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INTERNATIONAL TRADE FLOW ANALYSIS USING THE GRAVITY MODEL –THE NIGERIAN CONONDRUM

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Abstract- ***The work surveyed several international trade flow models applied to transportation and spatial interaction analysis. The connectivity between international trade flow, port development and hinterland acquisition were analyzed based on evolving market demands.The relevance of the gravity model both to the international trade and port hinterland analysis were identified. Methods for the estimation of trade flows using natural logarithms applied to the gravity model were developed. Furthermore, the work assessed the rising influence of both hub and dry ports in the world of international trade. While the later is situated in the hinterland, the former is situated at few major world ports. The relevance of the gravity model in determining the location of these port types was emphasized. The strategic roles of rising hub ports to world trade were also discussed. Relevant data were picked from the Nigerian Import and Export environment.***

Keywords **-** gravity model; International trade flow; Port location; Nigeria; spatial analysis

1. INTRODUCTION

The relationship between trade and distance has attracted the focus of economist in recent times. Head K. (2003). An inverse relationship has been attached to distance with respect to trade attractiveness. This presupposes that trade will decrease as the distance increases. Head K, (2003) has offered so many reasons why distance affects trade in the international shipping market.

- Firstly, he argued that shipping cost (including freight charges and marine insurance) increases with distance.
- Distance is a measure of the time elapsed during shipment. For perishable goods, survival probability decreases with distance. Perishability can be inferred where any of the following risks exists.

i) Where there is damage or loss of goods due to weather or mishandling

ii) Where decomposition or spoiling of organic materials occurs and

iii) Where market loss occurs due to delay in transit.

- The existence of synchronization costs. This type of cost exists when factories combine multiple inputs in the production process, some of which may be outsourced from international markets. These outsourced components would be required to arrive in time, otherwise bottlenecks will emerge.
- Communication costs. The more the distance, the less likely the possibilities of personal contact between managers and customers.
- Transaction costs. The more the distance, the more money that will be spent in reaching for trading opportunities
- Cultural distance, Geographic distance may likely be correlated with cultural differences.
- Analyzing international trade flow in recent times have been the subject o many researchers in modern times. Sledziewska. k and Czarny.E(2006) tried to analyze international monopolistic competition with different forms of the gravity model. Citing Dabaere (2005) and Helpman (1987) they analysed the level of trade between two countries based on the export of the country as a component of the country's GDP. The analysis was further taken to the regional level comparing trade between countries in two countries in two trading regions. From their findings, two countries of unequal sizes would not trade as intensively as two countries of similar sizes will do. This goes to say that the intensity of trade between two countries depend to a reasonable extent on the size both countries.

Striking a balance between international trade flow, port development and tributary hinterland acquisition is a subject of evolving market demands. This will include changes in the technology of shipping and port management techniques.

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As the shape of the shipping market changes, so will the hinterland, as well as the shipping market demand in the various world markets. Aspects of these in modern times include.

- The rapid concentration of shipping in the cargo business sector entirely, excluding the passenger trade in major international routes after the world war I. This was brought about by developments in the aviation sector.
- The change in port handling facilities brought about by containerization since 1966.
- The rise in the influence of mega parts (hub ports) brought about by shipping investments in mammoth container ships and the rising concept of transshipment ports.

PROBLEM DEFINITION:

Given the gross difference in the multiple types of data available for analysis in both international trade and port hinterland evaluations, there is a need for a competent model of assessment for either side of the analytical frame-work. The gravity model easily yields itself as an available analytical tool for the broad based analysis.

OBJECTIVES:

In respect of the stated problems, this research seeks an analytical tool that will incorporate the relevance of distance in its assessment of international trade traffic, while contributing to the best possible location of hub ports (megaports) and dry ports.

2 BRIEF LITERATURE REVIEW:

Syabri Ibnu (2006) has suggested the use of exploratory spatial data analysis for origin and destination flow data. He stipulates the use of computers and graphic analysis as an aid to international trade flow analysis.

The CEPI programme on her part has suggested he reevaluation of trade flows to consist of the following sections one way trade, two way trade in similar product and two way trade in vertically differentiated products.

