MARITIME LOGISTICS AND THE ROLE OF ICT IN THE OPTIMIZATION OF CARGOTHROUGHPUT IN NIGERIA

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Abstract

The recurring problem of maritime logistics are delay at the port, increasing freight charges and inability to increase non-oil export which have not made the seaports perform to their optimum capacity and capability in Nigeria. This study examined the trend of inward and outward logistics traffic (cargo throughput) of selected Nigerian seaports and assessed the level of usage of Information Communication Technology (ICT) on seaport logistics optimization. Primary and secondary data were collected and Cochran's formula was used to determine sample size of 253 with systematic random sampling technique from a total of 743 population of selected relevant stakeholders in maritime logistics. Line graph was used to evaluate the import-export of liquid cargoes and bar chart shows the collective import–export of agricultural products in Nigeria. Again, Data Envelopment Analysis (DEA) was used to examine the use of ICT on seaport logistics optimization. Results revealed that, Nigeria's import-export has been progressively increasing without commeasurable capacity and capability to deal with it. The Decision Making Units (DMUs) i.e Seaports show Return to Scale (RTS) of only Apapa seaport increasing, Onne and Warri decreasing while Tin Can and Calabar were constant in relation to Information and Communication Technology (ICT). In order to meet up with their frontier targets, Apapa is expected to increase its ICT infrastructure while Onne and Calabar are to increase the intensity of utilization of ICT. The research concluded that, there is need to increase port capacity; improve on non-oil export logistics, skill capability and ICT infrastructure for the purpose of building or upgrading and maximum utilization of some existing seaports.

Key words: Logistics, ICT, Maritime, Optimization and cargo throughput

1. INTRODUCTION

Nations and regions of the world are separated by sea, rivers, lagoon and oceans. The movement across water bodies paved way for economic, social, political and industrial developments. According to Taaffee, Morrill and Gould (1963), there were about 100 small seaports in Nigeria yet to be developed. It was noted that maritime transport from inception in Nigeria was seen as a good agent to the development of slave trade which was prominent during this era. The Civil War between 1967 and 1970 caused a lot of set back to the Nigerian maritime industry and made traffic to be diverted to Lagos port only at the time. According to Gudehus and Kotzab (2012), maritime logistics can be described as a new integrative approach in general shipping that seeks to collectively move cargo or freight across river, channels or seas at minimum cost, minimum fuel, without any delay at the seaport and minimum emissions to the natural environment. Nigeria as a country depends heavily on exportation of crude oil, onions, starch, ginger, cashew nut and shell, flower buds, cotton among other agricultural produce to countries like Brazil, Senegal, France, Italy, Germany, Netherland, Benin, Cameroun, South Africa, Russia, U.S.A, Argentina, Turkey and Singapore. In turn, the country imports goods and machineries like shoes, bag, vehicle, pharmaceutical products, clothes, refined petroleum products, frozen foods, chemicals, equipment, etc. from China, Brazil, USA, Germany, Japan among other developed countries. Port logistics has not been optimized in such a way that the best service efficiency is witnessed in Nigeria. The challenge of port logistics especially in Niger Delta area of Nigeria is accruable to militancy and community restiveness (Muhammed, 2008). Entsuah (2011) explained that, African seaports are not competitive which made it to be less attractive and the cause of high costs of shipments.

Maritime trade and ports evolution are affected by revolutions in the transport sector and consequently the industries, as well as the globalization of the economy (Chew, Lee and Tang, 2011). In the past, the maritime logistics was not organized because goods were carried as they come, ship could easily spend more time in port than at sea while dockworkers manhandled cargo into and out of tight spaces below decks. There was also high risk of accident, loss and theft. The modern approach was brought up by the revolution in communication, containerization and building of larger vessels. The clearing process in Nigeria is not void of "port rats", huge port charges and inadequate handling equipment. The essence of logistics is to satisfy customers, and once Nigerian seaports are not productive in this direction; there is every tendency of losing to other neighboring countries. Ndikom (2013) noted that, making use of agents for the inspection of goods and the oversight function of Nigerian Customs Service (NCS) by the contractors with regards to Risk Assessment Report (RAR) is a bane to Nigerian maritime logistics' progress. Another dimension to the issue of Nigerian port system and maritime logistics is the non-availability of the required equipment to facilitate movement of cargoes from one point to another either because they are not adequate, faulty or the operators cannot operate the latest technology (Ihenacho, 2005). The circumstances that need urgent attention in Nigerian ports are the issue of energy supply, cooperation among agencies to avoid

unnecessary strike actions and 100 % destination inspection for the sake of effective maritime logistics.

