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AN APPLICATION OF THE ERROR CORRECTION MODEL IN ANALYZING THE LONG RUN EQUILIBRIUM BETWEEN GHANA'S EXPORTS AND IMPORTS

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Abstract: *This study investigates the long-run relationship between Ghana's exports and imports for the period of 1948 to 2012. Using the Engle Granger two-step procedure we find that Ghana's exports and imports are cointegrated. However, the slope coefficients from the cointegration equations were not statistically equal to 1. Furthermore, application of the error correction model reveals that 1% increase in the imports will significantly result in 0.56% increase in exports, suggesting that the exports' responsiveness to imports is low. The estimated error correction coefficient suggests that 32% of the deviation from the long run equilibrium relation is eliminated, leaving 68% to persist into the next period. These results suggest persistence in the trade deficit and an option of curbing the deficit is to re-order the relationship between imports and exports with a view to reducing imports demand. These results imply that though Ghana's past macroeconomic policies have been effective in bringing its imports and exports into a long run equilibrium, it is yet to satisfy the sufficient condition for sustainability of foreign deficit.*

Keywords: *Foreign deficit, sustainability, exports, imports, cointegration.*

Introduction

Recent empirical studies analyzing the sustainability of external deficits have focused their attention on the long run relationship between imports and exports. This is because the presence of a long run equilibrium relationship between exports and imports indicates that trade deficit is only a short run phenomenon that is sustainable in the long run. Cointegration of exports and imports is desirable by countries since this knowledge can be employed in the design and evaluation of macroeconomic policies aimed at achieving external trade balance. Fundamentally, a stable long run equilibrium relationship between imports and exports implies that the economy is not in violation of its international budget constraint as its macroeconomic policies have been effective in keeping exports and imports in equilibrium.

However, little is known about the exports and imports of Ghana. In order to shed light on the exports and imports of Ghana, Annan and Acquah (2011) analysed the long run equilibrium relationship between the exports and imports of Ghana using nominal annual time series data for the period of 1948 to 2010. The analysis specifically examined whether there is cointegration between exports and imports. Though the study found cointegration, it failed to include the long run equilibrium in modeling the relationship between the exports and imports. However, when two variables are cointegrated, it is important to include information on the long run equilibrium when modeling the relationship between the two variables. This study extends the work on exports and imports cointegration by Annan and Acquah (2011) to include error correction modeling of the exports and imports which allows the inclusion of the long run equilibrium, when explaining the relationship between the exports and imports. The current research seeks to add to existing knowledge about the exports – imports relationship in Ghana. One way in which the current study differs from previous study (Annan and Acquah, 2011) is that the issues of causation and error correction modeling which has not been considered in the previous study has been given ample attention using an extended data from 1948 to 2012. The focus of this study is therefore to examine the nature and direction of the relationship between exports and imports and explore the policy implication for managing trade deficit in Ghana.

Long run relationship between exports and imports

Numerous researchers have investigated the issue of long run equilibrium relationship between exports and imports of countries. Noticeably, the different methods employed by researchers' leads to different conclusions.

For example, in the US, Husted (1992) estimates the long run relationship between exports and imports using quarterly US trade data between 1967 and 1989. He finds a long-run relationship between US exports and imports pointing that its trade balances are sustainable in the long run. However,

Fountas and Wu (1999) studying US data ranging between1967 and 1994 and applying a different methodology found that the hypothesis of no cointegration between exports and imports cannot be rejected. Their finding suggests that US trade deficit was not sustainable and conflicts with the earlier findings of Husted (1992). Bahamani-Oskooee (1994) used cointegration technique and tested long run relationship between Australian exports and imports. He found out that they will converge in the long run.

