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Influential Factors of Exchange Rate Behaviour in Ghana: A Cointegration Analysis

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Abstract

This study investigates whether short run movements in the exchange rates could be predicted by the past history of GDP, consumer price index, imports, exchange rates themselves and government expenditure. Secondly, the study investigates if there are stable long run equilibrium relationships among the variables. Using quarterly data spanning twenty four years, the techniques of cointegration, vector error correction mechanism, granger causality test, variance decomposition and impulse response functions have been used to analyze the data. The study reveals that there are significant long run equilibrium relationships among the variables. It also reveals that government expenditure is significant in forecasting the exchange rate movements. In addition, the past history of the exchange rates has dominant effects in forecasting the exchange rates. It is recommended that government expenditure should be controlled to reduce drastic fluctuations in the exchange rate in the short run.

Keywords: exchange rate behavour, cointegration, influential factors, Ghana

1. Introduction

The exchange rate is one of the macroeconomic variables that occupy a central place in the management of most economies. The volume of empirical studies on the subject attests to this assertion (Abuaf & Jorion, 1990; Calderon & Duncan, 2003; Cheung & Lai, 2001; Diebold, Husted, & Rush, 1991; MacDonald, 1993; Sarno & Taylor, 1998; Taylor, 1995). The issue becomes more imperative especially for countries that depend heavily on importation of essential commodities such as crude oil and raw materials for industrial production. Given the foreign prices of these products, rises in the exchange rate result in higher prices for domestic consumers. Because of the inflationary effect of devaluation, policymakers in the sixties and seventies generally maintained a fixed exchange rate with occasional devaluations. There was extreme reluctance on the part of most governments during this period to vary the exchange rate because of concern over adverse political consequences (Harrigan & Oduro, 2000). Because of an unfavorable balance of payments and the deflationary effect of the fixed exchange on the Ghanaian economy, the Cedi was devalued in 1971 during a Busia government (Dordunoo, 1994). Not more than six weeks after the devaluation, the Busia government was overthrown in a military coup and the currency revalued by 29% (Osei, 1996).

The economy of Ghana persistently declined since the early 1960s (Jebuni, Sowa, & Tutu, 1991). GDP declined at the rate of 1.3 percent between 1960 and 1982. By 1983, the rate of inflation had climbed to 123 percent. Food production also declined over the years while the population was growing at a staggering 3.2 percent. All these factors meant economic hardship for the country. Balance of payment difficulties and a shortage of foreign exchange also meant low industrial output since importation of essential raw materials could not be imported. Most industries in Ghana were operating greatly below capacity prior to 1983. The severe economic downturn in the late 1970s and early 1980s compelled the Provisional National Defense Council (PNDC) government in 1983 to implement the International Monetary Fund (IMF) /World Bank supported Economic Recovery Program (ERP). The ERP sought to remove controls and distortions in the economy so as to restore incentives for economic growth and development (Ocran, 2007). A lot of reforms were introduced during the process including the deregulation (liberalization) of the exchange rate determination (Kwakye & Sowa, 1993). Because of the political consequences of devaluation, a gradual systematic approach was adopted toward this goal. By the early 1990s, the exchange rate was fully liberalized with the legalization of foreign exchange bureaux to operate as legal entities (Bhasin, 2004). The fact that macroeconomic variables were important in determining exchange rates was again made evident in 2008 when the

Cedi depreciated by 24.7 percent against the US Dollar. This was associated with a substantial growth in government expenditure of about 42 percent. The main objective of this study is to determine the variables that explain variation in the exchange rate.

2. Methodology

2.1 Theoretical Framework

The model assumes that Ghana is a small country in the world capital market and hence faces a given foreign interest rate. Ghana, being a market economy, allows movement of capital into and out of the country with slight restrictions. This capital mobility will ensure the equalization of net expected yields so that the domestic interest rate, adjusted for the rate of depreciation, will equal the interest rate of her trading partners. This is summarized in equation (1). Recalling (1) and expressing the sport exchange rate in terms of other variables, we have

$$InE_t = InE_{t+1} - r + r^* \tag{1}$$

where E_t, E_{t+1}, r and r^*denote the current spot exchange rate, the long run exchange rate, the domestic interest rate and foreign interest rate in that order. From equation (1), it can be seen that the spot exchange rate is influenced by the domestic interest rate. The logical progression then is to find out how the domestic interest rate is determined. In this framework, the domestic interest rate is determined by the conditions in the money market. The money market equilibrium condition requires that the real money supply equates real money demand. For now, we assume money supply is exogenously determined but will be relaxed later. The real demand for money is assumed to depend on the rate of interest and income. The equilibrium in the money market is represented in the equation. Solving for Gives u equation (2) and substituting it into (1), we have

$$InE_t = InE_{t+1} - \{1/\lambda(\phi InY - InM + InP)\} + r^* \tag{2}$$

As suggested by Becker (2006), economic models are abstractions of the real world for the purposes of studying the relationship among some variables of interest. For this reason, economic models should not be proliferated with variables. Guided by this suggestion, money supply will be assumed to depend on domestic credit, which is made available to the public by commercial banks, budget deficit which is proxied by government expenditure and balance of payments disequilibrium proxied by imports. That is

$$InM = f_1(GOVEXP, DOMCR, IMPORTS) \tag{3}$$

Substituting equation (3) into (2) we have

$$InE_t = InE_{t+1} - \{1/\theta\lambda f_1(GOVEXP, DOMCR, IMPORTS)\} + r^* \tag{4}$$

