Optimization of costs of Port Operations in Nigeria:
A Scenario For Emerging River Ports

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Abstract

This study attempts to optimize the cost of port operations in Nigeria. The quantitative estimates are concerned with the activities associated with the operations of Nigerian ports, the costs and the benefits derived by users of these ports. A Linear Programming Model was formulated from the cost components associated with the vessel-port relationships. With the aid of QM for Windows Software, an optimal solution was derived. The result shows the minimum cost of port operations as well as determining the optimal time frames for the decision variables of port operations. This provides a basis for future projection to determine the range of values of the constraints and decision variables for which the solutions will continue to be optimal.

1.0   Introduction

In many markets, firms compete over time by expending resources with the purpose of reducing their costs. Sometimes, the cost reducing investments operate directly on costs. In many instances, they take the form of developing new products that deliver what customers need more cheaply. Therefore, product development can have the same ultimate effect as direct cost reduction. In fact if one thinks of the product as the services rendered to customers, then product development often is just cost reduction.

The globalization of trade and subsequent breakdown in trade barriers has generated tremendous growth in maritime transportation. Thus the stiff competitions among part operators have increased the desire to attract port uses. Therefore, port operators will have to optimize the cost of their operations if they must benchmark good productivity and performance for their terminals. There is no doubt that the maritime sector especially the port system is vital and instrumental to the national economic survival of the country. Nigeria is a popular nation, renowned for her international nature of business. Quality customer service is the benchmark principle for the maritime professional and customer care techniques. Therefore, the economic justification of a port is its ability to satisfy its customers at a lower price and also be able to make profits.

With regards to costs emanating from the vessel, it can be affirmed that port costs, above all are the most significant, since they

depend on the gross tonnage of the vessel and the time it spends in the port. Bulk carriers are those which tend to spend most time in port as well as being the greatest in size. The costs of towing, which depend on the circumstances of the movement, tend to represent approximately 10% to 15% of the cost scale of the vessel [5]. More so, other costs due to the vessels stay at port, including agency fees average approximately 5 or 10% of the total. The port tariffs on the merchandise are situated at less than 50% of the total. Where all costs of unloading are considered in relation to port costs, the former are situated at about 70% of the total where all costs are also included storage, weighing etc. With a clear tendency to drop when using cranes of greater efficiency and capacity, about 30% would correspond to port costs.

It is evident that Nigerian ports operate at very low optimal capacity, in spite of the expected large volume of cargo traffic that passes through it. It is very pertinent to note that vessel delay period is a very serious problem that contributes to over 60% of our ports low productivity problem in recent times. Ndikom [3], further confirms that regrettably, at Lome port, dock workers load 700mts per day as against less than 250mt per day at Nigerian ports. The five days difference in loading arrangements between Nigerian ports and other ports in terms of ship delay rate billings of US$4,000 is rather too staggering and unfortunate. In clear terms, this is enough to deny Nigerian ports cargo and revenue that would ordinarily have come our way.

Kaspi, et al, [2], looked at the minimization of cost and optimum port performance as anchored on reducing port turnaround time. They developed a regression model to relate turnaround time and port cost which was highly related with allocation of port facilities. Beatriz et al [1], argues that the optimal organization of the industry can be studied by means of cost and production functions. They reviewed the literature on econometric ports' structure and propose that the calculation of key cost indicators (economics of scale, scope and so forth) is best in determining optimal port structure is order to minimize the cost of port operations.

In the light of the above, this study attempted bridging the gap by offering an optimal cost to port operations in Nigeria. In relation to this problem, the broad objective of the study is the analysis of optimum cost of port operations. The specific objectives include:

- Determination of the minimum cost of port operations.
- Determination of the optimal time frames for the decision variables of port operations.
- Determination of the optimality range of cost variability.
- Determination of the optimality range of resource variability.
- Determination of the amount to be paid in hiring a unit of the resources for the objective function to be optimal.

