and 2019 is:

InBERTHEFFICIENCY = 23.320 + 0.252InSHTRTIME + 0.072InCARGODWELLTIME - 0.041InWAITINGTIME -8.535InBERTHTIME + e

This implies that a unit annual increase in ship turnaround time in the Lagos Apapa port increases berth efficiency with regards to ship output productivity (number of ship calls handled) by 0.252 units while a unit increase in cargo dwell time also increases berth efficiency in the port by 0.072 units. Also, a unit increase in vessel waiting time decreases berth efficiency in the port by 0.041 units while a unit increase in the average time spent by vessels at berth being worked decreases berth efficiency of the port in handling of ship calls by 8.353 units. By implication, increasing ship turnaround time, and cargo dwell time in Lagos Apapa port increases berth efficiency of the port in ship handling while increasing vessel time at berth and waiting time decreases berth efficiency in the Lagos Apapa port.

The coefficient of determination R^2 which measures the explanatory power of the model is 0.990. This indicates that about 99% variation in the berth efficiency of Lagos Apapa port in handling ship calls is explained by maritime logistics performance of the port.

The section 4.3 below shows the test of the hypotheses of the research to determine the significances of the effects of each indicators of maritime logistics performance on port efficiency in each of Onne and Lagos Apapa port complexes which handles significant cargo and ship traffic in Nigeria.

4.3: Test of Hypotheses

Under this section, the various hypotheses proposed in the study were tested as shown in the tables below.

Table-4.19: Test of H_{02a}: There is no significant effect of maritime logistics on the efficiency of Onne port in cargo handling within the port

Hypotheses	F-cal.	F-critical	p-value/sig.	Decision
H_{02}	4.654	3.68	0.031^b	Reject H_{02}
Variable	**t-cal.**	**t-critical**	**p-value/sig.**	**Decision**
InSHPTRTIME	-2.426	1.75	.041	Significant
InCARGODWELLTIME	.633	1.75	.544	Not significant
InWAITINGTIME	2.521	1.75	.036	Significant
InBERTHTIME	-1.252	1.75	.246	Not significant

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Accept null hypotheses if F-cal.< F-critical*

The test of hypothesis H_{02} shown above shows F-score of 4.654, F-critical of 3.68, and p-value of 0.031. Since F-score is greater than F-critical, (4.654> 3.68), we reject the null hypothesis H_{02} and accept the alternate. We conclude that there is significant effect of maritime logistics performance on the efficiency of Onne port in cargo throughput productivity between 2007 and 2019.

Similarly, t-test was conducted to investigate the significance of the individual effects of the maritime logistics performance indicators- ship turnaround time, cargo dwell time, vessel waiting time, and vessel time at berth on the efficiency of cargo throughput output of the port over the 13 years covered in the study. As shown in the table above, only ship turnaround time and waiting time have t-cal score greater than t-critical (2.426> 1.75) and (2.521>1.75). Thus only ship turnaround time and vessel waiting time have significant effects on the efficiency of onne with regards to cargo throughput productivity. Cargo dwell time and vessel time at berth both have t-cal. less than 1.75. As such, they have no significant effects on the efficiency of the port in cargo handling between 2007 and 2019.

Table-4.20: Test of H_{03a}: There is no significant effect of maritime logistics on the efficiency of Onne port in handling ship calls within the port

Hypotheses	**F-cal.**	**F-critical**	**p-value/sig.**	**Decision**
H_{03}	29.973	3.68	0.000^{b}	Reject H_{03}
Variable	**t-cal.**	**t-critical**	**p-value/sig.**	**Decision**
InSHPTRTIME	10.566	1.75	.000	Significant
InCARGODWELLTIME	-.065	1.75	.949	Not significant
InWAITINGTIME	.640	1.75	.540	Not significant
InBERTHTIME	.601	1.75	.565	Not significant

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Accept null hypotheses if F-cal.< F-critical*

The test of hypothesis H_{03} shown in table-4.11 above shows F-score of 29.973, F-critical of 3.68, and p-value of 0.000. Since F-score is greater than F-critical, (29.973> 3.68), we reject the null hypothesis H_{03} and accept the alternate. We conclude that there is significant effect of maritime logistics performance on the efficiency of Onne port in handling ship calls in the port between 2007 and 2019.

