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REGIONAL HUBS AND MULTIMODAL LOGISTICS EFFICIENCY IN THE 21ST CENTURY

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Abstract

The work assessed the connectivity between hub ports and allied transport networks in the move towards realizing sustainable transport system in the global multi-modal transport supply chain.
The total transport chain connecting the sea, rail and road transport chain or the sea/rail/air chain modifies itself with renewed increasing costs, a good number of which includes additional dredging costs for regional hub ports, infrastructural and super structural costs, for modal and intermodal transfers, dry port construction costs, additional rail infrastructural costs among others.

Keywords: Logistics efficiency, DEA, regional hubs.

New port tariffs have therefore been introduced in such hub ports to absorb the cost effects of introducing hub ports in such regions. The impact of the hub system is not perceived with equal understanding in all water regions of the world. While the south East Asian region, the European water region and the Caribbean region have continued to improve investment in this concept, other water regions are yet to make reasonable investment in this new concept. The hidden issue remains the fact that the rise of hubs, super hubs, and even mega hub ports now constitute a new trend in the multimodal logistics trend of the 21st century. They determine the routes of the multimodal shipping lines in the same way Suez and Panama canal fashion the routes of world shipping trade since the twentieth century.

The technological improvements brought about by improved sea chain transfer demands, efficient intermodal hinterland linkages as well as environmental regulato-

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ry compliance in the face of a dynamic, fast changing port organizational philosophy. Infrastructural changes, institutional changes and technical advancement are compulsory for both the port complexes; otherwise, the efficiency frontiers will reduce the best industry practices of the organizations to an inefficient level.

This work in realization of the above problem has identified areas in the total transport multimodal logistic chain that require improvement. Furthermore, new methodologies applying data envelopment analysis (DEA) and an ecosystems approach were applied in solving the problems of inefficiency in the total multimodal logistic chain.

INTRODUCTION

The continual growth in containerization in the 21st century has forced shipping lines to evolve new methodologies in the handling of excessive capacity problems associated with such growth. The major innovation brought about as solution to this problem is the emergence of hub ports across the major water regions of the world. Hub ports emanate from the struggle of shipping lines operating in a competitive environment to cut costs through economies of scale. The resulting benefits, when analyzed in terms of cost per TEU, are always smaller for large ships.

One definition of hub port is that which defines it as a container port that provides terminal and marine services that handle and facilitate the transfer or transshipment of containers between feeder and motherships in the shortest possible time. Hub ports or load centers provide for minimum ship calls to few ports within an ocean region. Deposited container freight within these load centers are then feedered down the line across the sub-regional ports, and further down to the hinterlands, via connecting infrastructural facilities and existing corridors.

Campbell (1994) defines hubs as facilities that serve as transshipment or switching points, functioning as connection centers among several origins and destinations. Campell (1994) further exposed five types of discrete problems associated with the location of hub ports, thus:

1. P-hub Median problem (P-HM)
2. Uncapacitated hub location problem (UHLP)
3. Capacitated hub location problem (CHLP)
4. P-hub centre problem (P-HC), and
5. Hub covering problem(HCV) (Aversa *et al*, 2005)

The basic requirements for the location of hub ports have been outlined in Baird (2000). Such a port must have, in addition to a natural deepwater and adequate shelter for motherships, the following features:

a) It must be strategically positioned in a geographically suitable location, sufficiently centrally located to serve a large sub-region with minimum feeding costs.

b) A proximate location to trunk routes where deviation time for ships is kept to a minimum, allowing for minimum short-haul transit time.
c) Lastly, there must be an availability of feeder services to ensure door-to-door movements for various origin/destination cargoes, while remaining cost and time competitive at the same time, with alternative service options.

Transport Networks Adjoining Hub Ports

The search for efficiency across the multimodal transport network requires smooth intermodal interface, efficient transfer of unitized cargoes between the hub port and the feedered port, down through the stacking areas to hinterland dry ports etc. The level of attention given by the government and national port Authorities of nations to the provision of infrastructural facilities, appropriate rail linkages, barge transfer facilities and new freight corridors would go a long way to determining efficient intermodal transfer along the transport & logistics supply chain. Ocean regions with well developed hub and hinterland transfer mechanisms derive cost reduction benefits in the overall logistics transport supply chain. The capital invested in constructing hub ports is a recoverable expense via port dues, though.

Planning an efficient multimodal operation with sustainability is no mean task. Such plan must incorporate environmental issues like the reduction of air and noise pollution from trucks and ships, preservation of the marine ecosystems through ballast water control and efficient garbage, sewage, and oil pollution management, yard management at ports, traffic congestion reduction planning; optimal use of rail & barge services to ensure quick evacuation of several origin/destination containers, the use of dry ports, adoption of logistics theories like the lean port logistics productivity theories, etc.

