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The effect of monetary policy and inflation on the exchange rate: A case study of Ghana

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The Ghanaian Cedi has recently experienced persistent depreciation against its major trading partners. This paper investigates the contribution of inflation and monetary policy in this persistent depreciation. The paper makes use of the Autoregressive Distributed Lag (ARDL) and Bounds test of cointegration and the Toda and Yamamoto (1995) Augmented Granger Causality test to determine the long and short-run dynamics of the impact of monetary policy and inflation on exchange rates in Ghana, using data ranging from 1970 to 2017. The paper finds a short-run depreciation effect of contractionary monetary policy on the exchange rate, reflecting the exchange rate puzzle. The long-run results however show an appreciating effect. Inflation is also found to depreciate the currency both in the short and long-run. The causality tests also reveal a bi-directional relationship between the exchange rate and the inflation rate, while a unidirectional causal relationship exists between monetary policy and the exchange rate. The paper recommends that inflation stabilization policies should be prioritized in Ghana, as a means to curb the rising exchange rates. Improvement in terms of trade through export value promotion should also be given the needed attention as this is found to appreciate the currency in the long-run.

Key words: Exchange rate, inflation, money supply, Autoregressive Distributed Lag (ARDL), cointegration, Ghana.

INTRODUCTION

The recent surge in free trade among countries has made the exchange rate one of the most significant macroeconomic variables that are widely studied in the literature. Exchange rates have an effect on the returns to trade among countries as it determines the value of exports and imports. As a result, the exchange rate stabilization has become a major target for governments of most developing countries. Being heavily import-dependent, developing countries have had to face a recurring depreciation of their currencies. This has had a very significant effect on domestic businesses that are mostly dependent on imported raw materials and

intermediate goods. The exchange rate has implications for the rate of economic growth of countries because of the effect it has on the demand for imports and exports.

The demise of the Bretton Woods system in 1973 has seen countries abandon the fixed exchange rate system and adopt floating exchange rate systems. The exchange rate is now determined by the demand and supply of a currency against other currencies. This change has exposed the exchange rate to severe volatility as it is easily affected by factors that affect the demand and supply of a particular currency. The exchange rate is therefore one of the most volatile macroeconomic

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variables today. This has triggered attempts to understand the effect of fluctuations of other macroeconomic variables on the exchange rate. Both country-specific and cross-country studies on factors affecting the exchange rate have been conducted worldwide and these factors have been well documented.

Theories such as the International Fisher's Effect (IFE), purchasing power parity (PPP), and Mundel Fleming models have linked exchange rates to inflation and interest rates (Ebiringa and Anyaogu, 2014). The IFE and PPP theories for instance establish a depreciating effect of high inflation on the local currencies of countries. The IFE states that the future spot exchange rate is determined by the nominal interest rate differential (Sundqvist, 2002). The theory suggests that countries with high-interest rates will have their currencies depreciating with increasing nominal interest rates, compared to their trading partners, reflecting differences in the expected inflation (Ebiringa and Anyaogu, 2014). Countries with high-interest rates have high levels of inflation rates than those with lower interest rates. Hence, the currency depreciates when inflation rates are high. The PPP, attributable to Cassel (1918) also states that the equilibrium rate of exchange between currencies is determined by the quotient between the purchasing power of both currencies. Therefore, when a county's rate of inflation rises compared to its trading partners, it's currency will depreciate and vice versa.

Ghana has experienced a consistent decline in the value of the currency against the major trading currencies. Several measures undertaken by the Bank of Ghana, such as the re-denomination of the currency in 2007 has seen little success. This situation has shifted a lot of attention to examining the factors responsible for the continuous depreciation of the currency. This paper, therefore, seeks to determine if the rising levels of inflation have been particularly responsible for the rising exchange rates. The paper also seeks to test the validity of the exchange rate puzzle for Ghana.

The paper adopts an Autoregressive Distributed Lag (ARDL) and Bounds testing technique to determine the short and long-run dynamics of the relationship between the exchange rate, the inflation, and monetary policy rate in Ghana, using annual time series data ranging from 1970 to 2017. A test of long-run causality will also be done to further establish these relationships. The paper hypothesizes that higher inflation rates and expansionary monetary policy lead to exchange rate depreciation, in line with conventional macroeconomic thinking.

RELEVANT LITERATURE

Theoretical review

The International Fisher's Effect (IFE) otherwise known as Fisher's hypothesis, credited to Irving Fisher establishes a relationship between the differences in nominal interest rates and the spot exchange rates between countries. It suggests that the future spot exchange rate is determined by the nominal interest rate differential (Sundqvist, 2002). It states specifically that, the exchange rate is expected to change in the opposite direction to the interest rate differential. It is an extension of the Fisher effect, which shows that the difference between the nominal interest rate and the real interest rate is the expected inflation. Hence, a higher interest rate differential reflects a higher rate of inflation. Therefore, countries with low-interest rates have a lower inflation rate compared to countries with high-interest rates. High rates of inflation in a country are therefore expected to lead to a depreciation of the currency of the country compared to her trading partners. This theory, therefore, establishes a positive relationship between the exchange rates and the inflation rate.

The Purchasing Power Parity (PPP) also establishes a relationship between the price level and the exchange rates across countries. The theory states that the rate of exchange between the currencies of two countries is determined by the ratio of the purchasing power between the two countries. The theory builds on the Law of One Price (LOP) which asserts that the tradable value of goods across countries will be equal if converted to the same currency (Adrangi et al., 2011). If this is not the case, the exchange rates between these countries will adjust to ensure that the value of the good remains the same across countries. The theory, therefore, attempts to quantify the relationship between exchange rates and inflation by establishing that, exchange rates are caused by differences in the inflation rates across countries (Kara and Nelson, 2002). Therefore, higher inflation rates in one country will lead to the depreciation of its currency. This is due to the fall in the demand for its exports relative to its imports. This adjustment in the exchange rate is expected to continue until the inflation rate is equalized across countries. Though theoretically appealing, the PPP theory has faced several criticisms from empirical studies. Much of the criticisms have been based on its assumptions which are considered unrealistic, its neglect of the effect of the supply and demand of foreign exchange, and the fact that it rarely occurs. Eleftheriou and Mu¨ller-Plantenberg (2018) argue that the prices of traded goods affect the exchange rate through two major means, the price level effect and the interest rate effect. The price level effect reflects the PPP theory. They however argue that the two effects move in opposite directions. Hence the interest rate effect works to neutralize the price level effect, suggesting that market arbitrage is not a conducive condition for the PPP theory. They rather argue that the main force driving the exchange rate is the currency market pressure.