Nagy and Diofasi-Kovacs (2020) affirmed that Information Communication Technology (ICT) is capable of transforming logistics processes. They found out that ICT can be used for storage, communication, sharing and processing. Therefore, this paper expounded on cargo throughputs of Nigeria with the aim of improving exportation and involvement of Information Communication Technology to enhance seaport logistics processes**.**

2. LITERATURE REVIEW

2.1. Metaheuristics Models for Maritime Logistics optimization

Logistics decisions are usually complex as there are so many interconnected activities especially looking at its chains within the maritime sector with different but conflicting objectives. In most cases, the processes involved in analyzing, designing and managing total maritime logistics is complex and require experience, intuition and very view analytical model have been seen to be used for this process(es). It is a very difficult task therefore to find a model suitable for academic and that is also industry based. This is because the strategies and approach to solving different maritime logistics problem cannot be the same. A heuristic algorithm is a solution method that may not ascertain optimal solution but has a level of performance for the convergence of quality solution. Metaheuristics can be developed to solve single problem or arrays of multiple problems. It can be updated to accommodate new and latest development when identified variables for the logistical operations are known. The use of Metaheuristics model can be in form of Decision Support System for logistics managers or port authorities. The problem however can be realized when aggregation of complex data becomes an issue Simchi-Levi and Kaminsky (2000). It is not every port logistics or maritime logistics scenario can be computed, but time can be used to measure the yardstick of port logistic operations and various activities can be coded based on the actual time used. This however can be used for the model. For instance, total time taken to cover a particular distance; total time taken to load a vessel, total time taken to move out of the port and total time taken to inspect a vessel. Similarly, this can be extended to cost and other issues in the logistics system. This method can assist users by simulation of complex issues and produce a solution for decision support system in a situation of uncertainty. Internet of things (IoT) has provided leverage for integration of logistics processes to ease bottlenecks in logistics (Osmolski and Kolinski, 2020).

The model for distribution in the food and beverages industry was presented by Ribeiro and Lourenco (2001) using vehicle routine models with the aim of designing routes for different department in a firm. Remitta is heuristic software that can monitor the monetary transactions and to monitor the logistics of tankers. The use of GPS and GIS aided the algorithm of maritime logistics simulations. Adepoju (2015) used Shimbel connectivity Index for the assessment of connectivity and accessibility between road and rail to the identified Inland Container Depots in Nigeria. In that

findings, logistical decisions should be made in such a way that; rail will discharge to the ICDs and road can then take it up.

Maritime logistics concepts have been viewed by many authors differently and there are number of perspectives to its literature review. The general mandate of commercial shipping or maritime logistics has been to minimize costs, maximixe revenue. For these purposes, shipping companies plan and organize networks of shipping routes, and provide schedule and operate a fleet of ships (Gudehus and Kotzerb, 2012). The speed of the vessel has been looked into to play a major role in maritime logistics. However, in critical assessment of ship's speed; there are a number of factors that may be external which can influence the speed of the vessel for optimum turn-around logistics. Some of these factors are: rainfall, waves, hurricane, and typhoon among other environmental conditions that the seafarers or navigators will be forced to move at lowest speed. Bergh (2010) observed that ships should maintained lowest speed when it is faced with environmental challenges. Gudehus and Kotzarb (2012) opined that, fleet planning, capacity of carriage and travel times are yard sticks to measure maritime logistics. However, the speed has been noted to be increased with fuel consumption of a vessel and this in turn determines the operating costs, freight charges and profits. Apart from the parameters that are used to assess shipping logistics; distance and demand with scheduling strategies and managerial capabilities have also been identified.

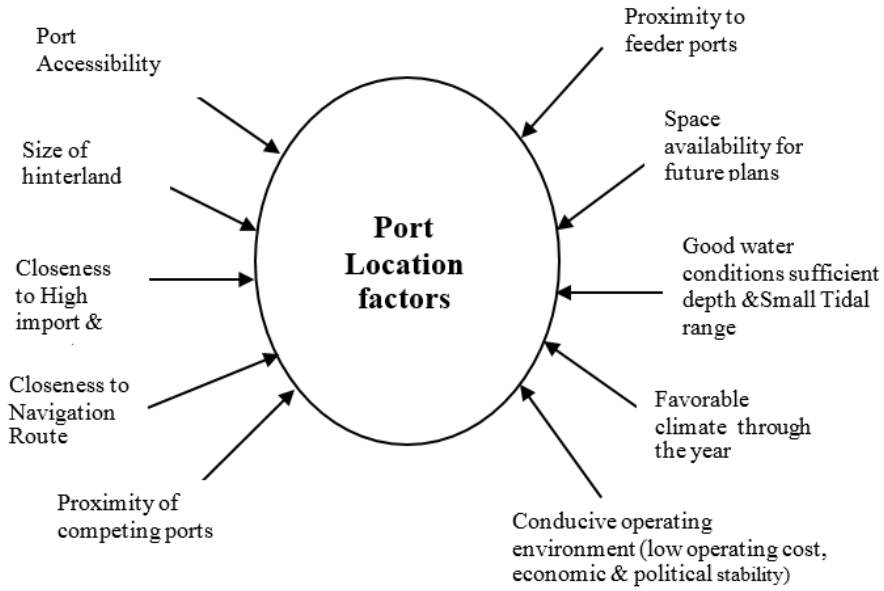
In the findings of Oyatoye et al. (2011) using queue theory application to solving Nigerian ports logistics problems where they reiterated that the berth allocations were enough but the planning of port must change to experience effective logistics system. The activities involved in port logistics have been enumerated by Jansson and Shneerson (1982) which stated as follows:

a) The ship's approach through river or canal and mooring the ship at the quay
b) The unloading of cargo from the ship's hold to the quay
c) Transportation of cargo to the transit shed/ storage from the quay
d) Loading the cargo from storage to loading platform
e) Storage transit
f) Loading to inland transport modes
g) Departure of inland from the port.

Researchers like Weigend, (1958), Fleming and Hayuth, (1994) and Sutcliffe and Ratcliffe, (1995) conducted researches to affirm that location of port is very crucial to port development and competitiveness. While Weigend maintained the location based on the deepness of the water, tidal range and a climate; Fleming and Hayuth (1994) noted the role of centrality, intermediacy and proximity. Sutcliffe and Ratcliffe, (1995) expressed the fact that, it must be cited at the hub for transshipment purposes. Robinson's (2002) opinion is different as he noted that, cost leadership (economies of scale) or service differentiation (economies of scope) is the tools to use to enhance port logistics. However, Heaver et al. (2001) expressed that, global carriers and forwarders used to challenge the flow of and ports can no longer expect to attract cargo because they are natural gateways to reach hinterlands. According to the postulation of Bird (1971), deep water is essential for terminal operations and larger

size of site is required. This he explained that, larger vessels will be accommodated with deep water for rapid turnaround time. However, Notteboom et al. (1997) argued that, vessel's capacity increments are accounted for by the beam of the ships rather than the draught. The example he cited was that of Hamburg and Antwerp based on the persistence upstream ports. The figure 1 shows the various factors to be considered before locating a seaport.

Figure 1. Location factors affecting port attractiveness and competitions



Source: Chew, Lee and Tang (2011)

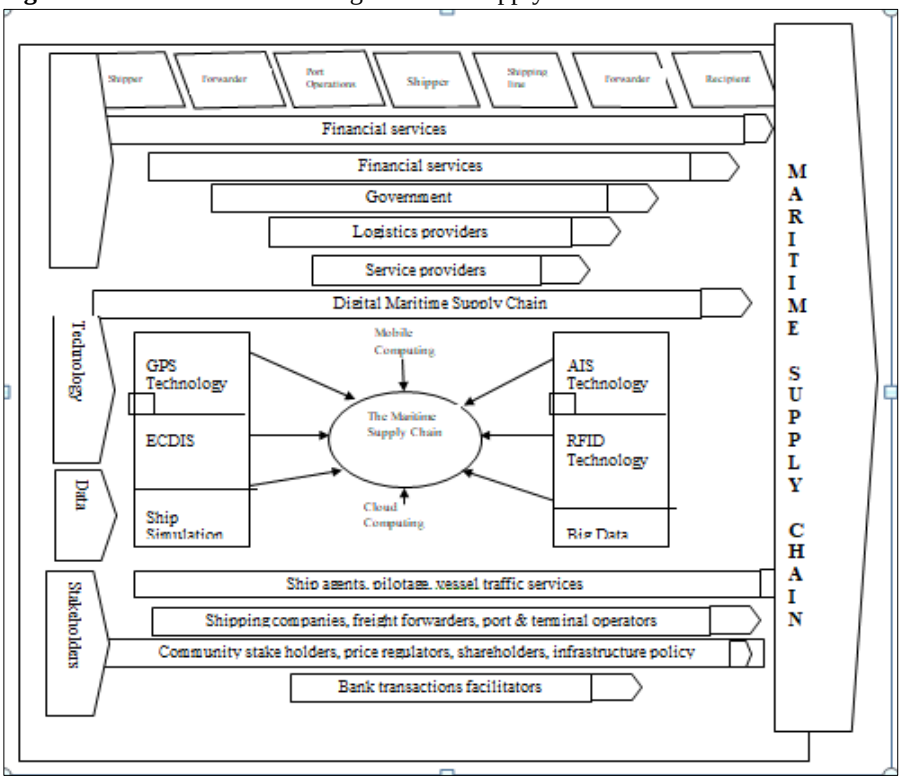
The identified factors are port accessibility, which is crucial for viability of seaport. If a seaport is located where it will not be accessible or the difficulties to be experienced before accessing it, the port cannot be productive (see fig 1). The more attractive a port the larger the required for space in hinterland. This has a connection with the import and export areas with the understanding of closeness to navigational routes and proximity to competing seaports. Sometimes, the feeder ports contribute to the attractiveness of a bigger seaport by supplying the bigger ports consignments for better formidable carriage. The depth of the water is another factor with space for future expansion of the port. The climatic condition, political stability, economic costs and operating environment are crucial issues in port attractiveness and competition.