Using the bounds testing approach to cointegration, Narayan and Narayan (2005) explore the possibility of a long-run relationship (cointegration) between exports and imports for 22 least developed countries (LDCs). They found that exports and imports are cointegrated only for six out of the 22 countries, and the coefficient of exports is less than one. Konya and Singh (2008) explore the presence of an equilibrium relationship between the logarithms of Indian exports and imports between 1949/50 and 2004/2005, using unit-root, cointegration approach. The results obtained point to no-cointegration between exports and imports. They therefore conclude that Indian's macroeconomic policies have been ineffective in bringing exports and imports into long-run equilibrium and that India was in violation of her international budget constraint.

Arize (2002) used cointegration technique and tested the long run relationship between exports and imports for quarterly data for the period 1973–1998 from 50 OCED and developing countries. The results obtained suggest that for 35 of the 50 countries there was evidence of cointegration between exports and imports; and 31 of the 35 countries had a positive export coefficient.

Similarly, Tang and Mohammad (2005) investigated the presence of a long run relationship between imports and exports for 27 Organization of Islamic Conferences (OIC) member nations. The results of unit root and cointegration tests indicate that only four of them, namely Benin, Burkina Faso, Cameroun, and Guyana show a long run relationship between imports and exports. They conclude that exchange rate and macroeconomic policies may be effective to improve the countries' trade balances in the long run. For the other countries, they find no cointegration between their imports and exports, and conclude that they are in violation of their international budget constraint, and that other macroeconomic policies are unfavorable to the countries' external balances in the long run. Similarly, Erbaykal and Karaca (2008) examined the long run relationship between Turkey's exports and imports and find that although there is a cointegration relationship between imports and exports, the slope coefficients obtained from the equations derived from exports and imports series is statistically not equal to one. They assert that it is doubtful that the foreign deficit of Turkey is sustainable. These findings suggest that the existence of a cointegration relationship between imports and exports is necessary but not sufficient to state clearly that the foreign deficit is sustainable. In order to be conclusive about this matter, when there is a cointegration relationship between imports and exports series, it is also necessary that the slope coefficients obtained from the equations derived from these series should be statistically equal to 1.

Methodology

The methodology describes the time series data and the econometric techniques employed in the study. Econometric techniques such as the Augmented Dickey Fuller and the Philips- Perron tests are used to test for the order of integration of the export and import data. Granger causality test is useful in resolving the problem of causal direction between exports and imports. Engle-Granger two-step procedure is employed to test for cointegration in the long run equilibrium between Ghanaian exports and imports. The Husted econometric model and the error correction model are employed to model the relationships between exports and imports.

Data

This study employed nominal annual time series data for the period of 1948 to 2012. The datasets were obtained from the statistics database of World Trade Organization (WTO). Specifically, total merchandise annual imports and exports data (measured in US $ value) of Ghana were used for the study. The variables of study are transformed into natural log form prior to the estimation process.

Data Analysis Techniques

Numerous tests have been developed and applied to time series data in order to test for the existence of a unit root. This section discusses commonly used test for stationarity such as the Augmented Dicky Fuller test and the Philips- Perron statistic. In addition, the Engle-Granger cointegration test is presented and sequentially utilized to model the export and import series for further examination. We also discuss the Husted econometric model and the error correction model that are employed in the study.

Unit Root Test

A series is considered non-stationary if it follows a unit root process, that is, it exhibits time varying characteristics (e.g. mean, variance and covariance). Alternatively, a stationary series is one that does not follow a unit root process. If a series is non stationary and the first difference of the series is stationary, then the series is said to contain a unit root or is referred to as integrated of the order one [I(1)] . In order to test for unit roots, the widely used Augmented Dickey Fuller test (ADF), is applied. Following Dickey and Fuller (1981), the ADF setup is specified as:

$$\Delta x_t = \delta_t + \eta t + k x_{t-1} + \sum_{k=1}^{n} \beta_k \Delta x_{t-k} + \varepsilon_t \qquad [1]$$

Where: Δx_t is the first-differenced (variable growth overtime) value, $k x_{t-1}$ is the first-lagged value and $\sum_{k=1}^{n} \beta_k \Delta x_{t-k}$ corresponds to the first to nth – lagged of first – differenced values of the series, x_i . ε_t is white noise error term.