2.0 Research Methodology
2.1 Sources of Data
Data required for this study were collected from primary and secondary sources. The primary source of data was through oral interviews administered to some Nigerian Ports Authority (NPA) as well as some employees of renowned shipping lines. Secondary source of data was a survey of existing documents and published materials such as the NPA

Simplified Tariff, NPA Handbook, NPA Annual Reports, Current Publication, Journals and from the internet.

2.2 Method of Data Analysis

In order to provide empirical answers to the research questions; Linear programming technique is applied by the use of QM for windows software for the analysis.

2.2.1 The Linear Programming Model

Linear Programming deals with the optimization of a function of variables known as objective functions, subject to a set of linear equalities or inequalities known as 'constraints'. The objective function in this study is cost which is to be obtained in the best possible or optimal manner. The constraints in this study are imposed by Gang time, ship turnaround time and warehouse time.

Linear programming is a mathematical modeling technique designed to optimize the usage of limited resources.

2.2.2 Definition of The Variables For Objective Functon

The variables for the objective function with respect to this study are:

Service Cost include all the cost associated with providing Tugs, Pilots, Anchorage, Launch, Radio/Radar, Services, Surveyors, Dockage .

Burnkers Cost includes the cost of oil, water and other liquid fuel.

Loading and Discharge Cost Comprises the cost associated with Stevedoring, Clerking and checking, Watching, Clearing and fitting, Equipment rental, Agency fee and other related costs.

Supplies Cost includes the cost of Chandler and provisions laundry, medical, waste disposal, security and other related cost.

Inland Movement Cost include the cost of using Long Distance Truck, Short Distance Truck, Barge, Air transport, Rail transport, Pipeline transport and other modes.

Government Requirement Cost includes cost paid to customs, Entrance/clearance, Quarantine, Fumigation and other associated cost.

In-transit Storage Cost includes cost paid for Wharfage, Yard Handling, Demurrage, Warehousing, Auto and truck storage, Grain storage, Refrigerated storage and other related costs.

Cargo Packing Cost includes the cost of export packing, container packing, stuffing/stripping, cargo manipulation and other related cost.

With respect to this study, the above mentioned variables are symbolized for the sake of developing the LP model as follows:

Service: X_1; Bunkers: X_2; Loading/Discharge: X_3; Supplies: X_4; Inland Movement: X_5; Government Requirement: X_6; Intransit Storage: X_7; Cargo Packing: X_8

3.0 Results and Discussion
3.1 *Data Presentation and Description*

This study identified the major cost variables in port operations and the constraints militating against them hence developed a linear programming model which was used to provide minimum cost of port operations in Nigeria. Data in Table3.1 are ship and port activities and expenses

generated which were used in model formulation.

These activities are influenced by the following constraints:

- Gang time (including idle time)
- Ship turnaround time
- Warehouse time

On an average, gang time is estimated as 28 days per month multiplied by 24hours in a day = 672 hours. Average ship turnaround time in a Nigerian port is 12days in a month multiplied by 24hours = 288hours. Warehouse time is the average time a cargo can stay in storage without accumulating excess demurrage given as 6 days multiplied by 24 hours = 144 hours. Time allocated for the various port activities are obtained by multiplying the fraction of the cost of the port activity relating to the constraint by the available time for each constraint.

It is observed that the various constraints are affected by a combination of variables. Gang time is related with service, loading and discharge, inland movement, in-transit storage and cargo packing. Ship turnaround time is related with service and bunkers while warehouse time is related with government requirement and in-transit storage. The constraints and the decision variables form the linear programming model as illustrated in Table 3.2.

Table 3.1 Ship/Port Activities And Expenses Generated Based On Averages Of Different Kinds Of Cargo

SHIP/PORT ACTIVITY	AVERAGE EXPENSES PER TONNE
Services	12.23
Bunkers	5.46
Load/Discharge	31.19
Supplies	0.55
Inland movement	46.95
Government requirement	3.37
In - transit storage	4.28
Cargo packing	10.62
Total	114.65

Source: Computed from NPA Handbook, NPA simplified Tariff and Abstract of Transport Statistics as complied by Nze, (2008).

