ERROR CORRECTION, CO-INTEGRATION AND IMPORT DEMAND FUNCTION FOR NIGERIA

Omoke, Philip Chimobi
Department of Economics
Ebonyi State University
Abakaliki, Nigeria

Email philomoke@yahoo.com

Abstract

The objective of this study is to determine empirically Import Demand equation in Nigeria using Error Correction and Cointegration techniques. All the variables employed in this study were found stationary at first difference using Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) unit root test. Empirical evidence from Johansen's multivariate framework suggests that the variables employed are not cointegrated in Nigeria data. This caused the null hypothesis of the presence of a cointegrating vector to be rejected, indicating non existence of a long-run relationship among the variables. Furthermore, the empirical results show that real GDP and Relative price as components of Import demand function positively affect the volume of Import (in Nigeria) in the shortrun. The estimates are statistically significant even though the results from cointegration analysis did not provide enough support for the existence of a long run relationship.

Keywords: Error correction, Import demand, Nigeria, JEL Classification, C32,F14

Introduction

The determinant of import has been the subject matter of a number of empirical studies in Nigeria (Olayide, 1968; Ajayi, 1975; Ozon ï Eson, 1984; Egwakhide, 1999). A significant weakness of many of these previous studies (Save for Egwakhideôs 1999 study) was that explicit attention was not paid to the stationarity of the estimated data. Thus, as Granger and Newbold (1974) and Philips (1986) show, it is possible that these studies estimated spurious regression. With this background, the purpose of this study is to determine whether there exists a long-run relationship between Nigeriaôs aggregate import volume and its major determinants. Following Dutta and Ahmed (1991, 2001) , we tested the hypothesis of the existence of its major determinant using cointegration technique developed by Johansen (1988, 1991) and Johansen ï Juselius (1990, 1992, 1994). The study also attempts to estimate an error-correction model (ECM) to integrate the dynamics of the short-run (changes) with long-run (levels adjustment process. Analyzing the import demand function for Nigeria has a special importance for policy in Nigeria, due to the high degree of dependence of the Nigerian economy on the international trade.

The remainder of this paper is structured as follows: Following this introduction is a review of the literature on determinant of import demand study. The next section presents specification of determinant of import model and describes the econometric methodology used. The following section contains a discussion of the empirical results while the last section concludes the paper.

Review of Related Studies

Aziz and Horsewood (2008) focused on the empirical modeling of the major determinants of imports demand of Bangladesh using annual data. They not only critically examined the determinants of imports demand following conventional wisdom but took into account some plausible new determinants like foreign exchange reserves and final expenditure components also. The paper investigated the impact of trade liberalizations as well. We finally employ the equilibrium correction mechanism (ECM) to investigate the short-run dynamics of imports demand. The estimated results demonstrated that the real GDP and relative prices of imports are statistically significant and show expected signs for Bangladesh. Relative imports prices is an important determinant of imports demand both in the short- and long-run. They found that the hypothesis of unit coefficient of income in the aggregate imports demand is apposite in Bangladeshi data. Trade liberalization could not make any special difference for the imports demand of the country. Finally, they argued on the basis of estimated results that the demand for Bangladeshi exports determines its aggregate imports demand.

Tang and Haji (2000) examined the long run relationship between Malaysia's aggregate imports and income and relative price using Johansen cointegration analysis. Annual data for the period 1970 to 1998 were used. The estimated long run elasticities of import demand with respect to income and relative prices are 1.5 and 1.8 respectively. In the short run, growth in imports is influenced by growth in current income and relative prices. The insignificance of the lagged error correction term in the ECM implies that there is no disequilibrium in the long run relationship. AS import demand is income elastic in the long run, economic growth may have negative implications on the balance of payments. The high long run cross price elasticity suggests that domestic inflation needs to be kept in check, as domestic inflation would increase the volume of imports.

Yoichi and Shigeyuki (2009) examined the long-run stability of import demand function in least developed countries (LDCs) using recently developed panel cointegration techniques. They tested for cointegration using two data sets: (a) annual data for 15 countries from 1965 to 2004; and (b) annual data for 22 countries from 1984 to 2004. They find that cointegration is present and that, indeed, there is a stable import demand function in these economies. The income elasticity ranges from 1.26 to 1.69 and price elasticity ranges from -0.72 to -0.75.