Functionally, equation (4) can be written more compactly as $e = f_2(y, bud, domcr, bop, p, r^*)$ where the current spot exchange rate depends on national income, government expenditure, domestic credit, imports, domestic price level and foreign interest rate. Since Ghana is a small country in respect of international transactions, foreign interest rate may influence the workings of the Ghanaian economy but the effect is not expected to be significant. For this reason, foreign interest rates will be dropped from the model. For the purpose of estimation, balance of payments is proxied by the imports, domestic price level of the consumer price index, national income by the nominal GDP and the domestic credit by the amount of credit made available to the banking public by the various commercial banks. We expect the nominal exchange rate to have a positive relationship with all the variables in the model except national income that can be either positive or negative.

2.2 Definition of Variables

Exchange rate refers to the quantity of domestic currency that is needed to purchase a unit of foreign currency. The nominal gross domestic product (GDP) refers to the total money value of all goods and services currently produced in a country over a given period usually one year. Domestic credit refers to the total amount of credit facilities made available to the general banking public by the various financial institutions. The consumer price index is the weighted average of price of a basket of goods and services used by an average consumer. The level of variation in this index measures the rate of inflation.

2.3 Estimation Technique

Ordinary Least Squares (OLS) are one of the techniques used widely in econometric model estimation. For results from OLS estimation to be valid, the various assumptions underlying the model must be satisfied. Of particular interest are the assumptions that the data to be used for the estimation must be stationary and that the disturbance term must not correlate with the regressors. A VAR model expresses the current value of an endogenous variable as a function of deterministic terms and the lagged values of the endogenous variables. In other words, in VAR, each endogenous variable is explained by its lagged or past value and the lagged values of all other endogenous variables in the model. This definition of VAR can, however, be modified such that other deterministic variables such as constants in each equation, the time trend t, dummy, and exogenous variable can be included in the model. The variables in the VAR can be expressed using a vector. In this study,

$$Y_t = (y, gov, \exp, domcr, imports, p, exch)^1 \tag{5}$$

is a vector of endogenous variables consisting of the nominal GDP, government expenditure, domestic credit, import, consumer price index and nominal exchange rate respectively. The basic p-order vector autoregressive (VAR [p]) model has the general form

$$Y_t = u + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots\ldots + \Pi_p Y_{t-p} + \varepsilon_t \tag{6}$$

for $t = 1, 2, \ldots T$where $\Pi_i$are kxkcoefficient matrices, $\varepsilon_t$is a $kx1$ unobservable zero mean white noise vector process and $u$is a kx 1 vector of constants. Before estimating equation (6), it is important to determine the order of the VAR model. The lag length for the VAR(p) model may be determined using model selection criteria. The general approach is to fit VAR(p) models with orders $p = 1, 2, \ldots P_{max}$ and choose the value p which minimizes some model selection criteria (Greene, 2002). Model selection criteria for VAR (p) models have the form

$$IC(p) = In\,\tilde{\Sigma}(p) + C_T.\psi(n, p) \tag{7}$$

Where $\tilde{\Sigma}(p) = T^{-} \sum_{t=1}^{T} \hat{\varepsilon}_t \hat{\varepsilon}_t^{I}$ is the residual covariance matrix without a degree of freedom correction from VAR (p) model,C_T is a sequence indexed by the sample size$T$, and $\psi(n, p)$ is a penalty function which penalizes large VAR (p) models. The three most common information criteria are the Akaike (AIC), Schwarz-Bayesian (BIC) and Hannan-Quinn (HQ). In this study, Hannan-Quinn (HQ) criterion has been used to determine the order of VAR. There are, however, other methods for selecting the appropriate lag length. After the correct lag length is chosen, the model is then estimated using OLS. Although the equation system in VAR can be exceedingly large, it is, in fact, a seemingly unrelated regression model with identical regressors. As such, the equations should be estimated separately by OLS (Greene, 2002). To guard against the dangers of spurious regressions and erroneous inferences emanating from the use of nonstationary data, tests of nonstationarity are conducted. The common type of nonstationarity in economic time series is the presence of unit root. The unit root tests are used to determine the order of integration of the variables. There are several ways of conducting the unit root tests. This study uses Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test. The ADF statistic tests the null hypothesis that the variables under consideration contain a unit root. The ADF test, for instance, is based on autoregression of each variable with lagged difference terms ranging from one to six added to ensure that the error terms do not correlate. The model with the least value of Akaike Information Criterion (AIC) is then chosen. If the variables are integrated of order zero, I(0), inferences from the OLS estimation will be valid (Greene, 2002). If the variables are integrated of order one, I(1), then, there is a possibility of invalid inferences from the OLS estimation. Johansen formulates a process of determining the number of cointegrating relationships in a VAR model. The context of analysis is an unrestricted path order VAR in K variables, formulated as a Vector Error Correction (VEC) model (Patterson, 2000). Equation (7) can be reformulated in terms of first differences and levels. This follows from Granger Representation Theorem, which states that if the K x 1 vector of variables Y_t is cointegrated, then the equation (8) can be expressed as a VEC model. The VEC form of (10) is