The interest rate parity theory has mostly been used to explain the relationship between interest rates and exchange rates. The theorem links the forward exchange

rate to the market interest rate differential (Aliber, 1973). In other words, the interest rate charge reflects the exchange value of a currency with other currencies (Ebiringa and Anyaogu, 2014). Therefore, lower interest rates are associated with a lower exchange value of the domestic currency (depreciation) and higher interest rates imply higher exchange value (appreciation) of the domestic currency. This assertion is in line with traditional macroeconomic thinking that higher interest rates or contractionary monetary policy tend to appreciate the domestic currency while lower interest rates or expansionary monetary policy depreciates the currency. Hnatkovska et al. (2016) however find that contrary to conventional thinking, contractionary monetary policies lead to depreciation of the currencies of developing countries, a phenomenon they call the exchange rate puzzle. This paper will attempt to determine if the exchange rate puzzle exists for Ghana, in the short and long run.

Empirical review

Expansionary monetary policy is generally known to result in the depreciation of a country's currency relative to its trading partners, while contractionary monetary policy leads to currency appreciation. High-interest rates lead to a fall in output, relative domestic prices, and demand, which includes demand for imports. Lower domestic prices imply higher export demand which increases the demand of the local currency relative to other currencies, resulting in domestic currency appreciation. Several empirical studies have established this fact. Zettelmeyer (2004) studies this situation for Austria, Canada, and New Zealand. He finds that on average, a 100 basis point contractionary shock appreciates the currency by 2 to 3%. Using intra-day data, Kearns et al. (2006) also study the impact of monetary policy on the exchange rate in the US economy. They find that a 25 basis point monetary policy tightening will cause the dollar to appreciate by 0.35%. They further argue that the effect depends on how the tightening affects the expectations of future monetary policy. If expectations are revised by the full amount of the change in interest rates, the impact on exchange rates is higher. Khordehfrosh and Tehranchian (2015) also found similar results for selected developing economies using a GMM approach. They found that expansionary monetary policy depreciates the currencies of developing countries while contractionary monetary policy appreciates the currency.

Hnatkovska et al. (2016) however discover an exchange rate puzzle. They found that unlike developed countries, contractionary monetary policy depreciates the currencies of developing countries. They identify three major channels through which monetary policy affects the exchange rate, namely: the liquidity demand effect, the

fiscal effect, and the output effect. The liquidity demand effect leads to currency appreciation in response to contractionary monetary policy while the output and fiscal effects lead to currency depreciation. They argue that for developing countries, the effect of the output and fiscal effects outweigh that of the liquidity effect, resulting in currency depreciation. They call this phenomenon the exchange rate puzzle. De Leo et al. (2017) however argue that the source of the puzzle was more empirical than theoretical. They argue that the puzzle emerged because of the failure of Hnatkovska et al. (2016) to account for responses of developing economies to business cycle shocks in the US economy. They argue that if these shocks are accounted for, the puzzle disappears. They see the exchange rate puzzle as a consequence of model misspecification.

This controversy calls for further analysis of this relationship, especially on a country basis. In this spirit, this paper will attempt to determine the short and long-run impact of monetary policy on the exchange rate, for the Ghanaian economy.

Several country-specific studies have established a significant relationship between inflation, monetary policy, and the exchange rate. The nature of the relationships is however varied across studies. Ali et al. (2015) study the impact of interest rates, inflation, and money supply on the exchange rate volatility in Pakistan using a Vector Error Correction Model (VECM), for monthly data from July-2000 to June-2009. They found that contrary to conventional thinking, higher inflation leads to the appreciation of the currency of Pakistan. Higher interest rates were also found to depreciate the currency. This goes against earlier findings of Bashir and Luqman (2014) for Pakistan. They found that high inflation depreciates the currency, using time series data from 1972 to 2013. Abbas et al. (2012) also explore the relationship between interest rates, inflation, and the exchange rate for 10 African countries for 15 years. They found positive but insignificant relationships between inflation, interest rates, and the exchange rate, using OLS estimations. Amin et al. (2018) found similar insignificant results for Bangladesh, using VECM on time series data from 1980 to 2015. Ebiringa and Anyaogu (2014) use ARDL cointegration analysis to explore the exchange rate, inflation, and interest rate relationships for Nigeria using time series data from 1971 to 2010. They found a positive relationship between inflation and the exchange rate, and a negative relationship between interest rates and the exchange rate.

Nucu (2011) also study the relationship between exchange rate and key macroeconomic variables for Romania. The results establish a direct relationship between the exchange rate, inflation, and interest rate.

The review reveals the varied nature of the relationship between inflation, monetary policy, and the exchange rates across countries. This makes it relevant to undertake a study for Ghana to understand the dynamics
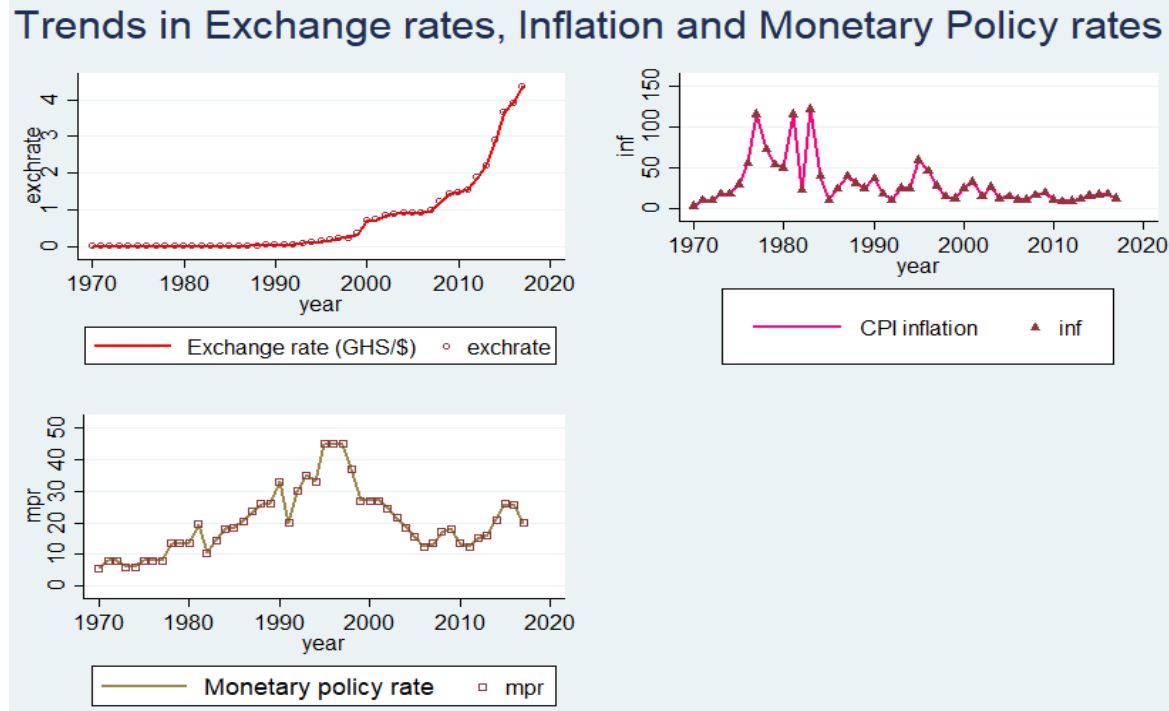
Trends in Exchange rates, Inflation and Monetary Policy rates

