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Assessment of Container Terminal Operations in South-Western Ports in Nigeria

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ABSTRACT*:* *Containers, a global maritime trade influencer, have increased the importance of ports. Ports serve as an economic catalyst for revenue and employment. The importance of container transport cannot be overemphasized in international trade especially in Nigeria. Hence, it becomes expedients to assess the elements of container terminal capacity, analyse the trend of cargo throughput and as well determine the relationship between handling equipment and cargo dwell time in Western ports in Nigeria. The study adopts multistage sampling. Also, both primary and secondary data were collected from the staff of the container terminal operators in Tincan Island Port Complex and Apapa Port Complex and 347 respondents were chosen using Yamene formular. Furthermore, Descriptive statistics such as frequency table, line graph, bar charts were used to examine the elements of container terminal capacity, analyse the trend of cargo throughput. The inferential statistics such as regression analysis was used examines the relationship between thandling equipment and cargo dwell time. The result showed a decline in cargo throughput from 2019 to 2020, a trend that can be directly attributed to the COVID-19 pandemic. Also, it was shown that the coefficient of handling equipment is 0.725, indicating that for every unit increase in the handling equipment score, the cargo dwell time increases by 0.725 units. The t-value of 21.558 and a significance level of 0.000 signify that the handling equipment is a significant predictor of cargo dwell time. Based on the findings of the study, it was concluded that terminal space, handling equipment, daily stock and port labour were significant factors or elements of container terminal capacity. It was recommended that Nigerian Ports Authority should invest more on sustainable infrastructure and terminal operators and stevedoring company should train and retrain their staff on modern handling equipment.*
KEYWORDS*:* Container, shipping, terminal operators, Nigerian Ports Authority (NPA), Cargo throughput, container terminal

INTRODUCTION

Shipping plays a significant role in international trade as it involves the movement of cargo across nations accessible by sea. Ships convey an enormous volume of cargo via port, which is just multiple times more than rail and multiple times higher than air transportation altogether (Stopford, 2008). Traditionally, ports have become a critical economic asset and a major driver of globalization (United Nations Conference on Trade and Development) UNCTAD, (2015) it is because almost 80% of all global trade is made possible by ocean transportation. Shan et al. (2014). Ports, as the interface between sea and land transportation, have long been the heart of the transportation system and an economic determinant of any state that owns them. Globalization and the fact that more countries have joined the World Trade Organization (WTO) have led to more sea trade.

Containers, a global maritime trade influencer, have increased the importance of ports. Ports serve as an economic catalyst for revenue and employment. A World Bank study shows that the ratio of direct revenue from port operations to indirect revenue from port-related activities is 1:5, and the ratio of direct port employment to indirect employment is about 1:9 Wang, (2005). Taking Tianjin Port as an example, one 40TEU (twenty-foot equivalent units) container brings direct revenue of 800-1,200 Renminbi (RMB) to the port owners as a lump sum of port charges. The same container brings an indirect revenue of 4,800 -7,200 RMB to the port resulting from tugs, pilotage, ports and port ancillary services such as container repair, stockpiling, shipping agents, logistics, financial settlement, trailers and transportation. Every 10,000 tons of port throughput will contribute 1.2 million RMB to Gross Domestic Product (GDP) and create 26 jobs Wang, (2005). Containers have been described by Urry et al. (2016) as a mobility system that produces complex and paradoxical effects in the transport system. It is the object of the most advanced form of unitization, called containerization. In economic geography, containerization has been seen as a facilitator of international trade Coe et al. (2008).

Containerization brings openings and limitations to the oceanic business, generally pertinent to container terminals. Bandeira et al. (2009). The containers are big, standard boxes. Malcolm McLean, an American business visionary, came up with them in 1956. Cudahy, (2006). They are the best way for goods to move around in the history of sea trade. Container terminals should be fabricated and utilized alongside billets and cranes that are sufficiently incredible to deal with container ships. Also, container terminals are needed to put resources into ride transporters, farm haulers, and trailers to move containers from berthing offices to the yard and yard to the door and the other way around. Arrange adequate storage spaces to facilitate impermanent container stockpiling to work with import, fare, and transshipment techniques. These are only a few instances of the base required offices with the legitimate ability to move containers starting with one port and then onto the next.

