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Empirical Review on Port Operations Mechanism and Container Ship Trade Effectiveness in Tincan Island Port

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Abstract*—This study presents an empirical review of port operations mechanisms and their influence on container ship trade effectiveness at Tin Can Island Port, Nigeria. Within the context of intensifying inter-port competition in West Africa and persistent congestion challenges in Nigerian seaports, the paper evaluates institutional, operational, and infrastructural determinants of port performance. The analysis is grounded in Bureaucratic Management Theory, Traffic Congestion Theory, Resource-Based Theory, and Frischmann's infrastructure framework, which collectively explain administrative delays, congestion dynamics, strategic resource deployment, and infrastructure accessibility in port systems. The review synthesizes existing literature on maritime, terminal, and hinterland operational dimensions of port efficiency, highlighting key performance indicators such as vessel turnaround time, waiting time, berth occupancy rate, crane productivity, yard dwell time, and gate processing efficiency. Particular emphasis is placed on Nigeria's landlord port model, under which terminal operations are concessioned to private operators while the Nigerian Ports Authority retains regulatory and marine service responsibilities. Despite reform efforts and private sector investment, operational inefficiencies persist, reflected in prolonged vessel waiting times, cargo handling bottlenecks, congestion, and rising logistics costs. The study identifies administrative bottlenecks, infrastructural deficits, manpower and technological limitations, policy inconsistencies, and weak stakeholder coordination as primary drivers of inefficiency. Delays are conceptualized as both operational disruptions and economic burdens, generating direct costs and indirect losses in competitiveness and trade diversion. The review concludes that governance optimization, infrastructure modernization, digital integration, and performance-based monitoring are critical to enhancing container trade effectiveness and strengthening Tin Can Island Port's regional competitiveness.

***Key word:* Port Operations, Container Ship Trade, Port Efficiency, Congestion, Vessel Turnaround Time, Tin Can Island Port.**

I. INTRODUCTION

The effectiveness of any port industry to a very large extent depends on the administrative system of the National port. This study reviewed some theories on administrative systems as practiced in some civilized countries which could be applied for effective management of Tincan Island port to attain optimal operational and productivity. The study also discussed theoretical models to control delay variables in the port industry.

1.1 Bureaucratic Management Theory (BMT)

The BMT was developed by the German sociologist, Max Weber from 1864 to 1920. The theory was propounded to operate an organization in an efficient way. It contains two critical elements which include; constructing an organization into a pyramid of order or responsibilities and having clearly defined rules to help govern an organization and its members. The Bureaucratic management according to Max Weber's approach emphasizes the necessity of establishments to operate in a coherent way instead of following the "arbitrary whims" or irrational emotions and corrupt practices. According to Max Weber, the bureaucratic management theory in forms that to handle an organization professionally, it is essential to have a clear line of authority along with proper rules, procedures and regulations for controlling each business operation. Bureaucracy refers to the possessing of control over a group of people or activities through knowledge, power or authority. The theory further found different characteristics in bureaucracies that would effectively conduct decision making, controlling resources, protecting workers and accomplishment of organizational goals. Bureaucratic management approach developed by Max Weber is best suitable for government establishments rather than private business organizations (Sandro & Carlos, 2019).

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The organizational theory describes the organizational system as a decision-making process that involves many steps when making choice on producing outputs or rendering services. Shukla (2018) describes decision making process as one whose step provide an occasion to change decision. Organization has formation that are used to make up the working units of the organization, each of these functional structures are set into groups that have defined operations. With this arrangement and dependency of each of them to produce the overall output, issues arise to prevent organization to produce accelerated changes as well as deal with the demand they face (Zetterquist, et al, 2011) and these could be in form of delays caused by so many factors in the organization. It is for this reason that organization decision making process are ones that need timing and resources to be able to produce solution that have value addition to the organization. Organizations are difficult and making sense out of them may demand the use of multiple perspective and knowledge to be able to bear a wide range of analysis, decision and plan without having to delay its operations. Modern organizations focus on how to increase efficiency, effectiveness and other objective indicators of through the governing structure and control (Rodrigues, 2011). Port industry is a complex system with various units of decision making, administration and operations especially in the era of port privatization. Each unit of port operations requires a functional and proactive system to ensure a continuous flow in the systems without hitches or obstructions in the administrative flow and the operational functioning of the port industry. Inefficiency in the administrative system of local port industry would cause delays in the port operations. Managerial decisions inconsistent with time such as changes in port policy framework, unregulated price changes, strike actions, unannounced shorting down of systems and so on are organizational decisions that can affect the operational of port industry, as well as inadequate in manpower supply, equipment unavailability etc. are areas of administrative deficiencies that have great impacts on operations and causing delays in the port industry. To a large extent, this affects the efficiency of port industry. Port efficiency is a measure of port in the global shipping trade which affects many decisions of potential ship owners and cargo owners in port choice.

The relevance of a seaport cannot be over emphasis. Seaports play vital roles in overall supply chain and the major determinant of total transportation cost for every imported and exported container. Modern container vessels can handle up to 20,000Twenty-foot Equivalent Units (TEU) and leading shipping companies operate fleet of more than 500vessels and hence, transport more than 10,000,000 full containers annually, which invariably imply that ports handle over 500vessels with over 10,000,000 TEUs for each leading shipping companies annually passing through the port industries worldwide. Therefore, the huge pressure to attract shipments to any particular port of a given region lies on competitiveness of the port in terms of its operational efficiency amongst other neighboring hub ports. The global maritime business environment today is highly competitive, impacting every port organization large or small. According to Qiao and Chris, (2020), the impulsive or spontaneous reaction under the current circumstances is to ensure that local ports provide port users satisfactory port services within their estimated time and costs to attract more customers and in doing this, every aspect of port operations must be carefully structured and evaluated through quality assurance of good managerial expertise to eliminate unnecessary delays and non-value adding costs to retain its competitive service position.

According to Onwuegbuchunam (2018), the concerns about and efficiency in port terminals led national governments to embark on port reforms. The Federal government of Nigeria, for example, adopted the Landlord port model which brought about concession of the port terminals to private operators. Despite high investments in terminal facilities by the private terminal operators, there are still complaints about level of service offered to port users. Port efficiency analysis is a methodology applied in most port for self-evaluation (Nwoloziri, et al, 2021). The efficiency analysis of a port is part of what happens in these three dimensions - maritime, terminal and hinterland operations (Athanasios and Jean-Paul, 2022). These dimensions are interrelated and necessary in efficiency analysis since inefficiencies in one dimension is likely to impact the others. For instance, issues in terminal operations are most likely to negatively impact maritime and hinterland operations with delays. According to Brooks, et al., (2020), the efficiency of port access is a component of port, which includes average anchorage time, where ships are waiting for an available berthing allocation and long waiting times at anchorage can be the outcome of a lack of berthing space able to accommodate specific ship classes (e.g., draft and cargo type) as well as terminal productivity issues. The average ship turnaround time (or ship dwell time) represents the time it takes to service the ship once it has docked. Enhancing such a system is clearly to the benefit of maritime shipping companies. Terminal operations represent the most common indicator to measure port efficiency. For container terminal operations, this commonly involves several key operations. Crane is a common bottleneck in terms of the average number of crane movements per hour. For maritime shipping companies, this is a crucial factor since it is related to the amount of time their ships will spend at the port. How cargo (in containers) is brought back and forth to the storage yard is also a component of port and often related to the number of movements per crane hour. Many container terminals use holsters or straddle carriers for such operations. Container storage yard operations involve stacking and related stacking density, an important variable determining terminal capacity. The average yard dwell time for inbound, outbound, and transshipment cargo is also a common indicator. When trucks enter the terminal to pick up or drop off cargo, space and equipment are required. This is often a critical bottleneck for trucking companies since it dictates the amount of time they will spend at the terminal, reflected in the average truck turnaround time (Brooks, et al, 2020). Gate concerns the efficiency of tasks related to document processing and security inspections. A truck is admitted and cleared to pick up or drop cargo at the facility. Gates used above their capacity are characterized by long truck lines waiting to be processed and enter the terminal for the cargo they are already chartered to handle. Therefore, the average gate waiting time can be used as a indicator. For terminals having on-dock rail facilities, the of the rail loading/unloading equipment can also be an important component of the terminal's (Brooks, *et al.,* 2020). On the part of the hinterland operations, congestion and bottlenecks at street intersections impair the port's in many of the supply chain management strategies of the port's customers (Athanasios and Jean-Paul, 2022). In many gateway ports, Trans loading activities that transfer the contents of maritime containers into domestic truckloads (or domestic containers), or vice-versa, are an element of the of hinterland operations (Athanasios and Jean-Paul, 2022). Port authorities have an oversight, either directly or indirectly, of port efficiency (Pallis and Syriopoulos, 2007).

Furthermore, Pallis and Syriopoulos (2017) infer that where the terminal operations are concessioned to private operators, port authorities tend to have direct oversight of maritime operations and several elements of hinterland operations, such as local roads directly connected to the port terminals, some of which are on land owned by the port authority. Although cities are not directly involved in port operations and commonly have limited control, if any, jurisdiction on port land, they commonly provide and maintain crucial road infrastructure connecting the port with its hinterland. They also bear many of the externalities of port operations, namely local congestion. Therefore, the port authority and the city are important stakeholders in the port evaluation. Ports measure to monitor their activities, check their efficiency, compare present with past , and compare current with targeted . Based on the outcome of these exercises they adopt any necessary alignments to structures and strategies to improve. The measurement output can also be used to promote the business of the port. The questions that each port management and terminal operator have to answer are - what to measure, how to measure, and how to use this measurement. In conclusion, Pallis and Syriopoulos, (2017) notes that the list of indicators that ports and terminal operators use to measure their includes: production measure; productivity measures, utilization measures; and service measures. According to Chang and Tongzon, (2018) many ports around the world are very much concerned with measurement reports and feedback on evaluation of their port s for organizational improvement. Ports are striving to offer competitive services in order to attract a huge market share as well as sustaining patronage of the users and hence remain at the peak in the business of international shipping trade. The result of this intense inter-port competition in the container port sector is the interest in efficiency analysis (in terms of quality, efficiency, productivity and cost advantage) by port users as well as port operators (Wang, et al., 2015). Efficiency analysis provides port operators or port authorities with a means of making more informed decisions with regards to port planning or operations whiles it provides port users (especially shippers, carriers or shipping lines and freight forwarders) with a means of assessing the relative competitiveness of ports in order to make informed decisions on port utilization.