Similarly, t-test was conducted to investigate the significance of the individual effects of the maritime logistics performance indicators- ship turnaround time, cargo dwell time, vessel waiting time, and vessel time at berth on the ship output efficiency of the port over the 13 years covered in the study. As shown in the table above, only ship turnaround time have t-cal score greater than t-critical (10.566> 1.75). Thus only ship turnaround time has significant effects on the efficiency of Onne with regards to handling of ship calls in the port. Vessel waiting time, cargo dwell time and vessel time at berth, all have t-cal. less than 1.75 (0.640<1.75; 0.065<1.75; and 0.601<1.75). As such, they have no significant effects on the efficiency of the port in handling ship calls between 2007 and 2019.

Table-4.21: Test of H_{04a}: There is no significant effect of maritime logistics on the berth efficiency of Onne port Nigeria

Hypotheses	F-cal.	F-critical	p-value/sig.	Decision
H_{04}	56.250	3.68	0.000^{b}	Reject H_{04}
Variable	**t-cal.**	**t-critical**	**p-value/sig.**	**Decision**
InSHPTRTIME	1.409	1.75	.196	Not significant
InCARGODWELLTIME	.171	1.75	.868	Not significant
InWAITINGTIME	1.155	1.75	.282	Not significant
InBERTHTIME	-11.028	1.75	.000	Significant

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Accept null hypotheses if F-cal.< F-critical*

The test of hypothesis H_{04} shown in table-4.12 above shows F-score of 56.250, F-critical of 3.68, and p-value of 0.000. Since F-score is greater than F-critical, (56.250>3.68), we reject the null hypothesis H_{04} and accept the alternate. We conclude that there is significant effect of maritime logistics performance on the berth efficiency of Onne port between 2007 and 2019.

Similarly, t-test was conducted to investigate the significance of the individual effects of the maritime logistics performance indicators- ship turnaround time, cargo dwell time, vessel waiting time, and vessel time at berth on the ship output efficiency of the port over the 13 years covered in the study. As shown in the table above, only average time spent by vessel at berth while being worked have t-cal score greater than t-critical (11.028>1.75). Thus only average time spent by vessel at berth has significant effects on the berth efficiency of Onne port. Vessel waiting time, cargo dwell time and ship turnaround time, all have t-cal. less than 1.75 (0.171<1.75; 1.155<1.75; and 1.409<1.75). As such, they have no significant effects on the berth efficiency of the port between 2007 and 2019.

Table-4.22: Test of H_{02b}: There is no significant effect of maritime logistics on the efficiency of Lagos Apapa port in cargo handling within the port

Hypotheses	**F-cal.**	**F-critical**	**p-value/sig.**	**Decision**
H_{02}	8.146	3.68	0.006[b]	Reject ***H_{02}***
Variable	**t-cal.**	**t-critical**	**p-value/sig.**	**Decision**
InSHPTRTIME	3.562	1.75	.007	Significant
InCARGODWELLTIME	0.534	1.75	0.608	Not significant
InWAITINGTIME	-0.310	1.75	0.765	Not significant
InBERTHTIME	-0.162	1.75	0.875	Not significant

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Accept null hypotheses if F-cal.< F-critical*

The test of hypothesis H_{02b} shown above shows F-score of 8.146, F-critical of 3.68, and p-value of 0.007. Since F-score is greater than F-critical, (8.146> 3.68), we reject the null hypothesis H_{02b} and accept the alternate. We conclude that there is significant effect of maritime logistics performance on the efficiency of Lagos Apapa port in cargo throughput productivity between 2007 and 2019.

Similarly, t-test was conducted to investigate the significance of the individual effects of the maritime logistics performance indicators- ship turnaround time, cargo dwell time, vessel waiting time, and vessel time at berth on the efficiency of cargo throughput output of the port over the 13 years covered in the study. As shown in the table above, only ship turnaround time have t-cal score greater than t-critical (3.562> 1.75). Thus only ship turnaround time have significant effects on the efficiency of Lagos Apapa port with regards to cargo throughput productivity. Cargo dwell time, waiting time and vessel time at berth all have t-cal. less than 1.75. As such, they have no significant effects on the cargo handling efficiency between 2007 and 2019.

