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Cost Optimization Models of Port Operations in Nigeria: a Scenario for Emerging River Ports

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ABSTRACT

This study attempts to model the cost of port operations in Nigeria. The quantitative estimates are concerned with the activities associated with the operations of Nigerian seaports and especially river ports, the costs and the benefits derived to users of these ports. More so, a structural equation model(SEM) of the river port operations is derived and estimated by the application of LISREL software to generate reduced form of equations and parameter estimates of the form: $Y_1 = -0.307X_1 - 0.403X_2 - 0.496X_3, Y_2 = -0.507X_2 - 0.443X_3$, $Y3 = -0.640X_2 - 0.301X_3$ and $Y_5 = 1.183X_1 - 1.390X_2 + 0.597X_3$. The results of the SEM technique shows that available time for port operations is significant to handling cost, ship turnaround time and warehouse time. It further reveals that the demand for port services is significantly related to vessel supplies cost. It is proven that the SEM met the order and rank conditions and as such is structurally unique. Hence, Inland Waterways Transport (IWT) will conveniently divert traffic from the congested corridors of road transport by the optimization of handling costs and utilization of available time for port operations. Therefore, river ports will yield significant benefits to the economic growth of Nigeria, which is revealed in the models by the reduced form parameters that quantified the magnitude of economic activities at the river terminals considering key variables- ware house operations, gang operations and ship turnaround time. The study concludes that Inland waterways transportation has a significant contribution to economic development of Nigeria, if the potentials are fully harnessed. Therefore, it is recommended that government should enforce sustainable legislation to make IWT operations attractive to private organizations for optimal benefits.

1. Introducción

Tally et al (2006) posits that a port is a place that provides for the vessel transfer of cargo and passengers to and from waterways and shores. A port is a node in transportation network - a spatial system of nodes and links over which the movement of cargo and passenger occurs. A port is also an economic unit that provides a (transfer) service as opposed to producing a physical product.) posits that the amount of this transfer service is referred to as the port?s throughput. In a competitive environment, ports not only compete on the basis of location and operational efficiency, but also on the basis of fact that they are embedded in the supply chains of shippers. (Biswas, 1987) asserts that important waterborne inland transportation networks have developed along major rivers over some centuries ago, including their tributaries and lakes. For instance, the Ganges, Brahmaputra, Narmda, Chang Jiang and Mekong in Asia; the Nile in Africa; the Rhine, Main,Seine, Danube, Elba, Volga and Don in Europe; the Mississipi and the Great Lakes in North America. (Ndikom, 2013) maintains that the advent of air transportation and the construction of extensive highway and railway systems have sometimes reduced the importance of inland wa-

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terways. This implies that Inland waterways have been used as important corridors of transportation in different parts of the world from pre historic times (Dogarawa, 2012).

In furtherance, (Ashraf, 2013) posits that many of the industrial centers in Europe during the Industrial Revolution developed along the various rivers, since it provided easy availability of water for industrial processes, discharge of waste products to the rivers at minimal costs and transportation of raw materials to factories and manufactured goods to customers. Additionally, (Biswas, 1987) reveals that the increase in energy prices has given inland waterways an added advantage during the past decade, and many countries especially the oil importing developing countries that have potentials for this type of transport are now making a determined effort to expand and modernize their existing waterways transportation by the establishment of well equipped river ports at strategic positions. (Brenthurst, 2010) infers that there are complementary relationships between road and rail transportation and waterway carriage of goods. This therefore, reveals the importance of river ports as terminals and nodes of water transportation for the carriage of goods and persons. It has therefore become imperative for governments of developing countries blessed with vast coastline and inland rivers to maximize such potentials for economic diversification and multipliers.

1.1. Problem Statement

Managing cargo flows between ports and inland destinations has remained a challenge for terminal operators. Delay in ports means rising costs for shippers as it adds to customer pressure for goods to be delivered just in time. Most studies indicate that it is difficult to model the entire container terminal in a single integrated optimization model. Consequently, most of the studies have focused on developing models to solve individual problems related to specific terminal equipments and not integrated or combine problems relating all handling equipments. It is necessary for the terminal yard and quays to be managed in an integrated fashion i.e. with simultaneous regard for parallel processes. Such problems, as selecting which equipments to invest on or to deploy, may need to be approached from an integrated perspective since they affect the entire terminal.

