Modelling Stability in the Demand for Sea Transport in Nigeria's Freight Market: A Cointegration Analysis.

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Abstract

Using time series data on seaborne trade, government public expenditure and Gross Domestic Product (GDP), we investigated the existence of long run equilibrium relationship among these variables in Nigeria's shipping market. The object was to determine stability in demand for shipping services while relying on the assumption that volume of seaborne trade is a proxy for sea transport demand. We subjected these time series variables to unit roots tests and found they were not stationary at level but at first difference i.e. they are integrated of the order $I(1)$. However, to assess the underlying relationship between the variables, seaborne trade was separately regressed against government expenditure and GDP. Analysis of the regression residuals confirms the existence of cointegrating relationship between seaborne trade and GDP. Much against our a priori expectation, it was also found that no such relationship exists between seaborne trade and government expenditure. In addition, Granger causality tests also showed that seaborne trade 'granger cause' GDP and not vice versa. Thus, the empirical evidence from our study indicates that GDP stabilizing policies are a pre-condition to maintaining stability in the freight market for shipping services in Nigeria.

Keywords: shipping demand, freight market, seaborne trade, stability, cointegration.

1 Introduction

Much of International trade data relating to a country's imports and exports are time series in nature and hence are subject to stationarity issues frequently addressed in time series econometrics. Consequently, statistical modelling with such data can only be meaningful if requisite statistical tests and transformations are applied to the data to make for stationarity. Various modeling techniques have been developed by econometricians for this purpose. The most widely applied techniques for handling non-stationary time series data are the Box-Jenkins techniques: Box and Jenkins (1976); Units Roots tests: Dickey and Fuller (1979) and Phillips and Ouliaris (1990); Cointegration: Johansen (1988) and Engel and Granger (1987). In this paper, we model the stability of demand for shipping tonnage in Nigeria's freight market using time series data on: government public expenditure, Gross Domestic Product (GDP) and international seaborne trade (which proxies demand for shipping services). In transportation discipline literature, demand for shipping service is measured as an index: ton-miles. This is derived as the quantity of shipment made in metric tonnes multiplied by the distance it was hauled along a shipping route. However, demand can also be proxied by volume/value of seaborne trade or aggregate tonnes of import and export commodities handled in Nigeria over time; ignoring the distance component for the time being. According to Stopford (2009), among the factors which affect demand for shipping or sea transport in international freight market, the state of the World economy is the most dominant. By extension, the state of the Nigeria's economy has a major influence on demand for sea transport service in the shipping freight market. However, the state of the economy can be measured by level of government expenditure and GDP. Government expenditure on public projects improves money supply which in turn drives economic activities and hence seaborne trade. Although many empirical papers have established direct relationship between government expenditure and Gross Domestic Product (GDP), yet the relationship between total seaborne trade and GDP appears not to have been clearly defined. It is therefore necessary to examine the long run *equilibrium* relationship between level of seaborne trade, government public expenditure, and GDP with respect to their influences on the shipping freight market. Thus for our purposes, we have therefore chosen to model separately the long run equilibrium relationship between government public spending, GDP and seaborne trade since the latter captures the potential demand for shipping services. Simply put, ships are needed to transport seaborne trades generated in the economy and the latter is affected by level of government public spending and GDP.

1.1 Objectives of Study

The central objective of this paper is to assess the stability in Nigeria's freight market using three time series variables: total seaborne trade, government expenditure and GDP. We seek to ascertain if government expenditure or GDP separately has a long run equilibrium relationship with total seaborne trade. The outcome would enable us assess the prospects of stability in demand for shipping services in Nigeria's shipping freight market. Thus, in this paper long run equilibrium relationship between any pair of series is investigated within the framework of Cointegration.

