International Journal of Management Research and Technology
Volume 1 Number 1● January-June 2007:1-20

A Monetary Approach to Exchange Rate Liberalization Regime in Ghana

I. K. Acheampong*

* Senior Lecturer, Department of Economics, University of Cape Coast, Cape Coast, Ghana
Address for Correspondence: Department of Economics, University of Cape Coast, Cape Coast, Ghana
E-mail: ikacheampong@yahoo.co.uk

Abstract: *One of the major thrusts of the financial sector reforms that Ghana embarked upon in 1988 was the liberalization of the exchange rate. The liberalization of the foreign exchange market was albeit with a managed floating exchange rate regime. It was argued that a liberalized exchange rate regime would ensure that exchange rates reflect relative scarcities, minimize economic distortions and ensure efficient allocation of resources, since then the exchange rate has been persistently and irreversibly fluctuating (depreciating) against the major international currencies over the period. This paper examines econometrically the impact of exchange rate liberalization regime on the Ghanaian cedi-US dollar exchange rate and the parameters that affect the exchange rate within the framework of the flexible price monetary approach to exchange rate determination. The results show that the exchange rate liberalization regime had positive impact on the exchange rate implying there was consistent depreciation of the exchange rate during the period. It was evident that when the exchange rate was shocked in the short run it returned to its long run equilibrium rapidly. Furthermore, relative money supply and income are key variables that influence the exchange rate. The policy implications has been laid down as government could consider maintaining monetary stability, macroeconomic stability and improved supply side policies to enhance the productive base of the economy within the ambit of a liberalized exchange rate regime. Finally, economic agents in the foreign exchange market are very responsive to the developments of the market and this further underscores the point of prudential management of the exchange rate in Ghana.*

Keywords: Liberalization of exchange rate, flexible price monetary model, financial sector reforms, exchange rate variation

Introduction

This paper seeks to examine the impact of exchange rate liberalization regime on the Ghanaian cedi-US dollar exchange rate in Ghana econometrically using the flexible price monetary approach to exchange rate determination and taking cognizance of the flexible exchange rate regime that has been operating in Ghana since 1988 when the financial sector reforms were implemented. We focus on the Ghanaian cedi-US dollar exchange rate most people in Ghana do business with the US dollar since the dollar is also acceptable globally. This phenomenon has been described as the dolarization of the Ghanaian economy by the Ghanaian media.

Ghana has in the past virtually operated a fixed exchange rate regime or a crawling peg. In 1988 the financial sector reforms were implemented and a flexible exchange rate regime was introduced albeit a managed float exchange rate regime. In the past as well as during the financial liberalization and flexible exchange rate regime monetary growth was found to be relatively high and therefore the monetary approach to exchange rate determination is a plausible model to apply to verify the impact of the exchange rate liberalization regime and the key parameters on the Ghanaian cedi-US dollar exchange rate in Ghana. The end product of this research will help to guide policy to stem the volatility in the exchange rate.

The rest of the paper focuses on the:

a) Theoretical underpinnings of the flexible price monetary model to exchange rate determination
b) Empirical literature review of the monetary approach to exchange rate determination
c) Exchange Rate Variations in Ghana
d) Methodology
e) Impact of exchange rate liberalization regime on the Ghanaian cedi-US dollar exchange rate in Ghana
f) Conclusions and Policy implications

Theoretical Underpinning of the Flexible Price Model of Exchange Rate Determination

There are various theoretical versions of the monetary approach to exchange rate determination. We principally focus on the flexible price variant of the monetary approach to exchange rate determination. Our hunch is that the factors encapsulated by the flexible price model and the application the dummy variable technique in the context of a small open economy and the exchange rate liberalization regime will give a better outcome that will be relevant for policy purposes.

The flexible price monetary model of exchange rate determination is attributed to Frenkel (1976), Mussa (1976) and Bilson (1978). The assumptions that underpin this theoretical model are as follows:

1. A small country assumption such that the activities of the country concerned is not able to influence the rest of the world.
2. Real income is at equilibrium.
3. Domestic goods and foreign goods are perfect substitutes.
4. There is a stable demand function that relates the real demand for money to the level of output (Y) and the nominal domestic interest rate(r).
5. There is money market equilibrium implying that demand for money is equal to supply.
6. Purchasing power parity (PPP) holds continuously.
7. Uncovered interest parity (UIP) holds.
8. Money supply is dependent on domestic credit and foreign exchange reserves.

The Flexible price model is formulated as follows:

$$m_t - p_t = \alpha y_t - \lambda r_t \quad [1]$$

$$m_t^* - p_t^* = \alpha y_t^* - \lambda r_t^* \quad [2]$$

$$e_t = p_t - p_t^* \quad [3]$$

$$\hat{e}_t = r_t - r_t^* \quad [4]$$

$$p_t = m_t - \alpha y_t + \lambda r_t \quad [5]$$

$$p_t^* = m_t^* - \alpha y_t^* + \lambda r_t^* \quad [6]$$

$$e_t = p_t - p_t^* = m_t - \alpha y_t + \lambda r_t - (m_t^* - \alpha y_t^* + \lambda r_t)^* \quad [7]$$

$$e_t = (m_t - m_t^*) - \alpha(y_t - y_t^*) + \lambda(r_t - r_t^*) \quad [8]$$

The definitions of the variables in the model as follows:

m_t is the log of the domestic nominal money stock, p_t is the log of the domestic price level, y_t is the log of domestic real income and r_t is the nominal domestic interest rate, m_t^* is the log of foreign nominal money stock, p_t^* is the log of the foreign price level, y_t^* is the log of the foreign real income, and r_t^* is the foreign nominal interest rate, e_t is the log of the exchange rate which is defined as domestic currency units per unit of foreign currency. $\hat{e}$ is the expected rate of depreciation of the home currency. It is assumed that there is a conventional money demand function, which is given, by equation 1 for the domestic economy and equation 2 for the foreign economy. Equation 3 exemplifies the fact that purchasing power parity (PPP) holds continuously, implying that the equilibrium exchange rate is given by the ratio of domestic to foreign prices. Equation 4 exemplifies the fact that the uncovered interest parity condition holds. This means that domestic and foreign bonds are considered to be perfect substitutes as such there are both perfect capital mobility and equal risky- ness between domestic and foreign bonds.