Kalyoncu (2006) estimated an aggregate import demand function for Turkey during the period 1994:1-2003:12. In the empirical analysis of the aggregate import demand function for Turkey, cointegration and error correction modeling approaches were used. Empirical results suggested that there exists a unique long run or equilibrium relationship among real quantities of imports, relative import price and real GNP

Tambi (1997) empirically estimated the determinants of import demand for consumer and non-consumer commodities in the Republic of Cameroon using cointegration and error-correction modelling. Disaggregation of total merchandise imports into three classes of consumer goods and seven classes of non-consumer goods revealed that imports of consumer goods are more sensitive to import price and income changes than is the case with non-consumer goods. Rising import prices have a depressing effect on trade in consumer goods and appear to encourage demand for domestic substitutes of these goods. Over time, income elasticities of import demand become larger than short-run elasticities, suggesting a greater degree of ñopennessò of the Cameroon economy.

Tang (2006) aimed to empirically re-examine Japanôs long-run aggregate import demand function using a variety of cointegration tests. The primary contribution of this study is to compare estimates obtained from samples of quarterly, biannual, and annual data for the period 1973 to 2000. The results of bounds test and Johansenôs multivariate test showed that the quantity of imports, real incomes, and relative import prices are consistently cointegrated regardless of data frequency. In contrast, the Engle-Grangerôs residual-based and error correction mechanism tests revealed no cointegrating relationship in Japanôs aggregate import equation. This study thus concluded that data frequency does not affect estimates of Japanôs aggregate import demand function, but that the choice of cointegration techniques does.

Tang (2005) also used cointegration techniques to re-examine the long-run relationships of South Korea's aggregate import demand behavior. The study considered four domestic activity variables; namely, gross domestic product, gross domestic product minus exports, national cash flow and final expenditure components for aggregate import demand in South Korea. The sample period covered quarterly data from 1970 to 2002. The study provided empirical evidence of a cointegrating relation in the South Korea's import demand in which it is significant to South Korea's trade policy implication, particularly to improve external balances.

Shigeyuki and Yoichi (2001) empirically analyzed the stability of the Japanese import demand function based on the concept of cointegration. The standard cointegration tests and the test developed by Gregory and Hansen (1996) were performed. The empirical results did not support the presence of a stable cointegrating relation among real GDP, real imports and relative import prices. Thus, they couldnôt say that there is a stable import demand function in Japan during the period analyzed. As a result, stimulation of domestic business conditions in Japan will not necessarily link to the quantity of imports.

Frimpong (2006) examined the behaviour of Ghanaôs imports during the period 1970-2002 using disaggregated expenditure components of total national income. he used the newly developed bounds testing approach to cointegration and estimated an error correction model to separate the short- and long-run elements of the import demand relationship. The study showed inelastic import demand for all the expenditure components and relative price. In the long-run, investment and exports are the major determinant of movements in imports in Ghana. In the short run household and government consumption expenditures was seen as the major determinant of import demand. Import demand is not very sensitive to price changes.

Dutta and Ahmed (2006) investigated the behaviour of Indian aggregate imports during the period 1971-1995. In the empirical analysis of the aggregate import demand function for India, cointegration and error correction modeling approaches were used. In the aggregate import demand function for India, import volume was found to be cointegrated with relative import price and real GDP. The econometric estimates of the import-demand function for India suggest that import-demand is largely explained by real GDP, and is generally less sensitive to import price changes. Import liberalisation is found to have had little impact on import demand.

Methodology

3.1 Model Specification

To carry out this research effectively, there is need to represent the study in a function which is thus specified:

$$M = f\,(C, Pt) \text{ -- } (1)$$

Represented in log-linear econometric form:

$$InM_t = \alpha_0 + \beta_1 InY_t + \beta_2 InPt_t + \varepsilon_t \text{ ------------------------- } (2)$$

Where

M_t = Import of goods and services (volume of import)

Y_t = real GDP

Pt_t = Relative Prices (Import Price Index/domestic Price Index)

Ŭ$_0$ is the constant term, άtô is the time trend, and άεô is the random error term.