1.2 Research Questions

The main research questions posed in this study are as follows:

(i) What is the level of stationarity in seaborne trade and government expenditure in Nigeria?
(ii) What is the level of stationarity in seaborne trade and GDP in Nigeria?
(iii) Is there a cointegrating relationship between seaborne trade and government expenditure in Nigeria?
(iv) Is there a cointegrating relationship between seaborne trade and GDP in Nigeria?
(v) Does level of GDP 'granger cause' level of seaborne trade and vice versa

2 Conceptual Framework of the Study

The time series under investigation are government expenditure, GDP, total volume of imports and exports in Nigeria's seaborne trade. The series span the period between the years 1970 to 2013. All are financial data denominated in US dollars and have been adjusted for inflation. As with most financial data, the series may not be stationary and may not yield accurate estimates if subjected to forecasting. Therefore, to make predictions about their long run characteristics, we apply the modelling framework of cointegration. The special interest in their long run characteristics is based on the economic fact that government expenditure in public sector dominated economy like Nigeria drives the level of economic activities and hence affects the GDP. The GDP on the other hand is a measure of economic activities and to a large extent reflects level of imports and exports trade volumes; though values of imports are deducted from GDP. However, import and export activities proxy the demand for shipping services in shipping markets since for example, raw materials, finished capital and consumer goods for production and consumption respectively are transported mainly via the sea mode of transportation. Based on the foregoing therefore, the conceptual position of our paper is: if long run equilibrium relationship between the drivers of sea transport demand (i.e. government expenditure, GDP and imports/exports) can be established, then insight can be gained into the nature of stability (or otherwise) of demand for shipping capacity/tonnage in Nigeria's shipping freight market.

2.1 Theory of Cointegration

In time series econometrics, a set of variables is defined as cointegrated if a linear combination of them is stationary. Many time series are non-stationary but 'move together' over time – that is, there exist some influences on the series (for example, market forces), which imply that the two series are bound by some relationship in the long run (Brook, 2014). A cointegrating relationship may also be seen as a long-term or equilibrium phenomenon, since it is possible that cointegrating variables may deviate from their relationship in the short run, but their association would return in the long run (Books, 2014). This phenomenon would be examined from time series graphs showing trends in imports, exports, total seaborne trade (imports + exports), GDP and government expenditure series.

According to Brooks (2014), if two variables that are $I(1)$ are linearly combined, then the combination will also be $I(1)$. More generally, if a set of variables $X_{i,t}$ with differing orders of integration are combined, the combination will have an order of integration equal to the largest. If $X_{i,t} \sim I(\mathrm{d_i})$ for $i = 1, 2, 3, ..., k$ so that there are k variables each cointegrated of order d_i. Mathematically, Engle and Granger (1987) illustrate cointegration thus:

Let w_t be a $k \times 1$ vector of variables, then the components of w_t are integrated of order (d, b) if:

(i) All components of w_t are $I(\mathrm{d})$

(ii) There is at least one vector of coefficients α such that

$$\alpha' w_t \sim I(d - b)$$

Closely associated with cointegration is the concept of unit roots. Unit roots tests confirm the order of stationarity or integration and these tests are preconditions for cointegration analysis.

3 Methodology

We explore the time series properties of proxy determinants of demand for shipping service namely; total volume of our import and export seaborne trade and its relationship with government public expenditure and GDP. These data series are secondary in nature and were compiled from the database of Kushnirs Research Institute Inc. (2013) and validated by data from statistical bulletins of the Central Bank of Nigeria. The data series covering the period from the years 1970 to 2013 are denominated in US dollars and have been adjusted for inflation. A data period of fourty four (44) years is deemed to have captured random shocks in Nigeria's economy over time and hence suitable for analysis of this nature. Therefore, the sample size can be adjudged suitable for statistical estimation purposes and for subsequent inferences to be drawn about Nigeria's freight market. Specifically two methods of data analysis shall be applied in addressing research questions posed in the study. These are descriptive analysis involving summary (moments) of the data set in addition to time series graphs and inferential statistics using unit root tests, cointegration and Granger causality models.

3.1. Graphical Analysis of Data

Informally, the graph of the data will be presented in order to know the movement of the series. If the series move continuously upwards or downwards, then, we suspect that the data is not stationary. More formal tests of stationarity shall be carried out using Unit roots tests.