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Ports in Western-Europe, North- America and East-Asia have, for many years, utilized efficiency analysis to improve operations by minimizing the use of resources for port production and time vessels spend in the ports (Chang and Tongzon, 2018). This implies cutting down costs by adopting cost reduction and cost control mechanisms; this has fueled port growth and massive investment in port related activities. In West Africa (WA), the port industry has seen major growth in recent times. In the last twenty (20) years, a number of West African ports have undergone restructuring and reform processes. These processes have been mainly centered on allowing more private sectors involvement in the port industry to generate investment for port development and to increase capacities and efficiencies of ports. More recently, port development in West Africa has been directed towards attaining hub port status (Van, 2015). This can be seen in vision and mission statements of most West African ports. For instance, Ghana Ports and Harbor Authority (GPHA) has on its vision statement "to be the leading trade and logistics hub of West Africa" and the mission statement is "to provide efficient port facilities and ensure quality services to port users"; The Togo ports aims "to make Lome into the gateway of choice to other hinterland countries and a prime transshipment platform, operating to the international standards"; Nigerian Ports Authority (NPA) vision is "to be the leading Port in Africa" and the mission is "to deliver efficient port service in a safe, secure and customer-friendly environment". Inter-port competition is at its highest level and private sector investment in port facilities continues to rise in the WA ports. At present, ports that play regional role in WA are generally viewed as the leading potential hub port contenders. They include ports in Nigeria, Ghana, Togo, Ivory Coast, Benin and Senegal, which provide transit services for landlocked countries in WA (Nwoloziri *et al.,* 2021). Nigeria which is the largest economy in WA and which has some of the largest ports in the region however does not play a significant regional role as the distance between its ports and the landlocked countries in the region is large (Cullinane, and Wang, 2017). In the past, Nigeria's large domestic demand was the government priority. Recently however, the Nigerian government is looking to play a more regional role in shipping and is directing its port development efforts to that effect (Van, 2015).

There are several examples of port development projects in WA that have regional focus and are directed at attaining regional hub status. In Nigeria for example, the Lekki Port project seeks to create a multi-purpose deep water port in the Lagos free trade zone area with a projected capacity of 2.5 million TEUs (Twenty-foot Equivalent Units) per annum. The port will include container, dry bulk and liquid bulk berths with a 14-metre draught and 670metres turning cycle to accommodate larger ships (Lekki Port, 2014). Similarly, the Ghana Ports and Harbours Authority (GPHA) has secured $1.5 billion for expansion of the Port of Tema (Van and George, 2015). The project involves the construction of four (4) deep water berths and an access channel to accommodate larger vessels with high capacity equipment. The aim of the project is to create the largest cargo port in West Africa with a capacity of 3.5 million TEU per annum (Port Finance International, 2014). The Port of Lomé has constructed a $640 million berth in Togo. The new quay has double docking capacity and measures 450metres able to accommodate vessels of more than 7000 TEU capacity (Van and George, 2015). Similarly, port development projects can be found in other West African countries as there is no exclusiveness in the selection of a hub by shipping lines provided there is efficiency in port container terminal operations and comparative cost advantage. The selection of any port by a shipping line to act as a hub depends on a number of factors. According to Van and George, (2015), in a recent survey, major shipping lines calling at West African ports were required to rank factors influential to the selection of a hub for the region; port efficiency, effectiveness and operational were ranked most in the list of 20 factors. West African ports were noted to be highly congested due to delays in ship and container handling operations and inefficient as compared with other ports in Europe and Asia (African Development Bank, AFDB, 2010). These were the reasons for less competitiveness of WA ports which make the ports operate at high cost for the patronage of shipping lines and other port users.

1.2 Traffic Congestion Theory

This study considered the traffic congestion theory propounded by Walter's in 1961. Walter states that if the traffic demand on a particular route is high, specially a narrow channel, traffic will be almost standby and the flow achieve with a very high traffic demand may in fact be lower than the flow achieve with a low traffic demand (McDonald, 2013). Walter derived a traffic flow supply curve that relates the time cost of the trip to traffic density which shows an increase in time cost with rise in traffic flow. Also, the study of Choi in 2013 on congestion theory infers that time cost rises at an increasing rate with traffic density (McDonald, 2013). Hence, Walters and Choi both posit a level of traffic density at which the marginal time cost of a trip approaches infinity. This theory can be applicable to a port system with a narrow channel, inadequate berths and berthing facilities, whereby increasing vessel traffic increases time cost of vessels in a congested seaport. Congestion as a result of delayed operations in ports or shipping industry is a global Philomena. The worse state of delays in port operations or shipping industry as a whole is that it can lead to congestion and thus, increase time cost which affects the overall cost of shipping trade. In fact, the concept of port congestion is primarily on delays as the basis for port congestion. Vessels can arrive at the required time but loading and unloading of containers takes a lot of time causing delays at ports making the shipping industry lost valuable time and incur cost. Delays in handling vessels and containers lead to port congestion. Port congestion is the obstruction in maritime operations, terminal operations and possible hinterland operations as categorized by Theo, Athanasios and Jean-Paul (2022) and witness at anchorage where vessels await berthing allocation; at the port terminals, stacking area, transit sheds, truck traffic, dockyard, boatyard or wharf due to massive anchorage of container ships waiting for loading or offloading of shipments; trucks entering and exiting the port, container awaiting customs clearance etc.

Crucial to the conceptualization of port congestion are terminals and gateway port. Therefore, terminals are sections of the Port where ships harbour or bunk for the discharging and loading of their merchandise. The equipment utilized in the terminals for discharging and loading of cargoes are the cranes, forklifts, lighters, etc. while the gateway is the route that connects shipments to the hinterland either by road or rail transportation (Wouter and Theo, 2010). The inability for ships to berth, load, and unload as early as possible when they arrive at the port is due to the ports incapacity to provide adequate spaces for container ships (Xchange, 2020), whereas, in Nigeria ports. Emeghara (2021) examined and described the ugly situation as resulting from managerial ineffectiveness and bottle-neck which is root on corrupt practices in Nigerian ports industry. Therefore, ships have no choice but to queue up and wait their turn literally. Unfortunately, this is dangerous and poses many problems for businesses, as it causes them to increase their operational costs. In addition, it presents a burden on shipping lines, cargo owners, and of course, port management losing its credibility and competitiveness in the global maritime industry. Therefore, port managers need to work towards increasing efficiency when managing ships, enlarging and developing their infrastructure, employing adequate staff strength (Xchange, 2020) and curbing corrupt practices especially in Nigerian ports (Emeghara, 2021). Ports are of utmost importance to international trade and the economy. The United Nations Conference on Trade and Development (NUCTAD) has stated that maritime trade contributes 90% of the world's supply chain, meaning that 90% of the goods transported all over the world is moved by ships, and any delay at the port costs 0.6% to 2% of the value of the goods daily (NUCTAD, 2019). Sea transportation remains the most common form of transporting goods all over the world, and its efficiency greatly matters. In Germany, ships were delayed for about 45 to 55 hours, although the Covid-19 pandemic has increased delay time to about two weeks (Kaufmann, 2021). In Nigeria, pre Covid-19, ships were delayed for about 20 days, and now the days have gone up to 50 days, sometimes very nearly three months (Anas, et al. 2022). There are several factors that cause port congestion and mitigate against the effectiveness and efficiency of international trade as a whole. There are issues such as extreme demand oversupply of port facilities, the government's inconsistent and unrealistic policies, poor and obsolete port infrastructure, lack of technological infrastructure to help improve the service rendered at the ports to compete globally (Nze & Onyemechi, 2018).

There are several ways in which congestion occurs as posited by (Nze & Onyemechi, 2018), there is ship berth congestion, mainly caused by the fact that several ships have engaged the spaces allotted to the newly arrived ships. Congestion can also occur (ship work congestion) when there are delays attributed to gaps when it comes to loading and unloading ships. This could be drastic in that it lengthens the amount of time a vessel should remain at Port, therefore causing more inconveniences. There is also vehicle gate congestion due to the port management's inability to properly program the way trucks can access the port to pick up and drop cargoes. Once laid out programs are followed through and trucks arrive and leave as they should, the port will run smoothly, and there would be no congestions. Otherwise, there would be port gate congestion. Cargo stack congestion refers to cargo continuously stored at the storage area beyond the allotted time frame. Finally, ship entry/exit route congestion deals with any incidental obstruction on the marine side access route to the port. It could cause queues, bunching and ships overstaying at anchorage and berth as well as cargoes at the stack and trucks on traffic within the ports. Oyatoye, et al., (2011) applied queueing theory to the problem of port congestion in order to enhance sustainable development of Nigeria ports. According to Oyatoye, *et al*., (2011), Nigeria Ports are characterized with incessant congestion problem in the recent past. This has resulted in diversion of ships scheduled for Nigeria Ports to other neighbouring countries which has caused the country to lose a lot of revenue. The effectiveness of a Port is contingent upon loading and unloading of ships. The traffic movement through a port is a complex phenomenon because of the random nature of the arrival and service time of the ships. This requires a systematic approach in port planning and management. Oyatoye *et al*. (2011) adopted Queuing model to the arrival and services pattern which causes the problems of congestion and proffer solutions to the problem areas. It was also used to predict the average arrival rate of ships to Tin Can Island Port and the average service rate per ship in a month. The study found that the number of berths in Nigerian port was adequate for the traffic intensity of vessels but other factors leading to port congestion were identified through the content analysis of the interview conducted with stakeholders at the port. Policy recommendations that could make Nigerian ports to be cost effective, more attractive and enhance quick turnaround of vessels at the ports were made.

1.3 Resources Based Theory

Resources based theory was expound in the study of Kor and Mahoney in 2004 which aimed at understanding how organization achieve competitive advantage with the application of estimable physical and non-physical resources at the firm's disposal. A firm may have many sources ranging from human resource (labour), equipment and financial resource viewed from the angle of the inputs. The resources-based theory by Kor and Mahoney is a strategic theory that fundamentally focuses on strategies that can be used to gain and support competitive power in a firm.

Resource-Based Theory (RBT) also was put forward by Penrose in 2009, which proposed a model on the effective management of firms' resources, diversification strategy, and productive opportunities. Penrose's study was the first to introduce conceptualization of a firm as a synchronized bundle of resources to address and tackle the means of achieving its goals and strategic behavior. The emergence of RBT was incidental to the Theory of Growth by Jay Barney in 1980. Today RBT has become the dominant model in strategic management and strategic planning in formal organizations. Port industry as well adopts the RBT as it experiences labour and infrastructural issues that are principally caused by processes and exercises within the port terminal operations. Planning for port labour and technological applications becomes a very complex task since the extent and outcome of wrong skill task to port terminal operations activities can result to adverse outcomes which could affect efficiency. Delays occur due to inadequate manpower and obsolete technology. Having the ability to determine the correct labour and skills required to perform certain operations in the port is necessary (Kor and Mahoney, 2014). Port suffer delays due to inadequate or manpower deficiency, lack of technological knowhow, right scheduling of work, planning and staffing. Resource management is fundamental in organizational efficiency and especially the ports industry in the era of industrialization, globalization and technological advancement, making time and cost most priorities in operational efficiency rating of the port industry which gives port comparative advantage.