The objective of containerization is to achieve optimum advantages of through-movement of freights. As described by Levinson, (2006) container is at the core of a highly automated system for moving goods from anywhere, to anywhere, with minimum of cost and complication on the way. Apart from cost minimization, the introduction of containerization has lowered time expended in transferring freight from manufacturer to consumer, as well as time spent in storage yard. The importance of container transport cannot be overemphasized in international trade especially in Nigeria. Hence, it becomes expedients to assess the elements of container terminal capacity, analyse the trend of cargo throughput and as well determine the relationship between handling equipment and cargo dwell time in Western ports in Nigeria.

LITERATURE REVIEW

Container Terminals

Decision problems at container terminals are comprehensively described by Vis and de Koster, (2003) with some 55 references up to 2001). An overview of relevant literature for problem classes like arrival of the ship, offloading of a ship, from stack, stacking of containers, inter-terminal transport and complete terminals is provided. These terminals can be obtained by using, among other things, information technology and automated control technology. For example, Wan et al. (1992), it is shown that the application of information technology in the port of Singapore results in more efficiency and a higher performance.

Containers

Containers are large boxes that are used to transport goods from one destination to another. Compared to conventional bulk, the use of containers has several advantages, namely less product packaging, less damaging and higher productivity Agerschou et al. (1983). The dimensions of containers have been standardised. The term twenty-feet-equivalent-unit (TEU) is used to refer to one container with a length of twenty feet. A container of 40 feet is expressed by 2 (TEU) twenty-feet-equivalent-units. These specifications are based on recommendations by the International Standardization Organization. The containers have specially built corner fittings which enable the material handling equipment to pick them up from the top or from the side.

Container Terminal Facility

A variety of material handling facility is used in container port operation. Following is a brief description of the material handling equipment being used at Port.

a. **Gantry crane or transtainer**: This equipment has a 50-ton capacity and rubber wheels. Due to its heavy weight, it runs on a special concrete path. Wheels will turn 90 degrees to change direction during section changes. Normally, a transtainer is scheduled not to move between sections except when absolutely necessary. The beam spans over several stacks and the spreader bar moves down to reach a specific container. It can stack containers four high. It cannot reach the bottom container until the upper containers have been removed. McDowell E., Cho, D., & Martin, G. (1985)

b. **Ship crane.** The ship crane is electric-powered and has a 50-ton capacity. It can run on rails along the length of the dock. Ship cranes should be kept at least 50 ft apart when more than one crane is working at the same time in order to prevent crane interference.

c. **Trucks and chassis.** These are used to carry containers from the transtainer to the ship crane. They are specially designed for container port operations. Chassis may be adjusted to handle either two 20-fi or one 40-ft container. The trucks have special connections for chassis; they raise the chassis and travel with them without having to adjust the landing wheels. In general, three to four trucks are assigned to one transtainer-crane.

Container yard

The container yard, located next to the dock, stores the outbound containers while waiting for a ship and the inbound containers until they are picked up by road trucks. Containers are stored in the yard in a block formation, called the section. In the yard, the cargo is arranged by ship and voyage number. Furthermore, cargo is segregated by weight and commodities, if possible. If there are a large number of containers for the same voyage, an attempt is made not to place cargo for the same voyage in one spot. This is to ensure that two or more transtainers can work on these containers at the same time without interference. Boysen et al. (2017).