$$\Delta Y_t = u + \Gamma_1 Y_{t-1} + \ldots\ldots.. + \Gamma_{p-1} Y_{t-(p-2)} - \ldots\ldots. + \Pi Y_{t-1} + V_t \tag{8}$$

where the Γ_1 are functions of the Π_i which capture the short-run dynamics involving the differenced variables and $\Pi = I-\Pi_i-\ldots-\Pi_n$ is a matrix capturing the number of long run equilibrium relationships among the $Y_t$variables. The vector ΔY_t contains the first differenced variables and Y_t is a vector of the variables in their levels. If the vector Y_t is integrated of order one I(1), casual inspection of (8) seems to suggest there is an imbalance in model (4.8) since the left-hand side (LHS) is stationary while the right-hand side (RHS) appears to be nonstationary because it contains Y_{t-1}, which is nonstationary. In order to balance the time series property on the LHS of (8), the RHS must also be I(0). What can solve this contradiction lies in whether there is a linear combination of I(1) variables in Y_{t-1}which is I(0). If so, equation (8) is balanced in its time series properties and when this occurs, the variables in the vector ... are side to be cointegrated. Let r denote the number of cointegrating vectors in equation (8). The matrixΠcan be decomposed into two matrices, $\Pi=\alpha\beta^2$ where $\alpha$is a $k\ x\ r$. matrix of adjustment coefficients with each column associated with one of the cointegrating vectors and $\beta^2$is $r\ x\ k$ matrix of cointegrating vectors among the k variables. The dimension of Π is, therefore, $k\ x\ k$ the rank of, Π, p (Π) is equal to the number of cointegrating vectors (8) denoted by r. The number of cointegrating vectors can be checked by calculating the eigenvalues,λ_i, of Π. The behavior of Y_t vector depends on the values of λ that solve the characteristic equation

$$\left| \lambda^{p} I - \lambda^{p-1} \Pi_{1} \ldots - \lambda \Pi_{p-1} - \Pi_{p} \right| = 0 \tag{9}$$

The λ_i are ordered such that $\lambda_1 > \lambda_2 > \lambda_3 \ldots \lambda_k$ Johansen has developed two tests that facilitate the determination of the number of cointegrating vectors r in the model. The trace statistic is given as:

$$\left(r_0 / k \right) = -T \sum_{1=r_0+1}^{k} In(1 - \hat{\lambda}_i)$$

The implications of the test are that If $p(\Pi)=k$ meaning each root in Π has modulus less than one, Π will have full rank and be nonsingular. All the variables in equation (9) will be I(0), and unrestricted OLS estimates will yield identical inferences about the parameters. If $p(\Pi)= r<k$.This situation will occur if there is a unit root with multiplicity (k-r) and the remaining roots are numerically less than one. The Y_t vector will be I(1)or higher and Π may be expressed as the outer product of two (kxr) matrices, each of rank r. The RHS of equation (9) then contains r cointegrating vectors. In other words, equation (8) must be expressed as equation (9 incorporating both short-run dynamics and static equilibrium. This model must reflect the number of cointegrating vectors. If $p(\Pi)=0$. This will occur only whenΠ=0, implying no long run relationships among the variables and the model must be expressed solely in terms of first differences of the variables (Johnston & DiNardo, 1997). The results of Johansen tests will determine how the model will be formulated finally. This is because the final estimation must reflect the number of cointegrating vectors in the model. The presence of cointegration in a given model does not mean that all the variables tend to move together. It only suggests that some of the variables tend to drift together. Likelihood Ratio (LR) test can be used to determine which variables to include in a long run relationship. The LR test simple compares the maximum likelihood of observing an endogenous variable in the presence of its entire explanatory variables (unrestricted model) to the maximum likelihood of observing the same endogenous variable in the presence of some of its explanatory variables (restricted model). This statistic has a chi-squared $|x^2(q)|$ distribution with q degrees of freedom being the number of explanatory variables excluded from the restricted model. If the excluded variable(s) are significant, the likelihood ratio will be large leading to the rejection of the null hypothesis. This method is used to exclude insignificant variable from a given long run relationship. One shortcoming of this technique is that it is asymptotically valid and may be biased in small samples. Granger causality test determines whether the lagged values of a particular variable are significant in predicting the regressor and can be based on simple F tests in the single equations of the VAR model (Greene, 2002)