Equations 1 and 2 can be re-arranged by making $p\, and\, p^*$ the subject of formula as demonstrated in equations 5 and 6. Further, by substituting equations [5] and [6] into equation [3] one obtains the basic unrestricted flexible price monetary model as shown in equation 7 or 8. Equation [8] is known as the reduced form exchange rate equation. We intend to focus on the unrestricted flexible price monetary model because of the focus of the study, which is intended to unearth the impact of the exchange rate liberalization regime and the relevant parameters on the exchange rate.

Under the assumption of flexible prices, the model has relative money, income, and nominal interest rate as explanatory variables. This flexible price monetary model also gives predictions about the effect of a change in relative money, income and nominal interest rate on the exchange rate. In the first place, the exchange rate is expected to rise (that is, the domestic currency will depreciate) if the domestic money supply grows faster relative to foreign money supply. This can be attributed to the fact that the faster the growth in domestic money supply relative to foreign money supply the greater will be the domestic inflation, and hence the lower will be the real return on investment in domestic currency denominated assets.

Furthermore, the exchange rate is expected to fall (that is, the domestic currency will appreciate) if the domestic income grows faster relative to foreign income. The rationale here is that the higher the domestic growth in income relative to the foreign income, the higher the demand for real money balances will be. As such the interest rate will increase leading to higher returns on investments in domestic currency denominated assets.

Finally, the exchange rate is expected to rise (that is, the domestic currency will depreciate) if the domestic interest rates grow faster relative to foreign interest rates. This is based on the assumption that uncovered interest parity (UIP) holds. The domestic currency will be expected to depreciate in the future if domestic interest rates are higher relative to foreign interest rates. Higher domestic interest rates are required to compensate for the capital loss that will be incurred when the domestic currency depreciates.

Various extensions have been made to the basic flexible price monetary model. These include: the sticky price model, tradable and non-tradable model, currency substitution model, portfolio balance and imperfect substitution model (Meese and Rogoff 1983; Hooper and Morton 1982 and MacDonald and Taylor 1993).

Review of Empirical Literature

While the relevance of the monetary approach to floating exchange rate analysis has been the subject of many studies they have been biased in favour of developed economies. However, some recent studies have been undertaken on developing economies to give a balance between developed economies and developing economies studies. Therefore, the empirical literature review will encompass both developed and developing countries.

Meese and Rogoff (1983) conducted a seminal work in the use of monetary models to forecast the exchange rate econometrically for developed economies including the USA. The main conclusion of Meese and Rogoff (1983) was that exchange rates could not be forecast from monetary fundamentals and the outcome of the study was a disaster.

Mark (1995) and Chinn and Meese (1995) also focused on developed countries by using the monetary model and their conclusion was that there was greater power to predict exchange rates at long horizons than at short horizons. This study was also partly a success in that predictions could only hold for the long run.

Rapach and Wohar (2001) undertook an extensive econometric evaluation of panel tests of the long run monetary model of exchange rate determination for developed economies. They found considerable support for the monetary model.

Groen (2000) and Mark and Sul (2000) tested the monetary model by using panels of post Bretton Woods data for developed countries and found some support for the monetary model.

Civcir (2000) used four variants of the monetary model encapsulating the flexible price monetary model, sticky price monetary model, tradable and non-tradable model, and Hooper and Morton's Model. The overall results appeared to show that the monetary models were useful in explaining exchange rate behaviour and exchange rates are predictable at short horizons.

Wong (2002) applied the monetary model to examine the exchange rate between British sterling and US dollar from 1973 to 1989 econometrically. The results showed that the monetary model could be used to predict the effects of changes in relative money supply, relative income level, and relative interest rate on the floating exchange rate. Three long run relationships among the variables of the flexible price monetary model were found but none of the variables conformed to theoretical expectations.

MacDonald and Taylor (1993) tested and reported that the flexible price monetary model appeared to hold as a long run equilibrium condition in explaining the Deutsch Mark-US $ exchange rate from 1976 to 1990. They found evidence of co-integration between the exchange rate, relative money supply, relative income and relative interest rates using Johansen's Maximum Likelihood Approach. Furthermore, MacDonald and Taylor (1994) examined the sterling-dollar exchange rate using multivariate co-integration procedure. They concluded that by treating the monetary model as long run equilibrium condition and allowing for short run dynamics a monetary type exchange rate equation could be found which had robust in sample proportion and forecast well out of sample. Once more, MacDonald and Taylor (1995) using a monetary error correction model, found that there were up to three statistically significantly co-integrating variables between the pound-dollar exchange rate and domestic and foreign money supply, industrial production and long-term interest rate. MacDonald and Taylor's results conflicted with their previous studies but they attributed this to improved estimation technique.

The studies that have been reviewed up to this point belong to the developed countries. We now move to review the empirical literature of studies that have been conducted on developing countries.

Kisukyabo (1998) examined the monetary model of Malawi Kwacha-US $ exchange rate during the current floating exchange rate system by applying recent techniques in econometrics. He found out that an unrestricted monetary model did provide a valid explanation of the long run nominal Malawi Kwacha-US $ exchange rate, thus lending support for the monetary model for long run analysis.

Fry (1976) examined the determinants of the exchange rate through the application of the monetary approach to balance of payments theory for Afghanistan. He applied the monetary model to Afghanistan data for the period 1955 to 1972 for the Afghani/dollar rate of exchange. The results showed a remarkable explanatory power of the model and the coefficients met a priori restrictions. The model explained significantly, among other things, the parameters related to the price level, nominal income, money supply and its lag. The only snag with this study was that he applied ordinary least squares as an estimation procedure, which gives one-way direction of causality.