3.2. Unit Root Tests/Cointegration Analysis

Formerly, in order to know whether or not a given series is stationary, unit root tests are carried out using the formula below:

$$Y_t = \rho Y_{t-1} + \mu_t \quad \ldots \quad (1)$$

We test to find out whether or not $\rho = 1$. If it is, then we claim that the series is not stationary i.e. it contains a unit root. But according to Gujarati (2004), equation (1) would be manipulated by subtracting Y_{t-1} from both sides of the equation to obtain:

$$Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + \mu_t, \text{ i.e.} \quad \ldots \quad (2)$$

$$\Delta Y_t = \delta Y_{t-1} + \mu_t \quad \ldots \quad (3)$$

Where $\delta = \rho - 1$ and Δ, the difference operator.

In practice, instead of estimating (1), we estimate (3) and test the null hypothesis that δ = 0. If $\delta = 0$, then, $\rho = 1$, meaning that the time series is non-stationary.

Under the null hypothesis, i.e. $\delta = 0$, the *t*-value of the estimated coefficient of Y_{t-1} does not follow the *t* distribution even in large samples; i.e., it does not have an asymptotic normal distribution. But Dickey and Fuller (1979) have shown that under H_0, the estimated *t* value of the estimated coefficient of Y_{t-1} in (3) follows the τ(tau) statistic. These authors have computed the critical values of the tau statistic on the basis of Monte Carlo's simulations and in the literature, the test is known as the Dickey–Fuller (DF) test in honour of the discoverers. Interestingly, if the hypothesis of $\delta = 0$ is rejected, we can use the usual (Student's) *t* test. The data will therefore be estimated as follows: (3) will be estimated by OLS. The estimated coefficient of Y_{t-1} will be divided by its standard error to obtain the tau statistic. Reference is made to the DF tables or to the result presented by the statistical package used for this work, i.e. Stata for Windows software. If the computed absolute value of the tau statistic $(|\tau|)$ exceeds the DF or MacKinnon critical tau values, we reject the hypothesis that $\delta = 0$, in which case, the time series is stationary. On the other hand, if the computed $|\tau|$ does not exceed the critical tau value, we do not reject the null hypothesis, in which case, the time series is non-stationary. In conducting the DF test in (3), it will be assumed that the error term, μ_t is uncorrelated. But in case the error term is correlated, Dickey and Fuller have developed a test known as Augmented Dickey-Fuller (ADF) test. The test is conducted by "augmenting" equation (3) by adding the lagged values of the dependent variable ΔY_t. Suppose equation (3) is modeled like a random walk with drift; i.e.

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + \mu_t \quad \ldots \quad (4)$$

Then, the ADF will consist in estimating the following regression:

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + \alpha_i \sum \Delta Y_{t-i} + \varepsilon_t \quad \ldots \quad (5)$$

$i = 1, 2, m.$

Where ε_t is a pure white noise error term and 'm' is the number of lags. The number of lagged difference to include is often determined empirically, the idea being to include enough terms so that the error term in (5) is serially uncorrelated (Gujurati, 2004). In ADF, we still test whether or not $\delta = 0$ and the ADF test follows the same asymptotic distribution as the DF statistic, so the same critical values can be used.

Another test for non-stationarity is the Phillips-Perron (PP) Unit Roots test. It is a nonparametric test that takes care of serial correlation in the error terms without adding lagged difference terms. The asymptotic distribution of the ADF test is the same as the PP test and so we will make our inference based on ADF test. In this work, the three data series: seaborne trade, government public expenditure and GDP shall be tested for stationarity using the unit root tests described in section 3.2 above. Then, the following Ordinary Least Squares (OLS) regression analysis shall be done:

$$Y_t = \beta_0 + \beta_1 X_t + \mu_t \quad \ldots \quad (6)$$

Where:

Y_t = Seaborne Trade (billion $)

X_t = Government Expenditure (billion $)

β_0, β_1, are the associated regression coefficients while;

μ_t = random error associated with Y_t.