Table-4.23: Test of H_{03b}: There is no significant effect of maritime logistics on the efficiency of Lagos Apapa port in handling ship calls within the port

Hypotheses	F-cal.	F-critical	p-value/sig.	Decision
H_{03}	16.990	3.68	0.002[b]	Reject ***H_{03b}***
Variable	**t-cal.**	**t-critical**	**p-value/sig.**	**Decision**
InSHPTRTIME	2.556	1.75	.016	Significant
InCARGODWELLTIME	-.065	1.75	.949	Not significant
InWAITINGTIME	.640	1.75	.540	Not significant
InBERTHTIME	.601	1.75	.565	Not significant

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Accept null hypotheses if F-cal.< F-critical*

The test of hypothesis H_{03b} shown in table-4.13 above shows F-score of 16.990, F-critical of 3.68, and p-value of 0.002. Since F-score is greater than F-critical, (16.990> 3.68), we reject the null hypothesis H_{03b} and accept the alternate. We conclude that there is significant effect of maritime logistics performance on the efficiency of Lagos Apapa port in handling ship calls in the port between 2007 and 2019.

Similarly, t-test was conducted to investigate the significance of the individual effects of the maritime logistics performance indicators- ship turnaround time, cargo dwell time, vessel waiting time, and vessel time at berth on the ship output efficiency of the port over the 13 years covered in the study. As shown in the table above, only ship turnaround time have t-cal score greater than t-critical (2.556> 1.75). Thus only ship turnaround time has significant effects on the efficiency of Lagos Apapa port with regards to handling of ship calls in the port. Vessel waiting time, cargo dwell time and vessel time at berth, all have t-cal. less than 1.75 (-0.526<1.75; -0.724<1.75; and 1.101 <1.75). As such, they have no significant effects on the efficiency of the Lagos Apapa port in handling ship calls between 2007 and 2019. This finding corroborates the findings of effects of maritime logistics performance on the efficiency of Onne port in cargo handling shown in previous section of this work.

Table-4.25: Test of H_{04b}: There is no significant effect of maritime logistics on the berth efficiency of Lagos Apapa Port Complex Nigeria

Hypotheses	**F-cal.**	**F-critical**	**p-value/sig.**	**Decision**
$\mathbf{H_{04}}$	301.697	3.68	0.000[b]	Reject H_{04}
Variable	**t-cal.**	**t-critical**	**p-value/sig.**	**Decision**
InSHPTRTIME	1.971	1.75	.084	Significant
InCARGODWELLTIME	0.345	1.75	.739	Not significant
InWAITINGTIME	-0.951	1.75	.369	Not significant
InBERTHTIME	-23.752	1.75	.000	Significant

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Accept null hypotheses if F-cal.< F-critical*

The test of hypothesis H_{04b} shown in table-4.25 above shows F-score of 301.697, F-critical of 3.68, and p-value of 0.000. Since F-score is greater than F-critical, (301.697>3.68), we reject the null hypothesis H_{04b} and accept the alternate. We conclude that there is significant effect of maritime logistics performance on the berth efficiency of Lagos Apapa port between 2007 and 2019.

Similarly, t-test was conducted to investigate the significance of the individual effects of the maritime logistics performance indicators- ship turnaround time, cargo dwell time, vessel waiting time, and vessel time at berth on the ship output efficiency of the port over the 13 years covered in the study. As shown in the table above, both ship turnaround time performance and average time spent by vessel at berth while being worked have t-cal score greater than t-critical (1.971 >1.75; 23.752>1.75). Thus both ship turnaround time and the average time spent by vessel at berth have significant effects on the berth efficiency of Lagos Apapa port. Vessel waiting time, and cargo dwell time have t-cal. less than 1.75 (0.345<1.75; 0.951<1.75). As such, they have no significant effects on the berth efficiency of the Lagos Apapa port between 2007 and 2019.

4.4 Discussion of Result and Policy implications of the Findings

The findings of the study indicate that both the Lagos Apapa port complex and the Onne port operate on high efficiency levels relative to the quantum of efforts in man-hours expended in working out the outputs. Between 2007 and 2019, however, the efficiency level is not consistent over the years as some years are marked with having efficiency levels lower than the prevailing average rates over the period. The implication to the port authority and the terminal operators is that the need exist to benchmark efficiency of the port at a level not lower than the average efficiency level determined overt the period. This will ensure that resources expended per annum is consistently utilized to produce output equal to or more than the average efficiency levels determined for each port efficiency types in each of the Lagos Apapa port and Onne port. This corroborates the position of Nze, Ejem and Nze (2020).