Mathematically, variable x_t is said not to granger cause variable Y_t if

$E\left(y_t \middle| y_{t-1}, x_{t-1}, x_{t-2}, \ldots \right) = E(y_t | y_{t-1})$, where E is the conditional expectation (Greene, 2002). Specifically, we test whether the past values of the nominal GDP, CPI, government expenditure, imports and domestic credit contain useful information for predicting exchange rates-Cedi-Dollar and Cedi-Pound. This test is performed on the lagged values of a particular variable one at a time. The endogenous variables can be expressed as a moving-average process under some conditions. Recalling equation (9) and using the lag operator notation, the general VAR can be expressed as

$$Y_t = u + \Pi_1 L Y_t + \Pi_2 L^2 Y_t + \ldots \Pi_p L^p Y_t + \varepsilon_t \tag{10}$$

From (10),

$$\Pi Y_t = u + \varepsilon_t \tag{11}$$

where $\left(l_p - \Pi_1 L - \Pi_2 L^2 - \ldots - \Pi_p L^p \right) = |\Pi$. For Y_t to be expressed in terms of ε_t and u, the matrix Π must have full rank. The presence of unit root implies that the matrix Π has reduced rank and therefore not invertible. This shows that VAR containing nonstationary variables cannot have a moving average representation. Instead, we must decompose the characteristic polynomial into a unit-root part and a stationary invertible part, written as the product:

$$(1 - L)Y_t = \Delta Y_t \Pi^{*-1} u + \Pi^{*-1} \varepsilon_t \tag{12}$$

Equation (12) tells us that VAR involving stationary variables have a moving average representation since the matrix Π^* is now invertible. Thus, if the variables are nonstationary, the VAR can be estimated using the first differences (Henry & Juselius, 2000). The moving average model is then estimated and the parameter estimates plotted to give us the impulse response functions. Plotting the impulse response functions (i.e., plotting the coefficients of the innovations against the time horizon) is a practical way to visually represent the behavior of the series in response to the various shocks. To illustrate, consider a two-variable first order VAR system

$$y_{1t} = a_{11} y_{1t-1} + a_{12} y_{2t-1} + \varepsilon_{1t}$$

$$y_{2t} = a_{21}y_{1t-1} + a_{22}y_{2t-1} + \varepsilon_{2t}$$

A shock in ε_{1t} has an immediate and one-for-one effect ony_{1t}, but no effect ony_{2t}. In period $t+1$, that shock in y_{1t} affects y_{1t+1} through the first equation and also affect y_{2t+1} through the second equation. These effects work through $t+2$, and so on. Thus, a shock in one innovation in the VAR sets up a chain reaction over time in all variables in the VAR system. Impulse response functions calculate these chain reactions (Johnston & DiNardo, 1997). Variance decomposition or forecast error variance decomposition indicates the amount of information each variable contributes to the other variables in a VAR model. While impulse response functions trace the effects of shock to one endogenous variable on the other variables in the VAR, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. In other words, variance decomposition assesses the importance of different shocks by determining the relative share of variance that each structural shock contributes to the total variation of each variable. PcGive and Eviews econometric softwares, which have routines capable of VAR analysis, have been used in the study. PcGive was used to do the following: natural log transformation of the data; time series plot of the variables; unit root tests; lag length selection tests and; forecasting the exchange rates. Eviews, on the other hand, was used in performing the following tasks: Johansen cointegratioin tests; error correction model estimation; computing error variance decompositions and; estimation of impulse response functions.

2.4 Data Sources

Quarterly data for this study were obtained from three sources namely, the Ghana Statistical Service (GSS, 2012), the Bank of Ghana (BOG, 2012) and International Financial Statistics (IFS) of the IMF, the paper version (2012) covering the period 1989–2012. The nominal GDP and consumer price index were obtained from the GSS. Domestic credit, measured in millions of Ghana Cedis, is obtained from the various editions of IFS. The quarterly exchange rates are indicative of the interbank market rates (1989–2012) obtained from BOG. Annual government expenditure, measured in thousands of Ghana Cedis, and imports, measured in millions of US Dollars, were all obtained from BOG.

3. Results and Discussion

3.1 Unit Root Tests

The Augmented Dicky-Fuller unit root test was conducted on the variables and the results are shown in Table 1.

Table 1. Augmented dickey-fuller unit root test

Variable	ADF (constant)	ADF (trend and constant)
LnnomGDP	-	-2.674(0)
ΔlnnomGDP	9.021**(0)	-
InCPI	-	-1.361(2)
ΔInCPI	3.822** (1)	-
Inimports	-	-1.452(2)
Δlnimports	4.613**(1)	-
Govtexp	-	-1.401(1)
Δ Govtexp	-7.643**(0)	-
InCedi-Dollar	-	-1.906 (4)
In ΔCedi-Dollar	-2.911*(3)	-
InCedi-Pound	-	-1.21(0)
In ΔCedi-pound	-8.902**(0)	-
InDomestic credit	-	-1.212(0)
InΔDomestic credit	-8.731**(0)	

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.The numerical figures in parenthesis indicate the number lags required to remove autocorrelation.

** the unit root hypothesis rejected at 1%.* the unit root hypothesis rejected at 5%.

The Augmented Dicky-Fuller (ADF) test results show that all the variables are nonstationary in log levels at one percent significant level. That is to say, the unit root hypothesis is accepted in all cases. When the variables are first differenced, the unit root hypothesis is rejected in all cases.