Jimoh (2004) used various formulations of the monetary approach to exchange rate determination to examine both the Nigerian monthly and annual data between 1987 and 2001 to determine whether it provided support for the monetary approach to floating exchange rate behaviour. He found out that the monetary approach models provided adequate representation of Nigerian's exchange rate behaviour.

Agbola and Kunanopparat (2003) investigated the determinants of the choice of exchange rate regime in Thailand by using time series data spanning the period 1990:1 to 2002:3 using Johansen's Maximum Likelihood Estimation (MLE) and multivariate co-integration tests. The Thai economy was then undergoing major financial sector reforms and the study had policy relevance. The outcome of the research was supportive of the generally held view that economic fundamentals, variables relating to macroeconomic stability of the economy and variables relating to the risk of currency crises are key determinants of the choice of exchange rate regime in Thailand in the 1990s. The implications of the study were that government was likely to choose a flexible exchange rate regime but this would be contingent on an open economy with a degree of economic development and foreign reserves.

The literature review for both developed and developing countries have been reviewed in this section. The conclusion that emerges from the empirical literature review is that the results appear to be mixed. However, it is clear that the few studies that have been conducted on developing countries applying recent econometrics techniques appear to find some support for the monetary approach to exchange rate determination. This also applies to some of the studies on developed countries. We shall see how this works out for Ghana by examining the impact of exchange rate liberalization regime on the Ghanaian cedi-US dollar exchange rate and the relevant parameters that explain exchange rate behaviour in Ghana in the next sections.

Exchange Rate Variations in Ghana

Ghana embarked upon financial sector adjustment programme (FINSAP) as part of the then on going Economic Recovery Programme (ERP) (Ghana's Economic Reform Programme implemented in 1983) in 1988 to revamp the financial sector to play its financial intermediation role efficiently in the economy. The major thrust of the (FINSAP) was financial sector liberalization including fully liberalized money and capital markets, the liberalization of the exchange rate as well as interest rate deregulation (FINSAP Status Report 1995). The liberalization of the foreign exchange market was albeit with a managed floating exchange rate regime and this is the focus of this study.

The financial sector liberalization has been guided by the intellectual advice of the McKinnon (1973) and Shaw (1973) paradigm that has been adopted by the IMF and the World Bank as part of the conditionality for economic reforms in developing countries. The McKinnon-Shaw school, for the case in point, argues that exchange rate liberalization allows the exchange rates to reflect relative scarcities, minimize economic distortions and leads to efficient allocation of resources.

Here our focus is on the exchange rate under liberalized exchange rate regime as reflecting relative scarcities and therefore minimizing distortions and ensuring efficient allocation of resources. We would like to observe that despite the gains chalked by the economic reforms, the exchange rates have been persistently and irreversibly depreciating against the major international currencies since Ghana adopted the managed float system in 1988, the time the financial sector liberalization programme started (FINSAP Status Report 1995) as shown in Appendix 1 Table 1.

Before the ERP was introduced in 1983, the exchange rate was fixed and the US dollar - cedi exchange rate varied between 1 to 2.75 cedis between 1970 and 1982. The rate of depreciation of the cedi from 1983 to 1987 was massive due to the fact that the economic reforms targeted putting the exchange rate right to stem the overvaluation of the cedi. The process of depreciating exchange rate continued to intensify from 1991 to 1994. As can be observed from Appendix1 Table 1, from 1993 to 1994 the cedi regained its value in relative terms even though the exchange rate was not able to catch up with the relative inflation during the period of economic crises. Part of the problem of the persistent depreciation of the cedi is related to higher monetary growth and inflation, which are linked to government deficit financing which has the tendency of being financed largely from inflationary sources. Between 1978 and 2000 the growth in broad money supply (m2) was volatile. However, the growth in broad money supply (m2) assumed a decreasing trend after 1995 (see Appendix Table 1). High monetary growth rate in Ghana has persisted for a long time. Even though attempts were made during the FINSAP to introduce tight monetary policies, there was an expansion in money supply and price instability due to government deficit financing and external shocks. Even though inflation has reduced considerably attempts at achieving single digit inflation has not been successful. According to the Monetarists, in a floating exchange rate regime, excessive monetary expansion leads to inflation and depreciation of the domestic currency in the long run (Ball, Burns, and Laury 1997). The exchange rate has persistently been depreciating because it has been difficult to control inflation. The tendency for continuous exchange rate depreciation or volatility within a managed float exchange rate system under exchange rate liberalization regime is a real challenge. It is important to underscore the fact that any unfavourable development in the exchange rate market tends to have wide-ranging effects on the structure and level of production, consumption, employment and the allocation of resources generally in the economy. The importance of a stable and economically viable level of exchange rate position in facilitating the adjustable process in less developed countries such as Ghana is very crucial and this has been underscored by some economists (Edwards1989a, 1989b; Elbadawi and Soto 1994).

Methodology

Based on the theoretical framework presented in the theoretical section of the paper, we formulate the unrestricted version of the flexible price monetary model as the empirical model for the study. Therefore, the empirical model for the study is specified as follows:

$$e_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3(r_t - r_t^*) + \mu_t \qquad [9]$$

The a priori expected signs are as follows: $\beta_0 > 0 \ or < 0$; $\beta_1 > 0$; $\beta_2 < 0$; $\beta_3 > 0$

The definitions of the variables used in the empirical model are as follows:

1. e_t is the log of the cedi US dollar nominal exchange rate. It measures the home price (¢ price) per unit of US dollar.
2. m is the log of domestic (Ghana) nominal money supply (M2+), which consists of notes and coins in circulation and deposits in current accounts plus time, savings and foreign currency deposits of the private sector in commercial banks.

