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Econometric Analysis of Domestic Transportation of Refined Petroleum Products in Nigeria

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Abstract: The Nigerian petroleum industry was born in 1956 following the discovery of the first commercially viable oil well at Oloibiri, in today's Bayelsa State. The country's first refinery was founded in 1965, since which time refined products are transported domestically by road, rail, pipeline and waterway, although the rail system has been comatose since the military era that ended in 1999. The study had the objective of determining which mode-pipeline, road or waterway- is more important in domestic carriage of white products since 2000. Adopting the methodology of econometrics, data relating to total volume of products transported, in millions of cubic metres, were sourced from the pipelines and products marketing company, along with the corresponding modal distribution. Treated specifically to the analysis of variance technique, the results obtained were F* = 0.870843801 (observed) and F = 3.89 (theoretical), leading to the conclusion that all three modes are basically of equal impotance in their contributions to domestic conveyance of white products.

Key words: Pipeline, road, waterway, refined products

INTRODUCTION

From the standpoint of international transportation economics, deep-sea shipping dominates the conveyance of petroleum products around the world. Jazayeri and Yahyai[1] using industry sources, claim that as much as 57% of the world oil, approximately 2,000 million tones, was transported by sea in 2001. This is in keeping with expectation. To begin with, most of the world's reserves of oil are deposited in the eastern hemisphere while the voracious consumers are of western location, Secondly, the consumers and producers are separated by the world's oceans, so that the only economical way of supplying the needs of western oil guzzlers from eastern surplus producers becomes the maritime option.

This pattern does not, however, replicate itself in domestic transportation in many countries, especially if they are endowed with extensive land mass. In the United States of America, the pipeline is by far the most important mode of domestic transportation of both crude and refined petroleum products. According to the American Association of Oil Pipelines, AOPL (2000), of a total oil transport of 6,400 billion board miles, BBM, rail accounts for 2%, trucks 3%, water carriers 27% and pipelines 68%. This distribution is attributable to comparative cost economics. Wilson[2] states that oil pipeline shipments account for more than 17% of the total freight moved nationally in the US but less than 2% of the national freight cost.

To further highlight the advantages of the pipeline in domestic oil transportation, Trench[3] estimates that if each truck holds 200 barrels and can travel 500 miles a day, it would take a fleet of 3000 trucks, with a truck arriving and unloading every 2 min, to replace a 150,000 barrel per day, 1000-mile pipeline.

Nevertheless, pipeline development in Sub-Saharan Africa has been constrained by financial bottlenecks, management incompetence and the issues of oil spillage and pipeline vandalisation. Nigeria has Africa's largest network of pipelines with a total length of about 5,000 kilometers. While some of the pipelines are underwater others are used on or under land. Most lines are multi-product in transportation and are all under the management of the Pipelines and Products Marketing Company PPMC, a subsidiary of the Nigeria National Petroleum Corporation, NNPC. The role of the pipelines in oil transportation in Nigeria has been documented by Dacon Associates[4], Petrostrategies[5] and Nnadi[61].

Yet, road transportation remains the most patronized mode in Nigeria. It is repeatedly estimated that more than 90% of Nigeria's goods and passenger movement is accounted for by the road mode[7-9].

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In petroleum products transportation in the country, road haulage continues also to be prominent. The significance of road haulage in this respect is what gave rise to the principle of zerorisation. The zerorisation principle, according to Mesaf[10] was adopted to ensure that positive and negative transportation cost differentials will zero out to ensure the maintenance of a uniform pricing mechanism for pump prices nation wide. It was operated by the Petroleum Equalisation Fund Management Board. Petroleum products tankers operating on Nigeria roads were estimated at 6,000 in October 2002[6].

The basic objective of the study is to determine which of the modes-pipeline, road and water way is more significant in the domestic transportation of white petroleum products in Nigeria.

The study is predicated on the need to provide answers to such questions as-which mode contributes more to fuel conveyance in Nigeria? Is the pipeline overwhelmingly dominant in Nigeria as it is in the US? Does the apparent predominance of the road in Nigeria's transportation operate in the realm of petroleum products movements? Does the Nigerian waterway system, whether coastal or inland, contribute at all to fuel transportation domestically? If it does, how much, relative to the better-known and more visible pipeline and road?

