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Article

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Relationship between Exchange Rate Volatility and Interest Rates Evidence from Ghana

Sarpong Mohammed¹, Abubakari Mohammed^{2*} and Edward Nketiah-Amponsah³

Abstract: This paper examines the effect of interest rates on exchange rate volatilities in Ghana. It utilizes the Quarterly Time Series dataset spanning 2000 Quarter 1 to 2017 Quarter 2 and the Autoregressive Distributed Lag model as well as the Vector Error Correction Model to investigate the long-run and short-run relationships between the variables. The results showed that in the long-run model, exchange rate volatility was seen to be influenced by money supply, inflation, Central Bank's policy rate, and the Ghana Stock Exchange composite index. However, in the short-run model, exchange rate volatility was found to be significantly influenced by its past values and the Central Bank's policy rate.

Subjects: Economics; finance; business, management and accounting

Keywords: Exchange rate volatility; interest rate; autoregressive-distributed lag

1. Introduction

There has been growing interest in assessing the relationship between interest rates and exchange rates in both advanced and developing economies in recent years. This is attributable to the important role these variables play in determining developments in the nominal and real sides of the economy, including the behavior of domestic inflation, real output, exports and imports (Sánchez,



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Sarpong Mohammed is a finance and internal control expert with over 9 years' experience in Accounting and Internal audit. He is a Chartered Accountant and a member in good standing with the Institute of Chartered Accountants, Ghana (ICAG). He holds a Bachelor's Degree in commerce (B. Com) from the University of Cape Coast and Master of Philosophy in Finance and Investment from the Kwame Nkrumah University of Science and Technology, Kumasi. He has worked with Ghana Broadcasting Corporation as an Internal Auditor and later as an Accountant. Currently, he is an Internal Auditor with the West African Examinations Council (WAEC). He is the National Auditor for the Youth Wing of the Ahmadiyya Muslim Mission, Ghana. His research interest is in the financial markets and macroeconomics.

PUBLIC INTEREST STATEMENT

Ghana, being a net importer of goods and services, is saddled with exchange rate volatility issues as more foreign currency is required to meet the needs of importers. Since independence in 1957, the country has gone through various exchange rate regimes in an attempt to ensure economic stability but to no avail as the local currency continues to perform abysmally with reference to major currencies.

Volatility increases exchange rate risk as the profit in trade or the rate of return on international investments are eroded due to changes in the exchange rate. Available data show a seeming relationship between Interest Rates and Exchange Rate Volatility.

Therefore, my team set out to explore how such a relationship, if any, could help stabilize exchange rates. The findings, among others, showed that interest rates could influence exchange rate volatility. In the end, appropriate recommendations have been tabled for consideration.

2005). The subject of exchange rate volatility and interest rate is even more critical due to globalization; countries intermingle with each other through trade and investment (Suranovic, 2012).

Volatile exchange rates are associated with random movements in relative prices in an economy. For this reason, stable exchange rate is a very significant factor to stimulate total investment, price stability and stable economic growth (AL Samara, 2009).

The Ghanaian cedi has witnessed long periods of depreciation against major foreign currencies, especially the US dollar (US\$) since the adoption of the floating exchange rate regime (Kwakye, 2015). While this regime offers the country some level of monetary independence, it is associated with exchange rate volatilities. For instance, at the beginning of January 2014, US\$1 was exchanged for GH¢2.3975, but by the end of September 2014, the cedi/dollar exchange rate stood at GH¢3.2 to US\$1, denoting about 33.48% decrease in value. Over the same period, the policy rate was revised from 18% to 19% by the Bank of Ghana (BoG, 2014).

Most researchers have considered the role of interest rates in stabilizing exchange rates by asking whether or not interest rates have the potential to influence domestic currency. A study by Kwakye (2015) examined the relationship between exchange rates and key macroeconomic variables in Ghana. The study employed Autoregressive Distributed Lag (ARDL) technique for cointegration and found that there is cointegration relationship between the variables, indicating the existence of a long-run equilibrium relationship between them. Further, the study established a significant effect of exchange rate lag (past exchange rate) on current exchange rate.

Another study by Nchor and Darkwah (2015) investigated the impact of exchange rate movement and the nominal interest rate on inflation in Ghana. The study examined the presence of Fisher Effect and International Fisher Effect scenarios. They made use of an autoregressive distributed lag model and an unrestricted error correction model (UECM). Ordinary Least-Squares regression methods were also employed to determine the presence of the Fisher Effect and the International Fisher Effect. The results showed that, in the short run, there exists a positive relationship between exchange rate and inflation while the relationship between interest rate and inflation in the short run is negative. The study further established the presence of both the partial Fisher Effect and the full International Fisher Effect.

It can be seen from the literature reviewed that much had not been done to examine the influence of interest rates on exchange rate volatility in Ghana. In this light, this study seeks to investigate the effect of a change in the Central Bank policy rate on exchange rate volatility in Ghana. The motivation to focus on volatility stems from the fact that, according to Chen (2006), empirical evidence in developing countries suggests that exchange rate volatility may discourage foreign trade and investment and hence reduce national income.

The rest of the paper is organized as follows: Section 2 reviews the existing theoretical and empirical literatures on interest rates and exchange rate volatility, while section 3 presents the methodology used in the study. The fourth section presents and discusses the empirical findings of the study. The last section presents the summary and concluding remarks.