3. m^* is the log of foreign (US) nominal money supply (M2+), which consists of notes and coins in circulation and deposits in current accounts plus time, savings and foreign currency deposits of the private sector in commercial banks.
4. y is the log of domestic real income measured by the Gross Domestic Product in real terms in billion of Ghanaian cedis.
5. y^* is the log of US real income measured by the Gross Domestic Product in real terms in billion of US dollars.
6. r is the discount rate, which is the most attractive instrument for portfolio investors in Ghana because they are risk free, and have nominal yields higher than any other instrument on the financial market.
7. r^* is the foreign (US) discount rate.
8. u_t is the stochastic disturbance term.

In order to determine the impact of the exchange rate liberalization regime on the exchange rate for the period 1988 to 2000 the flexible price model [9] in a form of vector error correction model is augmented with a dummy variable which is equated to unity after the exchange rate liberalization regime (1988 to 2000) and equated to zero before the exchange rate liberalization regime (1960 to 1987) in equation 10. It is intended to capture the impact of the flexible exchange rate liberalization regime on the exchange rate along side its relevant parameters.

$$D(e)_t = \alpha_1 + \sum_{1=1}^{m} \beta_{1i} D(M)_{t-i} + \sum_{1=1}^{n} \delta_{1i} D(Y)_{t-i} + \sum_{I=1}^{k} \lambda_{1i} (R)_{t-i} + \sum_{1=1}^{h} \psi_{1i} D(e)_{t-1} + \sum_{i=1}^{p} \partial_{1i} ECM_{r,t-1} + \theta\, DV1 + \mu_t \qquad [10]$$

where

$\alpha_1, \beta_{1i}, \delta_{1i}, \lambda_{1i}, \psi_{1i}, \partial_{1i}, \theta_t$ are parameters to be estimated.

D = first difference of a non-stationary variable from period t to period $t-1$; M = (m - m^*); Y= (y - y^*); R= (r - r^*); and DV1 = dummy variable (DV1=0 from 1960 to 1988) and DV1=1 from 1988 to 2000.

All the other variables are as defined previously.

The remaining vector error correction equations have been provided in Appendix 2. The estimation of the parameters of the model is based on Johansen (1988) and Johansen and Juselius (1990) multivariate co-integration and vector error correction framework and Granger causality test.

The study utilizes annual data from 1960 to 2000 to undertake the estimations and analyses. The data for all the variables were collected from various issues of the International Financial Statistics Yearbook, published by the International Monetary Fund and Bank of Ghana Annual reports. All tests and regressions were performed with the E-views 5 Statistical Package.

Empirical Evidence on Impact of Exchange Rate Liberalization Regime on Ghanaian cedi-US dollar Exchange Rate

This section examines the impact of the exchange rate liberalization regime on the exchange rate and also investigates other parameters within the flexible price monetary model that will be useful for policy in exchange rate management in Ghana. We shall first undertake diagnostic testing before we proceed to provide evidence on long run, short run and causality analyses.

Diagnostic Testing

Diagnostic tests are required because of the problems inherent in time series analysis such as non-stationarity and spurious regression results that are associated with simple regression analysis. Against this background, we have applied the Augmented Dickey-Fuller test (Dickey and Fuller 1979) to test for stationarity among the time series variables and Johansen's Multivariate Co-integrating approach (Johansen 1988) and Johansen and Juselius (1990) to test for co-integration and Granger causality test has been used to test for causality (See Appendix 6 for details).

Appendix 2 Tables 1 and 2 present the Augmented Dickey-Fuller (ADF) test for unit root for all the variables at their levels and first differences. It is clear that all the variables are non-stationary at their levels but stationary at first differences given the magnitudes of the test statistic, critical values and probability values. This means that running regression at their levels would have led to spurious regression results.

We proceed further with Johansen's Multivariate Co-integrating approach to test for the existence of long run stable relationship in the flexible price model (See Appendix 3 for the equations). All the variables are in their logarithmic form except the discount or interest rate and they enter the co-integration analysis at their levels. The results of the co-integration test are presented in Appendix 2 Table 3. The results show that our flexible price model is co-integrated with at least one co-integrated vector. This means that using only the first differences of the variables to run the VAR would have led to specification error since long run information about the relationship in the equations would have been lost. This means that the variables in the flexible price model can be run on their first differences with an error correction mechanism. On the basis of this, we embark upon vector error correction modeling (VECM) for the model and we report on the results in the next two sections.

Evidence from Long-run Analysis

The discussion will now focus on the nature of long run relationship between the variables in the flexible price model. The formulation of the equation has been presented in Appendix 4. Normally, in the estimation of the co-integration relationship, the coefficient of one of the variables is normalized to unity in each equation.

The estimated coefficients of the flexible price model are presented in Appendix 2 Table 4. It is important to note that if it is assumed that in the flexible price model the exchange rate is regarded as the endogenous variable while the other variables are exogenous then their respective estimated coefficients can be interpreted as negative change of the exchange rate and vice versa. The signs of the other co-integration coefficients are interpreted in a similar way (Mamoon 2004: 27).

Appendix 2 Table 4 shows that there exists a significant negative long run relationship between relative money supply and the exchange rate. Furthermore, the results reveal that relative income is significantly and positively related to the exchange rate at less than two percent significant level. Relative rate of interest has a significant positive long run relationship with the exchange rate. The results obtained here in terms of relative money supply and income is not consistent with theoretical expectation. However, the result for the relative interest rate conforms to theoretical expectation.

Evidence from Vector Error Correction Modeling and Short Run Dynamics

This section provides evidence on the VECM and short run dynamics of the flexible price model. There is a connection between co-integration and the error correction mechanism. The negative and significant lagged residual from the VECM is the error correction term. It determines the speed of adjustment to long run equilibrium. The negative coefficient implies that any shock that occurs in the short run will be corrected in the long run. The larger the error correction coefficient in absolute value the faster the variable returns to its long run equilibrium once it is shocked.

The estimated error correction coefficient of the flexible price model is presented in Appendix 2 Table 5. The focus of the analysis is on equation 1 which is directly linked to the exchange rate. From equation 1 the results show that the error correction term has the right sign and is statistically significant at less than five percent significant level with a coefficient of 1.2 in absolute terms, which is close to unity (equation 1 in Appendix 2 Table 5. This means that in the short run if the exchange rate is shocked it will rapidly return to its long run equilibrium. Theoretically, this implies that economic agents in the foreign exchange market are very responsive to developments in the foreign exchange market and they do not have sticky expectations.