2.1 THE GRAVITY MODEL:

The use of gravity model for the analysis of international trade flows was introduced in 1962 by Jan Tinbergen. Its application has since then been applied in several other fields to study social interaction. Mathematically, the model is expressed thus.

$$F_{ij} = \frac{G.Mi^{\alpha}Mj^{\beta}}{Dij^{\theta}}$$

Where

- $F_{.ij}$ is the flow from origin 'i" to destination 'j'
- M_i and M_j are the relevant economic sizes of the two locations.
- D_{ij} is the distance between the locations

The equation above will revert to Newtons law of gravity of 1687 if $^{\alpha} = ^{\beta} = 1$ and $^{\theta} = 2$. This shows that the law is an extension of Newtons gravity law.

When further subjected to include the Dixit – stiglitz model, the gravitational constant G is then replaced by a new term Rj so that the equation becomes.

$$F_{ij} = \frac{R_j.Mi\,Mj}{Dij^{\theta}}$$

The gravity model can be estimated using ordinary least squares regression after we have taken natural logs of both sides. A relationship between logged trade flows and logged economy sizes and distances can thus be obtained as follows.

$$\text{In } F_{ij} = {}^{\alpha}\ln Mi + {}^{\beta}\ln Mj - {}^{\theta}\ln Dij + \rho\ln + Єij$$

The variable Rj formally written as G stands for friction in the economy. In a frictionless world the value is assumed to be zero 0.

2.2. THE ROLE OF DRY PORTS IN BRIDGING INTERNATIONAL TRADE FLOW

Since the introduction of the container ship by Malcolm Mclean in 1966, eruptive developmental patterns in the port sector have become the by-product of evolving market demand in this new sector of the world shipping market. Firstly, there came the rapid transformation of the port industry to focus on containerized cargo known to be exceedingly more efficient, than conventional cargo. Then came the evolution of the hub and load centre ports now known as mega-ports whose constant customers are mega-ships. The basic requirements to be dubbed a megaport include:

i. Minimum quay length of 330 meters (m) .
ii. Minimum draft of 15m without tidal window
iii. A minimum crane outreach of 48m.

Lastly, in a bid to create good inland accessibility in the new containerized port hinterland, the concept of the dry port has been introduced. By definition, a dry port is defined as an inland intermodal terminal directly connected to a seaport, with high capacity traffic modes, where customers can leave/collect their goods in intermodal loading units, as if directly to the seaports.

Roso V., Woxenius J, & Olanderson . G. (2006) have tried to categorize dry ports into three types based on their distance from the seaport. Thus the three categories are distant, mid range and close range dry ports.

DISTANT DRY PORTS

Distance dry ports are those dry ports which derive their reason of existence from the mere fact that the shippers location are far from the seaport. Under a distant dry port, the size of the trade flow make the use of rail or barge a more viable option to the road system when compared in cost terms.

This implies that the system is a sustainable transport option with environmental benefits. Other benefits includes, reduction in road traffic congestion at the port city resulting from service transfer from road to rail-wagons; increased logistics services at the dry port locations rather than the ports etc.

Good examples of distant dry ports already exists in Africa. They include

i. Tenth of Ramaddan city dry port in Egypt

ii. Isaka dry port in Tanzania

iii. The Kaduna dry port in Nigeria. The Tanzania dry port at Isaka allows customs documentation to be done at Isaka instead of Dar es Salaam. The dry port at the tenth of Ramaddan city Egypt also offer custom clearance facilities at the dry port location. The same services are obtainable in Nigerian dry port locations.

MID-RANGE DRY PORTS

Under a mid-range dry port, consolidation which includes administration and use of technical equipment, specific for sea transport is carried out at just one point connecting different rail services. Mid range dry ports permit the use of dedicated trains where containers for a specific vessel can be loaded. A good example of a mid range dry port is the Virginia Inland Port (VIP) situated in the hinterland of port of Virginia(USA).

CLOSE DRY PORTS

To reduce congestion at the port gates the concept of close dry ports offers a rail shuttle option relieving the city streets and port gates. The close dry ports may be located at the ports immediate hinterland or at the rim of the seaport city. From the close dry port consolidation can take place and containers may be loaded in sequence to synchronize with the loading of ships at the port. Roso V. Woxenius J, and Olanderson G. (2006).