1.4 Frischmann Theories on Infrastructure Development

Brett Frischmann's (2005) economic theories on infrastructure development center on the idea that certain fundamental resources, like infrastructure, should be managed as open and non-discriminatory commons, maximizing social value and benefiting society as a whole. This infers that infrastructure development is essential and should be made available and open for accessibility. He argues that open access to infrastructure generates significant value, and that the costs of restricted access are often underestimated. In the port industry availability and accessibility of infrastructure has a lot to do with the of the port industry. His work challenges conventional approaches by emphasizing demand-side considerations and the social value of shared resources. Frischmann advocates for managing fundamental infrastructure resources through open and non-discriminatory access, similar to the management of natural resources. This means avoiding private property rights that exclude others from using the resource. His work highlights the significant social value generated by infrastructure when it's managed as a common. This value often goes beyond what is typically captured in economic analyses that focus solely on private benefits. Frischmann's approach emphasizes the importance of considering how infrastructure resources are used and how they benefit consumers and society. His theories challenge the prevailing wisdom that private control of infrastructure is always the most efficient or socially optimal approach. Frischmann's work has implications for various fields, including intellectual property, cyberlaw, and telecommunications, by suggesting a new framework for understanding and managing resources. Frischmann's work connects to the essential facilities doctrine in antitrust law, which deals with situations where a monopolist controls a necessary resource and may be required to grant access to competitors. In essence, Frischmann's theories promote a vision of infrastructure development that prioritizes the collective good and the equitable distribution of benefits derived from shared resources.

II. CONCEPTUAL REVIEW

2.1 Port Operations Mechanism

Lateef, *et al.* (2021) infers that a seaport is an important interface between various modes of transportation. It plays vital roles in the movement of ships and cargoes in which the port organization or port operators are required to provide various services to enable smooth flow of commercial functions of the port industry. Nwokedi, *et al.,* (2018) added the Maritime operations is a complex system/structure that comprises both the ship and cargo operations and these operations involve activities that make use of resources in terms of labour, equipment and other port facilities to provide the basic port functions at the require to ensure efficiency and effectiveness. According to Gunther, *et al*., (2016) port operations are those activities carried out on vessels and cargoes at the port for effective berthing, loading, discharging and other necessary services that may be required by vessel and cargo at the terminals. Activities at the haebour/terminals can be classified in two basic categories which are; Ship operations and Cargo operations. The port authority and private operators respectively provide the above functions to cargoes and vessels coming into the port and those leaving the port. Wachuku*, et al.,* (2026) studied how the Nigerian government's 2003 Cabotage Regime affected the growth of local shipping enterprises. The introduction of the Cabotage Regime in 2003 was an independent variable, and it included both tight and liberalized cabotage policies. The development of indigenous shipping businesses was measured using the dependent variable, which is the activity of building ships, the Cabotage vessel finance fund, and human capacity building. The study employed a cross sectional survey research design, and its theoretical foundations were the theory of relative state autonomy and the theory of policy implementation. We mostly relied on primary and secondary sources to compile our data. A structured questionnaire was used to gather primary data that was relevant to this investigation. All 101 registered indigenous shipping businesses in Nigeria comprised the study's population. However, the research focused solely on twenty-four (24) registered indigenous shipping enterprises. The research managed to collect 136 questionnaires out of a total of 144 that were distributed to 24 indigenous shipping enterprises in Nigeria. After reviewing all of the questionnaires, however, 133 (or 92.36%) were deemed useful for the analysis of the research. With a Cronbach's alpha threshold of 0.70, the research instrument was found to be reliable. The data was analysed using descriptive and inferential statistics in the research. The study objectives and hypotheses were tested using SPSS 25.0 and multiple regression analysis with an ordinary least squares estimator. The study found that there is much potential to improve the effectiveness of the Cabotage Regime 2003 in terms of shipbuilding, the cabotage vessel finance fund, and the human capacity building of indigenous shipping enterprises, all thanks to the rigorous cabotage policy. The research concluded that stringent cabotage rules help shipyards grow in Nigeria, but that issues with government policy inconsistencies, bad corporate practices, and procedural obstacles, among others, have hindered their implementation. The analysis identifies Section 9, which permits foreign ownership, as a weak point in the Cabotage statute. Findings indicate that human capacity building, a measure of indigenous shipping businesses' growth, is significantly impacted by stringent cabotage policy, which is a component of the Cabotage Regime 2003. However, the influence on the shipbuilding activity fund is favourable but small. Accordingly, the report suggested that the government initiate a procedure to evaluate the current Cabotage Regime in light of ground realities, ensuring that Nigerians reap the benefits of the program as intended.

According to Emeghara (2012) delay is one factor that affects the effectiveness and efficiency of port terminal operations. Delay occurs when there is overlap or backlog on the activities resulting from terminal operations and NPA workers negligence of duty, Emeghara (2012), further affirms that delays in the port industry has shifted from time waiting to berth rather time waiting in service. Maritime activities are such that is very sensitive to time as it is always said that there is no idle time in shipping which implies that ship incur costs at every point in time. Ship delay at the ports attracts additional cost on the part of ship and cargo owners. Port functions can be classified into two distinct roles in the administrative style of the Nigerians ports which is the landlord port system. In Nigerian ports especially, the basic port functions are clearly defined and classified between the port authority and the concessionaires. There are some provisions by law and regulations of the port industry that allow the port authority the right and sole responsibility to carry out some port functions while the roles of the private concessionaires are primarily on terminal operations on ship and cargo handling services.
The following reviews account the port authority establishment and functions:
The Nigerian Ports Authority was established by the federal government following the Act of 1954 and commenced operation in April 1955. The Nigeria ports at incision was managed as a public corporation comprising only the Lagos and Port Harcourt ports which were the first two established ports. The Lagos pier was the first establish by Portuguese (the Colonial masters) to transport the artifact such coals, graphite and cash crop from Nigeria to foreign country (Europe) as export commodities and the Port Harcourt (Rivers port) was later opened to support the Lagos port to handle excess cargoes and trade follow. Later, other ports were developed such as Onne port, Warri port and Calabar port to support the crude oil exploration in the Eastern Nigeria. While Lagos and Port Harcourt ports were managed as a public corporation, others were managed as private companies under Nigeria n Ports Authority (Emeka 2016). The Nigerian Ports Authority has the sole responsibility to managing cargo handling, quay and berthing facilities at the Lagos and Port Harcourt ports, the initial law also gave it the responsibility of managing harbours and approaches to all ports in Nigeria (Emeka 2016). NPA augmented the development of port services after the end of the cement armada which was the federal government-initiated project. The government built a new port, the Tin Can Island port with Roll-on and Roll-off (RoRo) services and also built a quayside in Apapa and expanded the Warri port services as well as the Calabar port. NPA also built three lighter terminals in Onne estuarine and Ikorodu (Henry, 2016).

Not quite later, during the government of the then president Olusegun Obasanjo, port restructuring program was initiated which brought a change of tide in port administration to improve the efficacy, output and attractiveness of the Nigerian ports. The consequent was the ceding of the port terminals to private operators for a period of time between 25-30 years as contained the concession agreement. Based on this, the functions of the port are categorized: NPA will remain and act as the landlord and deliver common user facilities, technical supports and other marine services. The expatriates or the concessionaires will be involved in loading and offloading of cargoes at the terminals (Emeka, 2016). However, the NPA was actually institutionalized for a particular purpose which was to regulate the activities of the stakeholders of Ports, which are the concessionaires in the ports. In other words, the NPA was designed to govern, as well as control the activities within the Nigerian Ports systems. As a federal government parastatal, it was authorised to oversee all operations within Ports in Nigeria, which include, the Apapa and Tin Can Island Ports in Lagos State; and Calabar port in Cross River State; Warri Port in Delta State; Rivers and Onne Ports in Rivers State. The Ports Authority is working under the direct regulation of the Federal Ministry of Transport, as well as, the Nigerian Shippers' Council. Through the activities and roles of the NPA, the ports in Nigeria are competitive, and as a result has helped increased the national resources, especially in the era of port concession (Eromosele, 2023).

The Nigerian Ports Authority maintains safety and security within the Nigerian Ports: Safety of lives and goods of the port users in Nigeria is very vital, it is the responsibility of the NPA to ensure that there is safety in the harbours. It is the function of the Authority to uphold security and ensure safety within the Ports environments particularly, where there is heavy duty or the busiest area of the Ports organisation. However, whatever the case may be, the maintenance of order, security and safety in the Ports is an intricate to the functions of NPA, without which NPA may not actualize its goals and objectives, thus, maintenance of security and safety is of utmost important in the Ports (Olalere, et al., 2015). The Nigerian Ports Authority guards against marine pollution and other incidents: Most times in an organization, accidents occur, sometimes accident happened due to the imprecision of the management of the organization. Since the NPA is such an organization with people working may not be exempted from risks of accidents or such occurrences, it is expected of the Authority to guard against such occurrences in the Ports environs. For instance, it is the responsibility of the Authority to discourage or avoid the art of polluting the water, as well as, guard against any other such incident that may be capable to hampering the functions of the Ports. This is very vital, and the responsibility is falls upon the shoulders of the NPA (Onwuegbuchunam, et al., 2017).

It is important to endorse bye laws and regulations, and also to follow such regulations up, monitor the operators' compliance to such regulations and laws, possibly enforce the laws and regulations where necessary. In spite of concession excise, port users still expect the NPA, to perform its pre-concession roles, explains the current roles of the NPA in port and cargo operations in Nigeria (Eromosele, 2023). However, the port reform of 2006 helped to reposition and transform Nigerian seaports for keenness and efficacy in order to compete favourably with its contemporaries in the African region and indeed the rest of the world. The concession policy implementation by Federal government was the Landlord model of port concession, which conceded cargo handling procedures to private terminal operators whereas the NPA retains the charge of providing marine services. The policy of port concession stanched from the desire of the federal government to pervade private sector efficiency into the port value chain by embracing Public Private Partnership (PPP) model, which is the global business approach. The port concession era misshapen the operational functions of NPA to a more technical regulation with core responsibilities of as long as and maintaining common user facilities such port internal roads, brilliance, dredging, buoyage, pilotage, towage and another technical enabler of safe navigation, in addition to working out regulatory lapses on terminal operators (*Lateef, et al., 2021)*.

