**PORT PERFORMANCE AND CRUDE OIL EXPORT LOGISTICS SYSTEM DISTRIBUTION IN NIGERIA**

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**Introduction**

This paper aims to explore strategies to improve port performance in crude oil export logistics system distribution in Nigeria. In addition, it aims to show the results and implications of the proposed strategies using Analytic hierarchy process (AHP) to determine their relative importance. The most pressing challenge is to ensure secure, efficient, effective, and sustainable supply chains of crude oil as a commodity. An important supply chains management issue involves port performance logistics in crude oil flows towards long-term benefit for all supply chain stakeholders in support of a healthy global economy. There is an increasing perception of high costs of doing business in Nigeria, and an inability to explore competitive advantage, hence causing delay for effective and efficient supply chain management (SCM) particularly in crude oil flows. Annual Ease of Doing Business Report (World Bank Report 2016), Nigeria ranks 169 among 189 countries with Mauritius ranking 32 as the best port in Africa. Report indicators showed that trading across the borders, which is a measure of a country’s port effectiveness; present a more depressing ranking of 182 out of 185 countries.

Further, World Trade Organisation (WTO) found that delays and other costs of moving goods in developing economies including Nigeria were equivalent to a 219 *percent tariff*. This invariably affects crude oil export logistics systems. “One day lost because of some logistics error means millions of dollars lost… cost of logistics in countries like Nigeria could be as much as 30% cost of a project total” (McKinsey, 2010). An - integrated logistics framework of customer services is significant in this study. Nigeria has many competitors including the Middle East, the USA, and some African oil producing countries, which export crude oil to international market. Thus, this paper’s contribution is about finding possible empirical measures of port performance in crude oil flows, which influence effective and efficient logistics, SCM, trade facilitation, and have an overall effect on socio- economic development of crude oil exploration and producing nations or companies in general. AHP is a popular multi criteria decision marking (MCDM) tool for formulating and analysing decision and its application to a decision problem involves four basic steps (Zahedi, 1986).

**Review of relevant literature**

**Measures of port logistics efficiency in oil transport using AHP techniques**

Pipelines are the most important and safest means of transporting bulk energy, as the economy of a country can be heavily dependent on smooth and uninterrupted operations of pipelines (Dey and Gupta, 200). Their considerable significance in ensuring smooth logistics operation of oil transport cannot be understated; oil pipeline projects are valuable investment decisions. Dey, (2004) explored AHP framework techniques to evaluate projects in the Indian oil pipeline industry to arrive at consensus decisions on project selection through the involvement of stakeholders. The sample size covered all project stakeholders’ requirement and concerns. This project spanned owner, managers, consultants, suppliers, contractors, community, government ministry, and so on. The comprehensive sample is instructive to the present study. Moreover, this present study draws all stakeholders in the crude oil export supply chain in Nigeria. Thus, the output of the study is largely relevant to current study. In addition, in the present study, Nigeria needs continuous investment to upgrade pipelines either offshore or onshore, as empirical data showed that outdated, ageing pipelines needs replacing with a modern and risk averse, and technology driven pipelines to meet international best practices. In addition, the utilisation of AHP technique in this study can prioritise strategies to improve port performance in crude oil export logistics in Nigeria. The impact of efficient pipeline on logistics is immense as it reduces pipeline attacks and thus, makes them less susceptible to militant attacks, leaks and sabotage.