Concept of Container Terminal Operations

Container terminals are described as open systems of cargo flow with two external interfaces: the quayside, with the loading and unloading of containerships, and the landside, where containers are loaded and unloaded on/off external trucks and trains. Containers are stored in stacks, thus facilitating the decoupling of quayside and landside operations, because the moment of loading and unloading a vessel does not always correspond to the moment of loading onto the hinterland mode.

From an operational perspective, the port terminal itself can also be considered to be a chain consisting of consecutive links (e.g. ship unloading, storage transport, storage, loading transport and hinterland loading) (Zondag et al., 2010) or, as commented in the introduction, as a group of independent processes or subsystems (ship to shore, transfer, storage, and delivery/reception), as depicted in Figure 1.

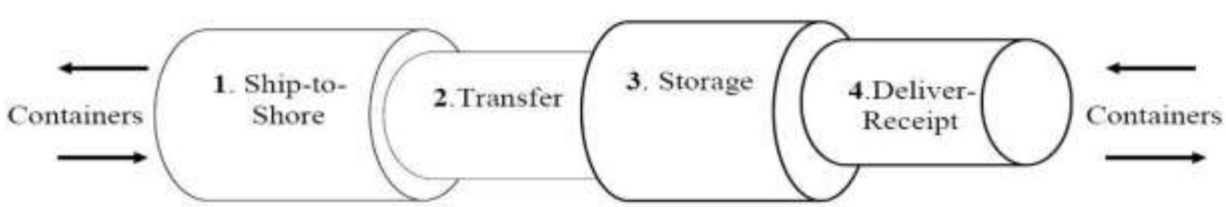

Figure 1: main subsystems in a container terminal
Source: Henesey, (2006).

Although port container terminals greatly differ by the type of handling equipment employed and geometric size and layout, processes and terminal operations have several aspects in common among container terminals, which are briefly described as follows:

Henesey (2004) was of the opinion that container terminal system has four main subsystems. The four subsystems are distinguished when functioning together so that the effectiveness of one subsystem affects the performance of the next subsystem. The four main subsystems: ship-to-shore, transfer, storage/stack and delivery/receipt can be expressed in figure 2.5. Ship to Shore System.

When a ship arrives, it will need to be assigned a berth along the quay. Berth allocation has a specific objective and this has to do with assigning vessel to an optimum position, while minimizing costs, such as berth resources (Frankel 1987). Fruitless and expensive container moves are obstacles that many terminal operators are experiencing. However, the number of handling equipment used to perform the operation varies depending on the size of the containership and the volume of containers to be handled (Henesey 2004).

Transfer System: Once a container is lifted from a containership, a transport vehicle may be waiting below to move the container to location within the yard. Alternatively, depending on the operation at the terminal, containers may be kept below or near the handling equipment as a temporary storage (string-piece) till a transport vehicle is able to pick up the container and move it to t65he yard. The choice of transport vehicles such as yard trucks, AGVs (Automated Guided Vehicles) or straddle carriers have varying advantages and disadvantages depending on the fusion of the Container Terminal operations. (Miller 2002).

Storage System: Managers consider storage system of a container terminal as what “steers” the overall Container Terminal performance (Miller 2002). However, factors such as the handling equipment and the stacking density of the containers a can influence the capacity of the yard immensely. The storage operations also rely on other operations in order to maintain good container handling performance. Storage systems can be categorised into three types; short term, long term, and specialized (Frankel, 1987). The transshipment of containers onto another containership are said to be short-term storage system, Long-term storage is for containers awaiting customs release or inspection. Specialized storage systems are meant for the following containers: refrigerated (called reefers), empty, liquid bulk, hazardous materials, or are out of gauge. Furthermore, stacking algorithms are software used in container storage system with specific purpose in assigning a space for the container till it is loaded or dispatched.

Delivery and Receipt System: The gate operations of a Container Terminal serve as the land interface to other modes of transport either rail or trucks. The gate consists of mainly two processes that link it with the yard operations. The first process is when arriving containers are checked and inspected. Each container has its information, which identifies its contents, owner, and directs its movements, known as a bill-of-lading. Once cleared, the import container is assigned to parking area where a transport vehicle may lift the container and place it in a stack. (Frankel, 1987).