The findings of the study also shows that average cargo handling efficiency, ship output efficiency and berth efficiency of Onne port between 2007 and 2019 is 187%, 73% and 609% respectively while the cargo handling efficiency ship output efficiency and berth efficiency of the Lagos Apapa port complex is 189%, 80% and 135% respectively. This indicates that the Lagos Apapa port complex over the period operated at efficiency levels greater than that of Onne port in cargo handling, ship handling and berth efficiency. This suggests that the Lagos Apapa port complex ensure the most optimal use of port-time in turning out higher level of cargo output, ship output and berth output.These results corroborates the findings of Nze, Ejem and Nze (2020), and Dere , Omoke, Ojukunle and Nwagbo (2021) using Data Envelopment Analysis (DEA). It however shows some levels of inconsistency in maintaining increasing the trend in efficiency over the years.

The findings of the study further indicates that maritime logistics performance has significant impacts on the efficiency and productivity of each of Onne port and Lagos Apapa port over the period covered in the study. The cargo handling efficiency, ship output efficiency and berth efficiency of each of the port were significantly affected by the maritime logistics performance of each port. The implication is that a poor implementation of port logistics management strategies will lead to poor logistics performance in the port which may subsequently cause declining effects on the efficiency and productivity of the ports. It suggests that the maritime logistics performance of the port is a significant factor to be considered in decisions related to port efficiency and productivity improvement matters.

For example, the result indicates that ship turnaround time and vessel waiting time are maritime logistics performance variables which have significant effects on efficiency of both Lagos and Onne ports with regards to cargo throughput productivity. This implies that to improve and sustain efficiency and productivity levels in both ports, ship turnaround and vessel waiting time constitute significant maritime logistics performance indicators that port and terminal operators must consider and strategically improve upon. This interpretation of the policy implications of the significant nature of ship turnaround time and vessel waiting time on cargo handling efficiency of the Lagos and Onne can be extended to interpreting other maritime logistics performance indicators that shows significant effects on ship output efficiency, and berth efficiency of the ports as guide for port authorities, terminal operators and other stakeholders in developing policies and measures for ensuring improved port efficiency and sustaining port productivity in Nigeria.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The maritime logistics performance has significant effects of the efficiency of the port in cargo throughput productivity ship output productivity and berth productivity between 2007 and 2019.

Ship turnaround time has significant effects on the efficiency of Lagos and Onne with regards to handling of ship calls in the port. Vessel waiting time, cargo dwell time and vessel time at berth, all have t-cal. less than 1.75 (0.640<1.75; 0.065<1.75; and 0.601<1.75) and as a result, they have no significant effects on the efficiency of the port in handling ship calls between 2007 and 2019.

Also only ship turnaround time have t-cal score greater than t-critical (10.566> 1.75) and as a result has significant effects on the efficiency of Lagos and onne with regards to handling of ship calls in the port. Vessel waiting time, cargo dwell time and vessel time at berth, all have t-cal. less than 1.75 (0.640<1.75; 0.065<1.75; and 0.601<1.75). They have no significant effects on the efficiency of the port in handling ship calls between 2007 and 2019.

Finally, there are significant effects of maritime logistics performance on cargo handling efficiency, ship output efficiency and berth efficiency in both Lagos Apapa port and Onne port in Nigeria between 2007 and 2019. Since the Lagos Apapa port complex and Onne port handle between 65% and 7% of total volume of imported cargo and vessel calling to Nigerian ports which is significant, we conclude that there is significant impact of maritime logistics on port efficiency in Nigeria.

5.2 Recommendations

It is recommended among other things, in line with the findings of the study that:

1. Maritime logistics has significant effects on port efficiency in Nigeria, therefore port authorities and terminal operators must implement maritime logistics strategies to improve the maritime logistics performance indicators and subsequently improve port efficiency.
2. To increase the efficiency of the port in cargo throughput productivity, port authorities and terminal operators should concentrate more on decreasing ship turnaround time and average time spent by vessels at berth, since both indicates decreases in port efficiency when allowed to assume increasing trend.
3. Since the result indicates that increasing cargo dwell time causes decline in port efficiency with regards to handling of ship calls to the port; port authorities and terminal operators in order to improve the efficiency of the port in handling ship calls to it, should implement strategies that will lead to declining trend in cargo dwell time in the ports.
4. In order to improve the berth efficiency of the port, port authorities and terminal operators should target to achieve declining trend in the average times vessels spend at berth while being worked.