PROBLEMS DEFINITION

The problem of cost reduction drives logistics organizations towards efficiency. To this end the search for better ways of accomplishing tasks has been a continuous exercise. Rising demands by developing nations and the developed world for international cargo has created new types of problems for the port logistics expert. Such problems are bound to rise infinitely unless adequately checked by new innovations.

These new problems commonly appear along the multimodal linkages across the globes in terms of congested traffic at the port gates, excessive cost of goods in developing African nations brought about by excessive transport costs, blocked stacks at container terminals, delays in cargo delivery time, excessive ship turn round time etc.

The construction of hubs in trade regions across the world's seas will certainly reduce shipping costs as well as produce multiplier effects on cargoes. The logistical benefits of sub-regions adopting the hub concept are also numerous. The chief among them would include the adoption of lean port logistics principles incorporating the lean port enterprise. The challenges posed for port authorities would then become basically knowledge centered. This would then mean improvements in applied logistics, port environmental policies, and ecosystems management, to mention but a few.

RESEARCH OBJECTIVES

The focus of this work has to do with the assessment of hub infrastructural sufficiency as an element of the total multi-modal transport logistics chain. Special attention will be given to intermodal interface efficiency, optimal distribution of intermodal transport units in a sustainable transport regime, as well as ecosystems preservation under an exclusive economic zone (EEZ) legal regime. An attempt is made to create models that will capture efficient transport requirements in a hub controlled multimodal logistics chain.

JUSTIFICATION

Previous works have focused so far on sectors of the total multimodal supply chain like hub ports, ports logistics, urban transport management etc. Works focusing on the total multimodal logistics chain is rare to find, thus justifying the need for this piece of research. Wherever they appear, however, only limited variables are considered. New legislations affecting the environment of ports thus require the formation of new models of efficiency and cost effectiveness in the world's new multimodal logistic order.

BRIEF LITERATURE REVIEW

The challenge of multimodal logistics efficiency surpasses the application of a single performance measure. For this reason new empirical efficiency measures are being introduced to analyze different efficiency frontiers across the multimodal logistics chain. These measurement devices are not equally effective in measuring efficiency across the multimodal logistics chain (Talley, 1994). A distinction is, thus, often made between technical efficiency, scale efficiency and allocative efficiency in literature. Under technical efficiency, we have output and input oriented technical efficiencies. The producer on the other hand may reduce input (applying improved technology) given the same output. By the term scale efficiency, the divergence between actual and ideal productive size is measured. In contrast to the above two measures, which only address physical quantities, allocative efficiency studies the cost of production given that the information on prices and a behavioral assumption such as cost minimization or profit maximization is properly established (Coelli et al. 1998; Wang & Cullinane 2005).

DATA ENVELOPMENT ANALYSIS APPLIED TO HUB PORTS & THE TRANSPORT SECTOR.

The application of Data Envelopment Analysis (DEA) to efficiency studies in hub and container ports has concentrated mainly on the measurement of technical efficiency (Wang, Song & Cullinane 2005). This is as a result of different currencies being used by different nations, which makes the application of allocative efficiency literally impossible. Frontier models, of which DEA is an example, are said to have been applied to almost all transport modes including the railroad sector (Wang et al 2005, Oum et al. 1999, de Borger et al. 2002).

Many options of DEA models exist. The principal, however, among these options are the DEA – CCR model and the DEA – BCC model. While the first assumes constant return to scale, the later assumes variable return to scale (Fung & Lee, 2007). In analysis with DEA, the best performing ports usually with 100 percent scores occupy the frontier position, thus making themselves the reference ports. The rest of the ports with lower scores are enveloped within the production frontier line.

In most studies hub ports have always occupied frontier positions in productivity and efficiency measurements, making thus them the benchmark ports at the frontier position (Fung & Lee 2007). These authors, in their work with Data Envelopment Analysis computed their inputs based on the following indicators:

1. Berth length and number of quay cranes were used to reflect berth side productivity.
2. Yard side productivity was reflected by container yard area and number of rubber tired gantry cranes and straddle carriers.

In calculating output, they used container throughputs and number of ship calls. The work considered arguments raised by other researchers on the choice of input and output variables before choosing the above variables. Examples include Notteboom et al. (2000), Tongzon (2001), Cullinane and Song (2003) and Wang et al (2005) amongst others.

Multimodal Transport

Der Horst (2008) outlined four main categories of arrangements to improve coordination in hinterland transport chains.