While on the other hand, Brouer, Karsten, and Pisinger, (2017), United Nations Conference on Trade and Development UNCTAD, (2021) and Ziaul and Hans (2018) note that seaborne trade covers nearly 80% of the world merchandise and as such requires cost efficient modes of transportation. An efficient port as an important interface for transportation of cargoes, it is a port industry that can operate optimally within a specified time. A port that is efficient in administration with adequate manpower supply, container handling equipment and all other necessary port facilities, and most importantly a port void of delays and congestions which could result to additional unbudgeted cost on the parts of the cargo and ship owners (Jafari, 2013). Container transportation via the port industry is estimated to be six (6) times cost effective than trains, fifteen (15) times efficient than trucks, and over 200 times effective than aircraft (Brouwer, van der Woude, & van der Leun, 2017; Pal, & Ziaul, 2017). A prerequisite to achieve this efficiency lies on optimal port operations which maximizes the use of available capacity and port facilities combined with good managerial expertise to save time and cost while serving a large throughput of ships and cargoes at the port terminals. Delay is an act of obstructing that slow down a process which affects the rate of flow of the process and possibly affects the outcome of a system. In maritime industry, delay could also be referred to an unforeseen circumstance that causes setback in the planned schedule of a port operations such as bad weather etc., (Xiangtong, 2015; Achurra-Gonzalez, Angeloudis, Goldbeck, 2019). Delays could result to tasks and milestones not completed within the established deadlines, leading to an overall extension of the operational timeline beyond what was originally scheduled. Delay could result from any force (human or natural phenomena) that impedes the process of achieving organizational set objectives which has to do with deterring the rate of operations or free flow of the entire process of port operations and vessel voyage plan (Noorul, Fitri, Mohammad, Izzat, Aminuddin, & Alisha, 2019). Delays are detrimental to the overall maritime activities.

Further, delays have implication of cost of transport and overall maritime cost. Cost of port delays in terminal operations is a management concept used to quantify the impact of delay in service delivery. It is a measure of financial, operational and customer–related costs associated with a delay in the delivery of services. Cost of delay can be measured based on economic terms, estimating the economic impacts of delays on the success of a system. Cost of delays could help to evaluate and estimate the impact of time on an expected outcome. However, according to Linus (2024), the cost of delay is not just about financial loss on monetary terms, it also pertains to loss of opportunities, customer dissatisfaction and a decline in market share. Cost of delays could portray significant impacts on loss of organizational goodwill in a business (Linus, 2024). Goodwill is a reputation a port has that makes the customers to continue and return to the port as well as the ability of the port industry to attract new customers to increase its profitability over time. The effect of delay considers the economic influence of the time it takes to deliver port services to a vessel or cargo in a port. This includes factors such as loss opportunities, potential market share loss, reduced customer fulfilment, increased development budgets, and decreased team morale (Linus, 2024). Essentially, the cost of delay is a way to measure the impact of delaying the delivery of a port service, and is used to inform decisions about prioritization, resource allocation, and port management (Linus, 2024).

There are two key classifications of cost of delays in organization which include; direct and indirect cost of delays. The direct costs of delays are those that are directly related with the delay, such as the cost of additional resources due to delays, loss opportunities, and other factors. For instance, if a port service is delayed, the cost of resources such as berth, labour, materials, and equipment may increase. Additionally, the port may miss out on potential opportunities, such as new customers or markets, could have been gained if the port operations were completed on time. On the other hand, indirect costs of delays are those costs that are not directly related with port delays, such as cost of customer displeasure, loss market share, and other factors. For example, if a port service is delayed, customers may become discontented with the port services, leading to a decrease in customer faithfulness (goodwill) and a decrease in market share (Widyastuti, *et al.,* 2024).

2.2 Container Vessel Trade

Coşar, and Demir (2018) notes that container vessel trade is the determinant factor in the overall port operational. Terminal operations involve the handling of vessels, including navigation and maneuvering within the port, berthing and unberthing of vessels, and anchorage management. Terminal operations revolve around the quick and efficient handling of ships and its cargos. Vessel operations of port system is a core function of the port owners or operators to provide vessel with every necessary support to navigate in and out of the port environment, provide berths, berthing/mooring facilities as well as every compulsory and ancillary services needed by a calling vessel (*Carlo, et al 2013)*. In Nigeria, where Landlord system of port administration is practiced, the Port Authority has the responsibility to aid visiting vessels to navigate in and out of the port systems by providing tugs and pilotage services through the help of local port pilots, allocation berths, provide berthing and mooring facilities etc. while, on the other hand, port operators render services to enhance the operational of the port system through efficient cargo handlings. Efficient vessel and cargo operations would enhance vessel turnaround time of the port by reducing the number of days vessels spend in the port system. The effectiveness of the port systems encourages more vessel traffic; however, the reserve becomes the case when delays occurs at the port terminals, hence, increasing the periods of vessel stay in the port reduces the patronage, which reflects the number of times vessel call to the port industry (Richard et al, 2023).

2.3 Average Vessel Turnaround Time

A turnaround time is an indicator of an efficient seaport (Henry, 2020) ship turnaround times, Truck Turnaround Time and Equipment Dwell Time are various measures to determine time used in port operations (Henry, 2020). It has been observed that money is lost every minute ship stays in a port, hence in very highly efficient port; the cost of transportation is lower (Henry, 2020). It is pertinent to note that the reduction in a ship's time in port primarily depends of the port in fulfilling its functions (Henry, 2020). Henry (2020) states that ship turnaround time is the

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total time spent by a particular vessel in port. Also, it is defined in another sense as the average time spent in port by all vessels calling in a specific period. Then they are divided into two components namely, the Waiting Time and Ship's Time at Berth (Monday, et al, 2021). The time in the port is not only an essential factor to clients but also to the port as the most important element to reduce or increase port competitiveness, which should be observed all the time in port operations. Several Authors as well as the UNCTAD have given a strong interest to this issue as they believed that the time at port is the most important factor to develop the port and to achieve profits to all parties concerned in business in the port sector. Zhong, *et al.,* (2024) states that Ship Turnaround Time gives an excellent indication of the speed of service being provided to ship operators; it is a very important element in determining maritime costs and delays where the turnaround exceeds the expected time. This study is focused on modifying streamline an existing offshore supply vessel (OSP) hull form to an IMO standard one so as to obtain an improved ship hull form with low resistance and power and also with highly efficient energy saving performance. Using an analytical method there was significant increase in the design variables during the process of hull form modification and this was validated when Maxsurf software was used to modify the hull form. The analytical method used to perform the modification of pacific wrestler using response amplitude operator (RAOs) from Maxsurf then MATLAB to consider the modified and initial resistance values gotten from Maxsurf motion analysis used as the input values in comparing the resistance and power as against the vessel forward speed at 180 Degree and 135 Degree. Main dimensions of the ship were used to generate various hull models and Autodesk inventor used to present the various vessel hull form in solid form. The optimization was to improve on the vessel hydrodynamic performance in calm water as to achieve good sea-keeping condition, comfortability, manoeuvrability, reduced fuel consumption at 0,5,10,15,20,23 and 25 knots on regular sea wave condition of 4m. The various NURBs design diagrams gotten were used to run a computer motion simulation on regular sea wave of 4 meters for the both hull forms to ascertain a more favourable resistance, stability and rang at various speed on transit. MATLAB coding was used to calculate for the required power for both vessel considering the resistance values gotten from the maxsurf motion analysis which shows that there was reasonable reduction in the modified resistance of about 40 to 45%, and also power of about 30 to 25% and hydrodynamic location RAOs of up to 8 to 2% results. Comparing the results of the parent hull form to the modified hull form at 0 to 25 knots of the ship speeds on various location of the sea state towards the different degree of movement of the ship which demonstrates the validity of the proposed modification design strategy after bulb was designed into the bow section of the ship hull given the ship a better forward buoyancy, 20 to 25% of fuel efficiency, and increased speed MacPepple, *et al.,* (2025).

2.4 Average Vessel Waiting Time

The waiting time at ports refers to the period in which a ship is on the bar waiting to dock, and which, added to the time required for unloading or embarkment, becomes the total stay in the port (Shahpanah et al, 2014). This is what we call the turnaround time. This time is variable in each port and can differ considerably from the waiting time required for loading and unloading cargo. The waiting for berthing depends on several factors. Waiting time also, refers to the period a ship must wait before it can berth at a port. This can be due to several factors such as port congestion, tidal restrictions, or availability of loading/unloading facilities. High waiting times can indicate bottlenecks in port operations and can significantly impact the efficiency of cargo throughput. Longer waiting times can lead to higher operational costs for shipping companies, including fuel costs and potential penalties. Waiting time can affect lay time calculations in shipping contracts, potentially leading to demurrage charges. In 2020, for example, with the increase in exports and import waiting days at the bar to dock of many ports around the world increased. For instance, in ports of Japan the wait time in the bar for ships scheduled for the Export Corridor to load soy is around 30-40 days and that is because it has improved, as it has recently reached almost 45 days in some cases (Rezaei, et al., 2019).

The statistics of the waiting times of ships calling at ports around the world in the port anchorage area can be followed on a country basis to have information about the nature of the ports of the relevant country. Considering the services received by dry bulk cargo ships from ports in world ports, according to UNCTAD (2022) data, it is seen that the highest waiting time in loading operations is in Brazilian ports with 184 hours, and the highest ship waiting time in unloading operations is in Brazilian ports with 181 hours whereas, Türkiye, has 58 hours of loading and 72 hours of unloading in terms of waiting times of bulk cargo ships. With this data, Türkiye has a good value compared to the average of other countries. A similar calculation was made for tanker ships, according to UNCTAD (2022) data, Belgium has the highest average tanker holding time in loading with 81 hours, while Kuwait has the highest average vessel holding time with 115 hours. Türkiye's average data for this vessel type is 39 hours for loading and 36 hours for discharging. Delays in world container services had increased recently, especially from the second half of 2020 to January 2020 (Okpomo, 2021). Many ships were forced to wait offshore for days at major ports, especially in North America, Europe, China and Africa, causing a supply chain crisis that delayed the delivery of various goods and led to shortages of these goods. Container ship delays were caused mainly by congestion and low productivity of port/terminal before the crisis (Ali, et al., 2014), and were transmitted to the other ships through the terminals and ships. A general description is given of the issue of ship scheduling, where the waiting time of ships in ports is uncertain, as well as the response time. As noted, marine station operators frequently encounter unpleasant and unpredictable events that cause port congestion, further affecting ships' waiting times and port handling times. Tamunodukobipi, *et al.,* (2021) highlighted engine design technologies and computer-based performance simulations were well developed. However, these are not adequately complemented by detailed analytical techniques for preliminary design and performance optimisation. Thus, this paper performs a parametric study on engine design requirements for optimal performance. It utilises analytical procedures, infused with statistical and empirical relations. The dynamics and kinematics of the inertia masses of a trunk-piston diesel engine (of bore D=0.2m, crank radius R =0.2m, and connecting rod L=0.8m) are investigated in-line with its performance characteristics. The analyses show that the engine peak volume displacement, piston stroke and celerity are linearly dependent on the crank radius, and uninfluenced by the length of connecting rod. The peak celerity occurs at crank angle θ=90 and 270 , with zero value at θ=0 , 180 and 360 . It is noted that very high mean linear speed (Cm) can cause poor volumetric efficiency, high inertia induced power loss, friction wear, incomplete combustion, mechanical vibration and high exhaust emissions. Therefore, the ranges of Cm values for optimal design are: (4.5 m/s ≤ Cm ≤ 7m/s), (7m/s ≤ Cm ≤ 10m/s) and (10m/s ≤ Cm ≤ 15m/s) for slow, medium and high-speed engines, respectively. These limiting values should be followed to minimise the negative effects of very large reciprocating inertial and poor net power output.