This research tends to bridge the gap created by past researchers by developing econometric models for river port operations in Nigeria in an attempt to solve the structural equation model of Inland Waterways Transport (IWT) in Nigeria.

1.2. Objectives of the Study

The overall objective is to identify the range of costs provided by inland waterways port operations; the extent to which these can be quantified and structured to provide guidance to users on valuing the benefits. The specific objective is:

I. To develop a Structural Equation Model (SEM) of River port operations in Nigeria.
II. To test the SEM for rank conditions.
III. To test the SEM for order conditions.

1.3. Research Questions

In line with the specific objective, the research question for this research is:

I. Does this study produce a good Structural Equation Model (SEM) of river port operation in Nigeria?
II. Does the SEM meet the rank conditions?
III. Does the SEM meet the order conditions?

1.4. Hypothesis

I. H_0: The structural equation model of river port operation in Nigeria is not identified to be structurally unique.

1.5. Justification of the Study

The findings of this research will in no small measure be invaluable to shippers, terminal operators, policy makers and government; the academia and World Bank, in the areas of river port development and pricing in developing countries.

1.6. Scope of the Study

This study models the costs associated with the operation of Nigerian ports with emphasis on the optimization of operations at the river terminals in Nigeria. This involves the cost of doing business at the ports and the level of service offered and the utility obtained by users of the ports. This study concentrates mainly on econometric methods to achieve the set objectives, in consideration of the peculiarities of the sea and river ports in Nigeria which are assessed from 1996 to 2010 in isolation of and without regards to ports of neighboring countries and other global ports. However, review of related literature covers global and domestic perspectives.

2. Review if Related Literature

2.1. Inland Waterways Transport and Port Development in Africa

Governments across Africa have in recent times recognized the value of inland waterways. This makes African rivers invaluable to great effect by integrating transport network across the continent. While road and rail networks require constant maintenance and upgrading, navigable rivers and lakes call for far less investment and become of greater use when integrated with road and rail links (Ashraf, 2013). Various forms of cargo, particularly containerized commodities, can be easily moved using multimodal transport. This often requires Inland Container Depots (ICDs) to be developed at the nexus of road, rail and water transport networks, which means investment. A good example is Ather Ennaby river port, Cairo which is currently being developed to help boost Egypt's container throughput to 350 million by 2020 (Biswas, 1987).The Ballore ICD at Kampala, which serves the rest of Uganda, Rwanda, Burundi, Southern Sudan and Eastern DR Congo, is another good example.

(Ashraf, 2013) notes that governments have usually focus on other high profile, although often less effective projects. This results, however, in a lack of investment resources to initiate river waterway rehabilitation and begin the catalyst for barge traffic. A consortium comprising of donor agencies, governments of African estates and the private sector could secure the necessary finance and avoid this obstacle which decision-makers usually encounter. Much effort, He affirms is still needed to revive inland waterway transport in the community of Eastern and Southern African Estates (COMESA). Accordingly, relevant resolutions have already been taken to bring COMESA countries together. COMESA trade has expanded from US$3.1 billion in 2000 to nearly US$9.0 billion in 2007, due to the removal of tariffs among member states under the Free Trade Area (FTA) Agreement. COMESA countries have a combined GDP of about US$290 billion and a population of 400 million people. (Brenthurst, 2010) reports that Africa?s fishing grounds provide the single source of protein for the majority of its population and the rise of illegal activities, in particular piracy, is major contributory problems. Maritime security is a key component of collective security and thus forms part of the foundation for any economic development through the improvement of global competitiveness for its goods and services. However, Africa has yet to decide on the relative importance of its maritime environment against competing priorities - and allocate the requisite resources to ensure that it remains an asset.