2.3 THE ROLE OF MEGA-PORTS (HUB PORTS) IN BRIGDING INTERNATIONAL TRADE FREIGHT FLOW.

The rising influence of megaports/hub ports has contributed in no small measure to ease traffic flow across major world trade routes. From the carriers perspective for example, greater economics of scale are achieved by adapting to this concept. This implies that less transit time is spent crossing international sea routes when valued on a cost per TEU basis. The increase in mergers and acquisitions among shipping lines in recent years is a pointer to the fact that this trend will continue in the nearest future.

A hub port is defined as a container port tat provides terminal and marine services to handle and facilitate the transfer or trans-shipment of containers between feeder and motherships in the shortest possible time. Baird A (2000) has outlined some basic requirements for the location of hub ports. These include in addition to a natural deep water and adequate shelter for vessels the following;

i. a strategic position in a geographically suitable location, sufficiently centrally located to serve a large sub-region with minimum feeding costs.

ii. Close proximity to trunk routes where deviation time is kept to a minimum, allowing for as short a trunk-haul transit time as possible.

iii. The capability to use fast feeder services to ensure door-door movements for various origin/destination cargoes, while at the same time remaining cost and time competitive with alternative direct service options.

The current trend favours he diversion of ships to specially designed offshore hub terminals with its attendant benefits.

2.4 THE MARITIME SECURITY IMPLICATIONS OF HUB PORTS.

The hubs occupy a strategic position in international trade. Hub ports have been compared to maritime vulnerable trade flow, geographically defined constrictions, generally referred to as, choke points.

Good examples of choke-points are the strait of Hormuz, Suez Canal, and South China sea. The strategic implications of a disruption at hub ports are worse than that from choke points. For chokepoints, ships may follow an alternative route. In the case of hub ports, this is still possible but not so quickly. Disruption in the flow of global trade is bound to take place while companies will have to suffer unplanned rescheduling in their production lines. One good examples of this disruption was the great Hanshin earthquake that destroyed the Japanese port of Kobe on January 17, 1995. Up till then, kobe was Japan's biggest international trade hub and a major production and logistics centre. The effects of the quake which made the port unserviceable were felt in many parts of the world, thus disrupting the flow of global trade. The region was lucky because alternative ports like Pusan Osaka, Yokohama, Nagoya, Tokyo and Koahsiung absorbed the evolved transhipment trade. Coulter Y.D (2002). In some regions with few facilities that can handle ships of this size, the recovery time of the disruption would be higher.

The gravity model offers itself as an analytical model useful in the analysis of international trade flow when applied to world trade on R2 of 0.60 was derived. Also it was found that trade preference grouping like the European Economic Community EEC had a significant effect on the overall magnitude of trade between nations. Taffee E.J. and Gauthier H.L (1973). The gravity model is a good measure of the interaction between two cities or centers of trade and commerce. It increases as the population of the two cities increase and decreases with distance.

When applying the loglinear form of the gravity model, the distance coefficient is usually greatest for auto-transport. A lower figure will be recorded for bus and rail transport. The distance coefficient for air transport is usually very low.

Measurements with the gravity model have been divided into two thus the attractive factors and the impedance factors. Population is an altractive force while distance is an impedance factor.

3.0 RESEARCH METHODOLOGY

The work reviewed the role and usefulness of the gravity model in analyzing international trade flows. The suitability of the use of this model as a theoretical analytical tool for assessing the effectiveness of hub ports as well as dry ports is surveyed. The relevance of the gravity model as a tool with great capability is spatial analysis is strongly suggested.

REPORT OF FINDNGS.

TABLE 1 Gravity model assessment of Nigeria's export market

4.0 $F_{ij} = G_i(M_iM_j)/d_{ij}$
5.0 Where Gi =1(constant)
6.0 MI = Export freight volume from the country of origin(Nigeria) to a named destination country.
7.0 MJ =Import freight volume from the destination country to Nigeria.
8.0 dij = Distance of named country from Nigeria.
9.0
10.0 $\text{Log } F_{ij} = \alpha \log M_iM_j - \beta \log d_{ij}$
11.0 Where
12.0 MI = Export freight volume from the country of origin(Nigeria) to a named destination country.
13.0 MJ =Import freight volume from the destination country to Nigeria.
14.0 dij = Distance of named country from Nigeria.