The dummy variable representing the exchange rate liberalization regime impacted significantly positively on the exchange rate at less than one percent probability level. This means that the exchange rate liberalization regime led to an upward shift in the flexible price monetary function over the period therefore leading to the depreciation of the exchange rate (or the payment of more cedis for a unit of the US dollar per period) on the average. This outcome according to McKinnon (1973) and Shaw (1973) reflects the relative scarcity of foreign exchange, minimizes economic distortions and ensures efficient allocation of resources in the economy. However, the extent to which the exchange rate depreciates also matters to economic agents and affects their business plans and requires that it should be managed prudentially so that it does not stifle productivity and growth.

Further, the VECM shows that the lag of relative money supply, the lag of real income and the lag of the exchange rate significantly influence the exchange rate in the short run. In the context of Ghana's exchange rate liberalization regime these are key variables that are relevant for the policy implications of the study.

Evidence from Causality Analysis

Until quite recently, earlier studies assumed implicitly that there was one way causality between the exchange rate and economic fundamentals as such they committed the problem of simultaneous equation bias while those that conducted bivariate tests also fell into the pitfall of omitted variable problems and wrong causal inferences. In order to resolve such problems multivariate causality test, which takes all the variables on board in the causality test, is now used. In consonance with this, we applied the multivariate causality test to the variables in our flexible price model. Appendix 2 Table 6 reports on the Granger causality test in the pair of variables that are involved in the flexible price model.

At levels of the variables relative money supply and relative income granger cause the exchange rate at less than one percent significance level. There is a bi-directional causality between relative money supply and income at two percent and seven percent significance levels, respectively. Relative income granger causes relative interest rate. There is also a bi-directional causality between relative interest rate and money supply at nine percent and five percent significant levels, respectively.

However, since the variables are non-stationary at their levels we must focus attention on the first differences of the variables by analyzing the issue of causality. At their first differences, the results show that relative income and relative money supply granger cause the exchange rate at ten percent and six percent significant levels, respectively. Furthermore, relative income granger causes relative money supply at four percent significant level while relative money supply granger causes relative interest rate also at four percent level. The results obtained at the levels and first differences coincide but there are outstanding differences, that is, at the levels of the variables there is bi-directional causality between relative money supply and income and also interest rate and money supply but this is not the case at the first differences of the variables. The results obtained here are theoretically plausible and will be useful for exploring the policy implications of the study.

Concluding Remarks

The various facets of the analyses appear to indicate that relative income and money supply are key variables that must be considered in the exchange rate management of the cedi US dollar exchange rate in Ghana. Relative income influences money supply while relative money supply influences the rate of interest and the exchange rate as well.

The VECM results show that when the exchange rate is shocked in the short run it returns to long run equilibrium at a very fast rate. Theoretically, this means that economic agents are responsive to the developments in the foreign exchange market as such if it is prudentially managed it will help in the efficient allocation of resources in the economy.

The dummy for the VECM was significant and positive implying that during the exchange rate liberalization regime, the flexible price monetary function shifted upwards. This means that in conformity with McKinnon (1973) and Shaw (1973) dictum, the upward shift of the function ensured that the cedi-dollar exchange rate reflected the relative scarcity of foreign exchange to minimize economic distortions and to enhance efficient allocation of resources in the economy. There is no doubt that the exchange rate will have to vary within limits, however, the extent to which the exchange rate depreciates also matters to economic agents. It is therefore important that the exchange rate is managed prudentially so that it does not stifle productivity and economic growth. It is also relevant that the economy as whole be managed prudentially in tune with good economic management practices. The outcome of the error correction term in the VECM shows that economic agents in the foreign exchange market are very responsive to the developments in the market and this further underscores the point of prudential management of the exchange rate. Again the level of the current period exchange rate level is influenced by the level of the preceding period exchange rate.

Taking cognizance of the overall results, it is obvious that monetary stability, macroeconomic stability and improved supply side policies to enhance the productive base of the economy within the ambit of a liberalized exchange rate regime are the likely policy implications of the study. Finally, economic agents in the foreign exchange market are very responsive to the developments in the market and this further underscores the point of prudential management of the exchange rate in Ghana.

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Appendices

Appendix 1
Table 1
Some Macroeconomic Indicators

Year	GDP growth (annual %)	M2/GDP	Real Effective Exchange Rate 2000=100	Yearly Average Rate of Inflation	Exchange rate (Cedis per US Dollar)	Fiscal Balance (Billions of Cedis)
1980	0.47	0.191	801.49	51.3	2.75	-1.81
1981	-3.50	0.162	1784.91	114.7	2.75	-4.71
1982	-6.92	0.163	2231.53	22.3	2.75	-4.85
1983	-4.56	0.125	1505.44	122.9	8.83	-4.93
1984	8.65	0.118	583.59	40.3	35.99	-4.84
1985	5.09	0.136	423.67	9.8	54.37	-7.58
1986	5.20	0.135	243.50	24.6	89.20	0.30
1987	4.79	0.142	187.47	39.8	153.73	4.06
1988	5.63	0.147	180.19	31.4	202.35	3.91
1989	5.09	0.169	169.11	25.1	270.00	10.30
1990	3.33	0.134	168.32	37.4	326.33	3.3
1991	5.28	0.142	173.54	18	367.83	39.0
1992	3.88	0.188	153.3	10.1	437.09	-144.4
1993	4.85	0.172	133.49	25	649.06	-97.3
1994	3.30	0.186	107.94	24.9	956.71	111.7
1995	4.11	0.175	124.53	59.5	1,200.43	70.3
1996	4.60	0.159	134.59	46.6	1,637.23	-3335.5
1997	4.20	0.186	142.65	27.6	2,050.17	-297.6
1998	4.70	0.191	154.29	19.2	2,414.15	-1048.8
1999	4.41	0.187	155.05	12.4	2,669.30	-136.4
2000	3.70	0.196	100	25.2	5,455.06	-369.3
2001	4.20	0.207	100.65	32.9	7170.76	-121.5
2002	4.50	0.242	100	14.8	7932.70	-13.6
2003	5.2	N/A	102.5	26.7	8677.37	50.3.6
2004	5.8	N/A	100.35	12.6	9004.63	-13.2

Source: Bank of Ghana and IMF's International Financial Statistics (IFS)
Note: NA means not available.