In represents natural logarithm

Data Description and Source

The sample period runs from 1970 to 2005, to allow for a wide range of stability test. The data source is from the IFS CD ROM 2007. The data used in this work include Measure of the volume of Import of goods and services (M_t); real GDP (Y_t); and Relative Prices (Pt_t), which is a proxy for Import price Index (proxied by USA export Price Index) as a Percentage of Domestic Price Index.

Estimation Techniques

The technique used in this study is the cointegration and error-correction modeling technique. To estimate the cointegration and error-correction, three steps are required: these are testing for order of integration, the cointegration test and the error correction estimation.

Unit Root Test

The unit root test involves testing the order of integration of the individual series under consideration. Several procedures has been developed for the test of order of integration including the choice for this study: Augmented Dickey-Fuller (ADF) test due to Dickey and Fuller (1979, 1981), and the Phillip-Perron (PP) due to Phillips (1987) and Phillips and Perron (1988). Augmented Dickey-Fuller test relies on rejecting a null hypothesis of unit root (the series are non-stationary) in favor of the alternative hypotheses of stationarity. The tests are conducted with and without a deterministic trend (t) for each of the series. The general form of ADF test is estimated by the following regression

$$\Delta y_t = \check{U}_0 + \check{U}_1 \, y_{t-1} + \sum_{i=1}^{n} \alpha \Delta y_i + e_t \text{ -- (3)}$$

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum_{n=1}^{n} \alpha_1 \Delta y_i + \delta_t + e_t \text{ -- (4)}$$

Where

Y is a time series, t is a linear time trend, Δ is the first difference operator, $\check{U}_0$ is a constant, n is the optimum number of lags in the dependent variable and e is the random error term the difference between equation (1) and (2) is that the first equation includes just drift. However, the second equation includes both drift and linear time trend pp.

$$\Delta y_t = \alpha_0 + \alpha \, y_{t-1} + e_t \text{ --- (5)}$$

Cointegration Test

This is the testing of the presence or otherwise of cointegration between the series of the same order of integration through forming a cointegration equation. The basic idea behind cointegration is that if, in the long-run, two or more series move closely together, even though the series themselves are trended, the difference between them is constant. It is possible to regard these series as defining a long-run equilibrium relationship, as the difference between them is stationary (Hall and Henry, 1989). A lack of cointegration suggests that such variables have no long-run relationship: in principal they can wander arbitrarily far away from each other (Dickey et. al., 1991). We employ the maximum-likelihood test procedure established by Johansen and Juselius (1990) and Johansen (1991). Specifically, if Y_t is a vector of n stochastic variables, then there exists a p-lag vector auto regression with Gaussian errors of the following form:

Johansenȏs methodology takes its starting point in the vector auto regression (VAR) of order P given by

$$y_t = \mu + \Delta_1 y_{t-1} + - - - + \Delta p \;\; y_{t-p} + \varepsilon_t \text{ ------------------------------------- (6)}$$

Where

Y_t is an nx1 vector of variables that are integrated of order commonly denoted (1) and Ů is an nx1 vector of innovations.

This VAR can be rewritten as

$$\Delta y_t = \mu + \eta_{yt-1} + \sum_{i-1}^{p-1} \tau_i \Delta y_{t-1} + \varepsilon_t$$ --- (7)

Where

$$\prod = \sum_{i-1}^{p} A_{i-1} \text{ and } \tau_i = -\sum_{j=i+1}^{p} Aj$$

To determine the number of co-integration vectors, Johansen (1988, 1989) and Johansen and Juselius (1990) suggested two statistic test, the first one is the trace test (λtrace). It tests the null hypothesis that the number of distinct cointegrating vector is less than or equal to q against a general unrestricted alternatives q = r. the test calculated as follows:

$$\lambda\text{trace (r)} = -T \sum_{i=r+1} \text{In} \left(1 - \hat{\lambda}_t\right)$$ ------------------------------------ (8)

Where

T is the number of usable observations, and the $\lambda_{1,s}$ are the estimated eigenvalue from the matrix.

