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# ESTIMATING THE RELATIONSHIP BETWEEN GDP AND FREIGHT TRANSPORT VOLUMES IN ECOWAS NATIONS

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**ABSTRACT:** *This paper shows the effect of changes in GDP of ECOWAS countries on the growth of their freight transport volumes. The study is based on cross-sectional data from ECOWAS countries from 2000 to 2013 from the ECOWAS Commission. The study revealed a strong correlation between GDP and the volume of freight in ECOWAS countries. It also showed that the development of short sea shipping model depends considerably on growth in GDP and increase in seaport corridors of the ECOWAS sub-region. It is recommended that there should be sub-regional policy frameworks that benchmark best practices from other sub-regional success stories.*

**KEYWORDS:** freight, short-sea, shipping, transport, correlation, GDP and ECOWAS

## INTRODUCTION

Continuous changes in the international market of freight transport require not only the modernisation of the current transport infrastructure but also the introduction of modern technologies for shipping management built around analytical frameworks. In the ECOWAS sub-region, these changes are mainly driven by increased competition among modes, as well as the dynamic interplay of factors that affect freight movements such as fiscal regime, trade policy, non-tariff barriers, colonial influence and political stability of the member countries. The countries of ECOWAS sub-region determine the level of development of the maritime activities taking into account changes in fundamental economic indicators such as GDP, exchange rate, population, e.t.c. Methods of statistical analysis define the influence of these indices on the maritime freight transport industry. The many ECOWAS States have similar challenges and prospects in the development of the maritime industry. The following general conditions of development of freight transport are characteristic to the ECOWAS sub-region: similarity of geographical location; existing transport modes; economic structural imbalance; low level of trade; policy instability and weak regulatory environment.

The consideration and comparison of the primary indices of freight are conditioned by the level of economic development and by policymakers in the transport sector of the ECOWAS sub-region. A realistic analysis of freight transport indices of the ECOWAS member states must be conducted simultaneously within the period ECOWAS came into existence, especially the period it provided fundamental trade facilitation mechanisms. It is because it was only the coming into existence of ECOWAS that brought about structured effort at the multilateral level to promote trade among the

countries of the sub-region. Shipping and maritime transport infrastructure are underdeveloped in the ECOWAS sub-region despite being a mostly littoral region as most member countries are coastal states on the Atlantic Ocean. Most of the countries are similarly connected by strings of significant rivers with an excellent network of tributary rivers that traverse the hinterland and its main agricultural and other economic productive centres. In the ECOWAS sub-region, the major rivers include; rivers Niger, Senegal, Gambia and Volta, which connects two or more countries. This geographical feature naturally provides excellent maritime transport architecture for sub-regional economic integration through trade.

Ironically, the maritime transport infrastructure in the ECOWAS remains the least developed amongst other transport infrastructure. Other than the seaports at the major capital cities, the hinterlands especially, the landlocked countries are without essential shipping infrastructure to facilitate intra-regional trade which is most efficiently served by maritime transport. There are near lack of such critical infrastructure as inland waterways, river ports, inland container depots, e.t.c. The total land area of West Africa is approximately 5,112, 903 sq.km or 1, 974, 103 sq.ml. The sub-region has a population (2013 estimate) of 340 million with density of 49.2/sq.km or 127.5/sq.ml. GDP (nominal) as at 2013 estimate is USD675 billion and per capita of USD1.985. There are a total of 21 ports in the sub-region serving mostly ECOWAS countries' international trade. The combined annual cargo throughput is about 142,857,143 metric tons out of which Nigeria alone accounts for about 100,000,000 or 70%. In addition to a vast stretch of coastline measuring about 5, 286km, the ECOWAS sub-region has major rivers (Gambia, Niger, Senegal and Volta) that transverse the hinterland and providing a good network of inland waterways that connect high productive agricultural areas, as well as extractive industry and manufacturing zones. The rivers also link the countries with one another, thereby offering natural strategic inland transport architecture. The rivers and their key characteristics are shown in Table 1.