2.2. Maritime Logistics Digitization Models

According to Fruth and Teuteberg (2017), digitization and automation are constantly advancing and noticeably affecting all businesses and processes in the coming years. Berg and Hauer (2015) maintained that, the revolution in maritime

logistics will occur as a result of big data and increasing networking of technologies. The International Maritime Organization (IMO) has supported the introduction of electronic data exchange from ship to ship and from land to ship to improve the efficiency, safety, data security, navigation and communication. In this manner, Global Positioning System will be used to enhance the value chains mostly with details on vessel's arrival, data collection on weather in real time and smart technology on containers. Kuchta (2016) expressed that, Automatic Identification System (AIS) is being installed mostly into ocean-going vessels so as to accurately predict weather, tide and maritime traffic data. AIS uses transponders and can track ships with the automatic tracking system and also used by Vessel Traffic Services system. The information provided can relate to the position of the vessel, course and speed displayed on the screen or Electronic Chart Display and Information System (ECDIS). It is incorporated with GPS, GIS, Electronic Navigation sensor like gyrocompass and satellite receivers. The opinion of Berg and Hauer (2015) is that, the maritime logistics systems can be integrated in such a way that, sea containers are equipped with radio-frequency identification chips and thus become intelligent containers. With this, smart containers and a suitable networking of single information system to fully digitize and globally network the entire maritime transport in order to render transparent services can be executed. The influence and impact of automation in Nigerian maritime industry is yet to come. In this scenario, all terminal vehicles, machines and other devices involved in the transportation, loading, offloading of goods are interconnected and communicate with each other with the aid of information, communication and automation technologies (Bai, Zhang and Shen, 2010). The real time information system can be used to synchronise forward and hinterland logistics based on optimal transport mode and route combination. Lee, Tongzon and Kim (2016) maintained that, by this real time information integrated system there will be transport cost reduction and optimum utilization of transport means adhering to various delivery conditions.

Figure 2. Actors in Maritime Logistics and Supply chain



Source: Adapted from Fruth and Teuteberg (2017)

The figure 2 presented the various actors in maritime logistics and the processes involved in form of digital supply chain. The actors are the shippers, freight forwarders, port operators, vessel operators, forwarders and receivers of the goods. At the heart of bridging the gap of maritime logistics is the cloud computing and mobile computing. The components or technology that must be incorporated are the computer, the GPS, ECDIS and ship simulator. Directly, the works of AIS technology, RFID and big data analysis are crucial for modern maritime logistics. The services of ship agents, terminal operators, policy makers and external agencies like banks are crucial to the efficiency of maritime logistics. Keller, Pütz, & Siml (2012) discussed the role of software for maritime logistics linking industrial processes and technologies, as well as the related business processes with the new information and communication technologies (ICT). The progmmability can also be introduced to maritime sector for the purpose of artificial intelligence to digitize objects for storage capability, sensor and networking where ship operations can be enhanced. According to Berg and Hauer (2015), ports require multimodal transport process for an optimum networking of individual actors who coordinate their activities in transport chain to maximize traffic and flow of goods. Working with ship's data for instance; weather data, cargo data, machine data and aggregate data can effect good maritime logistics

management (Arndt, 2016). However, the fear of Schweer & Sahl (2016) is the security and protection of data in maritime logistics with the expertise required for its operations.