Appendix 2
Presentation of Results in Tables
Table 1
Test for the Order of Integration (Levels with Intercept)

VARIABLE	TEST STATISTIC	LAG LENGTH	CRITICAL VALUE 1%	CRITICAL VALUE 5%	CRITICAL VALUE 10%	P-VALUE
E	-0.176944	0	-3.584734	-2.928142	-2.602225	0.9681
M	-1.132890	1	-3.588509	-2.929734	-2.603064	0.9972
Y	-1.320560	0	-3.588509	-2.929734	-2.603064	0.9984
R	-1.340232	0	-3.584743	-2.928142	-2.602225	0.6027
Levels with Trend and Intercept						
E	-2.321487	0	-4.175640	-3.186854	-3.186854	0.4142
M	-2.554482	0	-4.175640	-3.513075	-3.186854	0.3020
Y	-2.689526	0	-4.180911	-3.515523	-3.188259	0.2457
R	-1.282647	0	-4.175640	-3.513075	-3.186854	0.8796

Notes: Null hypothesis: there is unit root. Alternative Hypothesis: there is no unit root.
If the calculated t-ratio is less than the critical value then we cannot reject the null hypothesis and vice versa.

Table 2
Test for Order of Integration (First Differences with Intercept)

VARIABLE	TEST STATISTIC	LAG LENGTH	CRITICAL VALUE 1%	CRITICAL VALUE 5%	CRITICAL VALUE 10%	P-VALUE
D(e)	-8.633443	0	-3.588509	-2.929734	-2.603064	0.00
D(M)	-8.341024	0	-3.588509	-2.929734	-2.603064	0.00
D(Y)	-5.618304	0	-3.592462	-2.931404	-2.603944	0.00
D (R)	-7.168446	0	-3.588509	-2.929734	-2.603064	0.00
First Differences with Trend and Intercept						
D(e)	-8.741698	0	-4.180911	-3.515523	-3.188259	0.00
D(M)	-8.694162	0	-4.180911	-3.515523	-3.188259	0.00
D(Y)	-5.886529	0	-4.186481	-3.518090	-3.189732	0.00
D®	-7.173404	0	-4.180911	-3.515523	-3.188259	0.00

Notes: Null hypothesis: there is unit root. Alternative Hypothesis: there is no unit root.
If the calculated t-ratio is less than the critical value then we cannot reject the null hypothesis and vice versa.

Table 3
Johansen's Multiple Co-Integration Test Results

Equation 5: Variables: e M Y R								
With Intercept or With Intercept and Trend	Lags	Trace Statistic	Critical value	P-Value	Max- Eigen value	Critical value	P-Value	Conclusion
With Intercept	1-1	54.19423	47.85613	0.0113	31.77977	27.58434	0.0136	At least one Co-integrated vector at 1% level
With Intercept and Trend	1-1	70.05972	63.87610	0.0138	36.63700	32.11832	0.0069	At least one Co-integrated vector at 1% level

Source: a) See Appendix 3 for the formulation of the equation. b) Estimated from Eviews 5 using the data for the study.
Notes: Null Hypothesis (Ho): There is no co-integrating vector.
Alterative Hypothesis (Ha): There is one co-integrating vector.
If the Trace Statistic and Max-Eigen value is less than the critical value then we cannot reject the null hypothesis and vice versa.

Table 4
Co-integration Coefficients

Variables	Intercept but no trend in VEC and no drift or trend in VAR	Intercept and Trend in VEC and drift but no trend in VAR	No intercept or Trend in VEC and no Drift or trend in VAR	Intercept but no trend in VEC and Drift but no trend in VAR	Intercept and trend in VEC and drift and trend in VAR
Equation : e M Y R					
E	1	1	1	1	1
M	1.72 (6.10)	1.95 (5.74)	0.19 (5.73)	1.71 (6.15)	1.94 (5.63)
Y	-1.97 (-10.79)	-1.94 (-10.85)	-1.14 (-9.11)	-1.96 (-10.9)	-1.97 (-10.89)
R	-0.059 (-3.28)	-0.07 (-3.5)	-0.01 (-0.20)	-0.06 (-0.06)	-0.07 (-3.38)