Dey, (2004, p.599) concluded that feasibility analyses of pipelines projects are presently conducted within a fragmented framework with many studies occurring prior to impact assessment, however, there are varied opinions and expectations of stakeholders input in the survey which led to desired decision of site selection. Thus, they found out that prioritising environmental and social factors for site selection problem would not only ensure a sustainable development, but also keep organisational productivity up, as it ensures interrupted operations with minimum failure throughout its life. The time and cost are critical physical performance indicators raised by (Dey, 2004, p.603) model, as the project under study completed successfully in 1999 without time or cost overruns. In contrast, these have impact on the logistics chains for instance Nigeria’s historic poor environmental and social factors as both empirical and archival data revealed appears hindering efficient, effective cost logistics, as some of the pipelines need upgrading to modern standard. This model can be apply whenever pipelines projects are required in crude oil supply chains. There is increasingly need for a deep-water seaport in the development of a modern economy, for instance Baltic Sea is an arterial transport corridor between Eastern and Western Europe. Zavadskas et al., (2015, p.180) used AHP and Fuzzy ratio assessment methods to propose a model that could be implemented in the development of deep – water seaport in Klaipeda. They found out facility locations decision are a critical element in strategic planning for wide range of private and public firms. This could be replicated in the current study particularly in the development of offshore/ onshore fields to find most appropriate facility location to avoid supply disruption in the chains. One comparison alternative criteria they used, and that is very relevant to this study is accessibility to the marine terminals for calling vessels. Qualitative data and observation by the author reveal some smaller joint venture oil-producing firms have challenges with dredging and hinders safe and easy access to export terminals during loading operation. The proposed model can be used to improve accessibility to marine terminal and this has huge impact on operating cost, for instance maritime insecurity has huge impact on operating cost, finding appropriate location prior to design is critical. For instance, empirical data show the whole logistics systems in Nigeria definitely suffered from a degree of investment such as occasional frequent breakdown often subsea lines, which have to be taken out of the export systems, and that reduces loading rate of vessel, lead to variations in exporting rate hence disrupting supply chain distribution network. There are similarities and differences between this study and present one. Both are case studies and used AHP technique aimed at proposing strategies for a competitive and attractive port strategic management. The major difference is in the use of fuzzy additive ratio assessment (ARAS) method and secondary data while current study use mixed methods.

Cargo loading operation is one of the most critical shipboard operation on board oil/chemical tanker due to nature of the work, hence maintaining safety operation for effective logistics system during oil shipment is vital. Akuz and Celik (2016, p.424) studied a hybrid error probability determination approach that involves case of cargo loading operation in oil /chemical tanker ship. They deployed human error assessment and reduction technique (HEART) and AHP method to determine human error probability (HEP), due its importance in the marine industry (Williams 1988). Their proposed a model is useful in marine operation such as cargo loading and discharge, which is central to current study. In particular, measurement of cargo quantity such as fixed tank gauging systems measure ullage locally and readings are usually displayed remotely on monitor in cargo control room. Qualitative data revealed differences in ship-shore difference tend to be quite significant sometimes, although measures like OUT Turn on delivery is used to mitigate this, nevertheless, its cost implications to supply chains partners has huge impact on operating cost, revenue, market reliability and could lead to disagreement on quantity loaded. More importantly, human error/ factor in gauging requires human capital investment in training and retraining on industry latest manual of petroleum measurement standard (MPMS) for custody transfer particularly for manual measurement. Akuz and Celik (2016, p.430)’s proposed solution in the design of user-friendly software which appears useful to transform operational task scenario in database into meaningful information for prediction HEP. Thus, technology would play a critical role in reducing human error element for reliable accurate metering system showing metred quantities for use as Bill lading data, thus, digitizing or standardising this will go a long way to definitely re- established confidence and accuracy of measurement.

**Nature of the problem**

The pressing challenge, which is overall research question; How can Nigeria improve its port performance and crude oil export logistics systems

**Methodology**

In March 2016, a qualitative study involving scoping interviews with nine experts in crude oil export supply chains was undertaken to understand the issues of concern. The results were analysed using informal ethnographic content analysis (ECA) as this allows categories to emerge ( Bryman and Bell, 2015, p.300). Some of the categories that emerged are “training and retraining, improve security architecture, lack of modern technology, security threat to operation, difference in quantity of crude oil lifted, inadequate funding model, clarification of contract models, changes in date of lifting programme”. In addition, “crude oil theft/ loss, deployment of new technology for pipeline protection, documentation, crude oil loss, multiple taxation, ineffective information sharing among stakeholders, maritime insecurity, and dispute over entitlement, and operational delay were identified”. This resulted in inferences and subsequently hypotheses that guided semi -structured interview questions and two phases of interviews. Next, twenty semi- structured depth interviews were conducted followed by four focus groups and documentary analysis of shipping and news sources. Fourteen items for improvement strategies were formed from a template of issues gleaned from the empirical data. The author used Likert scales to measure respondent’s attitude after which se*ven* items emerged; then used as instrument for experts to rank using AHP technique.