3. METHODOLOGY

The population of this study involved the stakeholders in Nigerian Maritime industry. Concerned agencies, departments, units, associations and executives in Nigerian seaport logistics are classified in the formation of the population of this study. The population lists are as follows:

a)	The Nigerian Ports Authority 22	
b)	The concessionaires 20	
c)	Shipping Companies/Depot and Oil marketers	101
d)	Association of Nigerian Customs Licensed Agents (ANCLA)	92
e)	Haulage Operators	137
f)	Nigerian Customs Service	371
		Total 743

Because we do not have homogeneous population, Cochran's formula was used to calculate the sample size.

$$\boldsymbol{n}_{\mathbf{0}} = \frac{z^2 Pq}{e^2}$$

In the equation above, "**e**" is called the "margin of error' or desired level of precision. "**P**" estimated proportion of the population which has the attributes**. "q"** is 1-P

$$n = \frac{n_o}{1 + \frac{(n_o - 1)}{N}}$$

Since our confidence level is 95%, we get the Z score by Z values of 1.96 per normal table. Therefore, a 95 % confidence level gives us Z values of 1.96, per the normal tables, so we get

$$n_{0=} \frac{(1.96)^2 * (0.5) * (0.5)}{(0.05)} = 385$$

Incorporating $n_{0,}$

The sample size then gives $n = \frac{385}{1 + \frac{(385-1)}{743}}$

385/1.52 = 253 to the nearest whole number as half a man cannot be sampled.

Furthermore, two stages of sampling technique were used to distribute the data collection instrument from the selected sample. The reason for using this sampling technique is for members of the population within the purview of stakeholders to be captured in the data. The first stage was systematic random sampling which systematically assigned the sample to all the representatives of the population and the random table was used subsequently to assign the instruments

4. RESULTS

Results from the analysis indicated that that, 85.8% 0f the respondents had imported or exported items from Nigeria and to Nigeria. However, 75.2 % wished they could have changed the Nigerian seaport if opportune because of clearing charges and average number of days required to clears their goods. In line with the objectives of this study, this chapter gives the detail of data analysis and presents the results with the implications cum the discussion of the findings. The first objective stated thus: ***"To examine the carriage capacity performance of inward and outward logistics traffic (cargo throughput) of variety of cargoes from 2000/2009 to year 2019 of selected Nigerian seaports"*** According to WITS (2019) there are many products that Nigeria imports from different countries of the world ranging from categorization as follows: Animal, Vegetable, Food products, Minerals, Fuels, Chemicals, Plastics or Rubber, Hides and Skin, Wood, Textile and Clothing, Foot wear, Stone and Glass, Metals, Machinery and Electricals, Transportation and equipment, Agricultural raw materials, Iron and ores etc. However, the Nigerian Export Promotion Council (2019) highlighted the following commodities that Nigeria exports are: Cashew nut, Ginger, Crude oil, dry bean, cocoa, leather and sesame. Though Nigeria's crude oil reserves are expected to last another 40 years, all indications are that oil prices will continue to crash and with the emergence of alternative energy sources and increasing focus on electric cars, oil will seize to play a prominent role in the international market which has implication on maritime logistics trade (Awolowo, 2019).

4.1. Discussion

To explain the trend and observe the capacity gap of the selected seaport, Standard Deviation has been used to analyse the various selected seaports' cargo throughputs as indicated in the table 1 below.

Table 1. Analysis of selected seaports' throughputs traffic performance

Statistic	No of Yrs	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Year	11	2012	3.317	2007	2009.5	2014.5	2017
Apapa	11	20122686	1181982	18567253	19052538	20677248	22528353
TinCan	11	13864060	4474815	1000300	13837585	15939755	17520504

Onne	11	24116912	3257082	17215120	21921982	26422356	27986821
Delta	11	6907170	2977997	1515092	5893922	9173246	10341766
Calabar	11	1793033	433509	946523	1652773	2115949	2341477

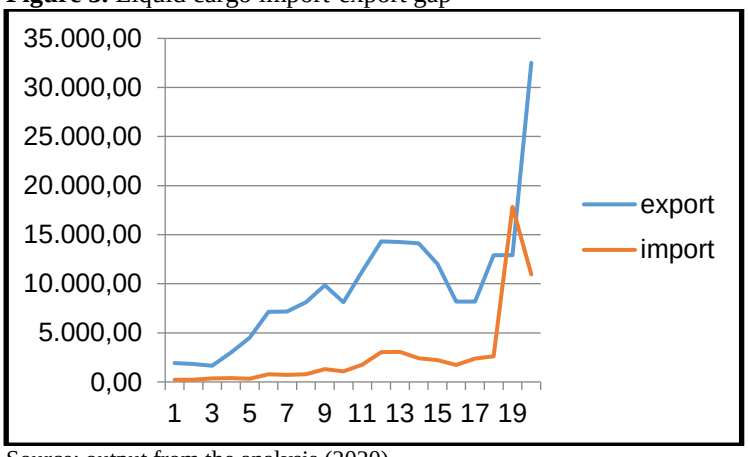
Source: NBS (2019)

The mean of the data set revealed that, Onne seaport has the greatest cargo throughput for cargo with the mean value of 2411912. Secondly, Apapa seaport has the next highest mean value with the mean value of 20122686. TinCan Island took the third position with mean value of 13864060 while Delta port came fourth with the mean value of 6907170. The lowest throughput came from Calabar seaport with the mean value of 1793033.