2.5 Average Berth Occupancy Rate

When a cargo ship arrives at a port, it cannot immediately begin unloading. First, it must secure a designated spot known as a berth. Berthing involves carefully guiding the vessel into its assigned location alongside a pier, quay, or dock, enabling cargo operations to proceed (Balci, et al., 2018). This step is vital for the seamless transition of goods and demands precise coordination between the ship's crew, port authorities, and terminal operators. Understanding the concept of berthing is essential to ensure the smooth movement of freight upon its arrival at the port. In maritime operations, understanding "berthing in shipping" is essential for efficient port management and vessel handling. Berthing in shipping refers to the act of bringing a ship to a designated dock or quay in a port. It involves positioning the vessel alongside the dock where cargo operations can take place. This process is critical for the safe and efficient handling of goods and ensures smooth port operations. Effective time refers to the duration a vessel spends actively engaged in cargo handling activities. It encompasses the time required for loading or unloading, excluding any interruptions or non-productive periods. Effective Time is a valuable metric for measuring the efficiency and productivity of the ship loading and unloading process whereas, Berthing Time, on the other hand, represents the total time a vessel occupies a berth at the port, from the moment it docks until the time it leaves. It includes all activities, such as cargo operations, refuelling, documentation, and any other procedures necessary for the ship’s stay. Rezaei, et al., (2019) concludes that Berthing Time provides a comprehensive overview of the entire port stay, considering both productive and non-productive activities (delays).

Effective Time focuses solely on the actual cargo handling activities. *Effective Time* specifically measures the efficiency of loading and unloading operations. Berthing Time encompasses the broader scope of a vessel’s stay at the port. It captures the entire range of activities associated with a vessel's visit. Efficient time management is vital in the shipping industry to ensure seamless cargo operations and minimize delays. Effective Time and Berthing Time serve as essential indicators for evaluating the efficiency of ship loading and unloading processes. By closely monitoring these metrics, shipping companies can identify areas of improvement, reduce idle time, and enhance overall productivity (Rezaei, et al., 2019). Optimizing these critical aspects leads to enhanced operational efficiency, reduced costs on vessel delay time / demurrage, and improved customer satisfaction. As the maritime industry continues to evolve, harnessing the potential of Effective Time and Berthing Time becomes increasingly crucial in driving success for shipping companies worldwide.

The estimated times of berthing in shipping can range widely, typically from 30 minutes to several hours (UNCTAD, 2022). This variation depends on multiple factors, including vessel size and port congestion. For instance, berthing a large vessel at a bustling port like the Port of Los Angeles can take significantly longer compared to a smaller freighter at a less busy regional port. The specific characteristics of the vessel, the nature of the cargo, and prevailing port conditions all influence the berthing time (UNCTAD, 2022).

2.6 Container Trade Traffic

Port container traffic measures the flow of containers from land to sea transport modes, and vice versa, in twenty-foot equivalent units (TEUs), a standard-size container. Data refer to coastal shipping as well as international journeys (Munim, and Schramm, 2018). TEU is the standard unit, referring to 20-foot equivalent units or 20-foot-long cargo container. The size of cargo containers ranges from 20 feet long to more than 50 feet long. The international measure is the smallest box, the 20-footer or 20-foot-equivalent unit (TEU). Two twenty-foot containers (TEUs) equal one FEU. Container vessel capacity and port throughput capacity are frequently referred to in TEUs (Munim, and Schramm, 2018). Measures of port container traffic, much of its commodities of medium to high value added, give some indication of economic growth in a country. But when traffic is merely transshipment, much of the economic benefit goes to the terminal operator and ancillary services for ships and containers rather than to the country more broadly. In transshipment centers empty containers may account for as much as 40 percent of traffic (Munim, and Schramm, 2018).

Global container traffic in 2024 amounted to 183,158,193 TEU, according to new data released by Container Trade Statistics (CTS), representing growth of 6.2% over 2023 (CTS, 2024). According to CTS figures, global volumes in December reached 16m TEU, a 4.5% gain on November and a 6.6% year-on-year increase on December 2023. This marks December as the second-highest lifting month of the year, following August, which saw a record-breaking 16.1m TEU reflecting the overall strength (CTS, 2024). There has been a significant evolution from 19.2M TEUs in 2010 to 34.9M TEUs in 2022, reflecting the continent's growing role in global trade routes (CTS, 2024). This growth is driven by the contributions of each African region, playing a distinct role in container traffic volume (CTS, 2024).

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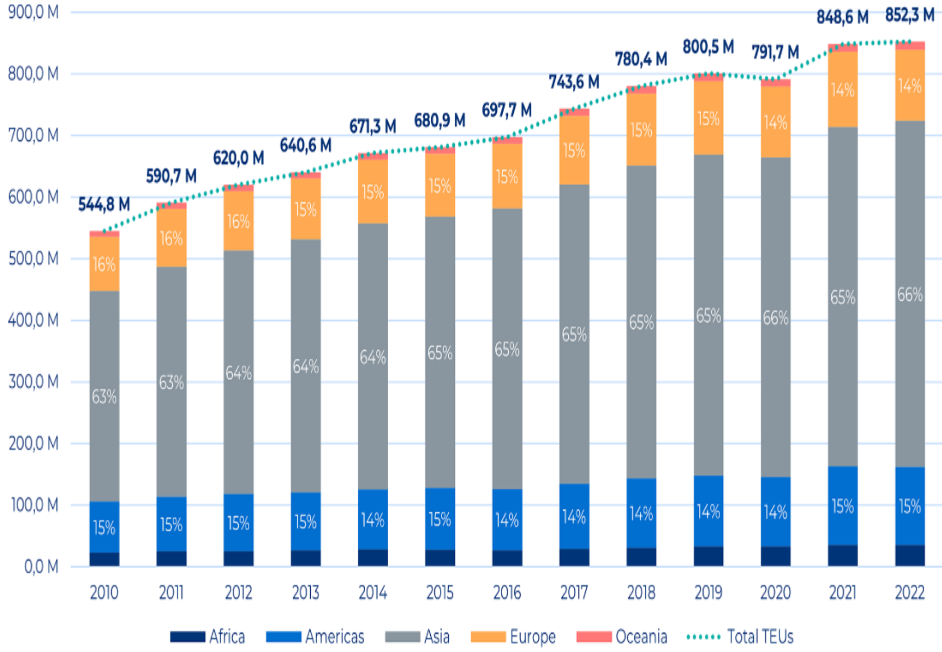

Figure 1: Global TEU throughput Source: CTS (2024)

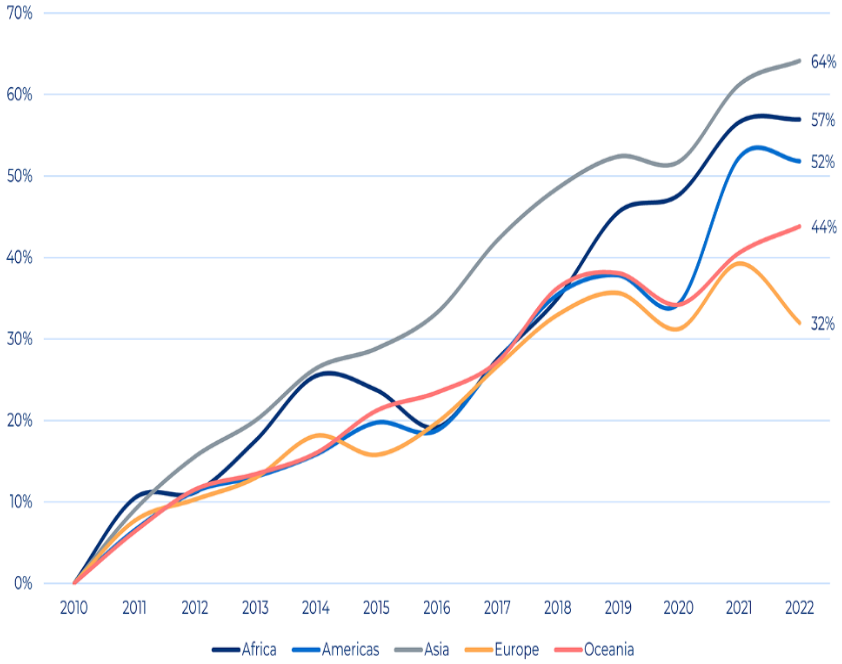

Figure 2: TEU growth evolution UNTAD (2023)

The growth of total container traffic in Africa between 2010 and 2022 has grown year over year, but unevenly across different regions of the continent. The following chart illustrates the cumulative growth in the five main regions of Africa.

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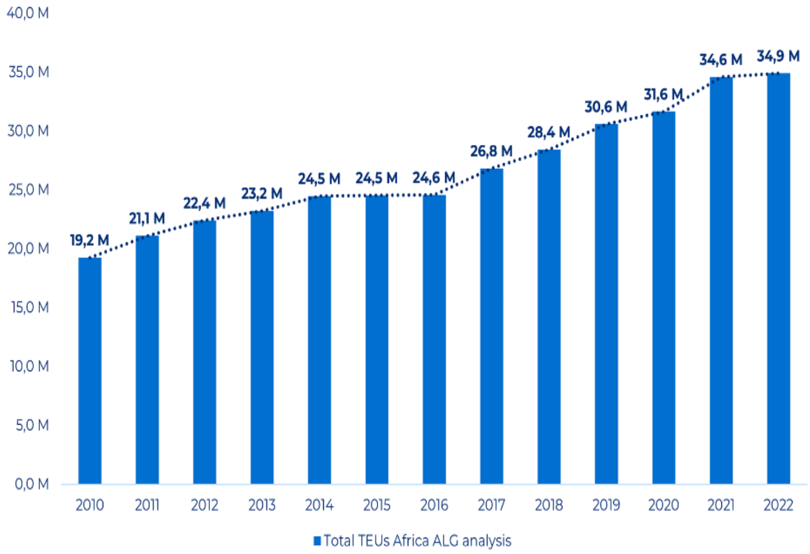

Figure 3: Africa TEU throughput Source: CTS (2024)

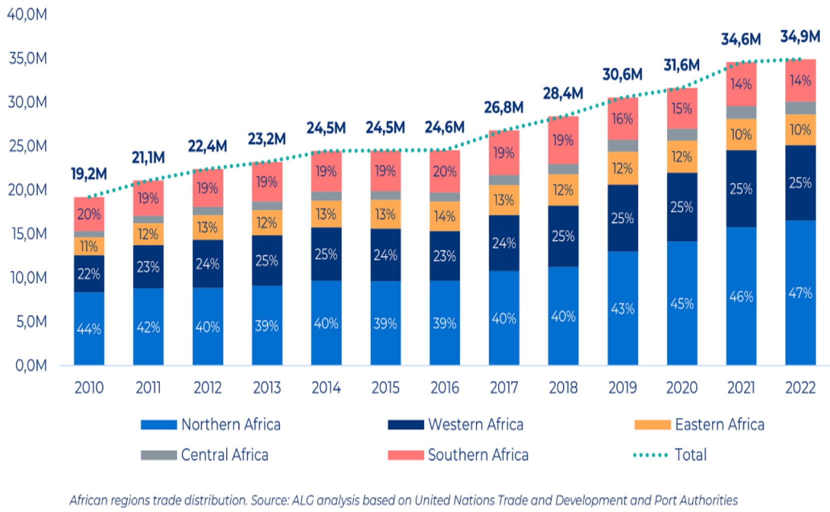

Figure 4: African Region Trade Distribution Source: UNTAD (2023)