**Table 1: Major Rivers in the ECOWAS Sub-region**

| S/No. | River | Length | Width | Volume | Connecting Nations |
|---|---|---|---|---|---|
| 1. | River Niger | 4,180km | 240m | 5,589$m^3$ | Guinea, Mali, Niger, Benin, Nigeria |
| 2. | Gambia River | 1,130km | NA. | NA. | Guinea, Senegal, Gambia |
| 3. | Volta River | 1,500km | 366m | 2,210$m^3$ | Ghana, Burkina Faso |
| 4. | Senegal River | 1,086km | 55m | 650$m^3$ | Senegal, Mauritania, Mali |

Source: Compiled by the author (2016)

Table 1 clearly shows that the four main rivers each have considerable length and traversing more than three countries. The lengths, widths and volumes of the rivers make them viable for development into veritable water transportation mode for cheaper and more energy-efficient movement of freight across the countries of the sub-region. River Niger provides potential inland waterway transportation link between Nigeria and countries far away as Guinea and Mali for improved trade between them.

## LITERATURE REVIEW

The relationship between freight transport and economic activity has been the major subject of several pieces of research. The bulk of these studies deal with analyses of time series data of GDP

and freight transport, measured in ton-km, in search of a correlation. In these studies, breaking the link between economic growth and transport growth is often termed as the decoupling of freight transport and GDP. Meersman and Van de Voorde (2003) did a comparative analysis of their projection concerning the increase in freight volumes with actual growth for the period 1990-99. The constructs developed by the authors comprised GDP, industrial production, and imports/exports as the main factors for freight transport demand. The estimates of the model were largely overcome by actual growth, in particular for the road haulage operation. Another contribution to knowledge by these authors is that GDP "had a greater effect on freight transport volumes in the 1990s than it did in the 1980s, while changes in industrial manufacturing became far less causal" (Meersman and Van de Voorde, 2003). To explain this discrepancy between freight transport and economic activity, the authors concur to the development of supply chain management, time-based competition and the worldwide growth of e-commerce in the 1990s as possible causes for this trend. McKinnon (2007) was of the view that in the UK between 1997 and 2004, a decoupling trend was observed. The study suggested possible reasons for this trend, and alludes to the growth of international road haulage operation, the reduction of road transport in the modal split and the increases in road freight rates as the most important ones. In the same vein, Tapio (2005) contrasted three general types of behaviours: the GDP growth and the growth of freight transport volume can be coupled, decoupled or negatively decoupled. This author also found that in the 1990s, there were differences between states within the EU in the extent of decoupling. In the UK, Germany, Luxembourg, Austria, Finland, the Netherlands and Sweden a weak decoupling trend could be seen, countries like Ireland, Denmark, France and Belgium showed expansive coupling (Tapio 2005). In researches with cross-sectional data, Benathan, Fraser and Thompson (1992) explored the domestic (non-transit) demand for freight transport with correlating ton-kilometres with total GDP and country area for 33 countries. The researchers contend that GDP and country area is the long-run determinants of domestic freight transport, measured in ton-km.
Correlation analysis is applied to the data to explore the possible correlation between transport indicators and GDP. When working with correlation analysis, it is advisable to screen the data for evidence of linear correlation beforehand. If there is evidence of linear correlation, the Pearson product-moment correlation coefficient has proven to be an appropriate statistic for measuring the level of association between the variables analysed. Otherwise, non-parametric methods will be more appropriate, and Spearman's rho or Kendall's tau-b are typically the statistics used. Preliminary analysis of the data consisted of 1) mapping economic and transport data, and 2) constructing scatter plots of transport indicators versus economic indicators. By building the scatter plots, it is intended to identify any visible pattern in the relation between the indicators. A visual pattern can be expected if GDP and Transport level are statistically strongly correlated. Moreover, if the GDP and Transport level are linearly correlated, the data points should revolve around a straight line. The preliminary analysis was inconclusive concerning providing this evidence. A limitation of the analysis at hand is that spatial effects are intrinsically present due to the nature of the question being investigated.

Transport indicators, whether measured in the number of trips or kilometre, suffer, to some extent, of spatial autocorrelation, meaning that the value for one region in the sample is not independent of the value for the neighbouring regions. Many authors alert to the problems inherent to statistical analysis in the presence of spatial effects: "In general, this reflects on higher variances for the

estimates, lower levels of significance in hypothesis tests and a worse adjustment for the estimated models, compared to data of the same dimension that exhibits independence." (Câmara, Monteiro et al., 2006) "Because of these spatial effects, if we casually carry out an OLS regression using aggregated geographic data… Some large subset of the following undesirable horrors almost certainly awaits us (the curse of Tobler's 1st Law): our estimated regression coefficients are biased and inconsistent, our estimated regression coefficients are inefficient; our $R^2$ statistic is exaggerated; we have made incorrect inferences (Voss and Ramsay, 2006).