Using Standard Deviation, Calabar seaport is the least deviated from the mean with 433509 standard deviation value followed by Apapa seaport with 1181982. Delta seaport deviated next with 2977997 Standard deviation value and Onne Seaport with 3257082 deviation value from the mean. The most deviated seaport from the mean was Tin Can Island with 4474815 values.

It is evident from the findings that Onne is the most less congested among the selected seaports with faster turnaround as indicated by the highest mean value in table 1. Apapa is the next in terms of port logistics and followed by TinCan Island while Calabar and Delta are the lowest performing seaport in throughput respectively. It them means that, Warri and Calabar seaports are to be enhanced in all forms of capacity and logistics to facilitate rapid turnaround time of vessels and more traffic needed to be channeled to these axis. Sequel to the findings from the Standard deviation results, it appeared that Tin Can Island seaport receives widest variation of cargo throughputs as noted in the highest SD figure followed by Onne, Delta, Apapa and Calabar respectively. The implication of this is that, there is no consistency in the order of import –export of these ports respectively.

Figure 3. Liquid cargo import-export gap

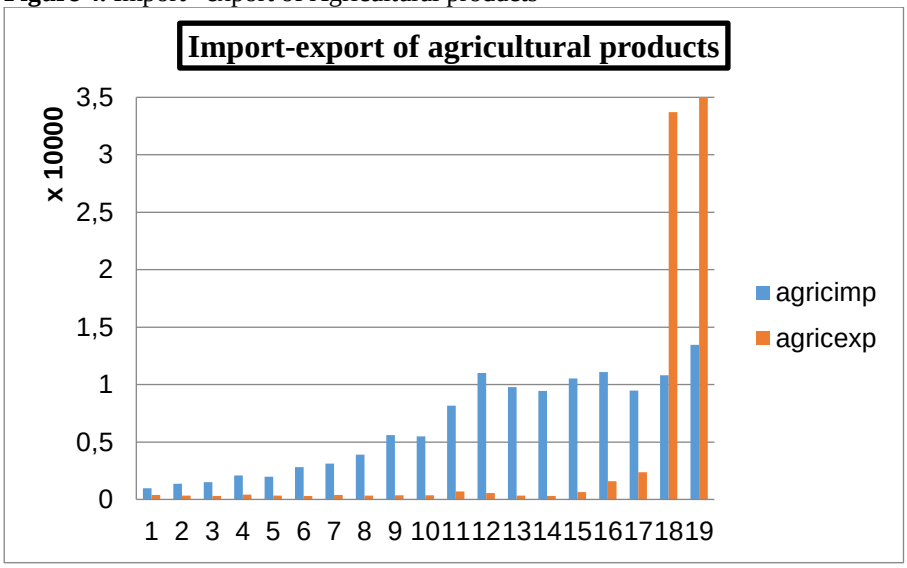


Source: output from the analysis (2020)

Figure 3 shows Nigeria's crude oil import-export graph where it was realized that crude oil export was increasing at almost 1000b barrel per annum between year 2003 and year 2009. It slightly came down between 2010 and 2011 and picked up again between 2012 and 2015 between steadily. However, there was drastic drop between 2015 and 2017 as the country experienced economic meltdown. It however picked up in the late 2017 and keeps rising gradually till 2019.

Crude oil has been realized to be the major source of revenue for Nigeria. Hence, the production and distribution of crude oil and other refined products must pass through shipping and ports to get to the international markets. The increase in the level of production led to increase in transportation and shipping and the initial capacity of port logistics was not enough to cater for the yearly increase of crude oil exportation. Meanwhile, not all the seaports in Nigeria are being used for the transportation of crude oil making the ones in use congested.

Figure 4. Import –export of Agricultural products



Source: NBS (2019)

The figure 4 shows the progressive increase in import-export of agricultural products in Nigeria. Basically from year 2000, the importation had always more than the exportation until 2017 and 2018. The terms of trade of recent are in favour of Nigeria as its agricultural products are now being exported more than being imported.

Table 2. Number and Gross Registered Tonnage (GRT) of vessels that entered all Nigerian Ports

Year	No of vessels	GRT
2007	4,849	84,806,792
2008	4,623	89,505,702
2009	4,721	90,603,611
2010	4881	106,689,553
2011	5232	122,614,716
2012	4837	120,818,683
2013	5369	130,628,057
2014	5333	148,323,065
2015	5014	141,250,703
2016	4373	134,066,547
2017	4292	130,357,357
2018	4009	128,671,805
2019	4,470	131,897,472

Source: NPA (2019)

In order to confirm the capacity gap of existing seaports, table 2 shows the increasing trend in number of tonnage carried though with an average number of 4500 vessels from 2007 to 2019. In order words, there is no corresponding expansion at the seaports that receive these cargoes which makes the seaports especially those receiving higher proportions to be congested.