However, the ADF test is unreliable in the presence of serial correlation and heteroskedasticity. A well known unit

root test that overcomes the possible weaknesses of the ADF test is the Philips-Perron statistic or test (PP). Similarly, the PP test is computed as:

$$x_t = \delta_t + \eta_0 x_{t-1} + \eta_1 \Delta x_{t-1} + \ldots + k\Delta x_{t-k} + u_t \quad [2]$$

Granger Causality

If changes in X precede changes in Y, we can rule out Y causing X. Based on this, we can estimate a regression of the following form:

$$Y_t = \beta_o + \sum \beta_j Y_{t-j} + \sum c_j X_{t-j} + u_t \quad [3]$$

If past values of X help determine current values of Y, we say X Granger causes Y. The test of H0: ci = 0 can be undertaken with an F test. The number of lags may be chosen using the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC).

Cointegration Analysis

Cointegration refers to the linear combination of integrated (i.e. non stationary) variables that is stationary. For cointegration to exist, between two variables, the variables should individually have a unit root (i.e. non stationary) or integrated of the same order. For example, integrated of the order one [I(1)]. In order to test for cointegration, the Engle and Granger (1987) two-step procedure is employed to analyze the long run relationship between the exports and imports. First, the long run relationship between exports and imports is estimated in the equation below using the ordinary least squares technique.

$$y_t = \alpha + \beta x_t + v_t \quad [4]$$

And the residuals from this cointegration regression, defined by:

$$\hat{v}_t = y_t - (\hat{\alpha} + \hat{\beta} x_t) \quad [5]$$

Where: β is the equilibrium parameter, α is intercept and v_t is the error term or residual.

In a second step, a Dickey Fuller test is conducted on the estimated residuals as follows:

$$\Delta v_t = k v_{t-1} + \sum_{k=1}^{n} \beta_k \Delta v_{t-k} + \varepsilon_t \quad [6]$$

When the null hypothesis of no cointegration is rejected, it implies that the residuals in the above equation are stationary. The rejection of the null hypothesis indicates that the imports and export series are cointegrated. The statistical inferences are based on MacKinnon (1991) critical values.

Husted's Econometric Model

Husted (1992) develops a framework that shows the long run relationship between imports and exports. His starting point is a current budget constraint for a country and is given by:

$$C_o = Y_o + B_o - I_o - (1+r)B_{-1} \quad [7]$$

Where: C_o is the current consumption, Y_o is output, I_o is investment, r is the one-period world interest rate, B_o is the international borrowing and $(1+r)B_{-1}$ is the initial debt. Based on the budget constraint equation, Husted (1992) makes several assumptions to derive the following testable model:

$$\text{Export}_t = a + b\text{Import} + e_t \quad [8]$$

Arize (2002) suggest an alternative approach to Husted model, which is given by:

$$\text{Import}_t = a + b\text{Export} + e_t \quad [9]$$

For an economy to maintain inter-temporal budget constraint in the context of this model, two conditions must be met: a cointegration relationship must exist between the import and export series; the slope coefficients from the cointegration equations should also be statistically equal to 1 (Erbaykal & Karaca, 2008).

Error Correction Model

A simple homogeneous Granger and Lee (1989) Error Correction Model data generating process can be specified as follows:

$$\Delta y_t = \beta_1 \Delta x_t + \beta_2 (y - x)_{t-1} + \varepsilon_{2,t} \quad [10]$$

$$\varepsilon_{2,t} \sim N(0, \delta^2)$$

where y and x are export and import series. If y and x are typically I (1) processes that are cointegrated, then there exists an equilibrium relationship between y and x which is defined by an error correction term ($(y-x)_{t-1}$). The long run dynamics captured by the error correction term are implicitly symmetric.