The Second statistical test is the maximum eigenvalue test (λ max) that is calculated according to the following formula

λ max (r, r + 1) = -T In (1 ï λr + 1) ---------------------------- (9)

The test concerns a test of the null hypothesis that there is r of co-integrating vectors against the alternative that r + 1 co-integrating vector.

Error Correction Model

This is only carried out when cointegration is proven to exist; it requires the construction of error correction mechanism to model dynamic relationship. The purpose of the error correction model is to indicate the speed of adjustment from the short-run equilibrium to the long-run equilibrium state. The greater the co-efficient of the parameter, the higher the speed of adjustment of the model from the short-run to the long-run. We represent equation (2) with an error correction form that allows for inclusion of long-run information thus, the error correction model (ECM) can be formulated as follows:

$$\Delta InM_t = \alpha_0 + \sum_{t=1}^{n} \beta_{1t} \Delta InY_{t-1} + \sum_{i-1}^{n-1} \beta_{2t} \Delta InPt_{t-1} + \lambda Ec_{t-1} + \varepsilon_t$$ ---------------------------- (10)

Where

Δ is the first difference operator

λ is the error correction coefficient and the remaining variables are as defined above.

Empirical Result Analysis

Unit Root Test

This is testing for the stationarity of the individual variables using both the Augmented Dickey Fuller (ADF) and Phillips ï Perron (PP) tests to find the existence of unit root in each of the time series. The results of both the ADF and PP tests are reported in Tables below:

ADF and PP Stationarity test at Levels

Variables	ADF (Intercept)	ADF (Intercept & Trend)	PP (Intercept)	PP (Intercept & Trend)
LY	0.887(-3.632)*	-1.478(-4.243)*	0.787(-3.632)*	-1.584(-4.243)*
LM	-0.138(-3.632)*	-1.470(-4.243)*	-0.220(-3.632)*	-1.700(-4.243)*
LPt	0.170(-3.639)*	-2.686(-4.252)*	0.874(-3.632)*	-2.063(-4.243)*

Note: *Significance at 1% level. Figures within parenthesis indicate critical values. Mackinnon (1991) critical value for rejection of hypothesis of unit root applied.*
Source: *Author's Estimation using Eviews 6.0.*

The above Table shows that the variables were not stationary in levels (except Population growth which was stationary at ADF Intercept). This can be seen by comparing the observed values (in absolute terms) of both the ADF and PP test statistics with the critical values (also in absolute terms) of the test statistics at the 1%, 5% and 10% level of significance. Result from the table provides strong evidence of non stationarity for the three (3) remaining variables. Therefore, the null hypothesis is accepted and it is sufficient to conclude that there is a presence of unit root in the variables at levels, following from the above result, all the variables were differenced once and both the ADF and PP test were conducted on them, the result as shown in table below

ADF and PP Stationarity test at First Difference

VARIABLES	ADF (INTERCEPT)	ADF (INTERCEPT & TREND)	PP (INTERCEPT)	PP (INTERCEPT & TREND)
LY	-4.623(-3.639)*	-4.706(-4.252)*	-4.583(-3.639)*	-4.716(-4.252)*
LM	-4.531(-3.639)*	-4.458(-4.252)*	-4.531(-3.639)*	-4.458(-4.252)*
LPt	-2.709(-2.614)***	-2.824(-4.252)*	-2.570(-3.639)*	-2.720

Note: *, ** and * denotes** Significance at 1%, 5% & 10% level, respectively. Figures within parenthesis indicate critical values. Mackinnon (1991) critical value for rejection of hypothesis of unit root applied.
Source: *Author's Estimation using Eviews 6.0.*

The table above reveals that all the variables (except population growth which has already tested stationary at levels) were stationary at first difference, on the basis of this, the null hypothesis of non-stationary is rejected and it is safe to conclude that the variables are stationary. This implies that the variables are integrated of order one, i.e. 1(1).