The second process is when a container is leaving the Container Terminal. The road or rail carrier that is taking the container out of the Container Terminal must clear documentation and security procedures. An export container is then removed from a stack and carried by a transport vehicle to the either the parking area for trucks or to the rail interface to be place on a rail wagon. (Frankel, 1987).

METHODOLOGY

Multistage sampling was used for the purpose of this study. Both primary and secondary data were collected from the staff of the container terminal operators in Tincan Island Port Complex and Apapa Port Complex. Firstly, stratified sampling will first be used to stratify the terminal operators based on their location. These are Lagos Port Complex and Tincan Island Port Complex. Secondly, purposive sampling was used to select a stratum. Eight (8) existing terminal operators within the Western Ports were purposively selected for questionnaire administration. Lastly, Random sampling was used in which each stratum has equal chance of being selected. Random sampling was used to select 347 respondents using Yamene formular. Descriptive statistics such as frequency table, line graph, bar charts were used to examine the elements of container terminal capacity, analyse the trend of cargo throughput. The inferential statistics such as regression analysis was used examines the relationship between handling equipment and cargo dwell time.

RESULT

The comprehensive examination of the container terminal capacity at Western ports in Lagos, Nigeria, is a crucial aspect of port performance and management. As indicated in Table 1, it covers key dimensions like terminal space, handling equipment, daily stock, and port labor. The terminal space aspect scored a mean value of 3.9683, indicating that on the Likert scale of 1 (strongly disagree) to 5 (strongly agree), respondents gravitated more towards agreement or strong agreement with the adequacy of the terminal space. This finding aligns with a report by the United Nations Conference on Trade and Development (UNCTAD) that highlighted the improvement of terminal spaces in several African ports, including Nigeria, as part of a broad program to enhance port efficiency (UNCTAD, 2019). However, a standard deviation of 1.16878 also reveals considerable variance in the responses, suggesting that some respondents had different experiences or opinions on terminal space adequacy.

The availability and functionality of handling equipment, with an average score of 3.9135, indicates that most respondents either agree or strongly agree that the equipment is satisfactory. This observation corresponds to Oyewole, (2019) which underscored the increasing investment in

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modern handling equipment across Nigerian ports as a strategy for boosting operational performance. However, a standard deviation of 1.09043 suggests a measure of diversity in responses.

The daily stock aspect received an average score of 3.6744, showing a more neutral position among respondents concerning the efficiency of daily stock handling. This neutrality implies some level of uncertainty about the adequacy of daily stock management. NPA (2018) noted challenges with logistics and customs procedures, which could potentially affect perceptions of daily stock handling. With the standard deviation being the highest at 1.30606, there appears to be a substantial disparity in opinions.

Concerning port labour, the mean score of 3.8098 suggests that the respondents were generally undecided, albeit leaning towards agreement, about the competence and effectiveness of the port labour force. This is in line with a study by Ezejiofor & Olisa, (2016), which found mixed opinions about labour productivity in Nigerian ports. A standard deviation of 1.27157 again indicates a substantial divergence in responses, reflecting differing perceptions and experiences.

Table 1: Container terminal capacity in Western ports, Lagos, Nigeria

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Terminal space	347	1.00	5.00	3.9683	.06274	1.16878
Handling equipment	347	1.00	5.00	3.9135	.05854	1.09043
Daily stock	347	1.00	5.00	3.6744	.07011	1.30606
Port labour	347	1.00	5.00	3.8098	.06826	1.27157
Valid N (listwise)	347					

Source: Author's field survey, (2022)

Trend of Cargo Throughput in Western ports

The cargo throughput trend analysis at the Lagos Port Complex and Tincan Island Port Complex offers a compelling overview of operational performance and economic indicators over a 13-year period (2007-2020) as shown in Figure 2. Cargo throughput, defined as the total volume of cargo loaded or unloaded at a port, serves as an essential barometer of port activity and often reflects broader economic and trade trends.