3.2 Cointegration Analysis

Two sets of models are estimated-inclusion of Cedi-Dollar exchange rate in a model precludes the Cedi-Pound exchange rate and vice versa. Johansen cointegration approach, which is multivariate, is adopted in this study and the optimal lag length for the VAR is pre-determined using Hannan-Quinn (HQ) criterion. Table 2 shows the HQ values at various lag length in a VAR with constant and deterministic trend for the model containing Cedi-Dollar exchange rate.

Table 3. Test of optimal lag length for Cedi-Dollar model

Lag	Hannan-Quinn (HQ)	Akaike Information criterion
1	-31.2453	-31.8715
2	-31.6012*	-32.5271
3	-30.6724	-32.0435
4	-29.8712	-31.5631
5	-29.2768	-31.4769
6	-28.4325	-31.5790

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.

The optimal lag length for the unrestricted VAR based on HQ criterion is two. This is confirmed by Akaike Information criterion (AIC). Table 3 shows the HQ values at various lag length in a VAR with constant and deterministic trend for the model containing Cedi-Pound exchange rate.

Table 4. Test of optimal lag length for Cedi-Pound model

Lag	Hannan-Quinn (HQ)	Akaike Information criterion
1	-31.0145	-31.6024
2	-31.1672*	-32.1682*
3	-30.1561	-31.4354
4	-29.4806	-31.2492
5	-28.6543	-30.7654
6	-27.6721	-30.2314

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.

The optimal lag length for the unrestricted VAR is two using Hannan-Quinn criterion for both models. This optimal lag length is also confirmed by the Akaike Information criterion. The VAR models are then reformulated as VECM and estimated using Full Information Maximum Likelihooh (FIML) Procedure. The cointegration results are presented in Table 5 for the model with Cedi-Dollar exchange rate.

Table 5. Johansencointegration test for Cedi-Dollar model

Eigenvalue	Trace statistic	5%	1%	Null hypothesis
0.29234	108.76435	94.11	103.15	None **
0.313345	73.08742	68.46	76.12	At most 1 *
0.174238	38.37562	47.13	53.56	At most 2
0.152341	19.14503	29.86	35.75	At most 3
0.043588	4.163256	15.01	20.14	At most 4
0.000125	0.011420	3.82	6.71	At most 5

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.The test assumes linear deterministic trend the data.

** significant at 1%. * significant at 5%.

The trace statistic indicates two long run equilibrium relationships among the Cedi-Dollar exchange rate, consumer price index, nominal GDP, imports, government expenditure and domestic credit at both one and five percent significance levels. The first null hypothesis of zero cointegrating vector is rejected at both one and five percent significance levels. The second null hypothesis of at most one cointegrating vector is rejected at five percent level of significance but accepted at one percent level of significance. The third null hypothesis of at most two cointegrating vectors is not rejected at both one percent and five percent levels of significance and this ends the test. With respect of the VAR model including Cedi-Pound exchange rates, the result obtained from the estimation are displayed in Table 6.

Table 6. Johansen cointegration test for Cedi-Dollar model

Eigenvalue	Trace statistic	5%	1%	Null hypothesis
0.333563	110.7765	94.16	103.21	None **
0.313452	73.61153	68.73	76.01	At most 1 *
0.194886	39.54432	47.11	54.51	At most 2
0.213314	19.34425	29.74	35.54	At most 3
0.041272	3.912231	15.21	20.01	At most 4
0.000162	0.021443	3.74	6.56	At most 5

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.

** rejection at 1%. * rejection at 5%.

The test assumes linear deterministic trend the data.

The first null hypothesis of no cointegrating vector is rejected at both one and five percent significance levels. The second null hypothesis of at most one cointegrating vector is rejected at five percent but accepted at one percent significance level. However, the null hypothesis of at most two cointegrating vectors is not rejected at both one and five percent levels of significance. It can, therefore, be concluded that there are at most two long run relationships among the Cedi-Pound exchange rate, consumer price index, government expenditure, imports, domestic credit and nominal GDP.

3.3 Cointegration Regression

Cointegration tests only indicate the fact that long run relationships exist among the variables without specifying which variables are actually cointegrating. Likelihood Ratio (LR) test was used to determine which variables to exclude from the long run relationships. Table 7 shows the results of the likelihood ratio test.

Table 7. Likelihood ratio test

Variables (excluded)	Cedi-Dollar ModelLR statistic	Cedi-Pound ModelLR Statistic
In(domcredit)	4.441*	4.210*
In(cpi)	5.562*	5.032*
In(imports)	5.012*	4.234*
In(nomgdp)	2.257	1.762
In(govexp)	7.4533*	5.345*

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.

* The null hypothesis is rejected at 5 percent significance level.

The 5 percent point of $X^2(1)$is 3.841 showing that nominal GDP should be excluded from the long run relationships since the null hypothesis of insignificance is not rejected. The results from the estimation of the long run relationship excluding nominal GDP are shown in Table 8.