Econometric evidence suggests that freight activity is closely correlated with GDP (Bennathan et al., 1992). This linkage between GDP and freight transport growth has for long been taken as a given, and freight transport is still seen as an essential driver of economic growth (e.g. DETR 1999). From the literature above, there is a piece of strong evidence that the relationship between GDP and freight volumes has not been established at ECOWAS sub-region. Hence this gap in the literature has provided an impetus to explore further the relationship between GDP and freight volumes in the ECOWAS states.

## METHODOLOGY

Data used in this study was sourced mainly from secondary sources. They include data provided by the national bureau of statistics of crucial member countries of ECOWAS (Nigeria, Ghana, Ivory Coast, Senegal, Togo, Mali and Niger). Data from these national institutions was complemented by trade and economic information provided by the ECOWAS Trade Commission at the ECOWAS Secretariat. The researcher undertook visits to these institutions in the respective countries, and the staff of Nigeria's High Commissions in the countries facilitated the researcher's access to the institutions, as well as relevant departments and officers. Several visits were made to the ECOWAS Trade Commission at Abuja because the researcher relied exclusively on the Commission for trade and economic statistics for the countries not visited. The researcher also relied on the Commission for the translation of data from French-speaking ECOWAS member countries to English.

For determining the relationship between GDP and freight transport volumes as well as for emphasising GDP significance to the transport industry development, we use the calculations of the coefficients of correlation between GDP and volumes of freight traffic. As shown in Table 2, not all the values of correlation coefficients are significant (p-value < 0, 05). For example, the analysis of the correlation between total freight volume and GDP for the Benin Republic is not significant. It shows that the freight transport industry of Benin Republic has little influence on the GDP. The insignificant development of the short sea shipping mode among the ECOWAS countries leads to this result. As the elasticity and correlation coefficients show only the presence or absence of the dependence between the analysed variables but do not give the whole picture of their linkage, it is useful to build the regression model:

$$Y_i = b_1 + b_2 X_i + u_i$$

Where,

$Y$ - Freight transport volume at the $i^{th}$ period in a million tonnes,

*X* - Value GDP at the $i^{th}$ *period* in a million US Dollars,
$b_1$, $b_2$ the parameters of the estimate.
The results of the estimation by the least-squares method are shown in Table 2

## RESULTS

Before using these models for the analysis of the influence of variable - GDP on freight volume, it is necessary to consider the fit/status of the model (see Table 4.8). $R^2$ – coefficient of determination. If the value is close to 1, it means the model is of good quality. F-statistics for testing the hypothesis about regression non-significant, at the level of significance 5% – the critical value is 0.95 *F (1, 6)* = 5, 99. *SEE* is a standard error of the regression, used as an essential measure of the quality estimated model. *Durbin-Watson (d)* is the statistics for testing the hypothesis about the absence of autocorrelation. In Table 3, the quality criteria of values of the significant models are emphasised.

Table 2: Estimated relationship between GDP and freight volumes of the ECOWAS Nations

| Countries | Total Freight Volume |
|---|---|
| **Benin** | 539.835+0.035*GDP |
| **Burkina Faso** | -140.113+0.976*GDP |
| **Cape Verde** | 87.280-0.861*GDP |
| **Cote d'Ivoire** | -1012.150+0.865*GDP |
| **Gambia** | -182.797+0.738*GDP |
| **Ghana** | -383.981+0.387*GDP |
| **Guinea** | 544.611-0.422*GDP |
| **Guinea Bissau** | 60.427-0.842*GDP |
| **Liberia** | -10.183+0.794*GDP |
| **Mali** | -342.706+0.887*GDP |
| **Niger** | -151.708+0.944*GDP |
| **Nigeria** | -3555.603+0.745*GDP |
| **Senegal** | 85.029+0.917*GDP |
| **Sierra Leone** | -89.240+0.554*GDP |
| **Togo** | -863.159+0.911*GDP |
| **ECOWAS** | 660.639 + 0.738*GDP |