However, from 2007 to 2011, an upward trend in cargo throughput was observed. This positive trajectory suggests a period of strong economic activity, increased import and export volumes, and potentially positive policy and infrastructural developments at the ports during this time. As the largest and busiest port complex in Nigeria, Lagos plays a pivotal role in the country's trade and economic dynamics. This growth phase aligns with Nigeria's overall economic expansion during this period, with a particular boom in oil prices contributing significantly to the country's revenue. (Gabor 2010).

Meanwhile, a downward trend in cargo throughput was registered from 2019 to 2020. This negative trend, as explicitly stated in the report, was a direct consequence of the COVID-19 pandemic. The outbreak of COVID-19 in late 2019 resulted in unprecedented global economic disruptions, impacting supply chains, trade, and port operations worldwide. According to a report by the United Nations Conference on Trade and Development (UNCTAD), global maritime trade fell by 4.1% in 2020, marking the largest decline since the 2009 financial crisis (UNCTAD, 2021). The decrease in cargo throughput at the Lagos and Tincan Island Port Complexes is a manifestation of these global trends on a local scale. The pandemic has also highlighted the vulnerability of ports to global disruptions, urging the need for greater resilience in port operations and supply chains.

Given the port's critical role in Nigeria's economy, this trend analysis offers invaluable insights into the country's economic performance and prospects. It is also a reminder of the interconnectedness of global trade and the impacts of global events on local environments.