The same OLS regression shall be carried out with government expenditure series replaced with GDP series. The object is to find out which of the series; government expenditure or GDP has long run relationship with seaborne trade. In testing for cointegration, use shall be made of DF and ADF tests for unit root on the residuals obtained as follows:

$$\mu_t = Y_t - \beta_0 - \beta_1 X_t \quad (7)$$

If the error is found to be stationary, then the two series are cointegrated. The parameter β_1 is referred to as the cointegrating parameter. It measures the long-run increase in GDP per unit increase in seaborne trade. The regression function in equation (7) is referred to as **a cointegrating regression**. We shall thus proceed to apply the steps discussed to our data series to determine if cointegrating relationships exists at all.

The descriptive summary of the data set used for the study is presented in table 1. For our analysis, we have aggregated import and export values to obtain total seaborne trade. In figure 1, we observe the trend in volume (in billion dollars) of imports, export for the period 1970 to 2013.

Table 1: Descriptive Statistics of Sample Data (billion, $)

Variable	Mean	Std. Dev.	Min	Max
imports	18.3	20.7	1.2	88.4
exports	28.5	33.3	2.0	144.9
tot_trade	46.8	53.3	3.2	217.4
gov_exp	23.5	21.2	2.9	68.8
gdp	143.3	120.3	25.4	515

Source: Author's Own computation

The graph for each component shows an upward trend thus signifying that the data are not stationary. Similarly, in figures 2, we also observe that the variables: imports, exports and government expenditure for the period 1970 to 2013, are not stationary as they all exhibit upward trends. However, since we are interested in demand for shipping services, we look at the trends of total trade volume, GDP and government expenditure. This is observed in Figure 2. We note also in this case that both series are not stationary judging by the trends. Again the series move together, though total seaborne trade appears higher than government expenditure.

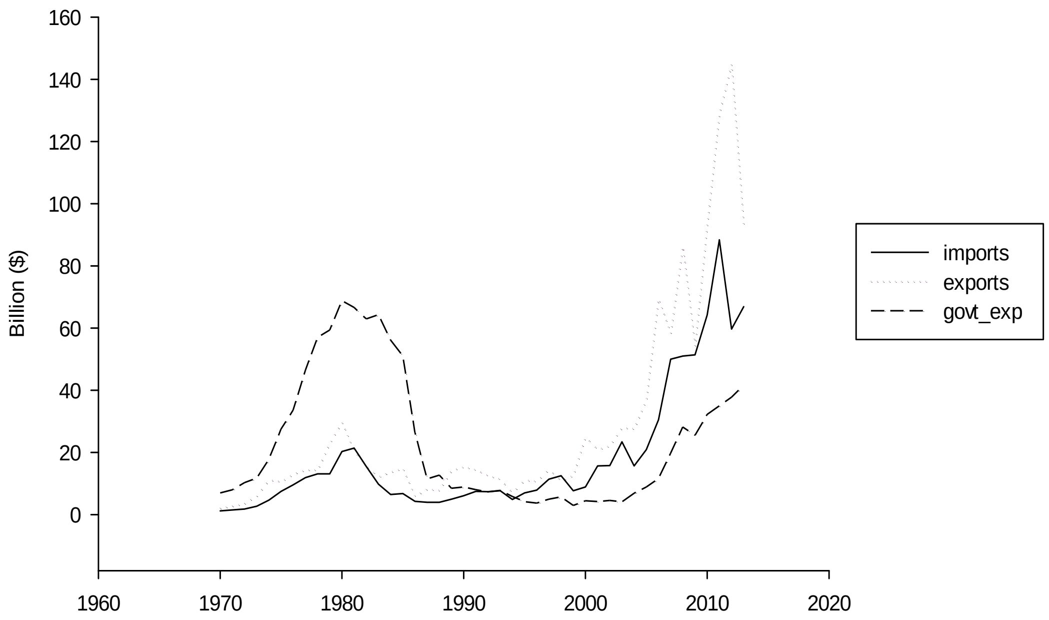

Fig 1: Trends in Imports, Exports and Govt_Exp.(billion, $) (1970 -2013)

In all cases, each set of series in respective graphs are seen to wander in different directions. If cointegrating relationship exists for any set of series variables then they would move together in the long run. But as a precondition for cointegration analysis, we need a formal unit roots test to confirm the level and order of integration of the data series. We hereby apply the Dickey Fuller tests.