5.3 Contribution to Knowledge

The study developed the following models of empirical relationships as the contribution to knowledge:

(1) The model showing the relationship depicting the effects of maritime logistics performance on the efficiency of Onne port in cargo throughput productivity between 2007

and 2019: ***InEFFICARPUT = 1.366 - 0.072InSHTRTIME + 0.081InCARGODWELLTIME + 0.014InWAITINGTIME -0.16InBERTHTIME + e***

(2) The model showing the relationship depicting the influence of maritime logistics performance on the efficiency of Onne port in handling ship calls to the port: ***InEFFISHTR = 0.007+ 0.109InSHTRTIME - 0.001InCARGODWELLTIME + 0.001InWAITINGTIME + 0.003InBERTHTIME + e***

(3) The equation of the relationship depicting the effects of maritime logistics performance on berth efficiency in Onne port between 2007 and 2019:

InBERTHEFFICIENCY = 1.103+ 1.667InSHTRTIME + 0.193InCARGODWELLTIME + 0.264InWAITINGTIME -5.706InBERTHTIME + e

(4) The model showing the relationship depicting the effects of maritime logistics performance on the efficiency of Lagos Apapa port in cargo throughput productivity between 2007 and 2019: ***InEFFICAPUT = 1.697+ 0.064InSHTRTIME + 0.016InCARGODWELLTIME -0.002InWAITINGTIME - 0.008InBERTHTIME + e***

(5) The model showing the relationship between the ship output efficiency of the Lagos Apapa port and maritime logistics performance of the port is:

InEFFISHTR = 0.698+ 0.27InSHTRTIME + 0.031InCARGODWELLTIME - 0.004InWAITINGTIME - 0.025InBERTHTIME + e

(6) The equation of the relationship depicting the effects of maritime logistics performance on berth efficiency in Lagos Apapa port between 2007 and 2019:

InBERTHEFFICIENCY = 23.320 + 0.252InSHTRTIME + 0.072InCARGODWELLTIME - 0.041InWAITINGTIME -8.535InBERTHTIME + e

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APPENDIXES

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
```

Notes

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	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /DESCRIPTIVES MEAN STDDEV CORR SIG N /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT BERTHEFFICIENCY /METHOD=ENTER InSHPTRTIME InCARGODWELLTIME InWAITINGTIME InBERTHTIME /RESIDUALS DURBIN /CASEWISE PLOT(ZRESID) OUTLIERS(3).
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Descriptive Statistics

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BERTHEFFICIENCY	6.4208	1.77607	13
InSHPTRTIME	6.6215	.09999	13
InCARGODWELLTIME	2.5377	.13875	13
InWAITINGTIME	.3777	.51960	13
InBERTHTIME	1.1054	.30165	13

Correlations

		BERTHEFFICIENCY	InSHPTRTIME	InCARGODWELLTIME
Pearson Correlation	BERTHEFFICIENCY	1.000	-.069	.657
	InSHPTRTIME	-.069	1.000	-.133
	InCARGODWELLTIME	.657	-.133	1.000
	InWAITINGTIME	.227	.027	.186
	InBERTHTIME	-.975	.168	-.661
Sig. (1-tailed)	BERTHEFFICIENCY	.	.412	.007
	InSHPTRTIME	.412	.	.332
	InCARGODWELLTIME	.007	.332	.
	InWAITINGTIME	.228	.466	.271
	InBERTHTIME	.000	.292	.007
N	BERTHEFFICIENCY	13	13	13
	InSHPTRTIME	13	13	13
	InCARGODWELLTIME	13	13	13
	InWAITINGTIME	13	13	13
	InBERTHTIME	13	13	13

Correlations

		InWAITINGTIME	InBERTHTIME
Pearson Correlation	BERTHEFFICIENCY	.227	-.975
	InSHPTRTIME	.027	.168
	InCARGODWELLTIME	.186	-.661
	InWAITINGTIME	1.000	-.149
	InBERTHTIME	-.149	1.000
Sig. (1-tailed)	BERTHEFFICIENCY	.228	.000
	InSHPTRTIME	.466	.292
	InCARGODWELLTIME	.271	.007
	InWAITINGTIME	.	.313
	InBERTHTIME	.313	.
N	BERTHEFFICIENCY	13	13
	InSHPTRTIME	13	13
	InCARGODWELLTIME	13	13
	InWAITINGTIME	13	13
	InBERTHTIME	13	13

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	InBERTHTIME, InWAITINGTIME, InSHPTRTIME, InCARGODWELLTIME[b]	.	Enter

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.983[a]	.966	.948	.40306	2.218

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	36.553	4	9.138	56.250	.000[b]
	Residual	1.300	8	.162		
	Total	37.853	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.103	8.513		.130	.900
	InSHPTRTIME	1.667	1.183	.094	1.409	.196
	InCARGODWELLTIME	.193	1.126	.015	.171	.868
	InWAITINGTIME	.264	.228	.077	1.155	.282
	InBERTHTIME	-5.706	.517	-.969	-11.028	.000

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.8609	8.9368	6.4208	1.74531	13
Residual	-.43695	.55324	.00000	.32910	13
Std. Predicted Value	-1.467	1.442	.000	1.000	13
Std. Residual	-1.084	1.373	.000	.816	13

a. Dependent Variable: BERTHEFFICIENCY

APPENDIX-2

REGRESSION
/DESCRIPTIVES MEAN STDDEV CORR SIG N
/MISSING LISTWISE

Notes

Output Created		04-DEC-2022 14:59:49
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Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /DESCRIPTIVES MEAN STDDEV CORR SIG N /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT EFFICARPUT /METHOD=ENTER InSHPTRTIME InCARGODWELLTIME InWAITINGTIME InBERTHTIME /RESIDUALS DURBIN /CASEWISE PLOT(ZRESID) OUTLIERS(3).
Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.19
	Memory Required	2348 bytes
	Additional Memory Required for Residual Plots	0 bytes

Descriptive Statistics

	Mean	Std. Deviation	N
EFFICARPUT	1.8754	.01506	13
InSHPTRTIME	6.6215	.09999	13
InCARGODWELLTIME	2.5377	.13875	13
InWAITINGTIME	.3777	.51960	13
InBERTHTIME	1.1054	.30165	13

Correlations

		EFFICARPUT	InSHPTRTIME	InCARGODWELLTIME
Pearson Correlation	EFFICARPUT	1.000	.415	.409
	InSHPTRTIME	.415	1.000	-.133
	InCARGODWELLTIME	.409	-.133	1.000
	InWAITINGTIME	.590	.027	.186
	InBERTHTIME	-.429	.168	-.661
Sig. (1-tailed)	EFFICARPUT	.	.080	.083
	InSHPTRTIME	.080	.	.332
	InCARGODWELLTIME	.083	.332	.
	InWAITINGTIME	.017	.466	.271