Cointegration test Analysis

The result of the cointegration condition (that is the existence of a long term linear relation) is presented in the Tables below using methodology proposed by Johansen (1990):

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.345706	22.68462	29.79707	0.2619
At most 1	0.212952	8.261856	15.49471	0.4378
At most 2	0.003523	0.120010	3.841466	0.7290

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.345706	14.42276	21.13162	0.3314
At most 1	0.212952	8.141846	14.26460	0.3645
At most 2	0.003523	0.120010	3.841466	0.7290

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Result from the tables rejected null hypothesis that there were no cointegrating vectors among the system. In other words, both trace statistic test and Maximum eigenvalue test indicated no cointegrating vector in the series. Having ascertained that the variables are non-stationary at their levels but stationary at first difference and that there is no evidence of cointegrating vector, we proceed to estimate the equation of Import Demand function in Nigeria using Ordinary Least Square without employing the error correction model.

Dependent Variable: LM

	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.637739	1.653760	-2.199678	0.0349
LY	1.286294	0.196810	6.535718	0.0000
LPT	0.197059	0.243588	0.808982	0.4243

R-squared	0.984062	Mean dependent var	3.870315
Adjusted R-squared	0.983096	S.D. dependent var	2.595666
S.E. of regression	0.337475	Akaike info criterion	0.745004
Sum squared resid	3.758346	Schwarz criterion	0.876964
Log likelihood	-10.41007	Hannan-Quinn criter.	0.791061
F-statistic	1018.768	Durbin-Watson stat	0.755189
Prob(F-statistic)	0.000000		

$$LM = -\ 3.637 + 1.286LY + 0.197LPt$$
$$(-2.199) \quad (6.535) \quad (0.808)$$

The observation from the regression result, is both that GDP and Relative price has a positive relationship with volume of import; although the Johansen cointegration test carried out earlier already suggested no cointegrating vector existing among the variables indicating non-existence of a long term relationship, the equation result reveals that 1% increase in Income (real GDP) will lead to 1.286% percent increase in Import (M) while 1% increase in Relative Price will lead to 0.808% increase in GDP Import. This result implies that when the income of a nation rises, the need for goods and services offered by other countries will easily be desired and also the positive relationship of the relative price to import is an indication that an increase in relative price which was proxied as a ratio of import price index to domestic price index will yield increase the volume of import.

Conclusion

The objective of this study is to determine empirically Import Demand equation in Nigeria using Error Correction and Cointegration techniques. All the variables employed in this study were found stationary at first difference using Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) unit root test. Empirical evidence from Johansen's multivariate framework suggests that the variables employed (Volume of Import, real GDP and Relative price) are not cointegrated in Nigeria. This caused the null hypothesis of the presence of a cointegrating vector to be rejected, indicating non existence of a long-run relationship among the variables.

Furthermore, the empirical results show that real GDP and Relative price as components of Import demand function positively affect the volume of Import (in Nigeria) in the shortrun. The estimates are statistically significant even though the results from cointegration analysis did not provide enough support for the existence of a long run relationship.

The above results could be viewed in the light of increase in income affecting the volume of import which is not abnormal considering the high level of import demand that has become a norm in Nigeria especially especially when the relative price of producing those products are considered higher compared to import price. Whether this will pose a problem to the further development of nation Nigeria is a questioin for further research which might necessitate the incorporation of further research variables.

References

Abbott, A.J., Seddighi, H.R. (1996) "Aggregate imports and expenditure components in the UK: an empirical analysis", *Applied Economics*, Vol. 28 pp.1119-25

Asseery, A. (1990),òUnit Roots and Cointegration Theory with Application to the Real Money Demand Functions of the Industrial World. Ph.D. Thesis, Wales U.K (1990).

Aziz N. and Horsewood N. (2008) Determinants of Aggregate Import Demand of Bangladesh: Cointegration and Error Correction Modelling. International Trade and Finance Association Conference Papers no. 1114

Bhargava, A. S. (1986) ñOn the Theory of Testing for Unit Roots in Observed Time Seriesñ, *Review of Economic Studies*. Vol. 53 (1986), pp.369-384.

Carone, G. (1996) ñModeling the U. S. Demand for Imports Through Cointegration and Error Correction,ò *Journal of Policy Modeling*, 18(1):1-48.