2. Literature review

The major exchange rate theories used by the researchers include Purchasing Power Parity, Balance of Payments, Interest Rate Parity, and International Fisher Effect Theories. These theories deal with parity conditions, which is an economic explanation of the price at which two currencies are exchanged based on factors including inflation and interest rates (Otuori, 2013; Madhura, 2008; Isard, 1995 & Fisher, 1930). These economic theories posit that, in situations where parity conditions do not hold, they give rise to arbitrage opportunities for market participants. Exchange rate theories are fundamentally based on the law of one price states that, in the absence of restrictions such as shipping costs and tariffs, the price of a product when converted into a common currency such as the US dollar, using the spot exchange rate, is the same in every country (Levi, 2005).

Volatility represents the degree to which a variable changes over time (Suranovic, 2012). Therefore, exchange rate volatility can be referred to as the rise or fall in the value of foreign currency in relation to the local currency. A study by the Research Department of the Bank of Ghana on financial and monetary policies in Ghana, cited by Quarkey and Afful-Mensah (2014), attributed the dynamics of exchange rates to policy directions and interventions in the exchange rate market. In December 2006, the Foreign Exchange Act was enacted to replace the Exchange Control Act as part of measures to deepen the country's financial system. Under the old exchange rate law, Ghana operated a controlled exchange rate policy where restrictions were placed on foreign transactions, including external loans contracted by residents and non-residents. The introduction of the Foreign Exchange Act was to ensure a shift from these restrictions to a more liberalized foreign exchange regime (Bank of Ghana Working Paper, Bank of Ghana, 2007).

Notwithstanding these interventions, however, maintenance of a stable value for the cedi vis-à-vis major international currencies, such as the US dollar, British pound, and the euro, has continued to pose a challenge to policymakers (Bank of Ghana Working Paper, Bank of Ghana, 2007). Interestingly, few researchers have attempted to examine the relationship between exchange rate volatility and interest rates. According to Saraç and Karagöz (2015), the issue of exchange rate volatility is one of the leading impediments to the progress of developing economies as it adversely affects macro-economic management. As a result, policymakers continue to use monetary policy instruments, key among which is interest rate to contain the rate of exchange rate fluctuations.

Although some researchers disagree on the empirical findings of the role of tight monetary policies, such as high interest rates in stabilizing exchange rates, there is considerable level of agreement among most of them (Chen, 2006). Perhaps, the support for this policy is premised on the traditional wisdom that, during periods of exchange rate fluctuations, rising interest rates make speculations against the domestic currency unattractive because, when domestic interest rates are raised, it has the potential to attract foreign investment. Additionally, it affects the decision of domestic investors to invest abroad which will lead to inflow of foreign currency which can stabilize the exchange rate (Verbeek, 2004).

Furman et al. (1998) employed simple regression analysis to establish the simultaneous relationship between interest rate and exchange rate in nine emerging markets which had temporarily high interest rates. They concluded that the quantum and length of the high interest rates were associated with exchange rate depreciation. Their interpretation of the results therefore questions the rationale for raising interest rates to defend exchange rates. This conclusion was however contested by Baig and Goldfajn (1999) who investigated the relationship between monetary policy and exchange rates in five Asian countries affected by the financial crisis using simple correlations. The study specifically focused on the role of monetary policy in stabilizing exchange rates after a large collapse. The results of the study showed no evidence to suggest that high interest rates impacted unstable exchange rates, which is in direct contradiction to the conclusions drawn by Furman et al. (1998).

Another study by Chen (2006) analysed weekly data totaling 296 data points to explain the relationship between exchange rate volatility and interest rates in six developing countries, namely: Indonesia, South Korea, Philippines, Thailand, Mexico, and Turkey using the Markov regime switching approach. This study employs a model anchored in the microstructural theory of exchange rates in Jeane and Rose (2002) which combines the theory of exchange rate determination with the noise trading approach to asset price volatility. The researchers found that when the nominal interest rate increases, it increases the probability of switching to a regime which allows for volatile exchange rates. This supports the traditional argument that one significant merit of the floating exchange rate regime stabilizes interest rates. This is because it saves monetary authorities the problem of having to intervene to allow the exchange rate to remain fixed (Reinhart & Reinhart, 2001). Equally, when the exchange rate is fixed, it induces inter-sectoral or intertemporal shifts in volatilities to other variables (Frenkel & Mussa, 1980).

Ali et al. (2015) used VECM and co-integration models to investigate the impact of inflation, interest rates, and money supply on volatility of exchange rates in Pakistan. They noted that monetary policies are crucial in stabilizing prices and reducing unemployment. They analyzed monthly data from July 2000 to June 2009 and concluded that exchange rate volatility is influenced by high money supply and an increase in interest rates which raises the price levels. Interestingly, another study by Asari et al. (2011) used VECM approach to explain the relationship between interest rates and inflation towards exchange rate volatility in Malaysia produced different results. The results showed a positive relationship between interest rate and inflation but an inverse relationship between interest rate and exchange rate volatility. The study therefore suggested that interest rates can be efficient in containing exchange rate volatility.

The Ghana Stock exchange (GSE) is an avenue for foreign investment. When macroeconomic factors such as inflation and interest rates are favourable, it attracts foreign investment. This has the potential to boost the performance of the GSE and hence improve the foreign exchange situation of the country. In view of this, some researchers have suggested that the stock market can affect the currency market through the rate of foreign cash invested in domestic companies. For instance, researchers, namely Bala Sani and Hassan (2018), and Farooq et al. (2005) among others have suggested the existence of causal relationships and positive and statistically significant relationships between the stock market general index and the exchange rate.