Table 8. Long run equilibrium relationships

Variables (excluded)	Cedi-Dollar ModelCoefficient	Cedi-Pound ModelCoefficient
In(domcredit)	0.74542	0.53422
In(CPI)	2.43654	3.21543
In(import)	-1.34532	-0.14553
In(nomgdp)	1.21433	0.42315
In(govexp)	7.12762	3.32667

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.

It must be noted here that since all the variables are in logs, the coefficients of the long run static relationships must be interpreted as percentage changes (or elasticities) rather than unit changes. With respect to the Cedi-Dollar model, 100 percent increase in domestic credit, CPI and government expenditure increases the Cedi-Dollar rate by approximately 67 percent, 240 percent and 120 percent respectively in the long run, A 100 percent increase in import, however, causes the Cedi-Dollar rate to fall by 135 percent. The CPI had the largest effect on the exchange rate while domestic credit had the least effect. Regarding the Cedi-Pound model, 100 percent increase in domestic credit, CPI and government expenditure increase the Cedi-Pound rate by approximately 54 percent, 322 percent and 42 percent in the long run. However, 100 percent increase in import causes the Cedi-Pound rate to fall by 15 percent in the long run. Again the CPI has the greatest impact on the rate while import has the least long run effect on the Cedi-Pound rates.

3.4 Error Correction Model

The outputs form the VECM estimation are so huge and for that matter, they are presented in Appendixes A and B. From the Cedi-Dollar model, the error correction term is correctly signed and significant at five percent level indicating that economic forces are in place to ensure the return of the Cedi-Dollar rate to its long run path. The coefficient of the error correction term indicates that about nine percent (9%) disequilibrium is eliminated each quarter by changes in the Cedi-Dollar rate to ensure that the rate returns to its long run path. The past history of the Cedi-Dollar rate and government expenditure are significant at one and five percent respectively in causing the exchange rate to deviate from its long run path. The CPI, domestic credit, imports and nominal GDP are not significant at the conventional levels. The past history of Cedi-Dollar rate, government expenditure, the CPI and domestic credit have the expected signs. With respect to the Cedi-Pound model, the coefficient of the error correction term is significant at one percent signifying that economic forces in place ensure the return of the Cedi-Dollar rate to its equilibrium path following short run deviation. The coefficient of the error correction term indicates that about twenty four percent disequilibrium in the Cedi-Pound rates is corrected each quarter by changes in the Cedi-Pound rate. While the past history of the Cedi-Pound rates is significant at five percent, government expenditure and the CPI are significant at one percent and also have the expected signs. Domestic credit, imports and nominal GDP are not significant at the conventional levels. The domestic credit, however, has the expected sign. As noted earlier, the error correction terms used as variables in the VECM are actually equilibrium residuals obtained from the cointegrating regressions. In the Cedi-Dollar model for instance, the first error correction term, *Eq.*1 (-1), is obtained from the following equation:

$$Eq1(-1) = LNCEDD - 7.641 - 0.64(Indomcredit) - 2.46(Incpi)$$
$$+1.31(In\,\mathrm{Im}\ port) + 0.19(Innomgdp) - 1.32(Ingov\,\mathrm{exp})$$

Similarly, the second error correction term, *Eq.*2 (-1), is generated from the equation:

$$Eq2(-1) = LNGOVEXP + 1.51 - 0.011(Indomcredit) - 0.44(Incpi)$$
$$-0.158(In\,\mathrm{Im}\ port) - 0.61(Innomgdp) - 0.03(Incedd)$$

In the Cedi-Pound model, the same logic is used to obtain the two error correction terms, i.e. LNCEDD is replaced by LNCEDP. Eviews software generates these error correction terms by itself once the long run restriction is imposed and uses them as variables in the VECM.

3.5 Granger Causality Test

A model containing the Cedi-Dollar exchange rates as the endogenous variable is estimated and the granger causality test results of the model are displayed in the Table 9.

Table 9. Granger causality test for cedi-dollar rate

Variables	F-statistic
InCedi-Dollar (-1)	19.812**(1,86)
InDomestic Credit (-1)	1.8748 (1,86)
Ingovexp (-1)	5.236*(1,86)
Inimports (-1)	0.0141(1,86)
InConsumer Price Index (-1)	0.83542 (1,86)
Innominal GDP (-1)	1.714 (1,86)
Bresusch-Godfrey autocorrelation test	$X^2_{df=5} = 6.117$

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.The granger causality test follows the approach described in Gujarati (2004).** significant at 1%. * significant at 5%.

It can be observed from Table 9 that imports, domestic credit, CPI and nominal GDP individually do not granger cause the Cedi-Dollar rate. The null hypothesis that imports, domestic credit, CPI and nominal GDP contain useful information in forecasting the Cedi-Dollar rate is rejected at five percent level. However, the lagged Cedi-Dollar rate and government expenditure contain useful information in forecasting the Cedi-Dollar rate. In other words, Cedi-Dollar rate and government expenditure granger the Cedi-Dollar rate. While the Cedi-Dollar rate is significant at one percent level, government expenditure is significant at five percent level. The test results with respect to the CPI confirm earlier studies (Corbea & Ouliaris, 1988; Frenkel, 1981).