Source: Compiled from SPSS 19.0 Output

Table 3: Quality analysis of the obtained regression equation for Freight volumes and GDP

| **Countries** | $R^2$ | *F* | *p-level* | *SEE* | *Durbin-Watson* |
|---|---|---|---|---|---|
| **Benin** | 0.001 | 0.009 | 0.928 | 1.569 | 1.236 |
| **Burkina Faso** | 0.952 | 139.292 | 0.000 | 4.752 | 1.566 |
| **Cape Verde** | 0.741 | 20.027 | 0.003 | 0.113 | 1.968 |
| **Cote d'Ivoire** | 0.748 | 20.819 | 0.003 | 0.067 | 1.347 |
| **The Gambia** | 0.545 | 8.387 | 0.023 | 0.548 | 0.739 |
| **Ghana** | 0.149 | 1.230 | 0.304 | 0.002 | 2.271 |
| **Guinea** | 0.178 | 1.521 | 0.257 | 0.917 | 1.741 |
| **Guinea Bissau** | 0.709 | 17.096 | 0.004 | 0.638 | 1.839 |
| **Liberia** | 0.630 | 11.942 | 0.011 | 0.533 | 1.009 |
| **Mali** | 0.786 | 25.782 | 0.001 | 0.021 | 1.835 |
| **Niger** | 0.892 | 57.648 | 0.000 | 0.599 | 1.764 |
| **Nigeria** | 0.555 | 8.732 | 0.021 | 0.001 | 1.386 |
| **Senegal** | 0.840 | 36.745 | 0.001 | 0.014 | 2.848 |
| **Sierra Leone** | 0.307 | 3.096 | 0.122 | 0.015 | 2.275 |
| **Togo** | 0.831 | 34.310 | 0.001 | 0.017 | 2.237 |
| **ECOWAS Aggregate** | 0.738 | 36.539 | 0.000 | 0.014 | 2.280 |

Source: Compiled from SPSS 19.0 Output

Based on the conducted analysis of the quality of the built regression equations, it is possible to draw the following conclusions:

1. Only two of the built models (Benin and Senegal) can be used for the analysis because the regression is significant;
2. By increasing GDP by 1 billion dollars the general freight traffic of Benin and Senegal will be multiplied by 35 million tonnes, and by 917 million tonnes respectively, the coefficient of GDP will show the number of times by which the GDP coefficient will be increased.
3. However, the ECOWAS aggregate model can be used for analysis because the regression line has reasonable goodness of fit. Hence, the freight volume of any ECOWAS country can be determined by plugging in the GDP of that state. Hence, increasing GDP by 1 billion dollars, the general freight traffic will be multiplied by 73.8 million tonnes.
4.

The conducted analysis of the development of freight transport in the considered countries confirms once again the close interconnection between the level of the development of GDP and freight industry of ECOWAS member countries. The calculations made utilising statistical methods demonstrated that developing freight transport industry influences GDP growth, especially in the states of Benin and Senegal. The geographical peculiarities of the ECOWAS countries influence the choice of modes of transport in each country. The analysis of the freight volume in Benin and Senegal according to the period 2000 to 2013 indicates that it is necessary to pay attention to short sea shipping mode. In this regard, more considerable attention should be focused on the close links between maritime, railroad and road transport in the ECOWAS sub-region.

Correlation is useful as measures of the relationship between the intra-regional volume of freight traffic and GDP. The correlation analysis is made using Pearson's product-momentum correlation coefficient, together with its significance level as a measure of the association between the variables. At this point, a linear relationship between GDP and freight volume is pursued. Table 4

shows the Pearson's correlation coefficient for chosen correlations of freight volume of ECOWAS nations and GDP. Significant positive correlation coefficients were found for the correlation between GDP and freight volumes in nine states, namely Burkina Faso, Cote d'Ivoire, Gambia, Liberia, Mali, Niger, Nigeria, Senegal and Togo. Also, significant negative correlation coefficients were attained for Cape Verde and Guinea Bissau. It was GDP that better explained the growth of freight transport volume of most ECOWAS countries. The analogue analysis is carried out here. It explored the relationship between freight volumes and the structure of the economy; hence the development of short-sea-shipping mode should be explored.

The analysis shows insignificant levels of correlations between GDP and freight volumes for Benin, Ghana, Sierra Leone and Guinea. This result invalidates the fact that freight volumes correlate with GDP. However, in the case of these ECOWAS countries, the informal nature of their economy could account for the lesser intra-regional trade which generates the freight volume. On the other hand, a country like Ghana has a very high GDP with small intra-regional freight volume because most of its economic operations come outside the ECOWAS countries, possibly from other regions of the world. Hence, our result strongly advocates the increased tempo of economic activity, especially in the productive sectors of her domestic economy.