Results and Discussion

In this study, both the ADF and PP tests are used to model stationarity of the import and export series. The empirical results of the ADF and PP tests on each variable in levels and in first differences are presented in Table 1.

Table 1: ADF Unit Root Test and Philips-Perron Unit Root Test

ADF Unit Root Test				
Variables	**Levels**	**P-Value**	**First Difference**	**P-Value**
ln Exports	-0.8653	0.9511	-3.5306	0.0463*
ln Imports	-0.7592	0.9604	-4.3420	0.01**
Philips-Perron Unit Root Test				
Variables	**Levels**	**P-Value**	**First Difference**	**P-Value**
ln Exports	-6.2605	0.7468	-82.3552	0.01**
ln Imports	-14.1168	0.2735	-75.8983	0.01**

*'***', '**' and '*' denotes 0.1%, 1% and 5% levels of significance respectively.*

With regards to the variables in levels the null hypothesis of non-stationarity cannot be rejected for any of the series on the basis of the ADF and PP tests. These findings suggest that the levels of the series are non-stationary. Applying the same unit root test to the first differenced series, they are found to be stationary, as null hypothesis of non-stationarity is rejected on the basis of the p-values. These results suggest that the variables are individually integrated of order one. For cointegration to exist, the two variables should be I(1) processes. Given that the variables are integrated of the same order, we proceed to test for cointegration between the exports and imports using the Engle-Granger two-step procedure. The results for the cointegration tests are presented in Table 2.

Table 2: Cointegration Test Results

Model	R^2	ADF	P-Value
Residual i. Exports = f(Imports)	0.9572	-4.2019	0.01**
Residual ii. Imports = f(Exports)	0.9572	-3.9653	0.0168**

*'***', '**' and '*' denotes 0.1%, 1% and 5% levels of significance respectively.*

ADF test statistics for both error equations have smaller p-values as indicated. This leads to the rejection of non-stationarity of the residuals. These findings suggest that both export and import series are cointegrated.

Table 3 presents the results of Wald test which was used to examine whether the slope coefficients are statistically equal to one. The magnitude of the slope coefficients from equations [8] and [9] i.e. either $b > 1$ or $b < 1$ show how much a country imports per dollar unit of export and vice versa.

The cointegration regressions in Table 3 suggest that a 1 percent increase in dollar-denominated imports raises the long run value of dollar-denominated exports by 0.81 percent (see equation i), while a 1 percent rise in exports elicits 1.18 percent increase in imports (see equation ii). These observations suggest that Ghana's exports responsiveness to imports is low but imports responsiveness to exports is high. This situation implies persistence in the trade deficit and that one sure way of curbing the deficit is to re-order the relationship between imports and exports with a view to reducing imports demand. Furthermore, there seems to be a positive relationship between exports and imports in the long run, as indicated by the estimated cointegrating regressions for both cases, which are 0.81 in (i) and 1.18 in (ii). Given that the estimated cointegrating vectors are positive and close to unity, these findings are interpreted as Ghana's adherence to the international budget constraint. However, in order to confirm this assertion, it is important to conduct the restricted cointegration test to examine the one-on-one ordering between imports and exports. Erbaykal & Karaca (2008) assert that when there is a cointegration relationship between imports and exports series, it is also necessary that the slope coefficients obtained from the equations derived from these series be statistically equal to 1. However, the F statistics lies within the rejection region of 0.1 percent significance level. This leads to the rejection of the null hypothesis that each slope coefficient for both cointegration equations is statistically equal to 1. These findings are consistent with the findings of Erbaykal & Karaca (2008), and Narayan and Narayan (2005).

Using the Granger causality test, we test for causation between exports and imports in the Granger sense. The result of the Granger causality test is displayed in Table 4. The p-value of 0.2011 fails to reject the null hypothesis that imports granger-causes export, whilst the p-value of 0.0079 rejects the null hypothesis that export granger-causes import at the 1% significant level. In summary a unidirectional causation is supported between the exports and imports.