Africa has to begin to take the lead in controlling its own maritime domain. Partnerships with global players and established commercial institutions, e.g., the oil industry, are crucial for maritime security. Apart from being the provider of trade routes, the sea provides food, commodities, income from tourism and even moderates the climate. Insecurity along the sea routes and waterway will also additionally impact on the cost of doing business and negatively impact on trade. Thereby resulting to dwindling development and reduced standard of living. Of the fifty-four countries of Africa, thirty-nine are either littoral states or islands; therefore it is confidently expected that the continent is acutely aware of the impact of the maritime domain. The importance, for example, of maritime trade to the economies of African states and its potential contribution to economic development through the potential for employment opportunities, can be demonstrated by the simple statistic that almost 91 per cent of continental trade by volume went by sea in 2008 (UNCTAD, 2010). There is no alternative given the nature of the imports and exports and the totally inadequate overland infrastructure. The present rate of degradation of the road systems in Africa, in spite of conscious efforts to improve them, means that coastal trade is going to grow ? supplementing the expected growth of international trade in commodities.

2.2. Inland Waterways Operation in Nigeria

As a maritime nation, Nigeria is endowed with a very large expanse of waterway frontier stretching from Lagos to Ogun, Ondo, Delta, Imo, Bayelsa and Rivers States. If the huge potentials are harnessed, several inland waterways can be put in good use for the safety of the citizens and socio-economic development of the country. For instance, a Warri-bound commuter will have no business passing through the Shagamu-Benin expressway when he can safely get to Warri from Lagos on a ferry or speed boat. Logistics experts say this is cheaper, faster and safer! For instance, it takes a medium-sized barge less than 20 minutes to move not less than 60 vehicles at a time from the Tin Can Island port to PTML's car terminal, Mile 2, via the Kirikiri waterfront. This saves time and the inconvenience of passing through the Tin Can stretch of the expressway where traffic gridlock is unending. (Dogarawa, 2012) asserts that Inland water transport includes natural modes as navigable rivers and artificial modes such as creeks and canals. In relative comparison to other modes, waterways in Nigeria and the huge potentials they offer for transportation presently remain largely untapped.

The successful dredging of the River Niger now makes it possible for inland waterway transportation from Lokoja, for instance, to Onitsha in Anambra State down to Warri, Oguta and even Port Harcourt without passing through the seemingly insecure Lokoja-Abuja highway occasioned by incessant armed robbery incidence. Petroleum products and other heavy wares could be moved via the waterways. This saves cost and time; it reduces traffic congestion and thus reduces wear and tear on the roads. The coastal States of West Africa are relatively equipped with seaports, cargo handling equipment as well as private and public maritime education and training institutions with the main seaports in Nigeria, for example, being operated by big international operators. Although the actual ship-port turnaround is about seven days in most West African seaports, Governments are encouraging officials and the operators to attain the 72 hours target time frame (UNDP, 2010). This is expected to be achieved through drastic reduction in delays and corruption as well as attracting investment in infrastructure thereby reducing the costs of goods and services.

2.3. Estimation of Production and Cost Functions in Ports

The estimation of key indicators representing the technical production properties of firms within an industry, such as economies of scale and scope, plays an essential role in the determination of the optimal industrial organization, i.e. that which induces the best assignment of resources. As known, technical properties can be analyzed directly through the study of the relations between inputs and outputs by means of production or transformation functions. (Beatriz et al., 2004) states that cost analysis permit the evaluation of port?s returns and productivity by calculating different indicators or cost drivers. This allows comparison of the productive efficiency among firms and a long time for a single firm. (UNCTAD, 1995) concludes that the provision of port infrastructure and extent of cargo handling services, go a long way to reducing port costs.

2.4. Port Pricing and Tariff

Recognizing that the application of short run marginal cost pricing in a decreasing cost industry, such as a port, would inevitably result in a financial deficit, (Brander et al., 2006) assess the viability of an economic based pricing system arguing also that the users of a port (when viewed as a public utility) should be charged the full marginal social opportunity cost of the resources that they use. (Steenken et al., 2004) proposed three ways of recouping capital expenditure. One of these would involve a two part tariff using the marginal social opportunity cost based method for the cargo handled plus a fixed periodic standing charge being levied for the right to use the facility. In such circumstances the regular users of the port could claim priority over infrequent callers since the use of 'first come first served' system fails to reflect the actual demand each vessel has for port services and opportunity cost of the vessel time. This reflects both the alternative income that the vessel forgoes by postponing the next fixture and the capital costs of the cargo.