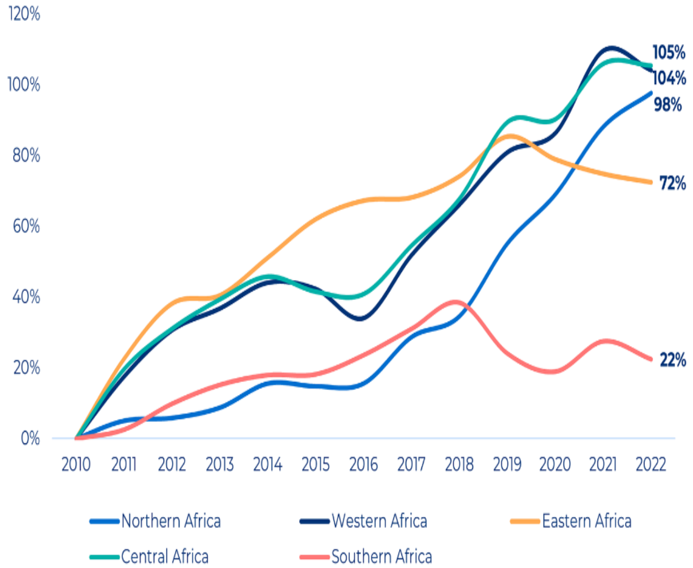

Figure 5: African regions growth Source: UNTAD (2023)

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2.7 Ship Traffic Trade

Ship traffic statistics/volume is a term used to denote the number and/or volume of vessels that called to a port over a period of time, usually one year. The volume and nature of shipowners' and/or ship agents' demand for port services and port patronage are shown by ship/vessel traffic statistics. The number of ships that stop at a port over time essentially determines how much money is recouped in ship dues, such as pilotage, berthing, and mooring fees. Global marine traffic has increased with container ships spending 13.7% longer in ports (Emenike, *et al.,* 2018). In 2021, the global commercial feet grew by under three per cent – second lowest rate since 2005 (UNTAD, 2022). The fastest growth, driven by global gas demand was for liquefied gas carriers followed by containerships and bulk carriers (UNTAD, 2022). Daily ship traffic volume statistics and prediction are of great significance to shipping market. Reliable prediction of daily ship traffic volume can instruct shipping company to make sound judgment and decision for operational management (Chioma, 2011). Because of the mobility of ships, it may be difficult to obtain the ship traffic volume automatically and frequently. In early 2022, the total fleet of seagoing merchant vessels amounted to 102,899 ships of 100 gross tons and above, equivalent to 2,199,107 thousand dwt of capacity (UNTAD, 2022). Over the same period, supported by robust global gas demand, the fleet of liquified-gas carriers continued to grow strongly, by 8.15 per cent (UNTAD, 2022). Ports and new demands for shipping following COVID-19 and the war in Ukraine have all had measurable impacts on people's lives. With ships carrying over 80% of volume of global trade, higher shipping costs and lower maritime connectivity lead to higher inflation, shortages of food, and interruptions of supply chains – all of which are among the features of the current global crisis.

In line with maritime trade, port calls also bounced back in 2021 amid unmatched port congestion with hotspots being concentrated in the United States, Europe and China (Emenike, 2021). According to David, et al., (2015), in Northern Europe, some shipping operators, seeking to boost efficiency, cut the number of port call locations per rotation. This pushed up the volume of cargo exchange per call, while extending work time at terminals and putting pressure on the main ports. The effects of congestion and logjams rippled across a range of industries such as car manufacturing, healthcare and electronics, and notably through a serious shortage of semiconductors.

Since the onset of the logistics disruptions in late 2020, there has been an overall global decline in liner shipping connectivity, though with variations between countries. The world's most connected country remained China which widened its lead. And India extended its regional connections by upgrading port capacity. Similarly, in North Africa continued development of port infrastructure helped mitigate the impact of the pandemic. These gains were offset by declines in connectivity elsewhere, including leading economies. In the United States of America, for example, container port operational was undermined by weakness in West Coast port infrastructure as a consequence of long-term underinvestment. But the picture was even worse in parts of the developing world: over this period, most of Africa and Latin America and the Caribbean suffered significant reductions in direct connections (Ugo, et al., 2021). Also, for passenger ship traffic volume there has been considerable traffic in major parts of the world.

2.8 Vessel GRT Trade

Gross Registered Tonnage (GRT) is the volume of space within the hull and enclosed space above the deck of a merchant ship which are available for cargo, stores, fuel, passengers and crews. Gross Registered Tonnages are actually measurements of cubic capacity. Gross tonnage is measured according to the law of the national authority with which the ship is registered. The measurement is, broadly, the capacity in cubic feet of the spaces within the hull and of the enclosed spaces above the deck available for cargo, stores, passengers and crew, with certain exceptions, divided by 100. Thus 100 cubic feet of capacity is equivalent to one gross ton. The GRT is on decline in India. The data pulled from the government sources indicate the decline in the national tonnage from almost 7 million GRT to 6.39 million GRT. Net tonnage is derived from gross tonnage by deducting spaces used for the accommodation of crew, navigation machinery and fuel. Gross or Net tonnage are usually the basis on which Port dues are charged. Naval architects are adept at building ships which can carry cargo in spaces not included in the tonnage. Deadweight is the weight of cargo, crew passengers and stores that a ship can carry. It is the difference between light and loaded displacement. It is a measure expressed in metric tons (1,000 kg) or long tons (1,016 kg) of a ship's carrying capacity, including bunker oil, fresh water, crew and provisions. It is the most important commercial measure of the capacity. Tamunodukobipi and Chuku (2023) concluded that maritime engineering serves as a lynchpin for unlocking Nigeria's immense blue economy potential across sectors like offshore oil and gas, fisheries, transportation, and renewable energy. Developing local expertise and knowledge in this arena through targeted investments, training programs, research centers, strategic partnerships, infrastructure development and progressive policies is therefore of vital economic and strategic importance for the country's future. Sustained commitment and collaboration between government, industry and academia is essential to build a vibrant maritime engineering ecosystem over the next decade. This can significantly advance Nigeria's journey towards becoming a globally competitive blue economy.

In January 2022, in dwt terms the global commercial fleet grew by 2.95 per cent, a historically moderate growth rate and the second lowest since 2005 (UNTAD, 2022). As an important part of the transportation system, shipping undertakes most part of international trade and goods transportation. With the continuous development of shipping industry, vessel traffic faced the challenges including concealment of vessel tonnage due port charges with regards to GRT. The existence of these problems seriously affects the safety of maritime transportation and the implementation of shipping management regulations (Wang and Yang, 2018). Vessel load management, as one part of shipping management, has always been an important part in water safety supervision. The vessel type, deadweight tonnage (DWT), and vessel scale affect the navigation mode of vessels entering and leaving the port, and different navigation modes determine the capacity of the channel in a large extent (Chen et al., 2019).

The estimation on the DWT or goods throughput of vessels entering and leaving the port is important to maritime supervision as it can help formulate a reasonable port operation plan to avoid the inefficiency of loading and unloading, berthing, or other unexpected problems caused by a sudden increase in traffic volume. Moreover, information on DWT can help to determine reasonable plans for the channel layout and maintain the waterway operation, which could ease the spatial demand and environmental pressure of the waterway. Despite its importance for shipping administrations and port development, vessel DWT was currently obtained through manual investigation in the vast majority of cases. Such methods are cumbersome and time-consuming. It can be easily affected by census error, and may not even be applicable in some cases where data source was limited. At present, there are few studies on a vessel's DWT, which are divided into two kinds: non-computer vision and computer vision. The former is usually calculated by the draft method, the empirical method, and the instrument method (Zhou et al., 2018). These methods have low automation, high equipment costs, and it is difficult to obtain the global vessel dynamic DWT. Computer vision is to obtain the vessel's image through the vision device, and calculate the vessel's DWT from the vessel image. This method is non-contact, real-time, and high accuracy. However, the camera will be greatly affected by weather conditions, or due to lens distortion, when the vessel appears at different positions in the field of view, the number of target pixels will be different, which will also cause. Some scholars have studied methods based on computer vision. Gong et al. (2009) used the hybrid coded immune identification algorithm to predict the vessel's load, and applied the method to the vessel's load prediction, but the method can only identify the vessel model with simple structure and easy identification. Some scholars have studied the deadweight and vessel parameters. Gurgen et al. (2018) used an artificial neural network to predict the vessel's length, width, and draft depth with the input of the vessel's maximum deadweight and design speed. The results show that the neural network can well predict the vessel's parameters, and the parameters of length and width have an important relationship with DWT calculation. Cepowski (2019). Studied vessel AIS by regression analysis, and established regression formulas for vessel length, width, draft, vessel mass, DWT, However, this formula only applies to individual tanker subtypes and uses more parameters. The above methods have certain defects. As an important aspect of maritime intelligent transportation, DWT calculation is becoming increasingly important, and we urgently need an efficient and accurate calculation method. High-resolution remote sensing satellites can easily obtain image information from vessels thanks to the continuous development and improvement of satellite remote sensing technology. However, research on using remote sensing technology to detect the load of vessels is relatively rare, mostly in the field of vessel detection. As an important carrier of vessel load management, a vessel is also the main object of vessel target detection, so it is necessary to research it.

III. EMPIRICAL REVIEW

3.1 Port Operations Mechanism and Container Vessel Trade (TEU)

Port characteristics and infrastructure is essential for the efficiency and effectiveness of the maritime network. Port characteristics and infrastructure endowment can be described by variables such as number of cranes, storage areas, quay length, maximum draught (water depth), and length of berth at origin and destination ports. According to Wilmsmeier and Martínez-Zarzoso (2019) the interaction of these variables is decisive; arguing that high technological applications of equipment in port industry, for example, installing ship-to-shore gantries and development of quay spaces will save time at the port and speed up operations at the container terminals, however, may well lead to higher port charges for a shipping line. However, development of port infrastructure is only worthwhile if the entire transport system benefits and not if bottlenecks are only shifted to another element within the system (Wilmsmeier, Jan Hoffmann and Ricardo, 2016).