The Data Envelopment Analysis is used to assess the level of relative efficiency of data based on linear programming. It involves about two three types of efficiencies: technical, allocative and economic efficiency. According to Farrel (1957), the allocative efficiency refers to the use of inputs optimally given their respective constituents. Secondly, if a firm produces more outcome as possible given certain set of inputs with a given technology, it is said to meet its technical efficiency. The economic efficiency arose from the use of the two efficiencies i.e technical and allocative will result in economic efficiency.

Achieving logistics optimization in maritime transport in Nigeria is very important in an attempt to bridge the gap that exists in the sector. The outcome of role of ICT on seaports' logistics optimization can be assessed using the following variables:

The use of ICT i.e intensity of usage (ITU)
The readiness of ICT (i.e infrastructure) (IFR)
The capability of ICT i.e skills (SKL)
ICT impact (Outcome)

The Data Envelopment Analysis (DEA) has been used to analyse the role of ICT on the optimization of the selected seaports. Data Envelopment Analysis is a mathematical programming tool to assess the performance or in this context role of ICT. DEA can be used for non- parametric data analysis and the most important aspect

is the outcome in terms of the level of efficiency obtained. Based on the level of applications of ICT at the selected seaports, this research for this objective focused on the selected seaports (Decision Making Units DMUs) and observed the input at various levels (ITU, IFR, SKL) as stated above and observe their respective results with specific outcomes. Roll and Hayuth (1993) were the first set of people to propose the use of DEA to assess port efficiency.

Table 3. Efficiency and targets

DMU	Intensity	infrastructure	Capability	impact	Efficiency
Onne	332.6387	53.79408	59.0853	66	0.88187
Apapa	680.1667	66.91667	63.25	77	0.89085
TinCan	742	73	69	84	1
Warri	194.5579	41.42228	47.86574	52	0.9205
Calabar	89	31	38	40	1

Source: Output from data analysis (2020)

In the table 3, the efficiency of ICT at Tin Can and Calabar seaports were considered to be good with the ratio of efficiency 1. This is followed by that of Warri, Apapa and Onne seaports. However, looking at the Return to Scale of the collected data (table 4), it shows that the Apapa seaport is the only increasing seaport in terms of ICT's role among the selected seaport though its efficiency is less than 1.

$\forall\lambda^{\kappa} \geq 0$ represents the efficiency score when DMU operation under Constant Return to Scale

$\forall\lambda^{\kappa} \geq 0 = 1$ represents the efficiency score when DMU operation under Variable Return to Scale (VRS).

$\forall\lambda^{\kappa} \geq 0 \leq 1$ represents the efficiency score when DMU operation under Decreasing Return to Scale

$\forall\lambda^{\kappa} \geq 0 \geq 1$ represents the efficiency score when DMU operation under Increasing Return to Scale. The level of ICT's role at Warri and Onne seaports is decreasing while those of TinCan Island and Calabar seaports remain constant.

Table 4. Return to Scale

DMU	Lambsum	Rts
Onne	1.2818	Decreasing
Apapa	0.9167	Increasing
TinCan	1	Constant
Warri	1.1438	Decreasing
Calabar	1	Constant

Source: Output from analysis (2020)

Table 4 shows the Return to Scale (RTS) of the selected DMUs (seaports). RTS are shown to either be increasing, decreasing or constant. According to Banker and

Morey (1986), the input-output relationship can be single input, single output; multiple inputs and multiple outputs and multiple output cases or single output cases. Examining the table 5 output, Apapa is the only seaport that is increasing based on RTS. Calabar and TinCan remain constant while both Onne and Warri are decreasing. RTS are considered to be increasing if a proportional increase in all the inputs results in a more than proportional increase in the single output. Let a represent the proportional input increase and b represent the resulting proportional increase of the single output. Increasing returns to scale(IRS) prevail if b > a, and decreasing returns to scale (DRS) prevail if b < a. RTS are considered to be increasing if a proportional increase in all the inputs results in a more than proportional increase in the single output. Let a represent the proportional input increase and b represent the resulting proportional increase of the single output. Increasing returns to scale (IRS) prevail if b > a, and decreasing returns to scale (DRS) prevail if b < a. RTS are considered to be increasing if a proportional increase in all the inputs results in a more than proportional increase in the single output. Let a represent the proportional input increase and b represent the resulting proportional increase of the single output. Increasing returns to scale (IRS) prevail if b > a, and decreasing returns to scale (DRS) prevail if b < a. In order to show the respective areas where the laxity occurs not to meet up with the optimization of port logistics system using ICT, the slacks as obtained from the identified variables were presented below in table 6.