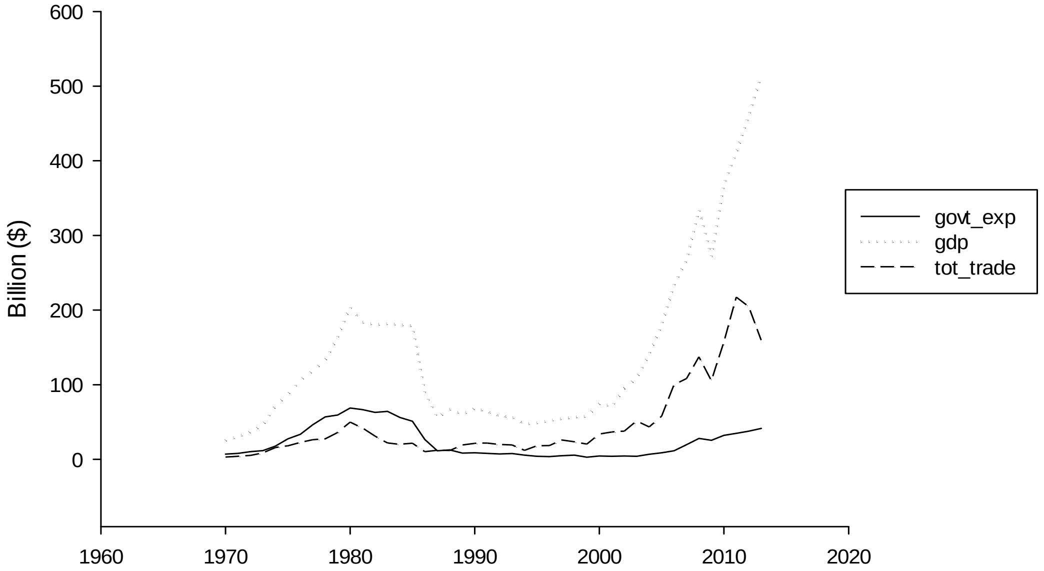

Fig. 2: Trends in govt_exp, gdp and total trade (1970-2013)

The results of unit roots tests are presented in table 2. Tests of stationarity for individual unit roots for seaborne trade, GDP and government expenditure are presented. Two unit root tests: Augmented Dickey Fuller (ADF) and Phillips Perrons were applied. Thus, from the table, all the variables are not stationary at levels as their p-values are not statistically significant. We cannot therefore reject the null hypothesis of unit roots. However, at the first difference, all the variables are stationary; as their p-values are significant this time. This implies that they are integrated of the order one or *I*(1).

Table 2: Unit Roots Test Results for: Trade, GDP & Gov_Exp.

	ADF		**PP**	
	First Diff.	Level	First Diff.	Level
Fisher Chi-square	24.2341	1.6651	37.4788	0.8328
***p*-values**	[0.0005]	[0.9478]	[0.0000]	[0.9912]

Source: Author. N:B Lag length selection based on Schwarz criterion: 0 to 4.

Having established that seaborne trade, government expenditure and GDP are not stationary at their levels but only in first difference; we now proceed to determine the pair that is cointegrated. Thus, we run a least squares regression of trade vs. government expenditure and also trade vs. GDP. We then check their residuals for stationarity (or white noise). As outlined in the methodology section; two steps are involved. In step one, trade vs. government expenditure regression is carried out. In step two, the residual obtained in step one is regressed against its lag. The residual of this second regression is then examined for stationarity using ADF tests. The procedure is followed for the next regression.

Table 3 shows outputs of the regression analyses: trade vs. govt_exp presented as model 1 and trade vs. GDP presented as model 2. In model 1, the govt_exp variable has a coefficient of 0.545 with a p-value of 0.157; this outcome is not significant. However, in model 2, the variable GDP has a coefficient of value 0.411 with p-value of 0.000. This result is statistically significant. Since we are interested in the residual analysis of these regressions (models 1 & 2); we cannot say anything about their cointegration until later. The residual analysis is discussed in the following paragraphs.