Figure 1. Trends in exchange rate, inflation, and monetary policy.
Source: Author's generation using data from WDI BOG.

of the effect of these variables on the exchange rate. Previous studies in this area have concentrated on the effect of exchange rates on inflation. Mahamadu and Phillip (2003) for instance, study the relationship between inflation and exchange rate for Ghana. Their empirical results show that inflation is positively related to the money supply and exchange rate. Nchor and Darkwah (2015) also study the effect of exchange rates on inflation for the Ghanaian economy, using data from 1991 to 2013. They found that in the short run, depreciation of the Ghana Cedi increases inflation. Adu et al. (2015) also found evidence of an exchange rate pass-through effect for Ghana, using quarterly data from 1980 to 2014. They further found that positive supply-side shocks appreciate the exchange rate while demand-side shocks depreciate the exchange rate.

Other macroeconomic variables such as GDP growth rates, external debts, and trade openness have been identified by other authors as significantly affecting the exchange rate. This paper will control for some of these variables.

Evolution of the Ghana cedi and exchange rates in Ghana

After independence in 1957, Ghana dropped the British West African pound and adopted the Ghanaian pound between 1958 to 1965. In 1965, the government adopted the decimal system and hence changed the currency to the Cedi, which after undergoing several revisions through the years was renamed the Ghana cedi in 2007, after a re-denomination exercise which was meant to help manage the rapid depreciation of the currency.

Ghana's story with the exchange rate started with the abandonment of the British West African pound. Ghana used a fixed exchange rate regime from 1957 to 1982 in line with the Bretton Wood agreement. The cedi was fixed to the British pound up to 1966 and the American dollar up to 1982 by law. The economic liberalization of 1983, following the Economic Recovery Program and the subsequent Structural Adjustment Program, saw a slow movement of the exchange rate till 1991 when the inter-bank exchange rate system was adopted. Currently, Ghana runs a managed float system. The exchange rate is determined by the forces of demand and supply but with some level of intervention by the Bank of Ghana.

Some major events in the exchange rate history include several devaluation episodes from 1983 until 1991 when the inter-bank system was adopted. Persistent inflation significantly eroded the value of the Cedi until 2007 when the government decided to re-denominate the currency and the name was changed to the Ghana Cedi. This has however not helped much as the currency continues to depreciate significantly against the major trading currencies in the world. Figure 1 shows the trends in exchange rates, policy rates, and inflation from 1970 to 2017.

METHODOLOGY

Data and variable description

The data sets for the estimations are retrieved from the 2018 World Bank Development Indicators data set for Ghana and from the Bank of Ghana database. The period ranges from 1970 to 2017. This period was chosen based on data availability. The dependent variable is the exchange rate, represented by the end of the period exchange rate (Local currency per dollar). By this definition, a high value of the exchange rate implies a depreciation of the local currency while a lower value implies an appreciation. The independent variables of interest include the consumer price index which proxies for inflation and the monetary policy rate and money supply which are the tools of monetary policy. A broad measure of money is taken here. Specifically, the paper uses M2+ which is the highest monetary aggregate used by the Bank of Ghana. It is the sum of M2 and foreign currency deposits. M2+ as a percentage of GDP is used in this study. Control variables include the GDP growth rate, government consumption expenditure as a percentage of GDP, terms of trade, which is proxied by the net barter terms of trade index, and debt service on external debt as a percentage of GDP. Consumer price index, the monetary policy rate, and the money supply are obtained from the bank of Ghana database, while the rest of the variables are obtained from the 2018 Word Development Indicators database.

By way of prior expectations, inflation is expected to have a positive relationship with the exchange rate as the conventional economic theory stipulates. The monetary policy rate is expected to have a negative effect on the exchange while the money supply is expected to have a positive effect. GDP growth rate and the terms of trade index are expected to have a negative effect on the exchange rate, while government expenditure and debt servicing are expected to have a positive effect.

Estimation technique

To determine the long and short-run effects of monetary policy and inflation on the exchange rate, the paper uses the ARDL model and Bounds testing of cointegration, espoused by Pesaran et al. (2001). The advantage of this technique is that it works with a combination of I(0) and I(1) integrated processes, unlike the Vector Error Correction which requires that all the series be I(1). Hence the long-run relationships can be accurately estimated irrespective of the order of integration, as long as no series is I(2). Also, since the ARDL model ensures that each underlying variable stands as a single equation, the problem of endogeneity is managed well (Nkoro and Uko, 2016). However, before the ARDL model can be used, preliminary tests such as stationarity need to be conducted to ensure that no variable is I(2), and the determination of the appropriate number of lags required for the model. The bounds test of cointegration then has to be conducted to determine the existence of long-run relationships. The error correction model will then be estimated to determine the short-run dynamics of the model. For the results to be valid, the model must pass diagnostic tests of heteroscedasticity, autocorrelation, and model stability.

The general form of the model is specified as:

$$exch = f(mpr, cpi, gdp, tot, gxp, dse, ms) \quad (1)$$

The specific form of the model is written as:

$$lnexch = \beta_0 + \beta_1 lnmpi + \beta_2 lncpi + \beta_3 gdpg + \beta_4 lntot + \beta_5 lngxp + \beta_6 lndse + \beta_7 lnms + \varepsilon_t \quad (2)$$

where $lnexch$ is the log of the exchange rate, $lnmpr$ is the log of the

monetary policy rate, $lncpi$ is the log of CPI, $gdpg$ is GDP growth rate, $lntot$ is the log of terms of trade, $lngxp$ is the log of government consumption expenditure (% of GDP), $lndse$ is the log of debt service on external debt (% of GDP) and $lnms$ is the log of M2+ as a percentage of GDP. $\beta 0$ is the intercept and β_1, β_2, ..., β_7 are the respective coefficients. ct is the random error term.