Subject to Table 3.2, linear programming model obtained is as follows:

Min $Z = 12.23x_1 + 5.46x_2 + 31.0x_3 + 0.55x_4 + 46.95x_5 + 3.37x_6 + 4.28x_7 + 10.62x_8$

Subject to;

$71.52 x_1 + 182.88x_2 + 275.28x_5 + 25.20x_7 + 62.16x_8 \geq 672$

$30.72x_1 + 13.68x_2 + 1.44x_4 \geq 288$

$4.08x_7 + 5.28x_8 \geq 144$

$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8 \geq 0$

Solution:

The optimum solution (using QM for windows software) is

Z = Minimum cost of port operations = 231.38 dollars.

X_1 = Service cost = 9.375 dollars

x_2 = Bunkers cost = 0 dollars

x_3 = Loading/discharge

cost = 0 dollars

x_4 = Supplies cost = 0 dollars

x_5 = Inland movement cost = 0 dollars

x_6 = Government requirement cost = 0 dollars

x_7 = Intransit storage cost = 27.273 dollars

x_8 = Cargo packing cost = 0 dollars

The activities having zero as their time frames do not mean that no time should be allocated to them. Rather, the solution provides a range of values for which time can be allocated. The ranging table and solution list are shown in Tables 3.3 and 3.4.

Table 3.2 Linear Programming Model for Nigerian Ports

Time	Gang Time	Ship Turnaround Time	Warehouse Time
Available time per month in hours	672	288	144
Port Activity			
Service (X_1)	71.52	30.72	
Bunkers (X_2)		13.68	
Loading/discharge (X_3)	182.88		
Supplies (X_4)			
Inland movement (X_5)	275.28		
Government requirement (X_6)			4.08
Intransit storage (X_7)	25.20		5.28
Cargo packing (X_8)	62.16		

Source: Computations using obtained data

Table 3.3 RANGING Table

Variable	Value	Reduced	Original Value	Lower Bound	Upper Bound
X_1	9.375	0	12.23	0	12.2611
X_2	0	0.0138	5.46	5.4462	Infinity
X_3	0	31.19	31.19	0	Infinity
X_4	0	0.55	0.55	0	Infinity
X_5	0	46.95	46.95	0	Infinity
X_6	0	0.0627	3.37	3.3073	Infinity
X_7	27.273	0	4.28	4.28	4.28
X_8	0	10.62	10.62	0	Infinity
Constraint	Dual Value	Slack	Original Value	Lower Bound	Upper Bound
Const. 1	0	685.7727	672	-Infinity	1,357.773
Const. 2	-0.3981	0	288	0.0001	Infinity
Const. 3	-0.8106	0	144	0.3143	Infinity

Source: Model run from Software

VARIABLE	STATUS	VALUE
X_1	Basic	9.375
X_2	Non Basic	0
X_3	Non Basic	0
X_4	Non Basic	0
X_5	Non Basic	0
X_6	Non Basic	0
X_7	Basic	27.2727
X_8	Non Basic	
Surplus 1	Basic	685.7727
Surplus 2	Non Basic	0
Surplus 3	Non Basic	0
Optimal value (Z)		231.3835

Source: Model run from Software

3.2   Result Discussion

Results are discussed here based on research questions.

Question 1

What are the optimal costs of port operation?

From the solution offered by the software used (QM for windows) shown in table 4.3, the optimal cost is given as 231.3835 US dollars per ton handled in a Nigerian port. This means that for optimal cost of operations in Nigerian ports, the cost should be kept at $231.3835 as charge for handling a ton of cargo.

Question 2

What are the optimal time frames of the decision variables for port operation?