Table 3: Output of the OLS Regression: Trade vs. govt_exp & Trade vs. GDP

		Model 1			Model 2	
Parameter	**Estimate.**	***t*-stat**	**P>|t|**	**Estimate**	***t*-stat**	**P>|t|**
β_i	0.545	1.440 [0.378]	0.157	0.411	**16.200** [0.025]	**0.000**
Intercept	34.050	2.860 [11.895]	0.007	-12.080	-2.560 [4.725]	0.014

Source: Author. Dependent variable: Trade. i = {govt_exp, GDP}, Standard Errors in parenthesis

In table 4, residual analysis following regression results involving total trade volume and government expenditure is presented as model 1. The *t*-ratio on the lagged value of estimated lagged residual (**$RESID_{-1}$**) is **-0.670**. The critical value has to be obtained from the Augmented Dickey Fuller table. The 5% critical value for a cointegrating regression containing an intercept is tabulated as -2.89 and the calculated *t*-ratio is greater the tabulated. The null hypothesis of no cointegration is not rejected. Therefore, there is no long run equilibrium between trade and government expenditure.

Table 4: Analysis of Regression Residuals: Trade vs. Govt_Exp./ Trade vs. GDP

		Model 1			Model 2	
D(RESID)[a]	**Coef.**	***t*-stat**	**P>|t|**	**Coef.**	***t*-stat**	**P>|t|**
$RESID_{-1}$.	-0.042	**-0.670** [0.062]	0.506	-0.370 [0.121]	**-3.05**** [0.121]	**0.004****
$D(RESID)_{-1}$.	0.171	0.87 [0.196]	0.389	0.443	2.21 [0.200]	0.033

Source Author. [a]Dependent Variable: Differenced Residual.

Similarly in model 2 of table 4, the *t*-ratio on the lagged value of estimated lagged residual (**$RESID_{-1}$**) is **-3.05**. The 5% critical value for a cointegrating regression containing an intercept is -2.89 and the *t*-ratio is less than this. The null hypothesis of no cointegration is rejected. In this case, there is significant evidence to reject the null hypothesis of no cointegration. This result shows that seaborne trade and GDP are cointegrated. Therefore, from model 2 in table 3, the static or long run seaborne trade/GDP Function is given by:

$$Y_t = -2.560 + 0.411 X_t$$

Where: $Y_t =$ Seaborne trade

$X_t =$ Gross Domestic Product (GDP)

As a further confirmation that the cointegrated series have uncorrelated error term, we observe in figures 4 and 5 (see appendices 1 & 2) the autocorrelation plots of residuals obtained from the two regressions in tables 4. It is interesting to notice that no significant spikes were found in the figures. All spikes are contained within the shaded threshold boundaries. Thus, while both regressions, show evidence of stationarity in residuals; only seaborne trade vs. GDP pair show the presence of long term equilibrium. However, we will apply further tests to explore how they are associated with each other. One such test is known as Granger Causality.

According to Oscar (2013), If you regress 'y' on lagged values of 'y' and 'x' and the coefficients of the lag of 'x' are statistically significantly different from 0, then you can argue that 'x' Granger-cause 'y', that is, 'x' can be used to predict 'y'. Applying this principle, we first regressed seaborne trade (y) on lagged values of GDP (x). A null hypothesis test that the coefficients on the lags of GDP are equal to zero yielded no statistically significant results. We then repeated this regression, this time interchanging y with x. As shown in table 5, a test of null hypothesis on the lags of trade yielded statistically significant results. Based on this outcome, we conclude that seaborne trade 'granger cause' GDP. This implies that level of seaborne trade can predict the level of GDP in Nigeria's economy and not vice versa.