They include:

1. The introduction of incentives
2. The creation of inter-firm alliance
3. Changing the scope of the organization and
4. Collective action

Notteboom (2008) stated that the emergence of global supply chains has placed intense pressures to implement containerization over inland freight distribution systems. Time, reliability and cost requirements were identified as new problems to which global supply chains must provide an answer.

Among the reasons that necessitated the multimodal transport convention of 1980 includes:

1. The fact that multimodal transport is one means of facilitating orderly expansion of world trade.
2. The need to stimulate the development of smooth, economic and efficient multimodal transport services adequate to the requirements of the trade concerned.
3. The desirability of ensuring the orderly development of international multimodal transport in the interest of all countries and the need to consider the special problems of transit countries, etc UNCTAD (1992).

REPORT OF FINDINGS MODEL FORMULATION

Applied frontier models presently used in determining the efficiency of sea – land intermodal interfaces (ports) ought to be modified to make them suitable for ecosystems efficiency evaluations. Such modification should incorporate at the input side, number of port side environmental processing equipment, MARPOL compliant regulatory enforcement procedures at the port (reflected by port state control agencies), existence of both national and company based port pollution contingency plans and number of existing port security units at the port and within the contiguous zone of the coastal waters.

If we make a distinction between port operational efficiency and port environmental efficiency, then an entirely separate input and output criteria can be applied for environmental efficiency measurement applicable to Data Envelopment Analysis. If we take the variables stated above as the input variables for our DEA environmental efficiency measures, then we are faced with a problem of how to determine the output variables for environmental efficiency.

Unlike the port operational efficiency where cargo throughput is easily available as a measure of output, output variables in environmental efficiency measurements are not easily available. In this paper, we recommend the use of opportunity cost approach. This means that the benefit (output) of port environmental investment is the damage that would have occurred if such investment were not in place. If we choose to limit our measurement at the ecosystems level, we may then represent output as the area of the Exclusive Economic Zone (EEZ) covering the coastal state, along with a value in dollar worth representing the economic richness of the entire zone. This is certainly very reasonable, since the environmental investment is applied as a protective measure to conserve the environment.

Therefore, by applying non parametric frontier measures like the DEA it is now possible to determine operational efficiency and environmental efficiency levels of sea/land intermodal interfaces (i.e. ports). Hubs ports including superhubs, and megahubs will, thus, qualify for major environmental investments in infrastructures given the multiple hinterlands they serve. Inefficiency at hub ports will certainly affect the global supply chain at the hinterlands served by the hub ports.

Multimodal Effeciency

Efficiency is a desirable property, not only at the hub port but also across the whole multimodal transport chain. Efficiency is required at the regional port, and also at the interface between port-to-rail linkage, inland port infrastructure, as well as the hinterland-to- port road network.

In measuring efficiency, different measures ought to be derived for efficiency assessment of the several sectors of the transport logistics chain. The data envelopment analysis (DEA) offers a means for a quantitative efficiency assessment. A qualitative measure is found in the lean port logistics approach (Paixao & Marlow 2003). The volume of rail activity connecting ports to dry ports should be used as an input factor in measuring port-to-hinterland efficiency using DEA. The other factor should include the level of adoption of short sea shipping in the country's cabotage/coastal transport system. This is because both rail and short sea shipping carry more loads, while they contribute to atmospheric pollution less, provided that they follow an appropriate regulatory regime. They are, thus, a more sustainable means of transport than the road system. They are also more cost effective, and as such more efficient. A DEA measurement obtained using these variables as input factors will thus be a measure of both operational and environmental efficiency in the port-to-hinterland logistics chain.

Hub Ports & Multimodal Logistics Effeciency In World's Ocean Regions

Great developments in world's ocean regions already exist in the South East Asian region, the European and Carribbean water regions. Existing hubs in these regions include: the Port of Singapore, Hong Kong, Shanghai in South East Asia, Rotterdam, Algeciras & Limassol in Europe, and Kingston in the Carribbeans, etc.

However, the search for appropriate location for hub ports in the Indian ocean region, the East Atlantic and the South Atlantic coast of South American water regions have been on the increase. While the public sector alone has been slow in welcoming this innovation, a combination of public-private sector initiatives in the West African sub region has advanced the hub struggle to a point of possible realization in the Lekki region of Lagos (EPZ), Nigeria.

The adoption of hub ports by shipping lines is due to its scale economy advantage, resulting in less cost per ton-mile, as well as cost savings in marine bunkers. The efficiency level will be further increased if coastal shipping and rail connectivity to dry ports is made an issue of national concern in all the port regions of the world.

This will reduce congestion of road vehicles at ports, thus reducing idling of wagons at port gates as well as noise and air pollution at the port gates, a common problem in present day ports, all over the world. The diagram below will illustrate this further.