Dickey, D. A., and Fuller, W. A.,(1979) ñDistribution of the Estimators for Autoregressive Time Series with a Unit Rootò. *Journal of the American Statistical Association*, Vol. 74, 427-431.

Dickey, D. A., and Rossana, R.. J. (1994) ñCointegrated Time Series: A Guide to Estimation and Hypothesis Testingò, *Oxford Bulletin of Economics and Statistics,* Vol.56,(3), pp325-353.

Domowitz, I. and El-badawi, I., (1987) ñAn Error Correction Approach to Money Demand: The Case of Sudanñ, *Journal of Development Economics*. Vol.26, pp. 257-275.

Dutta, D. and N. Ahmed (1997) ñAn Aggregate Import Demand Function for Bangladesh: A Cointegration Approach,ò *Applied Economics,* 31(1999):465-472.

Engle, R.F. and Granger, C.W.J., (1987) ñCointegration and Error Correction: Representation, Estimation and Testing,ò *Econometrica,* 55, pp. 251-76.

Frimpong, Joseph Magnus and Oteng-Abayie, Eric Fosu (2006) Aggregate Import demand and Expenditure Components in Ghana:An Econometric Analysis. Unpublished.

Goldstein, M. and M. S. Khan (1985) ñIncome and Price Effects in Foreign Trade,ò in R. W. Jones and P. B. Kenen (eds.) *Handbook of International Economics* (Vol. II), New York: Elsevier Science Publications, 1041-1105.

Hakkio, C., and Rush, M., (1991) òCointegration: How Short is the Short-Run?ò. *Journal of International Money and Finance,* Vol.10, pp. 571-581.

Houthakker, H. S. and S. P. Magee (1969) ñIncome and Price Elasticities in World Trade,ò *Review of Economics and Statistics*, 41:111-25.

Johansen, S. (1988) ñStatistical Analysis of Cointegrating Vectors,ò *Journal of Economic Dynamics and Control*, 12: 231-54.

Johansen, S. and K. Juselius (1990) ñMaximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money,ò *Oxford Bulletin of Economics and Statistics, 52: 169-210.*

Kalyoncu, Huseyin (2006) *An aggregate import demand function for Turkey: a cointegration analysis.* Published in: *The Indian Journal of Economics* 343 (2006)

Khan, M. S. (1974) "Import and Export Demand in Developing Countries" *IMF Staff Papers* 21, 678ï 693.

Khan, M. S. and K. Z. Ross (1977) ñThe Functional Form of the Aggregate Import Equation,ò *Journal of International Economics*, 7:149-60.

Murray, T. and P. J. Ginman (1976) ñAn Examination of the Traditional Aggregate Import Demand Model,ò *Review of Economics and Statistics*, 58:75-80.

Salas, J. (1982) ñEstimation of the Structure and Elasticities of Mexican Imports in the Period 1961-1979,ò *Journal of Development Economics*, 10:297-311.

Shigeyuki, H. and Yoichi, M. (2001) An Empirical Analysis on the Stability of Japanôs Aggregate Import Demand Function. *Japan and the World Economy*, volume 13, issue 2, pages 135-144

Tang, Tuck Cheong and Haji Alias, Mohammad (2000) An Aggregate Import Demand function for Maylasia: A Cointegration and Error Correction Analysis. *Utara Management Review*, 1 (1). pp. 43-57.

Tambi N. E. (1997) Testing for Cointegration in Import Demand for Consumer and Non-Consumer Commodities in the Republic of Cameroon. *Journal of International Food and Agribusiness Marketing*, Volume 9, Issue 1, pages 19-38

Tang, Tuck Cheong (2006) Cointegration analysis on Japan's aggregate import demand function: Does data frequency matter? *Labuan Bulletin of International Business and Finance*, 4 . 19-42 .

Yoichi, Matsubayashi and Shigeyuki, Hamori (2009) *Empirical Analysis of Import Demand Behavior of Least Developed Countries. Economics Bulletin*, Vol. 29, No. 2 (2009): pp. 1460-1475.