Yet, other scholars sought to ascertain whether inflation targeting as a monetary policy framework has the potential to influence exchange rate volatility (Fosu, 2015). For instance, Chow and Kim (2004) employed bivariate VAR-GARCH model to examine the empirical relationship between exchange rates and interest rates in Indonesia, Korea, Philippines, and Thailand and probed how the dynamics had changed following the Asian financial crisis. The results suggest that interest rates play no significant role in stabilizing exchange rates. Interest rates did not stabilize due to increased exchange rate flexibility.

On the other hand, Minella et al. (2003) also examined the difficulties brought about by the inflation targeting regime in Brazil after it has been in operation for three and a half years. They employed a VAR to model inflation targeting and also ran an OLS regression of the inflation target, the interest rate, and the 12-month inflation rate. The results suggested that the inflation targeting framework had helped to stabilize the macroeconomy.

Osei-Assibey (2018) investigated “Inflation Targeting under Weak Macroeconomic Fundamentals” and sought to find out if there was a need for monetary policy redirection in Ghana. He suggested a rethinking of Ghana’s inflation targeting (IT) regime, in order to accelerate the nation’s socio-economic development. The study found that, although IT had been successful in keeping inflation levels low, if the rule was implemented very strictly, an inflation target could severely limit the central bank’s flexibility in responding to changing economic conditions. Therefore, the study concluded that further interventions seem necessary to augment its effectiveness.

Numerous studies conducted in this field confirm the significance of the subject matter. It can be observed that extensive study has been done in other countries but Ghana. Studies in this area in the Ghanaian context have focused on long-run relationships. Studies that looked at volatilities did so in relation to other economic variables apart from interest rates.

It is worth noting that exchange rate fluctuations do not necessarily pose a risk. However, the rate of fluctuations (volatility) poses a risk to both traders and investors (Suranovic, 2012). This occurs when the expected profit in trade or rate of return on international investment is eroded due to the rate and extent of fluctuations in the exchange rate as it makes it more expensive to import.

Therefore, this study is different from previous studies conducted in Ghana in that the current study shifts from the relationship based on fluctuations which has been the area of focus of

previous studies conducted in Ghana and focuses on the volatilities (rate and extent of fluctuations). Further, the study looks at the relationship in the context of inflation targeting which uses interest rates as the key monetary policy operating instrument in macroeconomic stabilization (Chow and Kim, 2004). Studies have shown that, in the face of financial crisis, inflation targeting could stabilize exchange rates (see Minella et al. (2003), Mishkin (2004), Osei-Assibey (2018), and Roger (2010)).

3. Methodology

3.1. Volatility estimate

In this study, real exchange rate volatilities are estimated using the Generalized Autoregressive Conditional heteroskedasticity GARCH (1,1) model which is the Generalized ARCH introduced by Engle and Granger (1982) and Bollerslev (1986). The GARCH (1,1) is given as:

(i) The jointly estimated GARCH (1,1) model is given as:

$$a_t = \sigma_t \varepsilon_t; \varepsilon_t \sim \text{iid}(0, 1); a_0 > 0 \quad (1)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^m \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^s \beta_j \sigma_{t-j}^2; \varepsilon_t \sim N(0,1); \alpha_0 > 0; \alpha_i \geq 0; \beta_j \geq 0 \quad (2)$$

The variance equation σ_t^2 is composed of three terms:

α_0 = the mean (long-term average)

α_{t-i}^2 = News about volatility from the previous period (the ARCH term)

σ_{t-j}^2 = GARCH term

3.2. Regression model

Following the precedence of earlier scholars (see Ali et al., 2015), we present a theoretical model for the determinants of the exchange rate as shown in Equation (3). The Ghana Stock Exchange index has been included owing to its relationship with the exchange rate (see Bala Sani and Hassan (2018) & Farooq et al. (2005))

$$Er_t = f(IR_t, I_t, MS_t, GSE_t) \quad (3)$$

Where Er_t = exchange rate volatility;

IR_t = Central Bank policy rate;

I = inflation rate;

MS_t = Money supply;

$$Er_t = \beta_0 + \beta_1 IR_t + \beta_2 I_t + \beta_3 MS_t + \beta_4 GSE_t + \varepsilon_t$$

Equation (3) indicates that the exchange rate volatility is a function of the Central Bank policy rate, the inflation rate, the money supply, and the Ghana Stock Exchange composite index. For the purpose of econometric estimation, the theoretical model for the determinants of exchange rate volatility in Ghana is expressed empirically as:

$$\varepsilon_t = \beta_0 + \beta_1 IR_t + \beta_2 I_t + \beta_3 MS_t + \beta_4 GSE_t + \varepsilon_t \quad (4)$$

Where the subscript “t” represents a time period, that is, a quarter in this case, since the data set is quarterly data spanning the period of the first quarter of 2000 to the second quarter of 2017. ε_t = stochastic error term assumed to be white noise, while β_i , for $i = 0, 1, 2, 3, 4$, are regression parameters to be estimated.

3.3. Estimation procedure

To achieve the study’s objectives, we estimate the long-run relationship between Central Bank policy rate (a proxy for interest rate) and exchange rate volatility. This study will then apply the ARDL approach introduced by Pesaran et al. (2001) to investigate the long-run relationship between Central Bank policy rate and exchange rate volatility. The reason for using the ARDL Bound Testing approach is that it allows for a combination of variables integrated of different orders, i.e., I(0) and I(1). This makes the ARDL model superior to conventional approaches to cointegration such as the Johansen cointegration approach and the Engle-Granger two-step residual base test for cointegration (Johansen, 1991 & Engle, 1987).