Congestion pricing was discussed both by (Brander et al., 2006) and (Strandenes, 2004) with the former pointing out that congestion pricing poses practical problems, since prices will have to vary over the season. Depending on the relative bargaining power of the port and shipping firms, the mark up may accrue to the port or to the shipping firms. (UNCTAD, 1995), suggested that port tariffs were based on a mix of pricing strategies designed to reflect the demand for services, the competition between ports, and the cost of providing the services. The demand based pricing strategies are used when there is little competition and measures the demand according to the port use's ability to pay and the benefits derived from using the port's resources, time and inventory costs.

The cost based pricing strategy is similar to those discussed earlier, where (UNCTAD, 1995) considers a variety of measures on which to base costs. Average cost, average variable cost, marginal cost, and congestion costs are all possible bases. (Gidado, 2008) uses simulation and linear programming algorithms to model port pricing and tariff structure in Nigeria and thus proposes a reliable tariff structure for post reform era. He suggests that the appropriate units of measurement should be those that are correlated with the main measures of sensitivity of demand e.g. the value of the cargo or the size of the vessel. In this approach we take this a little further and allow for differentiation according to time sensitivity, which, of course, reflects the value of the capital bound up in the cargo and the vessel. Ultimately what matters is that the port tariff should be designed to be consistent with the objective of the port, which may be financial, marketing, operational, economic or developmental (Meyrick, 1989). Finally, there is a knowledge gap which exists in the literature with respect to structural equation modeling of river port operations in developing countries especially Nigeria. This study tends to bridge this gap.

3. Methodology

3.1. Secondary Data Collection

Secondary data consists of data collected from both internal and external data sources. Data collected from sources outside the case studied e.g. books, academic journals, publications and other scientific literature are considered as secondary data. One advantage with such data lies in the ease of acquisition. Secondary source of data was a survey of existing documents and published materials like NPA Simplified Tariff, NPA Handbook, NPA Annual Reports, Current Publication, Journals and from the internet as well as the publications of NIWA and the Federal Ministry of Transport.

3.2. Method of Data Analysis

Data are a key issue in developing optimization and structural equation models. How well the model behaves depends to a greater extent on the type of data used during model development. It is therefore necessary to get accurate data as much as possible. In order to provide empirical answers to the research questions, Lisrel 9.1 Software was used for the structural equation modeling.

3.3. Simultaneous-equation Techniques.

These are techniques which are applied to all the equations of a system at once, and give estimates of the coefficients of the function simultaneously. The most important are the Three-stage Least Squares method and the Full Information Maximum Likelihood technique. However, this research will adopt the most appropriate technique based on the relationships to be tested and the type of data to be gathered.

Secondary data sourced from NIWA Annual reports, Bankable Feasibility Studies and NIWA tariff.

Several computations were made from the above mentioned sources with respect to the following variables defined as follows:

Y_1 = Available time for labour per year (hrs);
Y_2 = Service cost per ton cargo (USD);
Y_3 = Bunker cost per ton cargo (USD);
Y_4 = Loading/discharge cost per ton (USD);
Y_5 = suppliers cost (USD);
Y_6= Inland movement cost (USD);
Y_7 = Government requirement cost (USD);
Y_8 = Intransit storage cost (USD);
Y_9 = Cargo packing cost (USD);
X_1 = GANG TIME (hrs)
X_2 = SHIP TURNAROUND TIME (hrs)
X_3 = WAREHOUSE TIME (hrs)

3.4. Definition of the Variables

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

Aviable Time for Labour includes the overall time in hours taken per year for operations in the ports engaging port workers.
Service Cost includes all the cost associated with providing Tugs, Pilots, Anchorage, Launch, Radio/Radar, Services, Surveyors, Dockage and
Bunkers Cost includes the cost of oil, water and other liquid fuel.
Loading/Discharge Cost Comprises the cost associated with Stevedoring, Clerking/checking, Watching, Clearing/fitting, Equipment rental, Agency fee and other related costs.
Supplies Cost includes the cost of Chandler/provisions laundry, medical, waste disposal, security and other related cost.
Inland Movement Cost includes the cost of using Long Distance Truck, Short Distance Truck, and Barge, Air transport, Rail transport, Pipeline transport and other modes.
Goverment Requirement Cost includes cost paid to customs, Entrance/clearance, Quarantine, Fumigation and other associated cost.
Intransit 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.