These objectives, pursuant to their accomplishment, generate a hypothesis.

The hypothesis: The hypothesis governing the study is stated as:

- There is no significant difference in the volume of refined petroleum products within Nigeria transported by pipeline, road and waterway.

The corresponding alternative hypothesis is

- There is significant difference in the volume of refined petroleum products transported within Nigeria by pipeline, road and rail.

METRIALS AND METHODS

The methodological approach adopted as appropriate in pursuit of the study objective and for the testing of the stated hypothesis is the analysis of variance, ANOVA. The aim of ANOVA is to detect differences among several population means. In this respect, ANOVA is applied in a bid to find out if there is real difference among the mean volume of refined petroleum products transported by the modes pipeline, road and waterway.

Procedurally, the ANOVA applied here entailed first, the sourcing of raw data from Nigeria's PPMC. The data is then processed to yield the source of variation between the modal means, or the treatment sum of squares, the source of variation within the modal means, or the error sum of squares; and finally the ratio of the former to the latter, from which emerges the test statistic, the observed F, or F*. The F* is compared to the theoretical F from Tables.

If it happens that

F* > F, the hypothesis is

Rejected, that is, there is significant difference as stated in the alternative hypothesis.

On the other hand, if

F* < F, the hypothesis is Accepted, meaning that, there is no significant difference among the means as stated.

Presentation of data: Transportation of petroleum products in Nigeria

	Pipeline	Road	Water	Total
2000	4.450476	8.627373	8.117966	21.195815
2001	3.564055	5.501113	5.732255	14.797423
2002	2.678744	3.608185	3.344323	9.631252
2003	2.127751	3.227238	2.444424	7.799413
2004	1.900256	2.605302	1.445423	5.950981

Source: PPMC. All in million Cubic metres

Analysis of data: The following tabulation is used to present intermediate results consisting of descriptive statistics.

	Pipeline	Road	Water	Total
$\sum x$ (sum)	14.721282	23.569211	21.084391	59.374884
X(mean)	2.9442564	4.7138422	4.2168782	11.8749768
$\sum x^2$ (sum of squares)	47.82319127	134.9154717	118.009072	300.747735

Further processing of the above results in compliance with the methodological stipulations of econometrics generates the following ANOVA Table.

Source of variation (1)	Sum of squares (2)	Degrees of freedom (3)	Mean square (4)=(2):	3)F*(test (statistic) (5)
Between the Means	8.329955595	3-1 = 2	4.164977798	4.164977798/
Within the Means	57.39230558	15-3 = 12	4.782692132	4.782692132 =0.870843801
Total Variation	65.72226117	15-1 = 14		From tables F0.05=3.89 V_1=2, V_2=12

Presentation of results: From the analysis of variance Table just presented, the results are

Observed F (F*) = 0.870843801

Theoretical F = 3.89 at the 5% level of significance, with

V_1=2 and V_2=12.

Findings: From the results presented in the preceding section, it is found that the test statistic

F* = 0.870843801 while

$F^{0.05}_{2.12}$ = 3.89

That is, F* < F 0.05

RESULTS

Given that F* < F0.05 the convention requires that the null hypothesis be accepted. It follows that the hypothesis governing the study, namely, that there is no difference in the volume of refined products transported by pipeline, road and waterway within Nigeria, is upheld. It should be remarked that the theoretical (or critical) value of F is the value of F that defines the critical region of the test at the chosen level of significance.

If the two variance estimates, one 'between' and the other 'within' the means are close to each other, their ratio will approach the value of one. In this study, our sample produces a result showing a relative closeness between the means and an F ratio close to one. The value of the F ratio in this case is interpreted to mean that the means tested are not statistically different from one another. What this boils down to is that the three modes are basically equal in their contribution to domestic transportation of refined petroleum products within Nigeria.

DISCUSSION

In the foregoing sections, analyses provide a basis for the upholding of the hypothesis defined to govern the study. Additionally, all the questions raised in support of the objectives can now be answered against the background of results obtained and the corresponding answers.