The optimal time frames computed using the model developed is given as:

X_1 = Service = 9.375hours
X_2 = Bunkers = 0hours
X_3 = Loading/discharge = 0hours
X_4 = Supplies = 0hours
X_5 = Inland movement = 0hours
X_6 = Government requirement = 0hours
X_7 = In - transit storage = 27.2727hours and
X_8 = Cargo packing = 0hours

Question 3

To what extent will cost (i.e. coefficient of the objective function) vary for the solution to remain optimal?

For the solution to continue to remain optimal, the coefficient of the objective function can vary as follows;

For X_1 = Service, the cost can vary from 0 to $12.2611
For X_2 = Bunkers, the cost can vary from $5.4462 to Infinity
For X_3 = Loading/discharge, cost can vary from 0 to infinity
For X_4 = Supplies, cost can vary from 0

to Infinity

For X_5 = Inland movement cost can vary from 0 to infinity

For X_6 = Government requirement cost can vary from \$3.3073 to infinity

For X_7 = In transit storage cost can vary from \$4.28 to \$34.28

For X_8 = Cargo packing cost can vary from 0 to infinity.

Question 4

To what extent will the resources vary (i.e the right hand size of the equation) for the solution to remain optimal?

The resources which are the available time for gang labour, ship turnaround and warehousing will continue to remain optimal as long as gang time lies between negative infinity to 1357.773 hours; ship turnaround time must be between 0.0001 hours to infinity and warehouse time between 0.3143 hours to infinity

Question 5

What amount can be paid in hiring a unit of the resources for the objective function to remain optimal?

685.7727 US dollars can be paid in hiring a unit of the gang time while 0 US dollars can be paid in hiring a unit of ship turnaround time and warehouse time for the objective function to continue to remain optimal.

4.0 Conclusions and Recommendation
4.1 Summary of Findings and Conclusion

The results reveal that our ports are not optimally operated. Thus, there is an overcharge of price of services of port operations and wastage of the available resources for the decision variable components.

The study further proves that the application of sensitivity or post–optimality analysis on the model reveals the extent to which the cost and the resources can vary while the solution remains optimal. This in essence helps us to achieve the objectives of this research work whose prime is to determine the optimum cost of port operations in Nigeria.

4.2 Recommendations

For effectiveness of port operations in Nigeria as well as providing services at optimum prices for competitiveness, the following recommendation are made:

The port should be operated as an economic unit which it really is. It should therefore make profit, maintain itself and provide reliable and efficient services for the revenue it receives.

The use of mathematical models like linear programming is a very reliable tool for management decision as it makes use of quantitative analysis and provides more reliable outcomes. Establishments other than ports can take advantage of these models.

- The administration of the solution should be a dynamic one as other factors can affect its reliability. Example of this may be a change in the mode of packaging of cargo which can consume a large amount of the available resources.

- Port authorities should strive to maintain the resources and decision variables within the range specified for the solutions to continue to remain optimal.

Further research should be done in this area to be able to understand and decipher more variables and constraints which can be used to develop more models for use in optimizing cost of port operations in Nigeria.

References

[1] Beatriz Tovar, Sergio Jara-Diaz and Lourdes Trujillo (2004). Economic Estimation of scale and scope Economics within the Port sector: A Review. Discussion Paper Series No 07/04; City University London.

[2] Kaspi, Mokhtar and Muhammaed Zaly Shah(2006). A Regression model for vessel turnaround time. A paper presented at the Tokyo Academic, Industry and Cultural Integration Tour. 2006, 10-19 December.

[3] Ndikom, O. B. (2008). 'The kernel concept of shipping operations, policies an strategies: the industry overview'. Lagos Bunmico.

[4] Nze, I. C.(2008), Economic impact assessment of Nigerian ports; A disaggregate analysis. An M.sc thesis submitted to the department of maritime management technology, federal university of technology, Owerri. February.

[5] Valverde, P. B.(1995). 'The importance of port logistics on the cost of transport and stowage at ports. CIHEAM, Tarragoza.