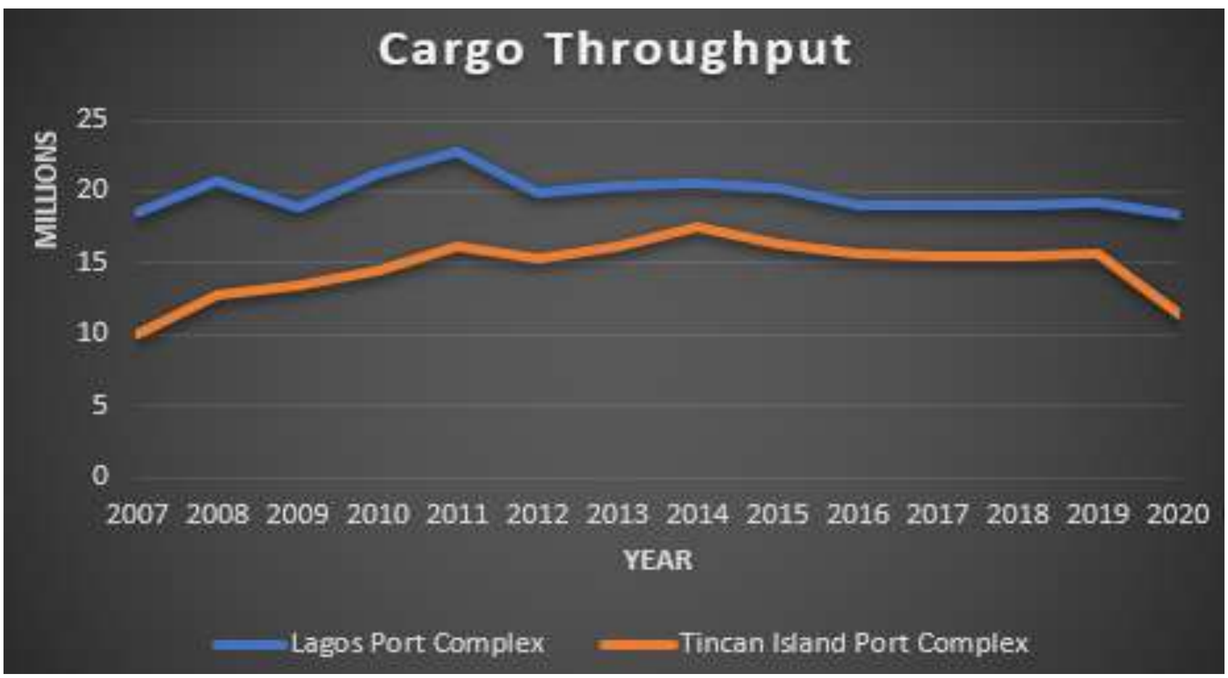

Figure 2: Cargo throughput
Source: NPA, 2020

The Relationship between Handling Equipment and Cargo Dwell Time

The regression analysis on Table 2 to 4 evaluates the relationship between the handling equipment (independent variable) and the cargo dwell time (dependent variable) in the port. In this context, cargo dwell time refers to the length of time cargo spends within the port from the moment of unloading to the time it exits the port's gate.

Table 2, the coefficients table provides the values of the regression equation. The constant (or the y-intercept) is 0.646. The coefficient for the handling equipment is 0.725, indicating that for every unit increase in the handling equipment score, the cargo dwell time increases by 0.725 units. The t-value of 21.558 and a significance level of 0.000 signify that the handling equipment is a significant predictor of cargo dwell time.

Table 2: Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	.646	.108		6.004	.000
	equipment	.725	.034	.758	21.558	.000

a. Dependent Variable: loading

Table 3, the R square value, often called the coefficient of determination, is 0.574. This value explains the proportion of the variance in the dependent variable (cargo dwell time) that can be predicted from the independent variable (handling equipment). Here, 57.4% of the variability in cargo dwell time is explained by the handling equipment. The Adjusted R square value of 0.573 is a more accurate measure as it adjusts for the number of predictors relative to the number of data points.

Table 3: Model Summary

	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.758[a]	.574	.573	.68888

a. Predictors: (Constant), equipment

Table 4, the ANOVA (Analysis of Variance) table provides information about the overall significance of the model. The F-value is 464.753 with a significance level of 0.000, indicating that the regression model predicts the dependent variable significantly well. In other words, the model is statistically significant, and the handling equipment does have a significant effect on cargo dwell time.

Table 4: ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	220.553	1	220.553	464.753	.000[b]
	Residual	163.723	345	.475		
	Total	384.277	346			

a. Dependent Variable: Cargo dwell time
b. Predictors: (Constant), equipment

DISCUSSION OF FINDINGS

The first objective of the study was examined, the findings present a multifaceted view of container terminal capacity at Western ports in Lagos, Nigeria. The evaluation, which involved four essential elements: terminal space, handling equipment, daily stock, and port labor, provided valuable insights into the perceptions of respondents towards these aspects. Starting with terminal space, respondents indicated a positive view with an average rating of 3.9683 on a 5-point Likert scale, suggesting an overall agreement with its adequacy. However, a relatively high standard deviation of 1.16878 pointed to considerable diversity in opinions. These findings echo a UNCTAD, (2019) report that emphasized the expansion of terminal spaces in numerous African ports, including Nigeria, to augment port efficiency. The state of handling equipment was also favorably perceived, as shown by a mean score of 3.9135.

This perspective aligns with Oyewole, (2016) study, which recognized increased investment in state-of-the-art handling equipment in Nigerian ports as a strategy to enhance operational performance. Still, the standard deviation of 1.09043 indicated varied responses, suggesting a difference in experiences with handling equipment across respondents. However, daily stock management was the area with the most neutral responses, denoted by a mean score of 3.6744, indicating some uncertainty about its efficacy. The Nigerian Ports Authority's 2018 report aligns with these findings, as it acknowledged logistical and customs procedures challenges, possibly affecting perceptions of daily stock handling. This element also had the highest standard deviation, signaling a substantial disparity in respondents' views. Finally, the port labor aspect revealed mixed feelings among respondents, with a mean score of 3.8098 hinting at general indecision, though leaning towards agreement, about the labor force's competence and effectiveness. This finding complements Ezejiofor and Olisa's (2016) study, which found mixed views about labor productivity in Nigerian ports. Here, too, a standard deviation of 1.27157 indicated varied perceptions and experiences.