**Research Method**

**Basic steps of AHP techniques**

*First, the author decomposed the decision-making problem into a hierarchy of seven criteria as seen in figure 1.* A typical hierarchical structure is developed consisting two levels: Objective and a category. There are seven possible improvement strategies gleaned from empirical qualitative data*. Second, a pairwise comparison and establishing priorities among elements in the hierarchy. Third, synthesis judgements in order to obtain the weight for achieving goal, finally evaluation and checking of consistency of judgement. In this case, each element* were compared with the corresponding level. . The pairwise comparism were done on a nine-point scale (Saaty and Kearns 1985). The author chose the following words to represent the scale key: 1 = Equally important, 3= slightly more important, 5= strongly more important, 7= Demonstrably more important, 9= Absolutely more important. In addition, calibrated on the numerical scale: n (n-1)/2 comparisons. Where n is the number of elements with considerations that diagonal elements are equal to or one and the other elements will simply be the reciprocals of the earlier comparisons.

The author-performed calculations using excel spreadsheet to find the maximum Eigen value, consistency index (CI), consistency ratio (CR) and normalised values for each criteria.If the maximum Eigen value, CI, and CR are satisfactory, then decision taken based on the normalised values; else, the procedure was repeated until these values lie in a desired range. This method appears most appropriate to propose improvement strategies for this study. After building the AHP hierarchy, the next phase is measurement and data collection. Qualtrix software was used for the survey. See below a graphic summary of response rate in table 1. Some of the respondents were contacted via email invite on Qualtrix. Due to sensitivity of the research, some of the respondents were not willing to respond immediately; this could be due to busy schedule, vulnerability to piracy, company policy, inadequate knowledge and or lack of interest. However, the completion time for the survey is approximately 13 minutes. In addition, some of them complained about the questionnaire link expiration and the author was able to know during follow up call or reminder. Therefore, a new link sent again in order to get sizeable number of respondents. See below Figure 1 showing AHP model for this study.

**Level 1: Goal**

**Some strategies to improve port performance in crude oil export logistics system distribution in Nigeria**

Criteria

Source: (Author, 2018)

Figure 1: AHP Model for Port performance and crude oil export logistics system distribution in Nigeria

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Distribution channel  | Audience | Survey started  | Response rate  | Uncompleted  | Completed  | No response  | Completion rate |
| Invite over email | 79 | 18 | 14 | 5 | 17 | 11 | 67% |
|  |  |  |  |  |  |  |  |
| Anonymous link  |  |  | 1 |  |  |  |  |
|  |  |  | 18 |  |  |  |  |
| **Total**  |  |  | **33** | **11** | **17** | **11** | **67%** |

Table1: Distribution summary of AHP Survey

**RESULTS /ANALYSIS**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Criteria | A | B | C | D | E | F | G |  |  | Normalised weight | Percentage | Rank  |
| A | 0.133 | 0.052 | 0.026 | 0.036 | 0.030 | 0.076 | 0.017 |  | 0.369 | 0.0528 | 5.28 | 7 |
| B | 0.331 | 0.130 | 0.091 | 0.091 | 0.091 | 0.226 | 0.039 |  | 1.000 | 0.1428 | 14.28 | 4 |
| C | 0.321 | 0.092 | 0.064 | 0.052 | 0.075 | 0.122 | 0.038 |  | 0.764 | 0.1091 | 10.91 | 6 |
| D | 0.386 | 0.151 | 0.130 | 0.106 | 0.087 | 0.187 | 0.042 |  | 1.088 | 0.1555 | 15.55 | 3 |
| E | 0.434 | 0.139 | 0.083 | 0.118 | 0.097 | 0.109 | 0.019 |  | 0.998 | 0.1426 | 14.26 | 5 |
| F | 0.516 | 0.170 | 0.153 | 0.166 | 0.261 | 0.294 | 0.038 |  | 1.599 | 0.2285 | 22.85 | 1 |
| G | 0.352 | 0.149 | 0.072 | 0.120 | 0.167 | 0.337 | 0.043 |  | 1.241 | 0.1772 | 17.72 | 2 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2.473 | 0.883 | 0.619 | 0.689 | 0.807 | 1.351 | 0.238 |  | 7.059 | 1.008 |  |  |