4. Estimation results and discussion

4.1. Descriptive statistics

Table 1 shows the descriptive statistics for these elected variables in the form of means, standard deviations, as well as their maximum and minimum values. For instance, the table shows that the average policy rate within the period of study was 19.3% while inflation was 16.8% within the same period. It can also be seen that inflation was as high as 41.9% at a point and went as low as 8.4% while policy rate ranged from 12.5% to 27.5% within the same period.

4.2. Preliminary data analysis

Preliminary data analysis as presented in Tables 1, 2, and 3 (see appendix) involves summary statistics of the data, normality tests, correlation analysis, and stationarity tests on the variables. It is interesting to note that the pairwise correlations are statistically significant at the conventional level in most cases, especially with regard to correlations between the dependent variable (exchange rate volatility) and independent variables. Gujarati (2004), however, argues that high zero order correlations are a sufficient but not a necessary condition for the presence of multicollinearity. Also, Figures 1 and 2 (see appendix) depict the evolution of exchange rate volatility and the Central Bank’s policy rate in Ghana, respectively. In Figure 1, in particular, we observe that the cedi/US Dollar exchange rate has been extremely volatile with the rate of volatility rising from just 0.06 to as high as

Table 1. Descriptive statistics of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
FX Volatility	70	0.0479782	0.044781	0.00398	0.19339
CB Policy Rate	70	19.33286	5.166551	12.5	27.5
Inflation	70	16.81043	7.622356	8.4	41.9
Money Supply	70	14,763.19	16,561.54	514.7	59,903.8
GSE Composite Index	70	3,582.037	2,726.189	763.1	10,890.8

Source: Authors’ own Computation

Table 2. Pairwise correlation matrix

	Er	GSE	I	IR	MS
Er	1				
GSE	-0.3467	1			
I	0.4657	-0.1744	1		
IR	0.5077	-0.4669	0.7373	1	
MS	0.3154	-0.3123	-0.2687	0.1313	1

Source: Author's computation

Table 3. Results of ADF and PP unit root tests

	AUGMENTED DICKEY FULLER (ADF) UNIT ROOT TEST	PHILLIPS-PERRON UNIT ROOT TEST
	ADJUSTED TEST STATISTIC	ADJUSTED TEST STATISTIC
VARIABLE	Trend and Constant	Trend and Constant
Er	-5.054791[1] (0.0005) ***	-2.43749 -0.3576
Der	-6.094780[1] (0.0000) ***	-8.682622 (0.0000) ***
GSE	-1.799165[0] -0.6945	-1.895996 -0.6459
DGSE	-7.158695[0] (0.0000) ***	-7.153575 (0.0000) ***
I	-2.635796[0] -0.2663	-3.234673 (0.0863) *
DI	-7.523462[3] (0.0000) ***	-5.902178 (0.0000) ***
IR	-1.538793[1] -0.8063	-1.233165 -0.8954
DIR	-5.448886[0] (0.0001) ***	-5.445427 (0.0001) ***
MS	-1.994393[4] -0.5933	-3.042747 -0.1285
DMS	-3.727496[5] (0.0276) * *	-19.81065 (0.0001) ***

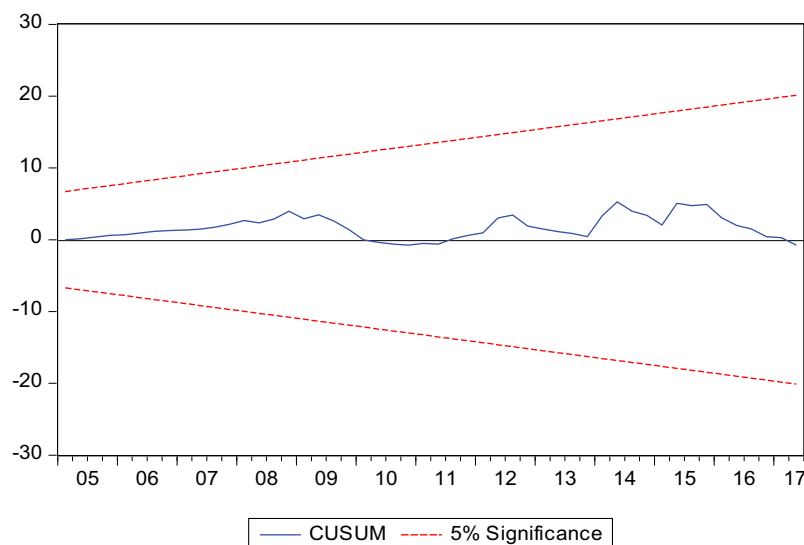
Notes: (1) *, **, and *** denote stationarity at 10%, 5%, and 1% levels of statistical significance, respectively; (2) Values in parentheses are the p-values, while values in square brackets are the lag length of the ADF unit root test regression; (3) the logarithm of money supply (MS) is used for the unit root test; (4) A maximum lag order of 10 was set for the ADF test according to the Schwartz formula for determining the maximum lag order. The number of lags selected for the ADF test was automatically selected based on the Schwartz Information Criterion. However, in applying the Phillips-Perron test (Phillips & Perron, 1988), the bandwidth was selected based on the Newey-West Bandwidth.

0.19. It is noteworthy, however, that the rate has been extremely oscillatory during the post-2007 period, i.e. the years after the redenomination of the Ghana cedi which converted GHc10,000 old Ghana cedis to GHS 1 new Ghana cedi. In contrast, the policy rate trended upward between the first quarter of 2012 and the first quarter of 2016.

The study utilised the Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test to examine the stationarity properties of the variables. This is done to ensure that the dependent variable is I(1)

Figure 1. Plot of cumulative sum of recursive residuals.