Note: t - ratios are in brackets

Table 5
Vector Error Correction Estimates

Equation	1	2	3	4
Variables	D(e)	D(M)	D(Y)	D(R)
D(e(-1))	0.722775	-0.018341	0.395183	2.624516
	[2.32895]	[-0.10720]	[3.43254]	[0.79773]
D(e(-2))	0.288867	-0.381077	0.168400	0.318895
	[1.35586]	[-3.24452]	[2.13069]	[0.14119]
D(M(-1))	-0.674701	-0.348958	-0.256420	2.790637
	[-1.87860]	[-1.76245]	[-1.92458]	[0.73295]
D(M(-2))	-0.353411	-0.179729	-0.042418	1.190568
	[-1.13952]	[-1.05119]	[-0.36869]	[0.36211]
D(Y(-1))	-1.405624	0.126239	-0.342183	-7.323934
	[-2.57602]	[0.41966]	[-1.69044]	[-1.26611]
D(Y(-2))	0.473233	0.902691	-0.126015	-0.482181
	[0.99517]	[3.44336]	[-0.71434]	[-0.09565]
D(R(-1))	-0.022216	0.005364	-0.023775	-0.372314
	[-0.99377]	[0.43526]	[-2.86675]	[-1.57098]
D(R(-2))	-0.035813	0.003649	-0.014295	-0.125255
	[-1.63792]	[0.30275]	[-1.76239]	[-0.54038]
C	-0.238282	0.137484	-0.070609	-0.789488
	[-1.48214]	[1.55121]	[-1.18390]	[-0.46322]
ecm1(-1)	-1.064348	0.043320	-0.511512	-2.968349
	[-3.96779]	[0.29294]	[-5.14022]	[-1.04383]
DV1	1.365080	0.097906	0.662742	2.773404
	[3.65457]	[0.47545]	[4.78281]	[0.70039]
R-squared	0.493894	0.445438	0.541427	0.163237
Adj. R-squared	0.330634	0.266547	0.393500	-0.106687
Sum sq. resids	6.724401	2.043679	0.925407	755.7153
S.E. equation	0.465743	0.256759	0.172777	4.937399
F-statistic	3.025200	2.490000	3.660096	0.604751
Log likelihood	-21.12495	3.885859	20.52360	-120.2853
Akaike AIC	1.529760	0.338769	-0.453505	6.251682
Schwarz SC	1.984864	0.793873	0.001599	6.706786
Mean dependent	0.225148	0.199486	0.204576	0.222619
S.D. dependent	0.569265	0.299805	0.221855	4.693381
Determinant resid covariance (d of adj.)		0.004304		
Determinant resid covariance		0.001277		
Log likelihood		-98.45991		
Akaike information criterion		6.974281		
Schwarz criterion		8.960189		

Note: t - ratios are in brackets

Table 6
Granger Causality Test Results at Levels of the Variables

Null Hypothesis:	Obs	F-Statistic	Probability
M does not Granger Cause e	39	5.50636	0.00848
e does not Granger Cause M		0.25256	0.77826
Y does not Granger Cause e	38	9.47631	0.00056
e does not Granger Cause Y		1.15481	0.32752
R does not Granger Cause e	39	1.48396	0.24106
e does not Granger Cause R		1.58392	0.21994
Y does not Granger Cause M	38	2.77940	0.07664
M does not Granger Cause Y		4.20184	0.02368
R does not Granger Cause M	39	2.57036	0.09130
M does not Granger Cause R		4.79162	0.01468
R does not Granger Cause Y	38	0.70048	0.50357
Y does not Granger Cause R		3.14226	0.05634

Table 7
Granger Causality Test Results at First Differences of the Variables

Null Hypothesis:	Obs	F-Statistic	Probability
DM does not Granger Cause D(e)	38	2.44352	0.10002
D(e) does not Granger Cause DM		1.66483	0.20472
DR does not Granger Cause D(e)	38	1.64744	0.20799
D(e) does not Granger Cause DR		0.32968	0.72149
DY does not Granger Cause D(e)	37	3.03658	0.06201
D(e) does not Granger Cause DY		0.07471	0.92818
DR does not Granger Cause DM	38	0.58070	0.56512
DM does not Granger Cause DR		3.42138	0.04464
DY does not Granger Cause DM	37	3.54020	0.04084
DM does not Granger Cause DY		2.16268	0.13153
DY does not Granger Cause DR	37	0.21800	0.80531
DR does not Granger Cause DY		0.57775	0.56690

Appendix 3: Typical VAR Models with More than One Endogenous Variable

$$\beta_1 e + \beta_2 M + \beta_3 Y + \beta_4 R = u_t \qquad [1]$$

Appendix 4: Normalized Co-integration Relationship Equations

$$\beta_1 e + \beta_2 M + \beta_3 Y + \beta_4 R = 0 \qquad [1]$$

Appendix 5: Vector Error Correction Modeling (VECM) Equations for the Flexible Price Model

$$D(M)_t = \alpha_2 + \sum_{1=1}^{m} \beta_{2i} D(e)_{t-i} + \sum_{1=1}^{n} \delta_{2i} D(Y)_{t-i} + \sum_{I=1}^{M} \lambda_{2i} D(R)_{t-i}$$
$$+ \sum_{1=1}^{h} \psi_{2i} D(M)_{t-i} + \sum_{i=1}^{p} \partial_{2i} ECM_{r,t-1} + DV1 + \mu_t \qquad [2]$$

$$D(Y)_t = \alpha_3 + \sum_{1=1}^{m} \beta_{3i} D(M)_{t-i} + \sum_{1=1}^{n} \delta_{3i} D(e)_{t-i} + \sum_{I=1}^{M} \lambda_{3i} (R)_{t-i}$$

$$+ \sum_{1=1}^{h} \psi_{3i} D(Y)_{t-i} + \sum_{i=1}^{p} \partial_{3i} ECM_{r,t-1} + DV1 + \mu_t \quad [3]$$

$$D(R)_t = \alpha_4 + \sum_{1=1}^{m} \beta_{4i} D(M)_{t-i} + \sum_{1=1}^{n} \delta_{4i} D(Y)_{t-i} + \sum_{I=1}^{M} \lambda_{4i} (e)_{t-i}$$

$$+ \sum_{1=1}^{h} \psi_{4i} D(R)_{t-i} + \sum_{i=1}^{p} \partial_{4i} ECM_{r,t-1} + DV1 + \mu_t \quad [4]$$

Appendix 6: Diagnostic Testing

Testing for the Order of Integration

It used to be thought that there was a stable long run relationship between the levels of macroeconomic variables. This implied that macroeconomic variables would not move far from each other in the long run equilibrium. However, it is now well-known that most macroeconomic time series in a growing economy are non-stationary (Dickey, Jansen and Thorton 1994) as such when such time series data are regressed together they lead to spurious regression results due to the strong trends involved in such time series data.

A series is said to be integrated of order'd' or I (d) if it has to be differenced 'd' times to produce a stationary series. As many economic time series are found to be I (1), co- integration is defined for I (1) variables: two series are co-integrated of order (1, 1) if the individual series are I (1) and a linear combination of them, called the counteraction regression, is I (0). It can be shown that in the case where the two series are I (1) and are co-integrated, the model can be given an error correction representation, also if an error correction model (ECM) provides an adequate representation of the variable, they must be co-integrated (Engle and Granger 1987). In the ECM the variable would be stationary. This provides the basis for using co-integration analysis in ECM models in order to separate the long-run relationship from the short-run relationship.