***Note: Consistency index (CI) =, 0.025568, Consistency ratio (CR) = 0.01937***

**Table 2: Preference order of 17 group decision makers (DM) AHP Result**

**Source: (Author, 2018)**

**Fig 2: Graphical representation of 17 respondents Group DM showing performance comparisons of criteria**

**In this section, the result of analyses on the preference order of major strategies for a combined group Decision Making (DM) compose of 17 respondents and four sub groups span crude oil traders, cargo analyst, academics with expertise in oil supply chain, crude oil export regulators and terminal operators managers. However, only group DM and terminal operators’ sub group were consistent. In essence the CR are less than 0.1, hence, consistency matrix is acceptable (Saaty, 1980). Further, can be useful and acceptable in the decision making; and selection process (Dagdeviren et al. 2009, p.8144).**

**In addition, other categories show fair idea of respondent intangible qualitative criteria alongside quantitative criteria (Badri, 1999, p.240). See above table 2 and 3 for result of both combined group and terminal operator’s sub group DM responses respectively.**

**First, combined group DM showed that information sharing and synergy between terminal operators and Nigeria security forces in oil and gas security courses and training to be highest with 0.2285 (22.85%) score above all other strategies. In the same vein, one of the interview empirical evidence supported this finding as seen below.** “However, at times, if there is any communication gap between Nigeria’s state oil company and Nigerian Navy (NN), Navy do arrest our export tanker. For instance, if an officer will transmit a message to NN and then probably is on Friday and the person that supposed to send signal to Port Harcourt or Lagos or Warri was not available and then the vessel came during the weekend. If they do not have the vessel name on the list, they do arrest. Nevertheless, we do try to make sure they release vessels as at when due” (Crude oil export supply chain manager, February 2017). Inadequate information infrastructure result to information delay could result to demurrage, thus increasing cost of logistics, which impact all the stakeholders in the supply chains.

Second, introduction of anti- piracy law with (0.1772) 17.72% score, which is a backdrop of maritime insecurity. For instance, an informative quote from crude oil trader with immense experience on Nigeria’s crude oil flow said”

*“*Nigeria has a bad reputation even doing vessel fixtures; vessel owners will charge you something known as “additional war risk” even to go Nigeria, this is something reserved for conflict zone areas known as conflict zone. Nigeria has picked up this reputation very unsafe place to load crude may be unsafe; definitely a place to be courteous when loading crude which has been the main problem the country has faced which is understandable. Occasionally, vessels have been fired upon offshore/onshore by militants but it is not the norm it is an exception. Still, occasionally bunkering is an issue with complexity from certain authority as well, maritime authority either Navy, customs have been found to be complicit” (crude oil trading manager in one of the world leading trading company, 16/02/2017). Furthermore, attacks in the gulf of Guinea account for more than 40% of global total in first of 2018, says International Maritime Bureau (IMB). The impact is that supply chain actors expected to load cargoes particularly the ship owner want money, the cargo buyer and receiver would be disappointed because they have schedule something to happen and it does not happen due to unavailability this leads to reputational issues, and discount of Nigeria’s crude price despite its quality, which is sweet crude with low.

Third, modern technology for capturing shipping document with accumulated weight of 0.1555 (15.55%). In essence, empirical qualitative study show excessive manual documentation during vessel clearances, information exchange among terminal operators; this is buttress in subjective view of senior official of an export terminal. “At times, you can hear some paper missing; if there is a way that a particular lifting can be trapped. May be; there is a system we can enter some information anywhere it goes, whether this paper got missing, we should not get worry of as nothing is going to happen, it will go a long way as things are changing”. The fourth and fifth are a reliable accurate metering system and increase in security boats, platform and capacity with accumulated weight of 0.1428 and 0.1426 respectively, the former is slightly higher than the latter with 0.0002 that is infinitesimal, implying that are virtually the same in hierarchical structure. More importantly, standardising measurement is critical for efficient logistics and in particular, supply chain and this will reduced impact of ship shore difference largely. Thus, increase add value-to the value chain by increasing level of trust on agreement on quantity loaded during crude loading operation. Further, the sixth criteria is simplifying cargo scheduling and marketing with a score of 0.1091 (10.91%) and lastly, presence of government officials during crude oil loading operation. This appears the least important one as empirical evidence from qualitative interview showed disagreement within those professional engaged in crude oil supply chains. For instance, some of the interviewees have divergent opinion on numbers of government/ regulatory officials during crude oil loading operation; issues raised are duplication of roles, unnecessary inspection despite presence of agreement of crude oil sales contract among parties. Nevertheless, there was consensus on a few numbers instead of too many people, standard practice requires keeping number of visitors to a minimum and all must be accredited.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Criteria | A | B | C | D | E | F | G |  |  | Normalised weight | Accumulated weight | RANK |
| A | 0.027 | 0.009 | 0.018 | 0.019 | 0.053 | 0.048 | 0.021 |  | 0.195 | 0.028 | 0.028 | 7 |
| B | 0.189 | 0.062 | 0.123 | 0.045 | 0.075 | 0.048 | 0.035 |  | 0.576 | 0.082 | 0.11 | 6 |
| C | 0.189 | 0.062 | 0.123 | 0.134 | 0.125 | 0.143 | 0.105 |  | 0.880 | 0.126 | 0.236 | 4 |
| D | 0.189 | 0.186 | 0.123 | 0.134 | 0.125 | 0.143 | 0.105 |  | 1.004 | 0.143 | 0.379 | 3 |
| E | 0.189 | 0.310 | 0.368 | 0.401 | 0.374 | 0.429 | 0.315 |  | 2.386 | 0.341 | 0.72 | 1 |
| F | 0.081 | 0.186 | 0.123 | 0.134 | 0.125 | 0.143 | 0.315 |  | 1.106 | 0.158 | 0.878 | 2 |
| G | 0.135 | 0.186 | 0.123 | 0.134 | 0.125 | 0.048 | 0.105 |  | 0.855 | 0.122 | 1.00 | 5 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |  | 7.000 | 1.000 | 1.00 |  |