Factors influencing productivity are physical, institutional or organizational. Physical limiting factors include the area, shape and layout of the terminal, the amount and type of equipment available, and the type and characteristics of the vessels using the terminal (Wilmsmeier and Hoffmann, 2018). Lack of cranes, insufficient land, oddly shaped container yards; inadequate berth space, inadequate gate facilities, and difficult road access are all physical limiting factors causing delays. Productivity must be considered in a system perspective for it to be of maximum value to industry. This is important from a policy perspective, thus emphasizing the need for co-modality and multimodal visions in policy recommendations and guidance. All players should have an awareness of the entire system and be cautious of becoming its weak link. Empirical results presented by Wilmsmeier *et al*., (2016) are quite clear and straightforward to illustrate this. It explains that increase in port efficiency, port infrastructural development, private sector participation and inter-port connectivity - all help to reduce the overall global maritime transport time and costs. In his study, two countries in their sample with the lowest port efficiency improved their efficiency to the level of the other two countries with the highest indexes; the freight on the route between them would be expected to decrease by a given per cent for several reasons which include time saved in port terminal operations. Improvements in port infrastructure and private sector participation have led to reduced maritime transport time and costs. Hence, improving port efficiency and productivity by introducing technical advances as well as port design characteristics and planning/administrative measures can reduce operational time and costs at the port industry.

Time spend at the ports is very necessary as it forms the basis for most charges on the services rendered to ships and container cargoes. Charges in shipping trade can be classified in various forms. It can be classified based on who incurred the charges and activities on which the charges were incurred. The term Port Systems (PS) is often used to refer to systems with multiple components that need to cooperate to achieve a common goal, trying to make efficient use of available resources. In general case, PS consists of many interacting sub-systems performing various planning and control functions. Container port terminal design of a PS presents a special challenge for the designers, because it involves more complex systems with various levels of interactions between its components and with mutual influences which could be deterministic or defined by stochastic values (Theo, Athanasios and Jean-Paul, 2022). The complexity of Port Systems of a container port terminal requires particular methodology or model choice for effective operations. Analytical models which are frequently used (models of queuing theory) for analysis of global solutions could estimate the of a port system. However, even with the simplification and decomposition of system, it is not always possible to adequately set the corresponding analytical model. Many operations research models have been used for the purpose of modeling various operations situations in port industries around the globe. Queuing models (QMs) play an important role in modeling and analysis of port systems, especially, in the era of technological advancement in container port terminal operations and industrial globalization of the shipping industry.

3.2 Port Operations Mechanism and Container Throughput Trade

In the recent time maritime trade has developed so rapidly with drastically effects on the world economic system. Many organizations in the maritime industry – the ship building construction, ship owners, freight forwarders, conference liners, and port operators have moved from traditional approach to modernized system of global technological advancement for economies of scale in ship and port terminal operations. The wind of civilization and recent economic downturn in the world economic system has brought about a conscious management of resource in the maritime sector. Time and cost have become a vital consideration in all maritime operations for all industries or sectors concerned in the shipping business. All actors in the industry seek how and the best mix of resources to minimize cost and maximize profit. However, this has been the order of the day in the history of maritime industry; the stakeholders had always sought through diverse approaches over the years to minimize delays and operating costs in ports since it contributes so much to non-value-added costs in shipping trade. Looking at the container ports globally, it is obvious that many ports around the world have developed programs in forms of policies and advance technology in container port operations which aims at high productivity, and efficiency. In summary, this is targeted at resources optimization to reduce cost especially from non-value-added activities and delays at ports to maximize profit through effective utilization of resources. The effectiveness of resources utilization is the function of the administrative system to manage resources to avoid delays and congestions at ports.

In Africa and among other ports of the world, privatization of container port terminals has been a means of container terminal development, to pull resources from the private sectors to invest in port terminal infrastructure. Ports are seeking patronage of shipping lines as well as shipping lines making choice of ports that are effective in operations without delays which would attract extra cost to their budgets, hence, ports operators need adopt good managerial approaches and technologies in container port terminal operations which will yield better efficiency, productivity and that port users can have a comparative advantage. Ports industries like other modern business enterprises see efficiency in port operations as a cost control measure. According to Wayne (2016), port operational efficiency signifies cost effectiveness. However, the following are areas of port operations that need to be managed effectively in port industry.

3.3 Port Operations Mechanism and Ship Traffic Trade

In the recent time maritime trade has developed so rapidly with drastically effects on the world economic system. Many organizations in the maritime industry – the ship building construction, ship owners, freight forwarders, conference liners, and port operators have moved from traditional approach to modernized system of global technological advancement for economies of scale in ship and port operations. The wind of civilization and recent economic downturn in the world economic system has brought about a conscious management of resource in the maritime sector. All actors in the industry seek how and the best mix of resources to minimize cost and maximize profit. However, this has been the order of the day in the history of maritime industry; the stakeholders had always sought to minimize operating costs through diverse approaches over time. Chuku, et al., (2023), states that the criticality of shipping operations in global trade requires a comprehensive understanding of its sustainability. This depends on the integrity/performance of the ship structure and vital systems, such as the ship propulsion engine. The current research paper presents the application of an adaptive machine learning formalism, the Bayesian network, for failure assessment of a ship propulsion engine considering nonlinear and nonsequential failure interactions. The model captures critical failure influencing factors and their complex interactions to predict the failure probability of the ship energy system. Sensitivity and uncertainty analysis was carried out to establish the degree of influence of vital failure influencing factors as they affect the ship propulsion engine's reliability and the associated uncertainty in the prior data processing. The model is tested on the propulsion engine of an ocean going vessel to forecast the likelihood of failure based on the logical dependencies among failure causative factors. Two scenarios were analyzed based on canonical probabilistic algorithms, and the results show that upon evidence on the three critical failure modes, the ship propulsion engine

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failure likelihood increased by 11.8%, 8.2%, and 9.4%, respectively. The model shows an adaptive/dynamic capability to capture new failure information and update the system's failure probability. The proposed approach provides a condition monitoring tool and early warning guide for integrity management of critical ship energy systems.

Talking about the port, it is obvious that many ports around the world have developed programs in forms of policies and advance technology in port operations which aims at high productivity, , and efficiency. In summary, this is targeted at cost optimization to maximize profit through effective utilization of resources. In Africa and among other ports of the world, privatizations of port industry have been a means of port development, to pull resources from the private sectors to invest in port infrastructural development. Ports are seeking patronage of shipping lines as well as shipping lines making choice of ports that offer effective cost advantage among other factors. Hence, ports operators invest rapidly at optimal cost which will yield better efficiency, productivity and that port users can have a comparative cost advantage.

Ports industries like other modern business enterprises see efficiency operations as a cost control measure. According to Adizes *et al*., (2019) port operational efficiency signifies cost effectiveness. However, the following are areas of port operations that need to be managed effectively in port industry. The arrival of container ships in a port is often irregular, and when it arrives, it may not be able to move directly onto a berth or has to wait until a berth becomes empty, if all berths are occupied. The berth time needed to serve a ship is also a variable, as it depends on the amount of cargo which the ship carries and the capacity of the present facilities for handling and storing cargo (Gokkup, 2015; Zdenka and Edna, 2015). The investigation of such random occurrences requires a complex and detailed analysis. The concept of "Queuing theory-waiting line problem" can successfully be applied in a port system operation. Queuing Theory is one of the most useful tools for analyzing the behavior of waiting units (ships in this case), for investigating the components of a multiple operations system behavior (Branislav and Nam, 2016). Thus, queuing theory may be adequate for studying container ship movement in a sea port. Two basic elements are necessary for the application of queuing theory to a waiting line problem: an arrival function and a service function. These functions should first be modeled. Once the validity of these models is tested, the different characteristics of the theoretical models, which describe the actual system with the accuracy that may be realized in estimating future traffic, can then be determined (Branislav and Nam, 2016).

Furthermore, the total waiting costs in a port terminal operation can be observed separately, i.e., costs from the ship owner's viewpoint and from the container terminal operator's viewpoint. A clash of interest exists between these two stakeholders - the ship owner and the container terminal operator. It is in the ship owner's interest to have the ship wait as short a period as possible and in the port container terminal operator's interest to handle as much traffic as possible in an observed time unit with the least number of berth facilities, hence, optimization in operations for the two interests is a major consideration in port operations. Nevertheless, the servicing process at the container terminal should be resolved taking into consideration total waiting costs as the interests of both, ship owner and port terminal operator, are mutually interwoven. The port container terminal is not indifferent to the long waiting time of the ships even though it has high berth utilization, as this waiting is expensive and can divert the ships to other ports; in the event of a short waiting time, the supposition is that the container berths are poorly employed and this may result in an increase of port service costs, which, in turn, is not in the ship owner's interest (Branislav, 2016). If costs are taken as optimization criteria, then the servicing process solution at the container terminal will represent the optimum number of berths for which total expenses of ship waiting time and expenses of berth occupancy are minimum in an observed unit of time (Branislav, 2016).

Onwuegbuchunam (2018) applied key indicator metrics and parameters of queuing model in assessing of Nigeria's concessioned port terminals. Data for the study were obtained from terminal level records of cargo and ship handling activities for years 2000 to 2015. Major findings indicate that cargo and vessel throughputs improved after the reforms in the six ports examined. However, much variability was observed in trends in ships' turnaround times across all ports after the concession policy implementation. Additional results from the queuing model analysis suggest that the high ships turnaround times observed in some ports are associated to delays in ship operation at the berths. The study recommends that policy interventions be focused on ship operations at the berths as a step-in improving service level in the port terminals.

El-Naggar (2020) studied the application of queuing theory to the container terminal at Alexandria seaport. He designed a methodology to support decision-making process for a developing seaport infrastructure to meet future demand. In order to determine an optimum number of berths at a seaport, the queuing theory was applied in the light of port facilities and activities. The aim was to avoid in advertent over and under-building. The study analyzed the movements in port, the waiting time of vessels outside the port and in queue was calculated in accordance with the considered queuing model. The theoretical functions representing the actual vessel arrival and service time distributions were determined. For the economic considerations, cost estimate studies including cost of port and waiting vessels were estimated and finally, the optimum number of berths that minimizes the total port costs was calculated, hence, the proposed mathematical and economical models were applied to Alexandria port in Egypt.

3.4 Port Operations Mechanism and Vessel GRT Trade

For a container port terminal effectiveness, ports operators should employ the right mix of resources (human and material resources) to ensure that calling vessels are handled promptly at the right time without delays. Vessel handling operations involve pilotage navigation and maneuvering within the port, tug services, berthing, and unberthing of vessels, and anchorage management. Cargo handling operations requires good number of cranes, forklift, skilled manpower, stevedores, space for container stacking, and standard trucks to load-on containers in and out the ports. According to Haralambites and Veenstra (2020), conventional general cargo ship operations involve a very labour intensive process. This has been the genesis of most problems in ports. Consequently, ships have to spend most productive time in ports during loading and unloading operations. A potential user of a port or a liner conference would consider such a port as very expensive and ineffective. But improved cargo handling rate will positively affect turnaround time of ship in ports as well as improve port viability. This of a truth, increase in cargo handling will leads to reduced shore and berth costs and henceforth leads to reduction in freight rates and overall maritime transport costs.