The second objective was as well examined, the trend analysis of cargo throughput at Lagos Port Complex and Tincan Island Port Complex over a span of 13 years (2007-2020) offers valuable insights into the ports' operational performance and its relation to broader economic and trade patterns. Cargo throughput, the total volume of cargo loaded or unloaded at a port, is a significant metric of port activity and often mirrors larger economic and trade movements. Between 2007 and 2011, there was a noticeable upward trend in cargo throughput, suggesting robust economic activity, heightened import and export volumes, and potentially positive infrastructural and policy developments at the ports during this period. Given Lagos's status as Nigeria's largest and busiest port complex, these trends align with the country's overall economic expansion at that time, significantly influenced by a surge in oil prices (International Monetary Fund, 2010). Contrastingly, a decline in cargo throughput was observed from 2019 to 2020, a trend that can be directly attributed to the COVID-19 pandemic. The pandemic, which began in late 2019, triggered unprecedented disruptions in the global economy, affecting supply chains, trade, and port operations worldwide.

According to UNCTAD, there was a 4.1% decline in global maritime trade in 2020, marking the steepest decline since the 2009 financial crisis (UNCTAD, 2021). The drop in cargo throughput at Lagos and Tincan Island Port Complexes mirrors these global phenomena at a local level. This downtrend has also brought to light the vulnerability of ports to global disruptions, emphasizing the need for improved resilience in port operations and supply chains. The cargo throughput trend analysis, therefore, serves as a key resource for understanding Nigeria's economic performance and outlook, while also underscoring the global trade interconnections and the potential impacts of worldwide events on local contexts.

The third objective of the study was also examined, the regression analysis, suggests a significant positive relationship between handling equipment and cargo dwell time at the port. In the context of port operations, this could imply that more efficient or a greater quantity of handling equipment can potentially reduce cargo dwell time. This is intuitively logical as the availability and efficiency of handling equipment are crucial determinants of the speed and effectiveness of cargo handling operations. The results corroborate with findings from previous studies in port operations and logistics. For instance, Ng and Gujar (2009) highlighted the significant role that handling equipment plays in determining container dwell time in ports. They found that the efficiency and capacity of handling equipment could significantly reduce dwell time, thereby increasing the overall operational efficiency of the port. Similarly, a report by the United Nations Conference on Trade and Development (UNCTAD, 2016) emphasized that dwell time is a key performance indicator for ports and can be significantly reduced by improving handling equipment and related logistics processes. Moreover, Wang, Song, and Cullinane, (2003) emphasized the importance of efficient and sufficient handling equipment in reducing cargo dwell time. Their research, focused on U.S. ports, found that ports with higher efficiency and capacity of handling equipment were able to significantly reduce dwell time, thereby boosting their competitiveness.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, it was concluded that terminal space, handling equipment, daily stock and port labour were significant factors or elements of container terminal capacity. Furthermore, there was an increase in cargo throughput from 2007 to 2011. It was an upward trend. Also, there was a downward trend from 2019 to 2020. The covid-19 pandemic was responsible for the downward trend of cargo throughput from 2019 to 2020. The values for port charges, stevedoring operations and unserviceable crane and ship calls are considered normal and suggested that cargo dwell time has a significant effect on container terminal capacity.

The following recommendations were made based on the findings of the study: -

i. Nigerian Ports Authority should invest more on sustainable infrastructure.
ii. Terminal operators and stevedoring company should train and retrain their staff handling modern equipment.
iii. Policy should be made to enhance port competitiveness and productivity.
iv. Railroad should be improved upon to enhance the movement of cargo entering and exiting the port facilities.

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