Appendix 1 shows the averages of handling costs and available or useful time in the river port operations. The respective values of Ys against Xs as described earlier will be subjected to a Structural Equation Modeling (SEM) technique by conducting the identification tests and the use of software (LISREL) application.

4. Modelling, Estimation and Discusion

4.1. Developing the Structural Equation Model (SEM) for River Port Operations in Nigeria

$$Y_{1t} = Y_{2t} + X_{1t} + X_{2t} + X_{3t} + \mu_{1t} \tag{1}$$
$$Y_{2t} = Y_{1t} + X_{1t} + X_{2t} + \mu_{2t} \tag{2}$$
$$Y_{3t} = Y_{2t} + X_{2t} + \mu_{3t} \tag{3}$$
$$Y_{4t} = Y_{3t} + X_{1t} + X_{2t} + \mu_{4t} \tag{4}$$
$$Y_{5t} = Y_{4t} + X_{2t} + \mu_{5t} \tag{5}$$
$$Y_{6t} = X_{1t} + X_{3t} + \mu_{6t} \tag{6}$$
$$Y_{7t} = Y_{6t} + Y_{8t} + X_{2t} + X_{3t} + \mu_{7t} \tag{7}$$
$$Y_{8t} = Y_{6t} + Y_{9t} + X_{1t} + X_{3t} + \mu_{8t} \tag{8}$$
$$Y_{9t} = Y_{7t} + Y_{8t} + X_{1t} + \mu_{9t} \tag{9}$$

This model can be rewritten in the form

$$-Y_{1t} + Y_{2t} + 0 \cdot Y_{3t} + 0 \cdot Y_{4t} + 0 \cdot Y_{5t} + 0 \cdot Y_{6t} + \\ + 0 \cdot Y_{7t} + 0 \cdot Y_{8t} + 0 \cdot Y_{9t} + X_{1t} + X_{2t} + X_{3t} + \mu_{1t} = 0 \tag{10}$$

$$0 \cdot Y_{1t} - Y_{2t} + 0 \cdot Y_{3t} + 0 \cdot Y_{4t} + 0 \cdot Y_{5t} + 0 \cdot Y_{6t} + \\ + 0 \cdot Y_{7t} + 0 \cdot Y_{8t} + 0 \cdot Y_{9t} + X_{1t} + X_{2t} + 0 \cdot X_{3t} + \mu_{2t} = 0 \tag{11}$$

$$0 \cdot Y_{1t} + Y_{2t} - \cdot Y_{3t} + 0 \cdot Y_{4t} + 0 \cdot Y_{5t} + 0 \cdot Y_{6t} + \\ + 0 \cdot Y_{7t} + 0 \cdot Y_{8t} + 0 \cdot Y_{9t} + X_{1t} + X_{2t} + 0 \cdot X_{3t} + \mu_{3t} = 0 \tag{12}$$

$$0 \cdot Y_{1t} + Y_{2t} + 0 \cdot Y_{3t} - \cdot Y_{4t} + 0 \cdot Y_{5t} + 0 \cdot Y_{6t} + \\ + 0 \cdot Y_{7t} + 0 \cdot Y_{8t} + 0 \cdot Y_{9t} + X_{1t} + X_{2t} + 0 \cdot X_{3t} + \mu_{4t} = 0 \tag{13}$$

$$0 \cdot Y_{1t} + Y_{2t} + 0 \cdot Y_{3t} + 0 \cdot Y_{4t} - \cdot Y_{5t} + 0 \cdot Y_{6t} + \\ + 0 \cdot Y_{7t} + 0 \cdot Y_{8t} + 0 \cdot Y_{9t} + X_{1t} + X_{2t} + 0 \cdot X_{3t} + \mu_{5t} = 0 \tag{14}$$