Test of stationarity

Nkoro and Uko (2016) define a non-stationary series as a stochastic process that contains unit roots or structural breaks. A time series is non-stationary if it has a time-varying mean and variance (Gujarati and Porter, 2009). To run an ARDL model, the order of integration of the various series used is very important. As stated earlier, no variable should be an I(2) series. For this paper, the Augmented Dickey-Fuller test is used to determine the stationarity of the variables. The ADF test is a test of the presence of unit root in a series. This test is better than the standard Dickey-Fuller test because it is still valid even if the errors are correlated. The general ADF test model is stated as:

$$\Delta Y_t = \gamma_0 + \rho_1 Y_{t-1} + \sum_{i=1}^{n} \gamma_1 \Delta Y_{t-i} + \mu_i \quad (3)$$

where Δ is the difference operator. The null hypothesis of the test is that the series contains a unit root process. This is the same as saying $\rho_1 = 0$. Failure to reject the null hypothesis means the series is non-stationary. This test will be conducted on all the variables in the model. The Phillip-Perron test will be used as a further check on stationarity.

ARDL bounds test of cointegration

Cointegration tests are necessary for the establishment of long-run relationships between variables. This idea was formalized by Granger (1981) and Engle and Granger (1987). The presence of cointegration provides the statistical basis on which an error correction model can be run. The error correction model provides both the short and long-run dynamics of the relationships between the variables. The ARDL bounds test of cointegration, attributable to Pesaran et al. (2001) will be used in this paper. This technique is used because of several advantages it has over other conventional Johanson cointegration tests. First, it does not require any unit root pre-testing and also allows for various variables to have different optimal lags (Ozturk and Acaravci, 2010). The ARDL model is specified as:

$$\Delta lnexch_t = \alpha + \sum_{j=1}^{n} b_j \Delta lnexch_{t-j} + \sum_{j=1}^{n} c_{ij} \Delta X_{(t-j)} + \gamma_1 lnexch_{t-1} + \beta_i X_{t-1} + \mu_t \quad (4)$$

$i, t, j = 1, 2, \ldots \ldots, n$; i = coefficient number; j= lag number; and t= time period. Where X is the vector that represents the set of independent variables listed in Equation 2. The short-run parameters are represented by c_{ij} while the long-run parameters are represented by β_i and Δ is the difference parameter.

The bounds test of cointegration conducts a joint significance test of all the long-run parameters. The null hypothesis, therefore, is that there exist no long-run relationships. Pesaran et al. (2001) provide

a set of critical values for I(0) and I(1) variables. The I(0) critical bounds assume that all the variables are I(0) or in other words, there is no cointegration and the I(1) critical bounds assume that all the variables are I(1), suggesting the presence of cointegration. The updated test computes the critical values and the p-values according to Kripfganz and Schneider (2018). The null hypothesis is rejected if the F-statistic is more extreme than the critical values for the I(1) bounds.

Error correction model

If the bounds test establishes the existence of cointegration in the model, the ARDL model is re-parameterized into an error correction model that espouses the long-run and short-run relationships. Equations 5 and 6 show the long-run and short-run ECM equations respectively.

$$lnexch_t = \alpha_0 + \gamma_1 lnexch_{t-1} + X_{t-1}\beta + \mu_t \quad (5)$$

$$\Delta lnexch_t = \sum_{j=1}^{n} b_j \Delta lnexch_{t-j} + \sum_{j=1}^{n} c_{ij}\Delta X_{(t-j)} + \varphi ECT_{t-1} + \epsilon_t \quad (6)$$

The error correction term ECT_{t-1} is the error correction term. Its coefficient (φ) represents how much of deviations away from the long-run results are corrected each period. The coefficient is expected to be negative and statistically significant.

For the results to be valid, the model must be free from heteroscedasticity and autocorrelation. The models must also be dynamically stable. A heteroscedasticity test will be conducted using White's test. The Breusch-Godfrey test will also be used to test for autocorrelation. The CUSUM and CUSUM squared graphs will be used to determine if the model is dynamically stable.

Causality tests

The paper also seeks to determine the direction of causality between the exchange rate, inflation, and the monetary policy variables used in the model. This follows from the findings from the literature. Most authors for instance have focused on the impact of the exchange rate on inflation rather than the direction of causality taken by this paper. The goal here will be to determine if such long-run reverse causation between these variables exist in the Ghanaian economy.

The paper will resort to the approach of Toda and Yamamoto (1995) in estimating long-run causality between time series variables. It is noted generally that the use of conventional Granger (1969) causality tests among cointegrated series may end up in spurious results (Aziz et al., 2000). Toda and Yamamoto (1995) argue that the F-statistic of the Granger causality test may not be valid since its distribution is not standard when the series are cointegrated. The Toda and Yamamoto (1995) test is applied to level VARS irrespective of whether they are cointegrated or not. The test procedure involves the estimation of an augmented VAR $(p + d)$ model. Where p is the optimal lag length for the original VAR and d is the maximum order of integration of the variables. The test involves two basic stages. The first stage involves the determination of the maximum order of integration d and the optimal lag length of the VAR. For this paper, the Akaike Information Criteria (AIC) is used to determine the optimal lag length. The second stage involves the estimation of the VAR $(p + d)$ system and conducting the relevant tests of causality.