Note: The straight lines represent critical bounds at 5% significance level



and none of the explanatory variables is $I(2)$ or higher. This requirement is necessary since the use of variables which are integrated of order $I(2)$ or higher invalidates the F-statistics and all critical values established by Pesaran. The unit root test results from ADF test and PP test presented in Table 4 shows that most of the regression variables are stationary in the first difference. On the basis of this, we present the order of integration of the regression variables in Table 4 as follows:

From Table 4, it is observed that none of the regressors is integrated of order two or higher and the dependent variable, exchange rate volatility (Er), is integrated of order $I(1)$ as depicted by the PP unit root test. This implies that the ARDL cointegration procedure can be employed in the analysis of the long-run cointegration relationship between the dependent variable (Er) and the vector of regressors.

4.3. Testing for the existence of a long-run relationship

In testing for the presence of a long-run relationship between the level variables in a multivariate framework under the ARDL or Bounds Testing cointegration procedure, we estimate an UECM and the error correction version of the ARDL model using Ordinary Least Squares (OLS). The Bounds Testing cointegration approach is simply an F Test for the joint significance of the lagged variables on the right-hand side of the UECM. Table 1A (appendix) shows the results of the estimated UECM. From this, we determine the maximum number of lags using the lag length selection criteria as shown in Table 1B (appendix). Given that most of the lag order selection criteria, such as the Likelihood Ratio (LR), Schwartz information criterion (SC), and Hannan–Quinn information criterion (HQ) choose a maximum lag of two, we set the maximum lag order of the ARDL model to two. The estimated ARDL model is presented in Table 1C (appendix).

Table 4. The order of integration of the regression variables

VARIABLE	ADF UNIT ROOT TEST	PP UNIT ROOT TEST
Er	$I(0)$	$I(1)$
GSE	$I(1)$	$I(1)$
I	$I(1)$	$I(0)$
IR	$I(1)$	$I(1)$
MS	$I(1)$	$I(1)$

Source: Author's computation

The null and alternative hypotheses of the ARDL Bounds Test F statistic is given by:

H_0 : No cointegration

H_1 : Cointegration

The decision rule is given as:

If the ARDL F-statistic value is greater than the upper bound (U) critical value at a chosen level of significance, we reject the null hypothesis of no cointegration. On the other hand, if the ARDL F-statistic value is less than the lower bound (L) critical value at a chosen level of significance, we accept the null hypothesis of no cointegration. The test is, however, inconclusive if the ARDL F-statistic value lies between the upper and lower bounds critical values at the chosen level of significance. The estimated results of the long-run cointegration test using the Wald coefficient diagnostic test are shown in [Table 5](#).

Based on the Wald Test result ([Table 5](#)), the null hypothesis of no cointegration is rejected at the 1% level of significance, indicating the presence of a long-run level relationship between exchange rate volatility and the regressors in the model. Given that a long-run relationship exists between the exchange rate volatility and the regressors in the model, the next step in the ARDL cointegration procedure is to estimate the long-run and short-run coefficients of the model.

4.4. Estimation and discussion of long-run coefficients

The existence of cointegration between the exchange rate volatility and the regressors makes it possible to estimate the long-run results of the regression equation. The results of the long-run model are presented in [Table 6](#).

Based on the long run results in [Table 6](#), we find that the exchange rate volatility in Ghana is significantly influenced by the Central Bank's policy rate (IR), money supply (MS), inflation (I), and the GSE composite index in the long run (see [Table 6](#)).

Specifically, the results in [Table 6](#) show that a percentage increase in the rate of inflation is associated with about 0.004 units increase in exchange rate volatility in the long run, whereas a percentage increase in the money supply raises the volatility of the exchange rate by about 0.015 units in the long run. Also, the empirical results suggest that an upward revision of the Central Bank's policy rate is associated with an increase in the volatility of the exchange rate in the long run. In particular, revising the Central Bank's policy rate by just a basis point increases the volatility in the exchange rate by about 0.8% in the long run. Furthermore, we observe that an increase in the GSE composite index reduces exchange rate volatility in the long run.

The finding in this study corroborates that of Furman et al. (1998) who concluded that the quantum and length of the high interest rates were associated with exchange rate depreciation.

Table 5. Results of the cointegration test

Test Statistic	Value	df	Probability
F-statistic	3.882929	(5, 50)	0.0047
Chi-square	19.41465	5	0.0016
Source: Author's computation			

Table 6. Long-run regression estimates of the effect of Central Bank's policy rate on exchange rate volatility in Ghana [dependent variable: exchange rate volatility (Er)]

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IR	0.008238**	0.003407	2.417981	0.0185
MS	0.014952***	0.003662	4.082992	0.0001
I	0.004033***	0.000644	6.258682	0.0000
GSE	-2.98E-06*	1.50E-06	-1.992008	0.0506
Constant	-0.141153	0.041711	-3.384067	0.0012
R-squared	0.51559			
Adjusted R-squared	0.485314			
Log likelihood	141.4746			
F-statistic	17.02985			
Prob(F-statistic)	0.0000			

Notes: ***, **, and * denote statistical significance at 1%, 5%, and 10% levels of significance, respectively; IR represents a quarterly adjustment in the Central Bank's policy rate; MS represents the money supply; I represent inflation rate; and GSE represents the Ghana Stock Exchange composite index.

Source: Author's computation

However, this finding is in contrast to that of Baig and Goldfajn (1999) who found no evidence to suggest that high interest rate impacted the unstable exchange rate.