**Table 4: The value of correlation and p-value for freight transport volume and GDP of ECOWAS States 2000-2013**

| | GDP FOR Benin | GDP for Burkina Faso | GDP for Cape Verde | GDP for Cote d'Ivoire | GDP for Gambia | GDP for Ghana | GDP for Guinea | GDP for Guinea Bissau | GDP for Liberia | GDP for Mali | GDP for Niger | GDP for Nigeria | GDP for Senegal | GDP for Sierra Leone | GDP for Togo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Freight Volume for Benin<br>p-value | 0.035<br>0.928 | | | | | | | | | | | | | | |
| Freight Volume for Burkina Faso<br>p-value | | .976**<br>0.000 | | | | | | | | | | | | | |
| Freight Volume for Cape Verde<br>p-value | | | -.861**<br>0.003 | | | | | | | | | | | | |
| Freight Volume for Coted'Ivoire<br>p-value | | | | .865**<br>0.003 | | | | | | | | | | | |
| Freight Volume for the Gambia<br>p-value | | | | | .738*<br>0.023 | | | | | | | | | | |
| Freight Volume for Ghana<br>p-value | | | | | | 0.387<br>0.304 | | | | | | | | | |
| Freight Volume for Guinea<br>p-value | | | | | | | -0.422<br>0.257 | | | | | | | | |
| Freight Volume for Guinea Bissau<br>p-value | | | | | | | | -.842**<br>0.004 | | | | | | | |
| Freight Volume for Liberia<br>p-value | | | | | | | | | .794*<br>0.011 | | | | | | |
| Freight Volume for Mali<br>p-value | | | | | | | | | | .887**<br>0.001 | | | | | |
| Freight Volume for Niger<br>p-value | | | | | | | | | | | .944**<br>0.000 | | | | |
| Freight Volume for Nigeria<br>p-value | | | | | | | | | | | | .745*<br>0.021 | | | |
| Freight Volume for Senegal<br>p-value | | | | | | | | | | | | | .917**<br>0.001 | | |
| Freight Volume for Sierra Leone<br>p-value | | | | | | | | | | | | | | 0.554<br>0.122 | |
| Freight Volume for Togo<br>p-value | | | | | | | | | | | | | | | .911**<br>0.001 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

## CONCLUSION

Freight transport model development is now a critical component of the overall transportation planning process as urban areas, states, and the nation considers mobility strategies for enhancing the safety and efficiency of freight transport. This study was aimed at developing a practical but straightforward modelling framework for estimating freight transport volumes in a sub-regional-wide pattern for the ECOWAS bloc.The model development is based on the ECOWAS's intra-trade freight volume database that is available from the ECOWAS Commission and National Bureau of Statistics in Nigeria. This database, providing freight volume information at the national level, was merged with population information and GDP information from the database. The resulting database constituted a comprehensive database for modelling freight volume among the countries of ECOWAS sub-region. The only missing component in the database is the modal level of service attributes that would potentially influence freight volume by mode (by commodity) between origin-destination pairs. The ECOWAS aggregate model can be used for analysis because the regression line has reasonable goodness of fit (with $R^2$ of 73.8% for the aggregate model). Hence, the freight volume of any ECOWAS country can be determined by plugging in the GDP of that country. Consequently, increasing GDP by 1 billion dollars, the general freight traffic will be multiplied by 73.8 million tonnes.

In consideration of the scenario in the EU region, Meersman and Van de Voorde (2003) compare their forecasts for the increase in freight traffic with actual growth for the period 1990-99. The models developed by the authors comprised GDP, Industrial Production, and Imports/Exports as the main determinants for freight transport demand. The estimates produced by the model were primarily overcome by actual growth, in particular for the road haulage. Another interesting point made by these authors is that GDP "had a stronger impact in freight transport in the 1990s than it did in the 1980s, while changes in industrial production became far less influential" (Meersman and Van de Voorde 2003). To account for this altered relation between freight transport and economic activity, the authors allude to developments like the emergence of supply chain management, time-based competition (TBC) and the worldwide growth of e-commerce in the 1990s as possible causes for this trend.

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