		QDT (Export)	MiMj	dij
1)	ANGOLA	(659500)	2366945500	1008
2)	Brazil	(3177965)	46803066 x 10^{12}	3366
3)	Canada	(2958294)	26557768 x 1 0^{11}	4510
4)	France	(2899145)	16307052 x 10^{12}	3820
5)	India	(4557952)	69549242 x 10^{12}	8045
6)	Indonesia	(1010558)	129091 x 10^{12}	8180
7)	Japan	(2164593)	14348153 x 10^{11}	11085
8)	Portugal	(1511147)	47540684 x 10^{10}	3612
9)	Spain	(4156130)	1658113 x 10^{12}	3612
10)	U.S.A.	(32257656)	63824578 x 10^{13}	4869
11)	U.K	(177516)	18930291 x 10^{11}	4112

Source: 1.Nippon(1973). 2: Appendices 1.2 and 3.Onyemechi,(2014)

GRAVITY MODEL ANALYSIS

DURBIN WATSON TEST FOR AUTOCORRELATION RESULT

In this case,the computed Durbin Watson statistic was found to be 1.7399.With a sample period of 11 years and 2 independent variables and an intercept,we apply the Savin and White Durbin Watson significance table to arrive at adescision.Observation from the table shows that at 5% significance level,thelower bound dL=0.758,while upper bound dU=1.604.Descision:Since thecomputed Durbin Watson statistic was greater than the upper bound dU,we thenrefuse to reject the null hypothesis of zero autocorrelation in the residuals.Again, our acceptance limit of 2 was not exceeded,therefore we confirm absence of first order positive autocorrelation.Onyemechi,(2014)

DRY PORTS PROBLEMS IN NIGERIA

The concept of dry ports is welcome in Nigeria. However the process of implementation lacks up to date technical ability. Firstly, the continued dilapidated condition of the Nigerian rail system has continued to belittle the inherent advantages of operating a dry port. Mostly the advantages of sustainable transport cannot be maximized with the continued restriction of the rail wagons from the ports. Furthermore the absence of sufficient necessary container freighting rail wagons makes the project a child's play. The gravity model offers a means of measuring the level of Interaction between the dryport itself, the seaport and the adjoining hinterland.

Again, the application of the gravity model to evaluate trade in the Nigerian subsector will only be meaningful where trade exists both ways. The one directional flow of trade at the international level in the container industry will yield grossly one directional result when the model is applied.One characteristics of trade flow in Nigeria's import and export containers and break/bulk market is that trade is tilted towards the import directions.

There must be activities in the hinterland to necessitate the trade assessments.

However, one important benefit of executing the dry port policy in Nigeria is the redirection of trade to the rail system in the distant dry ports sector. This benefit however is yet to be achieved in the close dry port sector where the rail system has not yet been considered in the overall plan As a result, environmental pollution still prevails in the port states of Lagos and Port Harcourt. The desired effect of sustainability in the overall transport sector can only be achieved when the rail system is considered at all levels of the dry port implementation strategy.

MEGAPORTS IN THE WEST AFRICAN SUB-REGION

For now, no port has yet assumed such a position in West Africa. However Maersk line services her West African ports through her Algeciras hub port located outside the region.

In the present, the general feeling is that the region does not generate enough trade to warrant the huge investment of a hub port. This area offers itself for a gravity model assessment. In applying the model, trade between the various nations and their foreign counterparts and the level of trade interaction can be calculated for the various countries. Through this process it will be possible to rank the level of trade entered into by the various countries of the region with other regions like Europe, Asia and fellow African nations.

CONCLUSION

The application of international trade flow data in a model meant for benchmarking the effectiveness of both hub and dry ports is indeed useful, since it advances our understanding of the mechanics and dynamics of the modern concept. It not only supplies theoretical explanation drawn from the field of spatial interactive analysis in Transportation Geography, but further provides a means of port to port comparison on a much broader basis.

For dry ports, the effectiveness of activities in the export source hinterland can thus be captured and compared, dry port to dry port basis. For hub/mega ports, the level of interaction between the megaport and its adjacent feeder ports can thus be captured and measured as well. All of the above are possible areas of application of the gravity model in improving our understanding of the economic behaviours of the dual modern concepts of hub/megaports and dry ports.

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