With respect to the Cedi-Pound model, the results of the granger causality test are shown in Table 10.

Table 10. Granger causality test for cedi-pound rate

Variables	F-statistic
InCedi-Dollar (-1)	13.16**(1,86)
InDomestic Credit (-1)	0.2567 (1,86)
Ingovexp (-1)	4.4621*(1,86)
Inimports (-1)	0.82764(1,86)
InConsumer Price Index (-1)	2.0774 (1,86)
Innominal GDP (-1)	0.2356 (1,86)
Bresusch-Godfrey autocorrelation test	

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.** significant at 1%. * significant at 5%.

It can be seen from Table 10 that the domestic credit, CPI, imports and nominal GDP contain no useful information in predicting the Cedi-Pound rate. The implication is that these variables do not granger cause the Cedi-Pound rate.

The lagged Cedi-Pound rate and government expenditure granger cause the Cedi-Pound rate. While the Cedi-Pound rate is significant at one percent level, government expenditure is significant at five percent level.

3.6 Forecasting with VAR

One of the good properties of an econometric model is its ability to forecast the variables that are being modeled. In this study, we estimate the VAR using data from 1985:1 to 2006:4 and forecast the exchange rate eight steps ahead. Results from this estimation and testing are shown in Table 11.

Table 11. Dynamic forecast for cedi-dollar exchange rate

Horizon	Forecast	SE	Actual	Error	t-ratio
2007-1	9.12564	0.07812	9.12763	-0.007823	-0.096
2007-2	9.15612	0.1324	9.14332	-0.022554	-0.186
2007-3	9.18465	0.2453	9.23745	-0.0378603	-0.345
2007-4	9.23253	0.2354	9.23546	-0.0546378	-0.346
2007-1	9.35476	0.2200	9.28465	-0.1457632	-0.330
2007-2	9.31402	0.2432	9.23457	-0.0756479	-0.325
2007-3	9.45637	0.2635	9.34112	-0.0235698	-0.085
2007-4	9.40745	0.3457	9.40187	-0.0057120	-0.022

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.MAPE = 0.407; Standard Error (SE) is based on error variance only. Mean (Error) = -0.0378. RMSE=0.0452(Error)= 0.025.

From Table 11, it can be observed that all the t-ratios are not significant implying that the forecast values, on the average, are not significantly different from the actual data points. For the model involving the Cedi-Pound exchange rate, reduced rank regression reflecting the number of cointegrating vectors is run. The model is then used to forecast the Cedi-Pound rate eight period ahead and these forecast values compared with the reserved data points. The outcome of the forecast and the test for significant difference between actual and forecast values are presented in Table 12.

Table 12. Dynamic forecast for cedi-dollar exchange rate

Horizon	Forecast	SE	Actual	Error	t-ratio
2007-1	9.79208	0.0939	9.78670	-0.0074589	-0.079
2007-2	9.81548	0.1300	9.83346	0.0161186	0.130
2007-3	9.79280	0.1460	9.94375	0.0198459	0.134
2007-4	9.87543	0.1832	9.94577	0.0196753	0.103
2007-1	9.91457	0.2043	9.94632	-0.0190233	-0.149
2007-2	9.94701	0.2242	9.91745	-0.0424463	-0.232
2007-3	9.97303	0.2307	9.87373	-0.0723672	-0.284
2007-4	10.0372	0.2514	9.70477	-0.277389	-0.912

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.Mean (Error) = -0.0397. RMSE = 0.0884. SD (Error) = 0.0789, MAPE = 0.5407.

It can be observed from Table 12 that all the t-ratios are not significant implying that the forecasts are not statistically different from the actual realizations.

3.7 Variance Decomposition

In this section, we report the percentage contribution of shocks emanating from the Cedi-Dollar rate, CPI, government expenditure, domestic credit, imports and nominal GDP in forecasting the Cedi-Dollar exchange rate over ten quarters following one standard deviation shock to the Cedi-Dollar rate. The results are shown in Table 13.

Table 13. Variance decomposition of cedi-dollar rate

Period	S.E	Cedi-D	CPI	Domcr	Gov	Import	GDP
1	0.06	99.7	0.00	0.00	0.00	0.00	0.00
2	0.10	95.24	0.62	0.53	2.72	0.22	0.53
3	0.15	92.18	1.23	0.45	4.24	0.52	1.21
4	0.16	89.66	1.74	0.43	5.47	0.87	1.94
5	0.20	87.12	2.16	0.33	6.24	1.33	2.53
6	0.21	85.34	2.50	0.27	6.87	1.72	3.10
7	0.23	83.88	2.76	0.21	7.41	2.05	3.50
8	0.27	82.60	3.01	0.23	7.72	2.33	4.00
9	0.28	81.34	2.20	0.27	8.11	2.54	4.33
10	0.30	80.59	3.31	0.31	8.34	2.76	4.64

Source: Computed from data from the Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.