The Figure may be described as our efficient multimodal logistics model. It proffers a link between hub ports, regional ports, and the port hinterland.

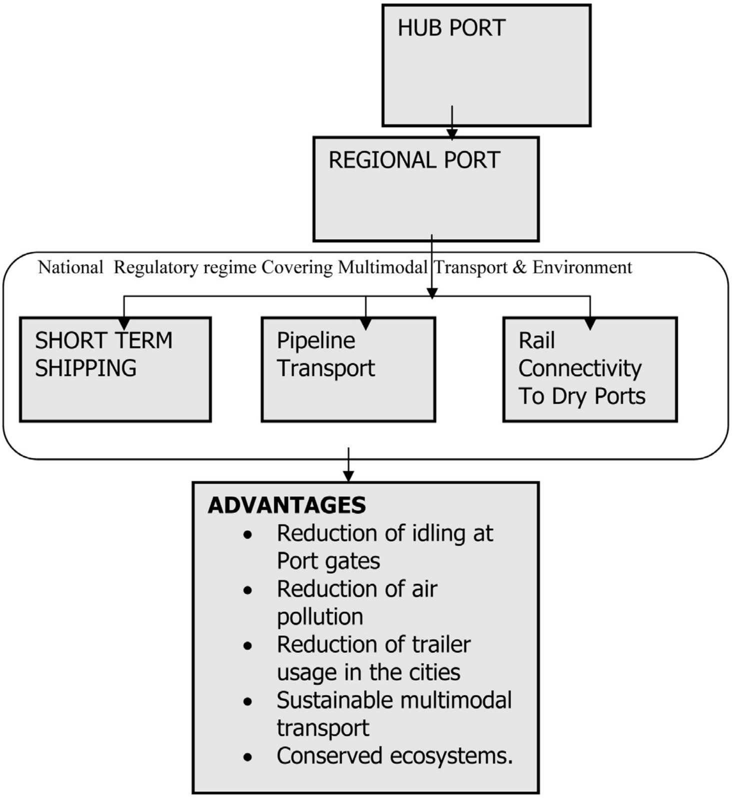

Figure1. Efficient Multimodal Logistics Model.

Further down the line goods are transferred to the hinterland via either the short sea shipping route or the rail lines connected to dry ports. Where this is made a matter of national regulation, the resultant benefits would then include the following:

— reduction of air pollution;
— reduction of idling of trailers at port gates;
— reduction of trailer usage in the cities,
— and overall sustainable multimodal transport and conserved ecosystems.

CONCLUSIONS

The application of frontier efficiency models in evaluating port performance should advance in the direction that will assess environmental efficiency of ports. Thus, variables included in the data envelopment analysis ought to include data that will reflect the number of port side environmental processing equipment.

Furthermore, an efficient multimodal logistics model useful in all the five ocean regions of the world was developed. Reference has been made to its inherent advantages, the most important of which is the development of a sustainable multimodal transport system.

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REFERENCES

Aversa R., Botter R.C., Haralambides H.E.and Yoshizaki: HTY (2005): A mixed integer Programming Model on the location of a Hub port in the East Coast of South America

Baird A (2000): Establishment of a container Transshipment Port in Scapa Flow; TRI Marine Transport Research Group/Napier University.

Campbell J.F (1994): Integer programming formulations of discrete hub location problems, European Journal of Operations Research 72.

Coelli et al (1998) An introduction to efficiency and productivity analysis. Kluwer Academic Publishers

Cullinane and Song (2003): A stochastic frontier model of the productive efficiency of Korea container terminals. Applied Economics 35, 251 – 267.

Der Horst M.R.V (2008): Coordination in Hinterland Transport Chains: A Major Challenge for the Seaport Community;

Fung and Lee (2007): Productivity Analysis of container ports in Malaysia: A DEA Approach : Proceedings of the Eastern AsianSociety of Transportation Studies. Vol.6, 2007

Notteboom Theo (2008): Containerization, Box logistics and Global Supply Chains; The Integeration of Ports and Liner Shipping Networks: Maritime Economics and logistics 10, pp. 152-174, palgrave.

Talley (1994): Performance Indicator and Port performance Evaluation Logistics & Transportation Review, 30(4), 339-352

Tongzon (2001): Efficiency measurement of selected Australia and other Intrnational ports using date Envelopment Analysis. Transportation Researcg port A. Policy & practice, 35 (2), 113-128.

Wang, T.F and Cullinane K.P.B (2005): Measuring the Economic Effeciency of Europe's container terminate International Association of maritime Economics, Annual conference, limassol, Cyprus, June 23 - 25

UNCTAD/UNDP (1992): Multimodal Transport Handbook . UNCTAD.