***Note: CI= 0.098, Consistency ratio (CR) = 0.074***

**Table 3: Preference order of Terminal Operators Group Decision Makers (DM)**

**For the terminal operator sub group an increase in security boats, platform and capacity is the main area of concern score = 0.341 because they see maritime insecurity as a pressing challenge in the crude oil export value chain. Hence increasing cost of logistics, from this perspective leads to increase in cost of chartering and likely demurrage, which reflects on the cost of tanker delays in port. Second, Information sharing and synergy between terminal operators and Nigerian security forces in oil and gas security, pipeline security courses and training score 0.158 has a link with the first scenario, because effective information sharing is key to curbing maritime insecurity. Next were modern technology for capturing shipping documents 0.143, simplifying cargo scheduling and marketing 0.126 and introduction of anti- piracy law 0.122 and a reliable accurate metering system showing metred quantities for use as Bill of lading data 0.082. E- Documentation remains a challenge in international supply chains due to limited trust, regulations and cyber security threat (Mei and Dinwoodie, 2005, p.198). Thus, despite some increasing electronic transfer of some shipping documents, manual documents predominate. Presence of government officials 0.028 was rated lowest.**

**Discussion**

**Implications for theory**

New areas worthy of consideration emerged in the logistics operation of crude oil flows including information sharing, a reliable accurate metering system showing metred quantities for use as Bill of Lading data and a need for anti – piracy law specific to Nigeria. Strategies for improvement are grounded in the experts’ knowledge, which can be replicated. **Academic literature emphasized that accurate information flow is central among supply chains links in a timely, coordinated fashion, which minimizes distortion; structured information management lies at the heart of SCM (Hull, 2002, p.8, Singh, 1996, p.28). Empirically the highest global weight complemented prior academic literature on information flows, in particular information sharing and synergy among the supply chain collaborators in Nigeria’s crude oil flows. These were supported by interview data.**

**Implication for industry/practice:**

An automation system for pipelines, inventory security systems and SCM concepts in logistics operation are central for efficient, effective SCM in crude oil flows and thus ensuring access to sustainable, affordable, and reliable sources of energy from Nigeria to the international oil market. In addition, other key items that needs improvement are legislation, training, effective electronic communication and information infrastructure. For Nigeria to have an edge over its competitors these empirical strategies are needed to optimise port performance and crude oil export logistics system distribution. *AHP assist in understanding the preference order of major criteria/attributes and proposing sustainable optimisation strategies.*

**Policy implications**:

In an era of increasing global oil demand despite increasing growth in an evolving transition scenario, there is an urgent need to shift from a traditional business model to a more modern model. The model must that accommodates challenges including climate change, collapse in oil prices, maritime insecurity/ geopolitical risk, investment in infrastructure (information infrastructure, digital technologies for efficient processes), and peak oil in an increasingly competitive market and a sustainable regulatory framework. Future research will be required to focus possibly focus group on monitoring and as well action research with terminal operator managers on strategies to curb maritime insecurity and safety of people.

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