The interpretation of the results of this study alongside that of Furman et al. (1998) therefore questions the rationale for raising interest rates to defend exchange rates as supported by the traditional view. It is important to note that monetary policy works best where financial markets are efficient and well developed, and market participants are committed to the achievement of overall national economic goals. Therefore, in less developed economies, high interest rates may actually not only discourage investments and slow economic growth but could precipitate financial-sector crisis thereby depreciate the local currency.

4.5. Estimation and discussion of short-run coefficients

The existence of a long-run level relationship between the regression variables implies that there is an error correction representation which gives information on the long-run relationship, short-run relationship, and the speed of adjustment. Thus, after establishing the existence of a long-run relationship between the variables and estimating the long-run coefficients, the final step in the ARDL bound testing approach involves the determination of the short-run dynamics associated with the long-run estimates of the variables in the model. This is achieved by estimating the ECM as shown in Table 7.

We observe from Table 7 that exchange rate volatility is significantly influenced by its past values and the Central Bank's policy rate in the short run. In particular, whereas the first lag of the Central Bank's policy rate positively influences exchange rate volatility in the short run, the second lag of the Central Bank's policy rate does not significantly influence the behavior of the exchange rate in the short run (see Table 7). However, by performing a joint significance test of the two coefficients (i.e., $D(IR(-1))$ and $D(IR(-2))$), we find that the null hypothesis of jointly non-significant coefficients is rejected at the 10% level of statistical significance (see Table 1D, appendix). The lag error correction term ($ECT(-1)$) represents the extent of disequilibrium or departure from the equilibrium in the previous period. The coefficients of ECT tell us the speed of adjustment towards the equilibrium. The coefficient of the lagged error correction term is negative (-0.365,399) and is significant at the 1% level of statistical significance, indicating convergence towards the long-run equilibrium. According to Afzal et al. (2010), the negative value of the error correction term implies that in each period, approximately 37% of the shocks can be justified as a long-run trend. The

Table 7. Short-run estimates of the determinants of exchange rate volatility in Ghana

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.007766	0.004954	-1.567721	0.1228
D(Er(-1))	0.474323	0.113045	4.195892	0.0001
D(Er(-2))	0.009292	0.123675	0.07513	0.9404
D(IR(-1))	0.005913	0.002372	2.492908	0.0158
D(IR(-2))	-0.00098	0.002344	-0.417986	0.6776
D(MS(-1))	0.036719	0.038896	0.944022	0.3494
D(MS(-2))	0.053989	0.039238	1.375934	0.1745
D(I(-1))	-0.000555	0.000852	-0.651793	0.5173
D(I(-2))	-0.0007	0.000702	-0.996428	0.3235
D(GSE(-1))	1.42E-06	2.18E-06	0.64966	0.5187
D(GSE(-2))	5.02E-07	2.15E-06	0.233799	0.816
ECT(-1)	-0.365399	0.11271	-3.241932	0.002
R-squared	0.405427			
Adjusted R-squared	0.28431			
Log likelihood	177.7255			
F-statistic	3.347406			
Prob(F-statistic)	0.001437			

Notes: ***, **, and * denote statistical significance at 1%, 5%, and 10% levels of significance, respectively.

Source: Author's computation

implication of this is that deviations in the exchange rate volatility away from the equilibrium are corrected by 37% within a quarter.

Intuitively, it could be explained that if a review of the Central Bank's monetary policy rate is a response to certain macroeconomic conditions prevailing at a particular time including fluctuations in exchange rates, then it is expected that the revision of the policy rate will have both short-run and long-run influence. That is, the Central Bank has as its primary objective to achieve macroeconomic stability and one of the instruments at its disposal is the policy rate. Such a policy rate could potentially be effective both in the short run and long run to stabilize exchange rates.

To ensure that the ARDL model is well specified, we conducted two major post-estimation diagnostic tests. The diagnostic test includes tests for serial correlation and the test of the stability of the ARDL model. The serial correlation test is conducted using the Breusch-Godfrey Serial Correlation LM test. A summary of the test results is shown in [Table 8](#).

From [Table 8](#), it is seen that the F-statistic value = 0.310378 and Prob. F(2,48) = 0.7346. This indicates that the null hypothesis of no serial correlation cannot be rejected. Hence, there is no serial correlation in the model and so it can be inferred that the model is correctly specified.

Table 8. Breusch-Godfrey serial correlation LM test

F-statistic	0.310378	Prob. F(2,48)	0.7346
Obs*R-squared	0.842642	Prob. Chi-Square(2)	0.6562

Source: Author's computation

The second diagnostic test is a test for the stability of the ARDL model. The stability of coefficients of regressors in a regression model is important for long-run policy analysis. Indeed, effective policy analysis requires that the model is stable over the long run. To assess the stability of the exchange rate volatility model, the CUSUM (Cumulative Sum) of recursive residuals tests is utilized. The CUSUM of recursive residuals test is depicted graphically in [Figure 1](#) (see appendices).

From [Figure 3](#) it is clear that the CUSUM test does not exceed the bounds of the 5% significance level (depicted by the two straight lines). This means that the model is stable as well as being correctly specified. Thus, there exists a significant and stable relationship among the variables in the model.

Also, from the correlation matrix in [Table 2](#) in the appendices it can be seen that there is a high correlation between inflation and policy rate (0.73), which raises concerns about potential multicollinearity. Therefore, the study went further to check for the existence of multicollinearity in the estimation equations by performing a VIF test. The test results are shown in the appendices. Appendix ([Table 1E](#)) shows a mean VIF of 2.4 which is far below 10. As a rule of thumb, if the mean VIF is below 10 it is interpreted as the absence of multicollinearity, which proves the robustness of the estimation equations in the study (Long & Freese, 2006).