$$0 \cdot Y_{1t} + Y_{2t} + 0 \cdot Y_{3t} + 0 \cdot Y_{4t} + 0 \cdot Y_{5t} - \cdot Y_{6t} + \\ + 0 \cdot Y_{7t} + 0 \cdot Y_{8t} + 0 \cdot Y_{9t} + X_{1t} + X_{2t} + 0 \cdot X_{3t} + \mu_{6t} = 0 \tag{15}$$

$$0 \cdot Y_{1t} + Y_{2t} + 0 \cdot Y_{3t} + 0 \cdot Y_{4t} + 0 \cdot Y_{5t} + 0 \cdot Y_{6t} - \\ - \cdot Y_{7t} + 0 \cdot Y_{8t} + 0 \cdot Y_{9t} + X_{1t} + X_{2t} + 0 \cdot X_{3t} + \mu_{7t} = 0 \tag{16}$$

$$0 \cdot Y_{1t} - Y_{2t} + 0 \cdot Y_{3t} + 0 \cdot Y_{4t} + 0 \cdot Y_{5t} + 0 \cdot Y_{6t} + \\ + 0 \cdot Y_{7t} - \cdot Y_{8t} + 0 \cdot Y_{9t} + X_{1t} + X_{2t} + 0 \cdot X_{3t} + \mu_{8t} = 0 \tag{17}$$

$$0 \cdot Y_{1t} - Y_{2t} + 0 \cdot Y_{3t} + 0 \cdot Y_{4t} + 0 \cdot Y_{5t} + 0 \cdot Y_{6t} + \\ + 0 \cdot Y_{7t} + 0 \cdot Y_{8t} - \cdot Y_{9t} + X_{1t} + X_{2t} + 0 \cdot X_{3t} + \mu_{1t} = 0 \tag{18}$$

Ignoring the random disturbances, the table of parameters of the model is as follows:

4.2. Test for Identification of the Structural Equation Model

4.2.1. Order Conditions

It is imperative note that for order conditions for identification to hold, $K - M \geq G - 1$

Where:

K = number of total variables in the model

M = number of variables, endogenous and exogenous included in a particular equation.

G = total number of equations (= total no of endogenous variables)

4.2.2. Rank conditions

From the table of parameters above, we consider for each equation, whose G - 1 matrix will produce a NON ZERO determinant. In the system of equations or model, equations 1,2, 7, 8 and 9are considered to be the most important or significant in port operations. It is found that they respectively satisfy the rank conditions for 2 - 1, 2 - 1, 3 - 1, 3 - 1 and 3 - 1 endogenous variable included in the equation whose determinants are none zero.

4.3. Discussion

The ports, including river terminals and the maritime industry are indeed a vital part of the Nigerian Economy. Not only do the ports and the maritime industry provide a significant impact to the regional and national economies, they also provide one of the most likely targets for future investments and development of the economy of Nigeria as documented in this study. In the light of the above, this study having developed structural equation model for the emerging river ports in Nigeria, have revealed relationships between key variables of port operations.

Table 1 shows the cost components of the variables of river terminal activities and available times for the operations from which a structural equation model (SEM) was developed. The model derived met both the ?Order? and ?Rank? conditions for identification. This provides the answer to the research question that asked whether a structural equation model could be developed in this study.

This is in agreement with (Joreskog and Sorbom, 2006) which posits that the measurement model specifies the relationships between the observed indicators and the latent variables while the structural equation model specifies the relationships amongst the latent variables. However, it is also possible and often desired to include observed variables as part of the structural model.

Table 1: Table of Parameters for SEM

Equations	Variables											
	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	X_1	X_2	X_3
1^{st}	-1	1	0	0	0	0	0	0	0	1	1	1
2^{nd}	0	-1	0	0	0	0	0	0	0	1	1	0
3^{rd}	0	1	-1	0	0	0	0	0	0	0	1	0
4^{th}	0	0	1	-1	0	0	0	0	0	1	1	0
5^{th}	0	0	0	1	-1	0	0	0	0	0	1	0
6^{th}	0	0	0	0	0	-1	0	0	0	1	0	1
7^{th}	0	0	0	0	0	1	-1	1	0	0	0	1
8^{th}	0	0	0	0	0	1	0	-1	1	1	0	1
9^{th}	0	0	0	0	0	0	1	1	-1	1	0	0