Concentrating on only the main variables of interest in this paper, the Toda and Yamamoto (1995) test equations, in line with Seabra et al. (2005) are presented as:

$$lnexch = \sum_{i=1}^{k+d} \alpha_{1i} lnexch_{t-1} + \sum_{i=1}^{k+d} \beta_{1i} lncpi_{t-1} + \sum_{i=1}^{k+d} \phi_{1i} lnmpr_{t-1} + \sum_{i=1}^{k+d} \varphi_{1i} lnms_{t-1} + u_{1i} \quad (7)$$

$$lncpi = \sum_{i=1}^{k+d} \beta_{1i} lncpi_{t-1} + \sum_{i=1}^{k+d} \alpha_{1i} lnexch_{t-1} + \sum_{i=1}^{k+d} \phi_{1i} lnmpr_{t-1} + \sum_{i=1}^{k+d} \varphi_{1i} lnms_{t-1} + u_{1i} \quad (8)$$

$$lnmpr = \sum_{i=1}^{k+d} \phi_{1i} lnmpr_{t-1} + \sum_{i=1}^{k+d} \alpha_{1i} lnexch_{t-1} \sum_{i=1}^{k+d} \beta_{1i} lncpi_{t-1} + \sum_{i=1}^{k+d} \varphi_{1i} lnms_{t-1} + u_{1i} \quad (9)$$

$$lnms = \sum_{i=1}^{k+d} \varphi_{1i} lnms_{t-1} + \sum_{i=1}^{k+d} \alpha_{1i} lnexch_{t-1} \sum_{i=1}^{k+d} \beta_{1i} lncpi_{t-1} + \sum_{i=1}^{k+d} \phi_{1i} lnmpr_{t-1} + u_{1i} \quad (10)$$

Out of these estimations, the various direction of causality can be tested using a Wald test. The test and the various null hypothesis are presented in Table 6 in the analysis. The null hypothesis is rejected when the p-value of the test statistic is less than the chosen level of significance.

ESTIMATION RESULTS AND DISCUSSION

Summary statistics

Summary statistics of the variables used in the model are presented in Table 1. Exchange rates had a mean value of 0.687 and a standard deviation of 1.093. Monetary policy rate averaged 20.198% with a variance of 10.307. Money supply, proxied by M2+ as a percentage of GDP averaged about 23.433% over the period. The CPI has averaged 37.18 over the entire period with a variance of 59.257. It can be inferred that that inflation has been very volatile over the period.

The exchange rate has a negative correlation with the monetary policy rate as expected. It suggests that high policy rates go with currency appreciation and lower policy rates go with currency depreciation. The exchange rate also has a positive correlation with the money supply. These correlations reflect the conventional idea that expansionary monetary policy goes with currency depreciation while a contractionary monetary policy goes with currency appreciation. The correlation matrix generally shows low levels of correlations. Exceptions are the correlation between exchange rate and CPI which is expected. Most of the goods that are captured in the CPI basket are imported and hence are affected by exchange rate fluctuations. Since the exchange rate is the dependent variable, this does not pose a problem in terms of multicollinearity. Debt service and monetary

Table 1. Descriptive statistics and correlation matrix.

Variable	Mean	Std Dev	Min	Max	1	2	3	4	5	6	7	8
Exchange rate(GHS/$)	0.687	1.093	0.001	4.351	1.000							
Monetary policy rate	20.198	10.309	5.5	45	-0.081	1.000						
Consumer Price index	37.818	59.279	0.002	232.257	0.99	-0.1260	1.000					
M2+ (% of GDP)	23.422	5.707	12.577	36.77	0.339	-0.247	0.348	1.000				
Terms of Trade index	145.097	39.088	89.216	215	0.300	-0.666	0.337	0.322	1.000			
Gov't Con. Exp. (% of GDP)	10.633	2.077	5.861	15.308	-0.154	0.229	-0.159	0.322	-0.092	1.000		
Debt serv. on External debt (% of GDP)	3.908	2.570	0.890	10.498	-0.285	0.728	0.-0.348	-0.368	-0.647	0.159	1.000	
GDP growth rate	1.568	4.688	-14.455	12.424	0.477	0.168	0.512	0.174	-0.102	0.112	-0.021	1.000

Table 2. Test of Stationarity.

Variable	Augmented Dickey-Fuller		Phillip Perron		Order
	Levels	First Difference	Levels	First Difference	
lnexch	-0.709	-4.764***	-0.911	-6.221***	I(1)
lnmpr	-1.810	-4.702***	-2.305	-7.899***	I(1)
lncpi	-2.885*	-	-3.046**	-	I(0)
lntot	-1.515	-5.886***	-1.669	-8.257***	I(1)
gdpgrwth	-3.398**	-	-4.176***	-	I(0)
lndse	-1.674	-4.656***	-1.718	-6.762***	I(1)
lngxp	-3.071**	-	-3.45**	-	I(0)
lnms	-2.029	-4.479***	-1.987	-6.07**	I(1)

***Significance at 5%; **Significance at 1%.

policy rate also record a correlation of 0.728 which is relatively high.

Stationarity test results

As stated earlier, the stationarity test of the various variables used in the model is done using the Augmented Dickey-Fuller test. The Phillip-Perron test is also used to further confirm the results of the ADF test. The results are presented in Table 2. Log of exchange rates, the log of the monetary policy rate, log of terms of trade, log of debt servicing, and log of money supply are stationary at first difference while log of the consumer price index, log of government expenditure and GDP growth rate are stationary at levels.

The mix of I(0) and I(1) integration orders of the variables necessitate the use of the ARDL model.

Bounds test of cointegration results

Before the ARDL Bounds test of cointegration is run, it is necessary to determine the optimal number of lags that are necessary for the model. The Akaike Information Criterion and the Hannan and Quinn Information Criterion (HQIC) suggest optimal lags of 3 while the Schwarz's Bayesian information criterion suggests 1 lag. I choose a maximum lag order of 2 for this paper. The optimal

Table 3. Pesaran et al. (2001) bounds test results.

Critical value	10%		5%		1%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F	2.223	3.644	2.681	4.295	3.781	5.870
t	-2.446	-4.067	-2.821	-4.534	-3.589	-5.493

Test results	Values	P-values	
		I(0)	I(1)
F	8.549	0.000	0.001
t	-4.217	0.002	0.081

lag selection results are presented in Table 3. The Bounds test of cointegration results is conducted on the ARDL model of order ARDL(2,1,1,1,1,1,1). The results are presented in Table 3. From the table, the F-statistic of 8.549 is more extreme than the critical I(1) bounds. This implies that there is cointegration among the variables. In other words, there exist long-run relationships among the variables. This then allows for the estimation of the error correction model which provides the long-run results as well as the short-run adjustments.

Long-run and error correction results

The results for the Long-run and the short-run error correction model are provided in Table 4. From the table, the error correction term is -0.529 and statistically significant at 1%. This implies that 52.9% of any disequilibrium in exchange rates in the current period is corrected in the next period. The model reflects a slow rate of convergence to the long-run equilibrium. The short-run results show that the monetary policy rate, the terms of trade index, debt-servicing, money supply, and GDP growth rate have a significant effect on the exchange rate. The monetary policy rate has a positive short-run effect on the exchange rate. Other variables held constant, a 1% increase in the monetary policy rate increases the exchange rate by 0.805%. This result confirms the existence of an exchange rate puzzle in the short-run. Contractionary monetary policy, depicted by higher policy rates, result in the depreciation of the currency[1], ceteris paribus.