Table 3: Cointegration Equations and Wald Test Results

Equation	Coefficient $\hat{\beta}$	Null Hypothesis	F Statistic	P-Value
i. Exports = 1.18 + 0.81 Im	0.81	$H_o : \hat{\beta}_{ex} = 1$	79.41	9.2×10^{-13}***
ii. Imports = -1.10 + 1.18Ex	1.18	$H_o : \hat{\beta}_{im} = 1$	34.18	1.9×10^{-7}***

*'***', '**' and '*' denotes 0.1%, 1% and 5% levels of significance respectively.*

Table 4: Granger Causality Test Results

Model	F-test	P-Value
Exports = f(Imports)	1.6703	0.2011
Imports = f(Exports)	7.5544	0.0079**

*'***', '**' and '*' denotes 0.1%, 1% and 5% levels of significance respectively.*

The result of the error correction model is presented in Table 5. The error correction equation is specified below. Noticeably, changes in imports have both immediate and long term effect on exports. ECT is the error correction term.

Table 5: Error Correction Modeling Results

Response Variable: (Δ ln Exports)

Variable	Estimate	Std. Error	P-Value
Intercept	0.0178	0.0215	0.4092
Δ ln Imports	0.5627	0.0855	1.21×10^{-8}***
ECT_{t-1}	-0.3225	0.1007	0.0022**
Breusch Pagan Test		0.7287	0.6946
Shapiro Wilk Normality Test		0.9832	0.5338
Durbin-Watson Test		2.0142	0.5049

*'***', '**' and '*' denotes 0.1%, 1% and 5% levels of significance respectively.*

$$\Delta \text{ In Exports}_t = 0.0178 + 0.563(\Delta \text{ In Imports}_t) - 0.322\ ECT_{t-1} + \varepsilon$$

In the short run, 1 % increase in the imports will significantly result in 0.56% increase in exports, suggesting that the exports responsiveness to imports is low. This situation implies persistence in the trade deficit and that option of curbing the deficit is to re-order the relationship between imports and exports with a view to reducing imports demand. As the results show, 32% of the disequilibrium in the exports and imports in the previous time period is eliminated in subsequent time period. The negative coefficient on the error correction term indicates that if export is above its long run equilibrium relationship with imports, it will decrease to return to equilibrium. The error correction term in the model is statistically significant, confirming the existence of long run steady-state equilibrium between exports and imports. The short term disequilibrium that is adjusted by the error correction term could result from structural or institutional break or macroeconomic policy failures among others.

The diagnostic statistics indicate that model assumptions are not violated. Noticeably, all the p-values for the various test (Breusch-Pagan test, Shapiro-Wilk Normality test and Durbin-Watson test) used in evaluation of model assumptions are large. This is in support of the fact that all the assumptions hold and the model satisfied the conditions of no autocorrelation, no heteroskedasticity and the normality of the disturbance terms.

Conclusion

Using cointegration techniques, the study investigated the long run relationship between nominal exports and imports for the Ghanaian economy for the period of 1948 to 2012. The results of the ADF and PP tests for the order of integration of the exports and imports indicated that the exports and imports are non stationary and integrated of the order one. Using the Engle-Granger two-stage cointegration procedures, we found that Ghana's exports and imports will converge in the long run. However, the slope coefficients obtained from the cointegration regression equations derived from exports and imports series is statistically not equal to one. In the light of the assertions of Erbaykal & Karaca (2008), this suggests that it is doubtful that the foreign deficit of Ghana is sustainable. Though Ghana's past macroeconomic policies have been effective in bringing its imports and exports into a long run equilibrium, the sufficient condition for sustainability of foreign deficit of Ghana has not been met. The policy implication for Ghana is that trade policy focus should be on reducing imports and raising exports in order to control the trade balance (deficits) at least in the short run. Direction for future research will be to investigate the long run equilibrium of the export import relationship using threshold cointegration techniques.

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