Source: Computed by Researcher

Table 2: Order Conditions

Equation No.	No of predetermined. Variables excluded (K - M)	No of endogenous. Variables included less one (G-1)	Identified?
1	12 -5 = 7	2 - 1 = 1	Yes
2	12 - 3 = 9	2 - 1 = 1	Yes
3	12 - 3 = 9	2 - 1 = 1	Yes
4	12 - 4 = 8	2 - 1 = 1	Yes
5	12 - 3 = 9	2 - 1 = 1	Yes
6	12 - 3 = 9	1 - 1 = 0	Yes
7	12 - 4 = 8	3 - 1 = 2	Yes
8	12 - 5 = 7	3 - 1 = 2	Yes
9	12 - 4 = 8	3 - 1 = 2	Yes

Source: Computed by Researcher

Table 3: Coefficients of the Structural Equation Model

Equations	Variables											
	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	X_1	X_2	X_3
1^{st}	$-\beta_{11}$	β_{12}	0	0	0	0	0	0	0	γ_{11}	γ_{12}	γ_{13}
2^{nd}	0	$-\beta_{22}$	0	0	0	0	0	0	0	γ_{21}	γ_{22}	0
3^{rd}	0	β_{32}	$-\beta_{33}$	0	0	0	0	0	0	0	γ_{32}	0
4^{th}	0	0	β_{43}	$-\beta_{44}$	0	0	0	0	0	γ_{41}	γ_{42}	0
5^{th}	0	0	0	β_{54}	$-\beta_{55}$	0	0	0	0	0	γ_{52}	0
6^{th}	0	0	0	0	0	$-\beta_{66}$	0	0	0	γ_{61}	0	γ_{63}
7^{th}	0	0	0	0	0	β_{76}	$-\beta_{77}$	β_{78}	0	0	0	γ_{73}
8^{th}	0	0	0	0	0	β_{86}	0	$-\beta_{88}$	β_{89}	γ_{81}	0	γ_{83}
9^{th}	0	0	0	0	0	0	β_{97}	β_{98}	β_{99}	γ_{91}	0	0

Source: Computed by Researcher

The results of LISREL software application reveal that the relationship amongst ship turnaround time, warehouse time and available time for port operations are significant. This therefore supports the rejection of the null hypothesis that ship turnaround time and warehouse time are not significant to the available or useful time for river ports operations in Nigeria. The model (y1) reveals that while available or useful time for river terminal operation increases, ship turnaround time, warehouse time and gang time decreases with the rates of 0.307, 0.403 and 0.496 respectively. The application of these indices in the river port operations in Nigeria would go a long way to maximizing useful time for terminal operations with the consequent minimization of idle time and costs.

The degree of relationship between the demand for port services and the vessel supplies cost was determined from the results, which reveals a high degree of significance. This is in line with the rejection of the null hypothesis that the demand for port services and vessel supplies cost are not significantly related. This relationship is supported by (Heaver, 2006), which agrees that the issue of the structure of costs and appropriate level of charges for the use of port facilities and services have been consistent issues in port economics. The study reveals the effects of the level and Structure of prices on the efficiency of shipping as well as the efficiency of ports by relating port charges to port costs and to time with respect to access to berths and service quality.

The structural equation models reveal that the demand for ports services is significantly related to the vessels supply cost. The demand and supply of port services is elastic as revealed by the structural equation model Y5. A proportionate change in demand will increase the supply by 0.597.

5. Conclusion

The study therefore concludes that Inland waterways transportation will have significant impact on the socio- economic development of Nigeria, when the potentials are fully harnessed. There is an overcharge of price of services of port operations and wastage of the available resources for the decision variable components.

5.1. Recommendations

For effectiveness in the functionality and operation of port operations in Nigeria and to also provide services at optimum prices so as to be completive, the following recommendations 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 yields to the government.

- NIWA should intensify efforts to actualize the concession of the terminals to private organizations for full capacity utilization of the terminals; this should be done in a cost effective manner in order to keep handling costs at optimal level.

- The significant variables revealed in this study should be a centre point for policy makers to hinge reform policies around such predictive variables.

5.2. Contribution to Knowledge

This research has produced a working document for Government and National Inland Waterways Authority (NIWA); policy makers and port users in Nigeria as well as the World Bank in the areas of Inland waterways development and pricing by producing and estimating the reduced form of the structural equation models for river port operations.