This is further confirmed by the short-run coefficient of the money supply. The money supply is found to have a negative effect on exchange rates in the short run. A 1% decrease in the money supply results in a 0.653% increase in the exchange rate. This implies that ceteris

paribus, a contractionary monetary policy or a reduction in money supply lead to a depreciation of the currency.

The long-run results however show a negative relationship between monetary policy and exchange rate as expected conventionally. A 1% increase in the policy rate reduces the exchange rate by 0.825% in the long-run ceteris paribus. This implies that contractionary monetary policy in the long-run will appreciate the currency while an expansionary monetary policy will depreciate the currency. This result is further supported by the long-run coefficient of the money supply. The money supply shows a positive relationship with the exchange rate in the long run. A 1% increase in the money supply results in a 1.288% depreciation of the Ghana cedi. This is significant at 5%. This implies that irrespective of the monetary policy tool adopted, the long-run effect of expansionary monetary policy is a depreciation of the local currency.

Inflation, proxied by the log of CPI is found to have a negative effect on the exchange rate in the short-run and a positive effect in the and long run. The short-run result is however statistically insignificant. The long-run results show that a 1% increase in the price level will depreciate the cedi by 0.988%. This implies that in the short-run, higher inflation may not have a significant effect on the exchange rate. However, in the long-run, higher inflation depreciates the currency. Terms of trade are found to have a very strong effect on the exchange rate both in the short and long-run. The short-run effect is positive while the long-run effect is negative. The negative sign of the long-run coefficient is as expected. A 1% increase in the terms of trade index reduces the exchange rate by 2.285%. Higher terms of trade imply a rise in the value of exports. This implies that export demand is high and hence, the local currency appreciates. The coefficient is significant at 1%. The positive sign of the short-run coefficient is against prior expectations. The short-run results show that a 1% increase in the terms of trade depreciates the cedi by 1.475%. This relationship, though unexpected is possible. This is especially true when the factors driving the rise in export value are not related to the demand for exports, but due to other factors such as

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[1]Per the definition of the exchange rate, a higher value implies a depreciation of the local currency

Table 4. Long-run and error correction results.

Variable	(1) ADJ	(2) LR	(3) SR
LD.lnexch	-	-	-0.0584 (0.109)
D.lnmpr	-	-	0.805*** (0.222)
D.lncpi	-	-	-0.349 (0.509)
D.lntot	-	-	1.475*** (0.343)
D.lngxp	-	-	0.128 (0.277)
D.lndse	-	-	0.289** (0.132)
D.lnms	-	-	-0.653* (0.380)
D.gdpg	-	-	0.023* (0.0122)
lnmpr	-	-0.825* (0.464)	-
lncpi	-	0.988*** (0.0702)	-
lntot	-	-2.285*** (0.726)	-
lngxp	-	-1.211 (0.783)	-
lndse	-	0.616** (0.232)	-
lnms	-	1.288** (0.524)	-
gdpg	-	0.069* (0.0346)	-
L.lnexch	-0.529*** (0.125)	-	-
Constant	-	-	4.117** (1.996)
Observations	42	42	42
R-squared	0.827	0.827	0.827

***p<0.01, **p<0.05, *p<0.1; Standard errors in parentheses.

Table 5. Diagnostic tests.

Test	Hypothesis	Test-statistic	p-value	Decision
Heteroscedasticity	Ho: Homoskedasticity	Chisq = 42.000	0.427	Homoskedasticity
Autocorrelation	Ho: No serial correlation	Chisq=2.258	0.132	No serial correlation
Model Stability	Ho: Model is dynamically stable	CUSUM and CUSUMSQ graphs lie with the 5% critical bounds		

the higher cost of production. In cases like these, higher terms of trade will reflect higher prices rather than a rise in export demand. This scenario has a tendency to depreciate the currency.

Government spending was found to have a negative effect on exchange rates in the long-run, while the short-run effect is positive. Both coefficients are however not statistically significant. Debt service on external debt also has a depreciating effect on the exchange rate in the long- run and short-run as expected. In the short-run, a 1% increase in debt-servicing depreciates the cedi by 0.289%. The long-run effect is stronger with a 0.616% depreciation, ceteris paribus[2].

They are both significant at 5%. GDP growth rate is also found to have a positive effect on the exchange rate in both the short and long-run. A 1% point increase in the GDP growth rate depreciates the cedi by about 2.33% in

the short-run and by 6.86% in the long-run. Both coefficients are significant at the 10% level. This finding is against prior expectations.

Diagnostic tests results

To ascertain the validity of the results, tests for autocorrelation, heteroskedasticity, and stability must be conducted. The White's test of heteroskedasticity and the Breush-Godfrey test of autocorrelation is used. The stability test is conducted using the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) attributable to Brown et al. (1975). These tests are general tests of structural breaks and do not require a prior determination of where the structural breaks occur (Ozturk and Acaravci, 2010).

The results and conclusions are presented in Table 5. Figure 2 presents the CUSUM and CUSUM square graphs. The results show that the error variance is homoscedastic, the errors are not autocorrelated

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[2]Higher debt service implies higher demand for foreign currency which results in the depreciation of the local currency