4.6. Robustness check

In order to check for the robustness of the estimated model, the authors used a simple OLS to estimate the same model with the same variables which can be seen in appendix ([Table 1F](#)). The results clearly show that the ARDL estimation technique is superior to the OLS because the F-statistic associated with the OLS is insignificant and is associated with a low Adjusted R-squared, meaning the regression equation explains less than 50% of the variability in the dependent variable.

5. Summary and concluding remarks

The study employed the ARDL Bounds Testing approach to investigate the relationship between exchange rate volatility and Central Bank's policy rate in Ghana. The results revealed that, in the long run, exchange rate volatility is influenced by Central Bank's PR, MS, I, and GSE composite index. Unlike the long-run estimates, results from the short-run estimation show that the exchange rate volatility is significantly determined by its past values and Central Bank's PR. This suggests that changes in the Central Bank's PR in Ghana will impact on exchange rate volatility both in the short run and long runs. Finally, the coefficient of the error correction term indicates convergence towards the long-run equilibrium.

The results from the study have several implications for policy action. First, the positive effects of Bank of Ghana policy rate on exchange rate volatility in the short run and long run add to the call for interest rate control as has been suggested by several studies on interest rates in Ghana. That is, the need to keep interest on borrowing down is no longer a mere call but a substantive one which is necessary to slow exchange rate volatility. Second, given that inflation and money supply influence exchange rate volatility in the long run, it is important for the Central Bank to adopt steps aimed at weighing down inflationary pressures. This is because an increase in money supply will likely cause higher inflation that eventually aggravates depreciation of the value of the local currency.

The conclusions of this research corroborate conclusions drawn in Furman et al. (1998), Ali et al. (2015), and Asari et al. (2011) among others who suggested a positive relation between interest rates and exchange rate volatility. However, this is in sharp contrast with the conclusion reached by Baig and Goldfajn (1999) who found no evidence to suggest that high interest rates impacted unstable exchange rates and therefore question the rationale for raising interest rates to defend exchange rates as supported by the traditional view.

The difference in outcome may largely be attributable to differences in jurisdictions. It is important to note that monetary policy works best where financial markets are efficient and well developed, and market participants are committed to the achievement of overall national

economic goals. Therefore, in imperfect market economies, high interest rates may actually not only discourage investments and slow economic growth but could precipitate financial-sector crisis thereby depreciate the local currency.

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APPENDICES

Figure 2 Evolution of exchange rate volatility in Ghana, 2000 (first quarter) to 2017 (second quarter).

Source: Author's illustration based on data from the Bank of Ghana

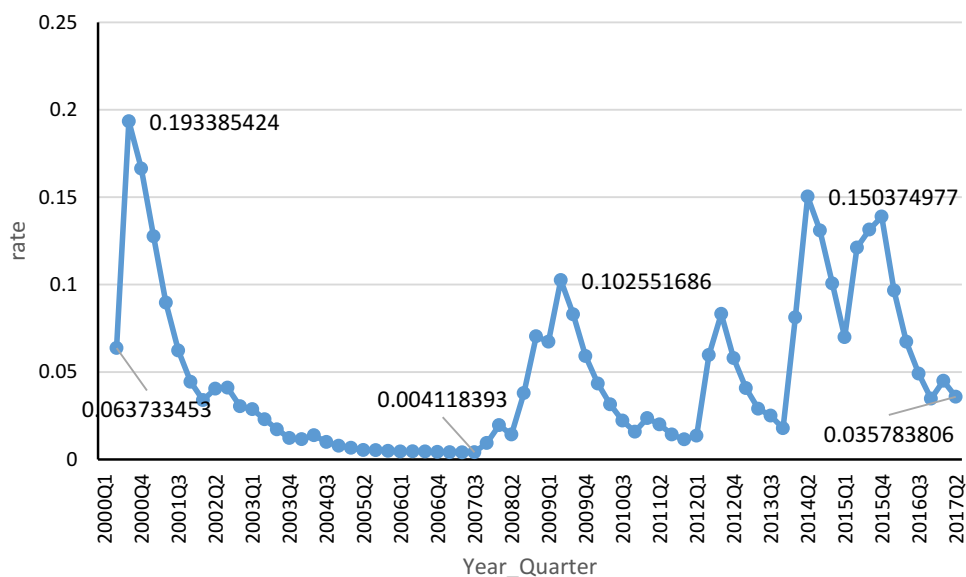


Figure 3. Evolution of Central Bank policy rate in Ghana, 2000 (first quarter) to 2017 (second quarter).

Source: Author's illustration based on data from the Bank of Ghana

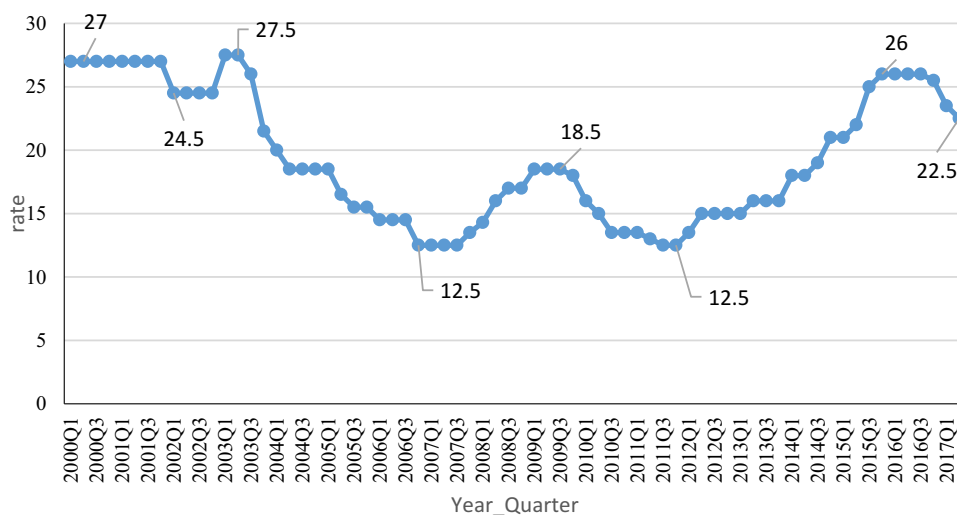


Table 1A. Unrestricted Error Correction Model (UECM)