5.3. Further Research Areas

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. Other areas include accident measurement and quantification of the value of lives lost from the inland waterways operation as well as computer aided simulation of cargo handling operations at the terminals.

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Table A.4: Source: Averages computed from NPA Abstract of Ports Statistics and Simplified Tariff; NIWA Annual Reports and Tariff

S/No	Period	Y1(hrs)	Y2(hrs)	Y3(,$)	Y4(,$)	Y5(,$)	Y6(,$)	Y7(,$)	Y8(,$)	Y9(,$)	X1(hrs)	X2(hrs)	X3(hrs)
1	1996	710	43,71	15,00	50,20	2,74	98,31	168	53,12	21,42	672	288	144
2	1997	710	45,63	15,10	50,20	2,74	90,23	163	53,12	21,42	672	288	144
3	1998	710	50,12	15,10	50,20	2,74	78,34	171	53,12	21,20	71,52	288	144
4	1999	720	56,80	15,50	55,70	2,20	85,65	156	51,60	28,50	71,52	288	144
5	2000	720	56,80	18,20	55,70	2,25	85,65	231	51,65	28,50	182,88	288	144
6	2001	740	61,17	27,31	65,30	2,20	80,23	261	56,10	28,50	182,88	288	4,08
7	2002	960	61,17	21,31	65,35	2,30	98,15	249	35,50	30,61	275	30,72	4,08
8	2003	960	61,17	27,35	85,61	2,70	105,20	335	45,50	30,61	295	30,72	4,08
9	2004	960	60,20	27,31	100,20	2,75	150,50	289	50,60	25,50	295	30,72	4,08
10	2005	14400	61,80	27,31	100,20	2,71	165,80	530	35,00	25,50	295	30,72	4,08
11	2006	14400	61,70	27,40	120,35	2,74	201,50	439	35,00	25,50	25,20	30,72	5,28
12	2007	14400	61,12	28,90	155,93	2,71	220	489	32,50	30,50	25,20	13,68	5,28
13	2008	14400	61,20	28,90	155,93	2,74	224	238	32,50	30,50	62,16	13,68	5,28
14	2009	14400	62,50	28,90	155,93	2,75	231	259	33,00	32,61	62,16	13,68	5,28
15	2010	14400	62,50	28,96	155,93	2,74	234	368	35,00	32,61	62,16	13,68	5,28

Appendix A. Data table for Port Operations Cost Variables

Appendix B. Estimated Equations

$Y1 = 0.0 - 0.307 \cdot X1 - 0.403 \cdot X2 - 0.496 \cdot X3 + Error, R^2 = 0.949$
Standerr (0.0657) / (0.127) / (0.119) / (0.0984)
t-values 0.0 / -2.418 / -3.374 / -5.044
P-values 1.000 / 0.032 / 0.006 / 0.000
Error Variance = 0.0647
Instrumental Variables: Y6 Y7 Y8 Y9

$Y2 = 0.0 - 0.114 \cdot X1 - 0.507 \cdot X2 - 0.443 \cdot X3 + Error, R^2 = 0.889$
Standerr (0.0970) / (0.187) / (0.176) / (0.145)
t-values 0.0 / -0.610 / -2.875 / -3.046
P-values 1.000 / 0.553 / 0.014 / 0.010
Error Variance = 0.141
Instrumental Variables: Y6 Y7 Y8 Y9

$Y3 = 0.0 - 0.172 \cdot X1 - 0.640 \cdot X2 - 0.301 \cdot X3 + Error, R^2 = 0.941$
Standerr (0.0705) / (0.136) / (0.128) / (0.106)
t-values 0.0 / -1.265 / -4.992 / -2.843
P-values 1.000 / 0.230 / 0.000 / 0.015
Error Variance = 0.0746
Instrumental Variables: Y6 Y7 Y8 Y9

$Y5 = 0.0 + 1.183 \cdot X1 - 1.390 \cdot X2 + 0.597 \cdot X3 + Error, R^2 = 0.809$
Standerr (0.127) / (0.246) / (0.231) / (0.191)