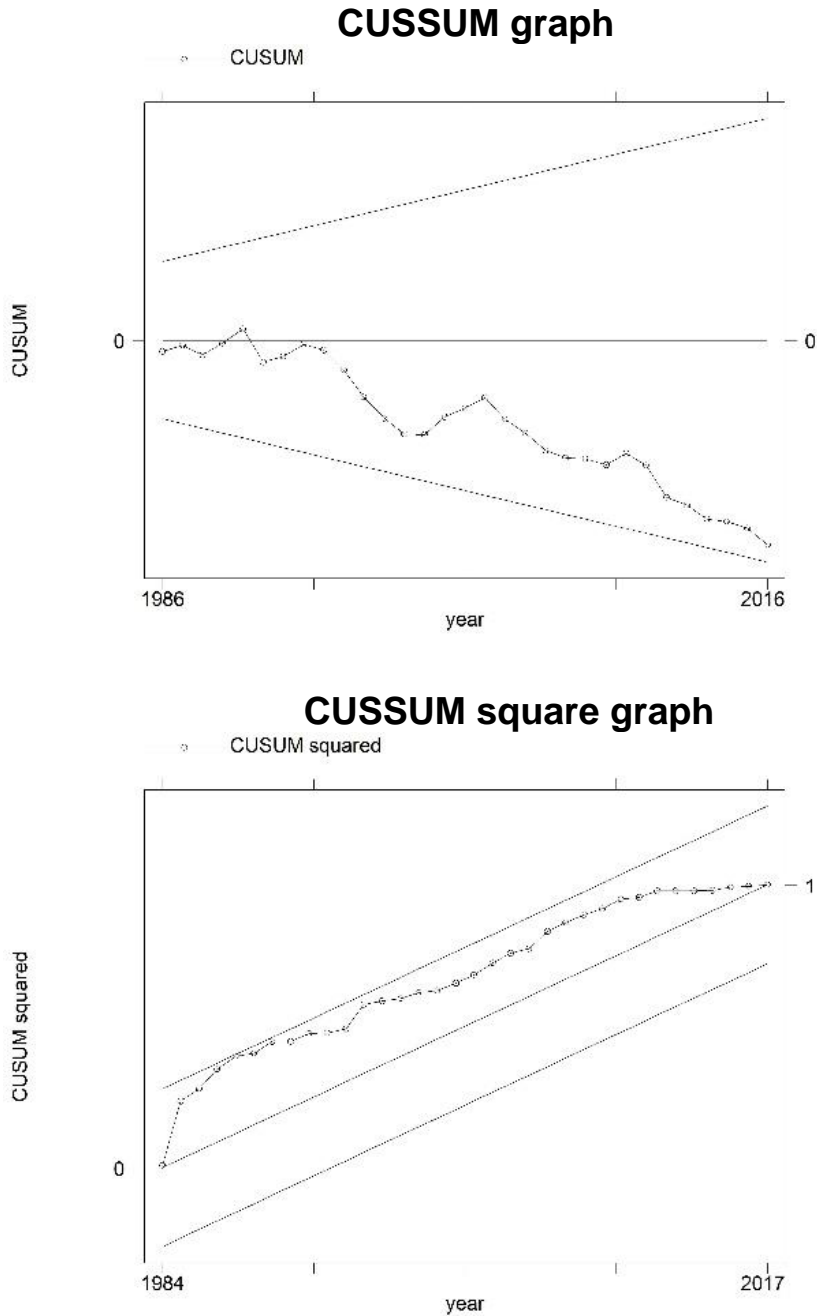## CUSSUM graph

CUSSUM square graph

Figure 2. CUSSUM Graphs: test for stability

and the model is dynamically stable.

Causality test results

To further determine the validity of the long-run model, a levels causality test is conducted between the main variables of interest in the model. The Toda and Yamamoto (1995) procedure is used in this paper. The optimal lag length for the VAR, *p* according to the Akaike Information Criterion (AIC), Hannan and Quinn Information Criterion (HQIC) and Schwartz-Bayes Information Criterion (SBIC) is one. The variables *lnexch, lnmpr,* and *lnm*2*p* are all I(1) while *lncpi* is I(0). Therefore, the maximum order of integration, *d* is 1. A VAR(2) is therefore run. The test results are presented in Table 6.

The results show that both the money supply, the policy rate, and inflation Granger cause the exchange rate, as

Table 6. Toda and Yamamoto (1995) Augmented Granger causality test.

Null hypothesis	Wald-test statistic	P-value
Lncpi does not Granger cause Lnexch	28.450***	0.000
Lnexch does not Granger cause Lncpi	19.130***	0.000
Lnmpr does not Granger cause Lnexch	13.630***	0.001
Lnexch does not Granger cause Lnmpr	3.730	0.155
Lnms does not Granger cause Lnexch	6.010*	0.074
Lnexch does not Granger cause Lnms	3.490	0.322
Lncpi does not Granger cause lnmpr	0.630	0.730
Lnmpr does not Granger cause Lncpi	9.660***	0.008
Lnms does not Granger cause Lncpi	15.650***	0.000
Lncpi does not Granger cause Lnms	11.180**	0.004
Lnmpr does not Granger cause Lnms	3.880	0.144
Lnms does not Granger cause Lnmpr	1.320	0.517

***Significance at 1%; **significance at 5%; *significance 10%.

expected. However, there is bi-directional causality between exchange rate and CPI. Several studies have focused on the effect of exchange rate on inflation and have found that higher exchange rates lead to higher inflation. Monfared and Akın (2017) and Osabuohien et al. (2018) found this positive effect for Iran and Nigeria, respectively. Much care must, therefore, be taken in exploiting the relationship between these two variables.

The monetary policy rate is found to Granger cause inflation. There however appears to be a bi-directional relationship between money supply and inflation. The money supply is expected to Granger cause inflation. However, CPI is not expected to Granger cause money supply. The finding of a bi-directional relationship is therefore unexpected and presents an empirical relationship that can be further explored. There appears to be no causality between money supply and the monetary policy rate. As required for the validity of the results, the VAR is free off autocorrelation.

Conclusions

The recent persistent depreciation of the Ghana cedi has stirred up a discussion on the factors responsible for this phenomenon. Popular among the culprits have been inflation and monetary policy. The study, therefore, centered on the impact of inflation and monetary policy on the exchange rate. Additionally, this study sought to determine the direction of causality between inflation, exchange rates, and monetary policy. The main goal is to understand the dynamics of the relationship between these variables as a basis for policy formulation and implementation. A data set covering the period 1970 to 2017, compiled from the WDI database and the Bank of Ghana database was used. The study used the end-of-period exchange rate as the dependent variable. The

consumer price index (CPI) was used as a measure of inflation. The monetary policy rate and the money supply (broadly defined) as a percentage of GDP, were the main monetary policy tools used. Other variables such as GDP growth, terms of trade, government expenditure, and debt servicing were controlled for. The paper adopted an ARDL model and Bounds test of cointegration to explore the long-run and short-run dynamics of the relationships. The augmented Granger causality test by Toda and Yamamoto (1995) was used to perform a long-run causality test.

The results established a long-run depreciating effect of contractionary monetary policy on the local currency, irrespective of the tool of monetary policy used. Inflation is also found to depreciate the currency in the long-run as expected. Terms of trade and government expenditure were found to have an appreciating effect on the currency while the GDP growth rate depreciates the currency in the long-run.

The error correction term also showed a very high rate of adjustment towards the long-run equilibrium. The short-run model reveals that the lag-value of exchange rates has a positive and significant effect on the exchange rate. The results also showed a positive short-run relationship between the policy rate and the exchange rate. This result is against prior expectations and reflects the presence of an exchange rate puzzle in the short-run. Terms of trade are also found to have a short-run positive effect on the exchange rate.