The test for co-integration then first requires testing whether the differenced series are stationary using in our case the Augmented Dickey-Fuller test. The Augmented Dickey-Fuller test involves running a regression on first difference of the series, on the series itself, lagged once, or with more lagged difference terms, a constant and a time trend.

$$\Delta y_t = \alpha + \rho\delta t - \rho y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t \qquad t = 1,\ldots,n$$

Where y denotes the variable in question, Δ is the first difference operator, and $\alpha, \rho, \delta, \gamma$ are parameters to be estimated, and ε_t is the stochastic random disturbance term.

The Augmented Dickey-Fuller procedure tests the null hypothesis that the series of a variable is non-stationary I (1) against the alternative hypothesis that it is stationary (I (0). That is:

Ho: $\rho = 0$

Ha: $\rho \neq 0$

The acceptance of the null hypothesis means that the variables are non-stationary and in that case it has to be tested again at their first differences and so forth until they become stationary.

If after first difference a non-stationary time series variable becomes stationary then it is integrated of order one (I (1)).

Against this background, the Augmented Dickey-Fuller test (Dickey and Fuller 1979) has been used to test for stationarity among the time series data.

Appendix 2 Tables 1 and 2 presents the Augmented Dickey-Fuller (ADF) test for unit root for all the variables at their levels and first differences. It is clear that all the variables are not stationary at their levels but stationary at first differences. This means that running regression at their levels would have lead to spurious regression results. Now that we have established the stationary status of the variables we next proceed to examine the co-integration status of the relationships specified in the in the model in the next section.

Johansen's Test for Co-integration

This test is an error correction representation of the standard vector autoregressive (VAR) model. The Johansen (1988) and Johansen and Juselius (1990) tests provide the procedure to examine the question of co-integration of co-integration. A two-step procedure is formulated and the standard vector Autoregressive, VAR model is of the form:

$$X_t = A_1 X_{t-1} + ... + A_k X_{t-k} + \mu + \theta D_t + \varepsilon_t \qquad [1]$$

where

X_t is an $Nx1$ vector of variables of interest, μ_t is a vector of constants, D is a vector of dummies while ε_t is a vector of $\Pi D(0,\Omega)$ error terms.

Equation 1 can be re-parameterized into an error correction model where:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \theta D_t + \varepsilon_t \qquad [2]$$

where

$$\Gamma_1 = -(I - \Pi_1 - ... \Pi_i); I = i,...,k-1;$$

$$\Pi = -(I - \Pi_1 - ... \Pi_k);$$

where

I is an identity matrix. The main task here is to investigate whether the coefficients contained in the Π matrix contain long run information. Taking the number of variables in the vector X_t to be N, and hence the number of equations in the VAR, and the rank of Π matrix to be r, three cases can be distinguished.

1. Rank $\Pi = N = r$: This implies that the matrix has full rank and that the process X_1 is stationary.

2. Rank $\Pi = r=0$: This implies that Π matrix is null and hence equation 2 corresponds to traditional differenced vector of time series variables, hence the variables are not co-integrated.

3. Rank $\Pi = r < N$ but not zero. This is the interesting case where the Π matrix is less than the full rank. In this case the rank, r is equal to the number of distinct co-integrated vectors linking the variables in, as such r is known as the co-integration rank.

The Johansen's test is better than the two-step procedure in almost all aspects. The practical problems originate from choosing a correct combination of lags and dummy variables to make the residuals come out as white noise. In limited sample this can be difficult and the results might change among different specifications of the system, just as it does in the two-stage procedure.

The Johansen approach yields maximum likelihood estimators of unconstrained co-integrating vector, and also allows one to explicitly test for the number of co-integrating vectors without relying on an arbitrary normalization.

The number of significant co-integrating vectors helps to determine the number of error correction terms.

It is important to note that the use of first differences of the variables in a VAR may lead to the loss of important long run information about the relationships in the model. To ascertain this we proceed further with Johansen's Multivariate Co-integrating approach to test for the existence of long run stable relationship in our model (See Appendix 3 for the equation). All the variables in their logarithmic form except the interest rate and enter the co-integration analysis at levels. The results of the co-integration test presented in Appendix Table 3 shows that our model is co-integrated with at least one co-integrated vector. This means that using only the first differences of the variables to run the VAR will lead to specification error since long run information about the relationship in the equation will be lost. The results mean that all the equations can be run on their first differences with an error mechanism. On the basis of this, we embark upon vector error correction modeling (VECM) for our model.

Granger Causality Test

Granger (1969) observes that sometimes it is difficult to determine the direction of causality between two related variables and whether or not there is a feed back. Using a simple two variables model he illustrates the issue of causality as follows:

Using the two variable model he states that let X_t, Y_t be two stationary time series with zero mean, the simple causal model is as follows:

$$X_t = \sum_{j=1}^{m} \alpha_j X_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + \varepsilon_t$$

[1]

$$Y_t = \sum_{j=1}^{m} c_j X_{t-j} + \sum_{j=1}^{m} d_j Y_{t-j} + \eta_t$$

where ε_t and η_t are taken to be two uncorrelated white noise series, that is $E(\varepsilon_t \varepsilon_s) = 0$ $E(\eta_t \eta_s), s \neq t$ and $E(\varepsilon_t \varepsilon_s) = 0$ for all t, s.

In equation 1 m can be equal to infinity but in practice, of course, due to finite length of available data, m will be assumed finite and shorter than the given time series.

The definition of causality given the above implies that Y_t is causing X_t provided $b_j \neq 0$. Similarly, X_t is causing Y_t if $c_j \neq 0$. If both of these events occur, there is said to be a feedback relationship between X_t and Y_t.