It can be observed in Table 13 that the shock to the Cedi-Dollar exchange rate in the first quarter comes completely from the shock in the foreign exchange market. In the second quarter, about 95% variation in the Cedi-Dollar rate is contributed by shocks from the foreign exchange market, followed by about 3% shock from government expenditure. The rest of the variables contribute less than one percent respectively to the variation in the Cedi-Dollar rate. In the sixth quarter, shocks from the Cedi-Dollar rate accounts for about 85% of total variation in the Cedi-Dollar rate, followed by 7% from the government expenditure and the shocks coming from CPI, domestic credit, imports and nominal GDP respectively account for less than 5% shock to the Cedi-Dollar rate. In the last quarter, about 80% of the shocks in the Cedi-Dollar rate is explained by shocks from the past Cedi-Dollar exchange rate. Approximately 8% of the shock to the exchange rate is coming from shocks to government expenditure. The CPI, domestic credit, imports and nominal GDP respectively account for less than 5% of the shock to the Cedi-Dollar rate. In all, most of the shocks to the Cedi-Dollar rate over the period come from shocks in the past history of the exchange rate, followed by government expenditure, nominal GDP, CPI, imports and domestic credit in that order.

With regard to Cedi-Pound exchange rate, the effect of a shock to the Cedi-Pound rate on the future value of the Cedi price of British Pound over the forecast period as shown in Table 14. It can be observed from Table 14 that a shock to the Cedi-Pound market in the first quarter account for all the shocks to the Cedi-Pound rate in that period. In the second quarter, the Cedi-Pound rate is explained by about 93% of own shocks, followed by 3% shocks from CPI and nominal GDP, imports, domestic credit and government expenditure respectively contribute less than 2% variation in the exchange rate shock.

Table 14. Variance decomposition of cedi-pound rate

Period	S.E	Cedi-P	CPI	Domcr	Govexp	Imports	GDP
Q1	0.07	100.0	0.00	0.00	0.00	0.00	0.00
Q2	0.12	93.16	2.73	1.51	1.42	0.65	0.32
Q3	0.13	85.92	4.83	3.86	2.13	2.64	0.45
Q4	0.17	76.43	6.12	5.47	2.45	5.51	0.68
Q5	0.17	74.21	7.10	6.32	2.43	8.91	0.94
Q6	0.23	69.63	7.78	6.10	2.67	12.41	1.43
Q7	0.21	66.06	8.35	5.87	2.76	14.65	2.02
Q8	0.22	62.81	8.93	5.51	2.96	17.04	2.70
Q9	0.24	60.16	9.31	5.03	3.12	18.93	3.30
Q10	0.25	57.83	9.74	4.61	3.22	20.52	3.82

Source: Computed from data from Bank of Ghana, International Financial Statistics, Ghana Statistical Service, 2012.

In the fifth quarter, about 74%, 9%, 7% and 6% variation in the Cedi-Pound rate is explained by own shocks, imports shocks, CPI shocks and domestic credit shocks respectively. Shocks coming from government expenditure and nominal GDP respectively account for less than 3% shocks to the Cedi-Pound rate. In the eighth quarter, about 63%, 17%, 9% and 6% variation in the Cedi-Pound rate is explained by own shocks, imports shocks, CPI shocks and domestic credit shocks respectively. Shocks coming from government expenditure and nominal GDP respectively account for less than 3% variation in the Cedi-Pound rate. In the last quarter, about 58%, 21%, 10% and 5% variation in the Cedi-Pound rate is explained by own shocks, imports shocks, CPI shocks and domestic credit shocks respectively. Shocks coming from government expenditure and nominal GDP respectively account for less than 4% variation of in the Cedi-Pound rate. In all, Cedi-Pound rate is explained mainly by own shocks, imports shocks and CPI shocks.

4. Conclusion

The principal objective of this study is to investigate the possible determinants of exchange rates in Ghana using the techniques of cointegration and error correction modeling. The study revealed that two major factors were responsible for the upward surge in the exchange rates, namely the government expenditure and the past history of the exchange rates. Secondly, it was discovered that long run relationships tie the exchange rates to the CPI, nominal GDP, domestic credit, government expenditure and imports. Thirdly, expansionary fiscal and monetary policies were found to cause the Cedi price of Dollar and Pound to rise sharply and persistently. Finally, it was discovered that the Cedi-Pound rate converged faster to equilibrium than the Cedi-Dollar rate. Considering the impact of government expenditure on future movements in the exchange rates, it is recommended that fiscal expansion should be moderate. This is to ensure that exchange rate volatility is minimal. The substantial foreign exchange reserves should be built by the central bank considering the length of time it takes the exchange rates to return to their equilibrium values. This is to ensure that in times of exogenous shocks, whose impact on the exchange rate may take a long time to diminish, the central bank could intervene to minimize the impact of the shocks. It is recommended that expansionary monetary policy should be gradual considering the drastic effect of credit expansion on exchange rates as demonstrated by the impulse response functions. In this direction, banks could be encouraged to support the export sector as against the import businesses that tend to increase demand for foreign exchange.Finally, policymakers should pay attention to the developments in the CPI as increase in the CPI tend to have depreciating effect on the Cedi as revealed by the impulse response functions.

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