Included observations: 66 after Adjustments

Standard errors in () & t-statistics in []

	D(Er)
D(Er(-1))	0.393641
	(0.11635)
	[3.38311]
D(Er(-2))	-0.263077
	(0.09346)
	[-2.81497]
C	-0.004573
	(0.00351)
	[-1.30149]
D(IR)	0.002886
	(0.00219)
	[1.31891]
D(MS)	0.056630
	(0.03919)
	[1.44495]
D(I)	0.000418
	-0.0008
	[0.52072]
D(GSE)	-2.78E-06
	(2.2E-06)
	[-1.26491]
R-squared	0.269885
Adj. R-squared	0.195637
F-statistic	3.634873
Log likelihood	170.9486

Source: Author's computation

Table 1B. VAR lag order selection criteria

Endogenous variables: D(Er)						
Exogenous variables: C D(IR) D(MS) D(I) D(GSE)						
Sample: 2000Q1 2017Q2						
Included observations: 62						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	155.5014	NA	0.000456	-4.854884	-4.683341	-4.787532
1	157.4479	3.516149	0.000443	-4.885415	-4.679563	-4.804592
2	162.4211	8.823489*	0.000390	-5.013584	-4.773423*	-4.919291*
3	163.5960	2.046632	0.000388*	-5.019226*	-4.744757	-4.911463
4	163.5996	0.006181	0.000400	-4.987085	-4.678307	-4.865851
5	163.6536	0.090531	0.000413	-4.956568	-4.613482	-4.821863
6	163.9506	0.488669	0.000423	-4.933891	-4.556497	-4.785717
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

Table 1C. Autoregressive distributed lag model

Dependent Variable: D(EXCHANGE_RATE_VOLATILITY)				
Method: Least Squares				
Sample (adjusted): 2001Q1 2017Q2				
Included observations: 66 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.078767	0.035164	-2.239975	0.0296
D(Er(-1))	0.376696	0.115956	3.248613	0.0021
D(Er(-2))	0.019483	0.119789	0.162643	0.8715
D(IR(-1))	0.006211	0.002405	2.582708	0.0128
D(IR(-2))	-3.96E-05	0.002443	-0.016200	0.9871
D(MS(-1))	0.047374	0.037875	1.250789	0.2168
D(MS(-2))	0.070587	0.038317	1.842186	0.0714
D(I(-1))	-0.000887	0.000884	-1.002944	0.3207
D(I(-2))	-0.000639	0.000785	-0.814146	0.4194
D(GSE(-1))	1.47E-06	2.15E-06	0.681672	0.4986
D(GSE(-2))	8.21E-07	2.16E-06	0.379743	0.7057
Er(-1)	-0.392991	0.109908	-3.575645	0.0008
IR(-1)	-0.000913	0.000918	-0.994062	0.3250
MS(-1)	0.008767	0.003255	2.693163	0.0096
I(-1)	0.001702	0.000872	1.951999	0.0566
GSE(-1)	-4.49E-07	1.03E-06	-0.435971	0.6647
R-squared	0.488367	Mean dependent var		-0.001978
Adjusted R-squared	0.334878	S.D. dependent var		0.021404

(Continued)

Table 1C. (Continued)

Dependent Variable: D(EXCHANGE_RATE_VOLATILITY)			
S.E. of regression	0.017456	Akaike info criterion	−5.051008
Sum squared resid	0.015236	Schwarz criterion	−4.520183
Log likelihood	182.6833	Hannan-Quinn criter.	−4.841254
F-statistic	3.181758	Durbin-Watson stat	2.011294
Prob(F-statistic)	0.001065		

Source: Author's computation

Table 1D. Joint significance test of the short run coefficients of policy rate in the exchange rate volatility model for Ghana

Wald Test:			
Equation: Untitled			
Test Statistic	Value	Df	Probability
F-statistic	3.108249	(2, 54)	0.0528
Chi-square	6.216497	2	0.0447
Null Hypothesis: C(4)=C(5)=0			

Table 1E. VIF test for multicollinearity

Variable	VIF	1/VIF
CB Policy Rate	3.5	0.285994
Inflation	3.2	0.312361
Money Supply	1.49	0.671686
GSE Composite Index	1.43	0.699653
Mean VIF	2.4	

Table 1F. OLS regression

Dependent Variable: Exchange rate volatility			
Variables	Coefficients	Standard Deviation	P-value
Intercept	−0.0152	0.0231	0.5138
PR	0.0003	0.0015	0.8292
INF	0.0035	0.0010	0.0007
MS	0.0000	0.0000	0.0001
GSE-CI	−0.0002	0.0001	0.2692
Multiple R		0.6723	
R Square		0.4520	
Adjusted R Square		0.4177	
Standard Error		0.0344	
Observations		69.0000	



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