To begin with, the question as to which mode contributes more to fuel conveyance in Nigeria now has a straight forward answer. The mean volume of petroleum products transported by the different modes do not show any statistically significant difference. It follows that no mode can claim any superiority over the others in fuel movement within Nigeria.

Also, the poser was raised whether the pipeline was overwhelmingly dominant in Nigeria as in the US. The answer has now emerged. It is NO. The results indicate that the pipeline is not ahead of any of road or waterway. The value of the critical F has shown that there is no difference among the three means.

Furthermore, it was asked whether the apparent predominance of the road mode in goods and passenger connectivity also replicated itself in the specific area of petroleum products haulage. To this also a ready answer has been provided. The predominance of the road does not extend into domestic transportation of refined products. Results produce the findings that, as a matter of fact, the road only carried as much as the pipeline and the waterway, leaving no rooms for any claims of superiority.

Finally, it was questioned whether the waterway, whether coastal or inland, did make any contribution at all to fuel transportation domestically. The response now is Yes. In fact, findings are that the waterway is of equal domestic fuel transportation significance as the road and waterway.

This result, however, it must be admitted, is fairly curious owing to the relatively backward condition of the inland waterway system in Nigeria. Estimated at about 3000 kilometers, the inland waterway system is based on the drainage formed by the River Niger[11]. The River Niger traverses a total length of 4,100 kilometer of which a run of about 1,271 kilometers occur in Nigeria. With a total drainage area of 1,869,000 square kilometers and a maximum discharge of up to 30,000 cubic meters per second (cumecs), the Niger ranks with the largest rivers in the world. Although there exists the Nigerian Inland Waterways Authority (NIWA), the waterway system is bedeviled by the problems of rickety and battered watercraft, lack of transport infrastructure and poor terminal facilities. It is therefore a bit flabbergasting to find that, in domestic fuel transportation, the waterway is rated equivalently with the pipeline and the road.

A further curiosity in the finding is that the pipeline did not emerge with any superiority in rating. It has come to be accepted as a fact that pipelines constitute the irreplaceable core of Nigeria's petroleum transportation system and therefore the key to meeting petroleum demand[2,5]. The conventional expectation is thus that the pipeline would transport more than the other modes, domestically, which is contradicted by our findings.

The finding also does not conform with the facts of the American situation. According to Trench[3], pipelines carry more than two thirds of petroleum transported domestically in the US, with its network of approximately 55,000 miles of crude oil trunk lines and 95,000 miles of refined product lines.

These findings logically lead to certain conclusions.

CONCLUSION

Juxtaposing the results of the analysis of variance on the one hand, to the governing hypothesis and study objectives on the other, the conclusion that visibly emerges is that the pipeline, the road and the waterway are of equal significance in the domestic transportation of refined petroleum products in Nigeria. What this boils down to is that none of the modes commands superiority over the others in fuel movement within Nigeria.

First, it is recommended that transportation authorities in Nigeria accord formal recognition to the importance, jointly, of the different modes of transport in the movement of freight and passengers in the country. The facts on ground currently indicate an excessive skewness in public sector resource allocation in favour of the road. There is almost a total negligence of all the other modes. For instance in the on-going National Economic Empowerment and Development Strategy, NEEDS, only road construction and rehabilitation is categorized as a priority sector.

Second, more effort should be applied to beef up security in pipeline operations. Insecurity in the pipeline sub sector is principally predicated on the high incidence of pipeline vandalizations[13-15]. With its nativity in October, 1995, pipeline vandalization has escalated in the country. The PPMC reported over 500 cases of vandalisation between 1997 and 2000 and over 180 cases in the first seven months of 2000 alone. If these acts of sabotage which severely compromise the integrity of the pipeline system are brought under control, the transportation significance of the mode will record a tremendous improvement.

With respect to the inland waterways and the coastal maritime trade in Nigeria, there exist the need to build up capacity by massive but phased dredging of the Rivers Niger and Benue. The purpose this would serve is two-fold. First, to ensure all season navigability of these major waterways and second, to enhance the capability of the waterways to handle heavier watercrafts in order to maximize the advantages of economics of scale.

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