According to Nze and Onyemaechi (2018), Port Congestion is a scenario associated with delays, queuing and extra time of voyage and dwell time of ships and cargo at the ports, which always have unpleasant consequences on Logistics and supply chain. These issues often escalate into extra costs, loss of trade and disruption of trade and transport agreements (Nze and Onyemaechi, 2018). This is the most critical and a chronic problem that many ports around the world face and this contribute to raises the cost of shipping to countries whose ports experience delays. Port delays are as results of many factors ranging from administrative ineffectiveness to inadequate berth spaces, cranes, manpower, and problem of bureaucracy, custom clearance and many other technical challenges. Ports associated with these challenges suffer delays in ship and cargo clearance and would operate at a very high costs and users incurring excess demurrage. Shippers and ship owners must choose ports where their cargoes and ships must be handled rapidly, efficiently and economically (Iaguo, Xinrui & Jihong 2023). Such quality service is not available in congested ports. There must be an improvement in labour and capital productivity with good managerial policy to tackle the problems of port delays. In other words, increase in cargo handling rates at the port will help remove congestion in the ports.

Asabe, (2021) studied on economic analysis of the European seaport system and port congestions using the hub-feeder container system and short sea shipping networks of the Mediterranean, it was found that there was increase from twelve percent to fourteen percent on the rate of port congestions (Asabe, 2021). This corroborating with the findings of the institute of transport and maritime management, on the effects of port congestion on market value, especially in the U.K ports and Baltic ports, realizing nearly a market share that is less than 10% each, less than 3% from Black seaport, and less than 30% from Mediterranean seaport (Asabe, 2021). This report traced the primary cause of port congestion to structural issues like infrastructural and connection obstruction to the borderland through road, rail and inland waterways, and scattered terminus for deep-sea vessels and feeders or barges (Asabe, 2021). This depend highly on the types of goods at the port, superstructures available and administrative system of the port. From the statistics documented on North Western port the congestions affected mostly 8% (40 million TEU) of containers, 7% (269 million tons) of dry bulk, 5% (391 million tons) of liquid bulk, 0% (62million tons) of conventional general cargo, and 8% (82 million tons) of RoRo (Asabe, 2021).

3.5 Average Vessel Turnaround Time and Container Vessel Trade Effectiveness

Average vessel turnaround time and container vessel trade effectiveness are key indicators of port efficiency and competitiveness. A shorter turnaround time, meaning the time a vessel spends in port, generally indicates better port and can lead to increased trade volume and profitability (Tiago. et al., 2024). Conversely, longer turnaround times can hinder trade and reduce port efficiency. In ocean shipping, Vessel Turnaround Time- the time frame of arrival and departure of the vessel at a port- turns out to be the most influential factor in operations and counting efficiency of the same. There have been numerous studies that propose several indicators as a measure of Port efficiency; UNCTAD in 1976 rolled out a list of finance and operational indicators, turnaround time being one of the vital factors (Nze, et al., 2020).

According to the of Osondu-Okoro, et al., (2022), which investigated the correlation between ship turnaround time and vessel traffic in four Nigerian ports of Onne, Rivers, Delta and Calabar with a view to providing empirical justification for or against the assertion that long ship turnaround time in Nigeria ports is associated with the declining trend of vessel calls at the ports. Secondary data on the ship turnaround time (STRTt) and ship traffic (STt) of the ports were obtained from Nigeria ports Authority (NPA). The data obtained for each of the variables covered a period of 10 years between 2010 and 2019. The statistical tools of correlation analysis and trend analysis were used to analyze the data obtained. It was found that the effects of the of ship turnaround time on vessel calls to ports are port specific, suggesting that factors other than ship turnaround time, such proximity to shippers' location, port charges and ship dues, cargo safety, absence of bottlenecks in the customs and clearing process, etc., may interact to influence the choice of ports. The study also found that there is a weak association/relationship between ship turnaround time in ports and ship traffic/ship calls at ports. The result also indicates that the Nigerian ports are far from achieving the global average benchmark ship turnaround time. The Average ship turnaround time in Onne port is about 49% while Delta port is about 92% higher than the global average benchmark of 2days in port. Calabar and Rivers ports have respective 150% and 241% higher ship turnaround times than the global average benchmark. It was recommended that port authorities and terminal operators should work to reduce the high ship turnaround time in Nigerian ports to meet with global average benchmark among other things (Osondu-Okoro, et al., 2022).

Drewry Carrier reports 2013 provide us with punctuality data scores that have enlisted Maersk, Evergreen, and Yang Ming as the top formers (UNCTAD, 2019). These data closely accord with them yielding the best percentage positive results among Ocean container carriers cited in 'Ship Turnaround Times in Port: Comparative Analysis of Ocean Container Carriers'. Evergreen emerged as the leader with only one of the 12 ports of call whose times below the port average (UNCTAD, 2019). Yang Ming claimed second place with 10 of its 12 port calls, and Maersk in third place with 14 out of 17 port calls being shorter than the port averages (UNCTAD, 2019).

3.5 Average Container Handling Rate and Container Vessel Trade Effectiveness

The work of Ronan and Arnaud, (2023) x-rayed the average container handling rate, which reflects the efficiency of loading and unloading containers at a port, as a key indicator of container vessel trade effectiveness. The study expressed average container handling rate as the number of containers handled per hour or per ship call which the rate is influenced by various factors, including port infrastructure, operational efficiency, and the size and type of container vessels (Ronan & Arnaud, 2023).

3.6 Research Gap

This study is basically is an analysis of the effects of port operational delays on container vessel trade in TinCan Island Port. It estimated the Average Vessel Turnaround Time, Average Vessel Waiting time, Average Berth Occupancy Rate, Container Trade Traffic (TEU), Ship Traffic Trade and Vessel GRT Trade of TinCan Island Port. The review of literatures on this study has identified gap in this area of research as there has not been any known work done in this area of study as long as TinCan Island Port is concerned. Many studies have been carried out which were premised on seaport congestions such works include Emeghara and Ndikom (2012) which focused on delay factors evaluation of Nigerian seaports, a case study of Apapa Ports Complex, Lagos, using ranking and multi-regression analysis. Nze and Onyemaechi (2018) studied on port congestion determinants and impact on logistics and supply chain on five African ports. The study applied the concept of ranking by inspection using the dwell time of ships in five African ports to evaluate the variations in ship turnaround time and relative efficiency level of the selected African ports. The approach was used to identify the active factors that cause port congestion in African ports. Yusuf, Shekwobagwu, bdulmalik and Damana (2022) studied on assessment of factors causing congestion and nature of cargo clearance in Apapa Port, Lagos using descriptive statistical method. The work of Oyatoye, Adebiyi, and Okoye, (2011) was an application of queue theory to port congestion problem in Nigeria. Queue model was applied to the arrival and services pattern which causes the problems of congestion in Tin Can Island port, while Asabe (2021) studied on assessment of factors causing port congestion in Nigeria; a case of Lagos-Apapa Port using analytical hierarchy process (AHP). Aruwei *et al.,* (2022) researched on impact of port congestion on Nigeria economic growth. The study investigated the impact of port congestion on economic growth in Nigeria using the Autoregressive Distributed Lag (ARDL) approach to co-integration and error correction modelling to analyze time series data from 1995 to 2019 in Nigeria Lagos-Apapa Port. Alamutu, (2018) studied the application of Queue Model to ease traveler's flow in Nigerian International Airports. The study examined the application of queuing model to ease travelers' flow in the Nigerian international airports. Muhammadu (2018), studied the application of queue theory in tackling the problem of port congestion at Apapa port, Lagos. The study demonstrates the applicability of queue theory models in addressing the problem of congestion in Nigerian Ports, by dealing with the application of multi-queue and multi-server queue models with infinite capacity, First-come First-served model in tackling the congestion problem at the Apapa port, Lagos. Nwachukwu, Akpudo, Enyinda and Stephens, (2023) used Queue Modeling Simulation to determine vessel traffic and optimal service rate for Nigerian ports.

Therefore, a significant gap exists on the real time quantification of effect of port operational delay on container vessel trade of TinCan Island Port. These delays to be quantified would be translated to model estimation of the effects on Container Trade Traffic (TEU), Ship Traffic Trade and Vessel GRT Trade of TinCan Island Port, which would eventually become a new contribution to the existing body of knowledge in Nigeria seaports port operations.

IV. SUMMARY

This empirical review examines the mechanisms governing port operations and their implications for container ship trade effectiveness at Tin Can Island Port, Nigeria. The study situates port performance within the broader context of global maritime trade, where seaborne transport accounts for approximately 80–90% of international merchandise movement. In this competitive environment, operational efficiency, cost control, and turnaround time remain critical determinants of port attractiveness and trade sustainability.

The theoretical foundation of the study integrates four major frameworks. Bureaucratic Management Theory explains how administrative structures, formal rules, and decision-making hierarchies influence operational efficiency and delay patterns. Traffic Congestion Theory provides insight into how increasing vessel density and limited infrastructure capacity escalate time costs and congestion. Resource-Based Theory emphasizes the strategic role of human capital, equipment, and technological capability in achieving competitive advantage. Frischmann's infrastructure perspective underscores the importance of accessible and adequately managed infrastructure in maximizing social and economic value. The review conceptualizes port efficiency across three interdependent dimensions: maritime operations (anchorage time, berthing allocation, pilotage, towage), terminal operations (crane productivity, yard management, cargo handling), and hinterland connectivity (gate processing, truck turnaround time, road and rail access). Inefficiencies in any of these dimensions generate systemic delays that increase vessel dwell time and logistics costs. Although Nigeria adopted the landlord port model in 2006, transferring cargo handling operations to private concessionaires while the Nigerian Ports Authority retains regulatory and marine responsibilities, persistent delays remain a defining feature of port operations. Empirical evidence from literature indicates prolonged vessel waiting time, berth congestion, cargo stacking inefficiencies, gate traffic bottlenecks, and inadequate technological integration. Administrative inconsistencies, manpower shortages, obsolete equipment, weak stakeholder coordination, and policy instability further exacerbate operational inefficiencies.

The economic implications of delay are substantial. Direct costs include increased berth charges, labour costs, and equipment utilization expenses, while indirect costs encompass loss of goodwill, reduced customer confidence, cargo diversion to competing West African ports, and declining regional competitiveness. Given the strategic aspiration of Nigerian ports to function as regional hubs, these inefficiencies undermine trade effectiveness and revenue potential.

The study concludes that improving container ship trade effectiveness at Tin Can Island Port requires systemic reform focused on governance optimization, infrastructure modernization, digitalization of port processes, enhanced manpower capacity, congestion management strategies, and performance-driven monitoring frameworks. Strengthening coordination among the Nigerian Ports Authority, concessionaires, customs services, and other regulatory agencies is critical to eliminating operational redundancies and minimizing delays. Achieving sustained efficiency gains will position the port competitively within the West African maritime corridor and enhance its contribution to national economic development.

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