Table 5. Slacks of the identified variables

DMU	slack_input.intensity	slack_input.infrastructure	slack_input.capability	impact
Onne	177.9642	0	0	0
Apapa	231.1678	2.569249	0	0
TinCan	0	0	0	0
Warri	123.0129	0	0	0
Calabar	0	0	0	0

Source: output from analysis (2020)

The slacks are the left overs of inefficiencies after adjustments of reduction or increase whenever the DMUs cannot achieve the efficiency frontier. The slacks are needed to make the DMUs attain their frontier targets. In this case, Apapa needs to use ICT more than the any other seaports in order to meet up with the targets as indicated in the figure 231.1678. Similarly, Onne seaport and Calabar are also expected to increase their use of ICTs in order realize targets with the value 177.9642 and 123.0129 respectively. Lastly, only Apapa seaport is expected to increase its ICT infrastructure among the selected seaports (see table 5).

Table 6. Lamdas (λ)

DMU	Onne	Apapa	TinCan	Warri	Calabar
Onne	0	0	0.3347	0	0.9471
Apapa	0	0	0.9167	0	0
TinCan	0	0	1	0	0
Warri	0	0	0.1421	0	1.0017
Calabar	0	0	0	0	1

Source: output from R studio analysis (2020)

Table 6 shows lamda (λ) from the output of the analysis which indicates the values of efficient ports corresponding to inefficient ports. The higher the value of lambda; the more the similarity of operations between the inefficient DMU (seaport) to the efficient ones. Hence, in this case, Tin Can Island seaport and Apapa have similar operations with the corresponding value of 0.9167. Similarly, Calabar seaport and Onne seaports has similar type of operations with highest value of 0.9471.
The Apapa, Onne and Warri seaports are seriously in need of ICT to get to optimal level of operations. Sequel to that, Apapa seaport also needs certain ICT infrastructure to operate efficiently as shown from the slacks. Though TinCan and Calabar seaports shows the best in terms of efficiency, as ICT and other related equipment are being supplied to Apapa seaport, it is bringing the best output more than all other seaport. In order to allow for optimization, more resources are to be deployed to Apapa seaport both in relation to the intensity and infrastructures. Moreover, the Warri and Onne seaports are to be looked into with specific attention to what is needed to be done in terms of ICT for these two seaports.

5. CONCLUSION AND RECOMMENDATIONS

Looking at Nigeria's import-export of variety of goods; there upward moment of cargoes for both inward and outward traffics over time under review with existing facilities and capacity without any form of possible upgrade for easy logistics. The mean value of the collected secondary data was used to determine cargo throughput of all the selected seaports. It was observed that, Nigeria's term of trade began to be positive in cargo throughput of agricultural products between 2017-2019 and except for recession in 2015-2016 for liquid cargoes. Onne seaport, Apapa and Tincan Island seaports are of greatest in demand for port services. The Calabar and Warri seaports are not in demand as expected. It was observed that, there was an increase in crude oil production within the year under review without commeasurable improvement in logistics capacity that can handle the ever increasing volume of traffic except between 2015 and 2017 when there was global economic meltdown. Since most of the seaports lack the capability to receive tanker vessels, the available ones in use were bound to be congested. Moreover, from the analysis of the import and export of agricultural produce; the import has always exceeded export except in the last two years. There was never a time export exceeds import across the year under review only with steady

increase of importation except in the last two years with upsurge in export compare to import.

Achieving logistics optimization requires that, ICT has to play a critical role in all the transactions of maritime logistics in the 21st century. The use of ICT, the level of preparedness in terms of infrastructure provisions and capability of skills are independent variables which are measured respectively base on intensity of usage, number of available infrastructure and skill of service providers predict the outcome or dependent variable. To this end, Data Envelopment Analysis revealed that, DMU Calabar and TinCan are the most efficient seaports with efficiency value of 1 in terms of ICT. Meanwhile it is only Apapa seaport that is showing Return to Scale (RTS) "increasing" among all the selected seaports. This means that, ICT usage, infrastructure and skills are increasing at Apapa seaport. While ICT levels at Onne and Warri are decreasing; TinCan Island and Calabar remain constant. The slacks however revealed that, to meet optimization; there is need for both Calabar and Onne to improve in their ICT usage. The research concluded that, there is need to increase port capacity; improve on non-oil export logistics, skill capability and ICT infrastructure for the purpose of building or upgrading and maximum utilization of some existing seaports. The area for further research is on how to enhance the competencies of human resource in shipping operations capable of using latest equipment or soft wares developed in maritime logistics.

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