	InBERTHTIME	.072	.292	.007
N	EFFICARPUT	13	13	13
	InSHPTRTIME	13	13	13
	InCARGODWELLTIME	13	13	13
	InWAITINGTIME	13	13	13
	InBERTHTIME	13	13	13

Correlations

		InWAITINGTIME	InBERTHTIME
Pearson Correlation	EFFICARPUT	.590	-.429
	InSHPTRTIME	.027	.168
	InCARGODWELLTIME	.186	-.661
	InWAITINGTIME	1.000	-.149
	InBERTHTIME	-.149	1.000
Sig. (1-tailed)	EFFICARPUT	.017	.072
	InSHPTRTIME	.466	.292
	InCARGODWELLTIME	.271	.007
	InWAITINGTIME	.	.313
	InBERTHTIME	.313	.
N	EFFICARPUT	13	13
	InSHPTRTIME	13	13
	InCARGODWELLTIME	13	13
	InWAITINGTIME	13	13
	InBERTHTIME	13	13

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	InBERTHTIME, InWAITINGTIME, InSHPTRTIME, InCARGODWELLTIME[b]	.	Enter

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.836[a]	.699	.549	.01011	1.813

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.002	4	.000	4.654	.031[b]
	Residual	.001	8	.000		
	Total	.003	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.366	.214		6.393	.000
	InSHPTRTIME	-.072	.030	.478	-2.426	.041
	InCARGODWELLTIME	.018	.028	.165	.633	.544
	InWAITINGTIME	.014	.006	.498	2.521	.036
	InBERTHTIME	-.016	.013	-.326	-1.252	.246

a. Dependent Variable: EFFICARPUT

APPENDIX-3

[DataSet0]

Descriptive Statistics

	Mean	Std. Deviation	N
EFFISHTR	.7285	.01144	13
InSHPTRTIME	6.6215	.09999	13
InCARGODWELLTIME	2.5377	.13875	13
InWAITINGTIME	.3777	.51960	13
InBERTHTIME	1.1054	.30165	13

Correlations

		EFFISHTR	InSHPTRTIME	InCARGODWELLTIME
Pearson Correlation	EFFISHTR	1.000	.964	-.170
	InSHPTRTIME	.964	1.000	-.133
	InCARGODWELLTIME	-.170	-.133	1.000
	InWAITINGTIME	.071	.027	.186
	InBERTHTIME	.227	.168	-.661
Sig. (1-tailed)	EFFISHTR	.	.000	.289
	InSHPTRTIME	.000	.	.332
	InCARGODWELLTIME	.289	.332	.
	InWAITINGTIME	.409	.466	.271
	InBERTHTIME	.228	.292	.007
N	EFFISHTR	13	13	13
	InSHPTRTIME	13	13	13
	InCARGODWELLTIME	13	13	13
	InWAITINGTIME	13	13	13
	InBERTHTIME	13	13	13

Correlations

		InWAITINGTIME	InBERTHTIME
Pearson Correlation	EFFISHTR	.071	.227
	InSHPTRTIME	.027	.168
	InCARGODWELLTIME	.186	-.661
	InWAITINGTIME	1.000	-.149
	InBERTHTIME	-.149	1.000
Sig. (1-tailed)	EFFISHTR	.409	.228
	InSHPTRTIME	.466	.292
	InCARGODWELLTIME	.271	.007
	InWAITINGTIME	.	.313
	InBERTHTIME	.313	.
N	EFFISHTR	13	13
	InSHPTRTIME	13	13
	InCARGODWELLTIME	13	13
	InWAITINGTIME	13	13
	InBERTHTIME	13	13

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	InBERTHTIME, InWAITINGTIME, InSHPTRTIME, InCARGODWELLTIME[b]	.	Enter

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.968[a]	.937	.906	.00350	3.162

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.001	4	.000	29.973	.000[b]
	Residual	.000	8	.000		
	Total	.002	12			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.007	.074		.100	.923
	InSHPTRTIME	.109	.010	.950	10.566	.000
	InCARGODWELLTIME	-.001	.010	-.008	-.065	.949
	InWAITINGTIME	.001	.002	.058	.640	.540
	InBERTHTIME	.003	.004	.071	.601	.565

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.7134	.7483	.7285	.01107	13
Residual	-.00361	.00389	.00000	.00286	13
Std. Predicted Value	-1.356	1.793	.000	1.000	13
Std. Residual	-1.030	1.110	.000	.816	13

a. Dependent Variable: EFFISHTR

1.82	.79	13.55
1.82	.79	12.95
1.84	.80	10.93
1.85	.79	11.54
1.84	.80	11.51
1.87	.79	12.13
1.86	.80	11.75
1.86	.81	11.58
1.87	.81	11.11
1.86	.81	11.98
1.87	.80	11.65
1.87	.82	11.62
1.87	.83	11.78

InTHRUT	InSHTR	InSTRT	InEFFORT	InATBERTH	InAWAITIBERTH	InDWELLTIME
16.54	7.21	1.32	9.08	1.22	-1.02	2.71
16.51	7.20	1.52	9.08	1.28	.01	2.94
16.67	7.23	1.88	9.08	1.53	.67	2.89
16.76	7.21	1.68	9.08	1.45	.10	3.00
16.71	7.23	1.70	9.08	1.45	.19	2.83

16.94	7.21	1.96	9.08	1.40	.54	2.77
16.86	7.28	2.10	9.08	1.44	-.14	2.94
16.89	7.34	2.07	9.08	1.46	-.67	3.00
16.95	7.37	1.97	9.08	1.53	-.48	3.04
16.90	7.35	2.01	9.08	1.41	-.49	2.94
16.99	7.23	2.02	9.08	1.46	.34	3.14
16.95	7.40	2.12	9.08	1.46	.47	3.04
16.99	7.52	2.05	9.08	1.44	.41	3.09