Table 5: Output of Granger Causality Test: GDP vs. Trade

Variable	**Coef.**	**Std. Err.**	***t*-stat**	**P>|t|**
GDP: Dependent Variable				
GDP_{t-1}	1.029	0.253	**4.060**	**0.000**
GDP_{t-2}	-0.178	0.339	-0.530	0.603
GDP_{t-3}	0.148	0.371	0.400	0.693
GDP_{t-4}	-0.404	0.264	-1.530	0.136
$trade_{t-1}$	-0.440	0.473	-0.930	0.359
$trade_{t-2}$	0.872	0.579	1.510	0.142
$trade_{t-3}$	-0.612	0.791	-0.770	0.445
$trade_{t-4}$	1.553	0.683	**2.270**	**0.030**
_cons	14.252	8.751	1.630	0.114
$H_0 = \mu_{t-1} = \mu_{t-2} = \mu_{t-3} = \mu_{t-4} = 0$: **F(4, 31) = 3.50, Prob. > F = 0.0180**				

Source: Author's Own Elaboration

4 Discussions and Conclusion

Before discussing the outcome and implications of this research, we would like to acknowledge that no elaborate attempt was made to examine the literature on determinants of seaborne trade and by extension the factors that affect demand for sea transport. Again, international trade literature is replete with theories that explain trade flows and barriers to trade; these were not addressed here. Our discussion on the relationship between trade, government expenditure and GDP is not extensive as would be expected of a study of this nature. Thus, while we accept these as part of limitations of this work; we would like to state that we consciously applied the principles of allowing the data speak. That is, the time series properties of the variables were explored to gain insights to our research problem. Our findings discussed in the following paragraph, should therefore be understood within the context of this background.

We found a cointegrating relationship between seaborne trade and GDP. Application of Granger causality tests shows that seaborne trade is not predicted by GDP but rather that GDP is predicted by seaborne trade. It was also found that there is no cointegrating relationship between government expenditure and seaborne trade. The major finding of this research is that seaborne trade and GDP are the only pair that will move together in the long run (based on cointegrating relationship between them). The implication is that demand for shipping services (proxied by seaborne trade) is associated with movements in GDP in the long run. This means that, stability on the demand side of shipping market is expected in the long run, given the observed equilibrium relationship between seaborne trade and GDP in Nigeria. Although more robust econometric models are needed to shed more light on stability modeling, this research may provide useful insights for related future research. We have been limited in the use of univariate cointegration technique. We suggest that future efforts in this direction should overcome our limitation by estimating cointegrating systems using the Johansen technique based on multivariate time series models like Vector Auto Regression (VAR).

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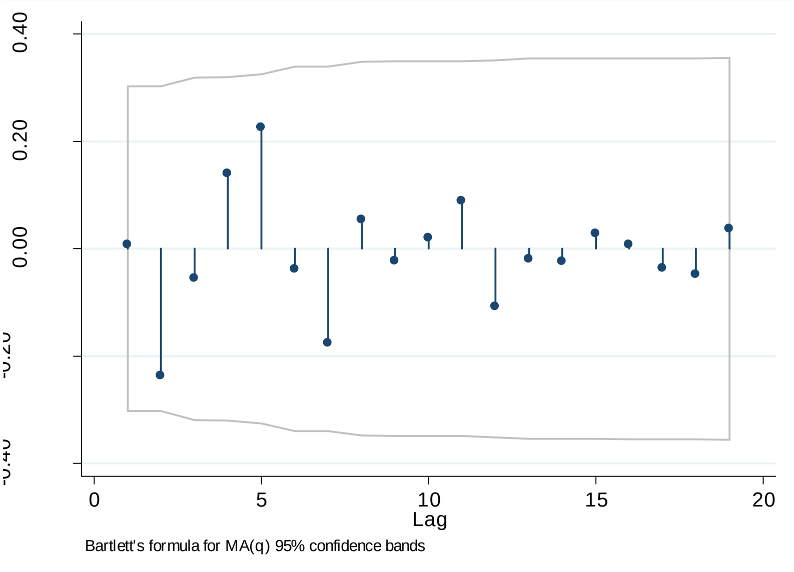
Appendix 1



Appendix 2