The causality test results confirm that inflation and monetary policy indeed affect the exchange rate. It also reveals bi-directional relationships between inflation and exchange rates. Similar bi-directional relationships were found between inflation and money supply.

The results lead to the conclusion that rising inflation contributes to the depreciation of the local currency in Ghana. Both the long and short-run effects are

consistent, although the latter was not statistically significant. It can also be inferred that contractionary monetary policy appreciates the currency in the long-run. The short-run effect was however the opposite. Contractionary monetary policy tends to depreciate the currency in the short-run. The exchange rate puzzle espoused by Hnatkovska et al. (2016) is confirmed to exist in Ghana in the short-run.

The implication of this is that the bank of Ghana should act more carefully in attempting to use monetary policy to stabilize the exchange rate in the short-run.

POLICY RECOMMENDATIONS

Based on the findings in this paper the following recommendations were made:

(1) Inflation stabilization should be given more attention in an attempt to stabilize the exchange rate. Measures put in place to stabilize the inflation rate will contribute to stabilizing the exchange rates. The discovery of a bi-directional relationship between these two variables also implies that more research should be conducted into the dynamics of the relationship between these variables to better inform policymaking.
(2) Contractionary monetary policy is also found to depreciate the local currency in the short- run. The use of monetary policy as a tool to stabilize the exchange rate should, therefore, be done with caution.
(3) Terms of trade were found to have the strongest impact on exchange rates both in the short and long run. Therefore, efforts should be made to improve the value of Ghana's exports. This will help stabilize the exchange rates.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

Abbas Q, Iqbal J, Ayaz L (2012). Relationship between GDP, inflation, and real interest rate with exchange rate fluctuation of African countries. International Journal of Academic Research in Accounting, Finance and Management Sciences 2(3):132-141.

Adrangi B, Allender ME, Raffiee K (2011). Exchange rates and inflation rates: Exploring nonlinear relationships. Review of Economics and Finance 1(2):1-16.

Adu G, Karimu A, Mensah JT (2015). An empirical analysis of exchange rate dynamics and pass-through effects on domestic prices in Ghana. International growth center working paper.

Ali TM, Mahmood MT, Bashir T (2015). Impact of interest rate, inflation, and money supply on exchange rate volatility in Pakistan. World Applied Sciences Journal 33(4):620-630.

Aliber RZ (1973). The interest rate parity theorem: A reinterpretation. Journal of political economy 81(6):1451-1459.

Amin S, Murshed M, Chowdhury MT (2018). Examining the exchange rate overshooting hypothesis in Bangladesh: A cointegration and causality analysis. World Journal of Social Sciences 8(3):69-83.

Aziz MA, Habibullah MS, Azman-Saini W, Azali M (2000). Testing for causality between taxation and government spending: An application of the Toda-Yamamoto approach. Pertanika Journal of Social Science and Humanities 8(1):45-50.

Bashir F, Luqman A (2014). Long-run determinants of real exchange rate: An econometric analysis from Pakistan. Pakistan Journal of Commerce and Social Sciences 8:2.

Brown RL, Durbin J, Evans JM (1975). Techniques for testing the constancy of regression relationships over time. Journal of the Royal Statistical Society: Series B (Methodological) 37(2):149-163.

Cassel G (1918). Abnormal deviations in international exchanges. The Economic Journal 28(112):413-415.

De Leo P, Cormun V (2017). Revisiting the exchange rate response to monetary policy innovations: The role of spillovers of us news shocks. In 2017 Meeting Papers, number 576. Society for Economic Dynamics.

Ebiringa OT, Anyaogu N (2014). Exchange rate, inflation, and interest rates relationships: An autoregressive distributed lag analysis. Journal of Economics and Development Studies 2(2):263-279.

Eleftheriou M, Mu¨ller-Plantenberg NA (2018). The purchasing power parity fallacy: Time to reconsider the PPP hypothesis. Open Economies Review 29(3):481-515.

Engle RF, Granger CW (1987). Co-integration and error correction: representation, estimation, and testing. Econometrica: Journal of the Econometric Society pp. 251-276.

Granger CW (1981). Some properties of time series data and their use in econometric model specification. Journal of econometrics 16(1):121-130.

Granger CWJ (1969). Investigating causal relations by econometric models and cross-spectral methods. Econometrica 37(3):424-438.

Gujarati D, Porter D (2009). Basic Econometrics. Economics series. McGraw-Hill Irwin.

Hnatkovska V, Lahiri A, Vegh CA (2016). The exchange rate response to monetary policy innovations. American Economic Journal: Macroeconomics 8(2):137-181.

Kara A, Nelson E (2002). The exchange rate and inflation in the UK. Bank of England, external MPC unit. Technical report, Discussion Paper.

Kearns J, Manners P (2006). The impact of monetary policy on the exchange rate: A study using intraday data. International Journal of Central Banking 2(4):157-183.

Khordehfrosh DA, Tehranchian AM (2015). The impact of monetary policies on the exchange rate: A GMM approach. Iranian Economic Review 19(2):177-191.

Kripfganz S, Schneider DC (2018). Response surface regressions for critical value bounds and approximate p-values in equilibrium correction models. Manuscript.

Mahamadu B, Phillip A (2003). Monetary growth, exchange rates, and inflation in Ghana: An error correction analysis. Technical report, Working Paper, WP/BOG-2003/05.

Monfared SS, Akın F (2017). The relationship between exchange rates and inflation: The case of Iran. European Journal of Sustainable Development 6(4):329-340.

Nchor D, Darkwah SA (2015). Inflation, exchange rates, and interest rates in Ghana: an autoregressive distributed lag model. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis 63(3):969-977.

Nkoro E, Uko AK (2016). Autoregressive distributed lag (ARDL) cointegration technique: application and interpretation. Journal of Statistical and Econometric Methods 5(4):63-91.

Nucu AE (2011). The relationship between exchange rate and key macroeconomic indicators. case study: Romania. The Romanian Economic Journal 41:127-145.

Osabuohien E, Obiekwe E, Urhie ES, Osabohien R (2018). Inflation rate, exchange rate volatility, and exchange rate pass-through nexus: The Nigerian Experience. Journal of Applied Economic Sciences 2(56):574-585.

Ozturk I, Acaravci A (2010). The causal relationship between energy consumption and GDP in Albania, Bulgaria, Hungary, and Romania: Evidence from ARDL bound testing approach. Applied Energy 87(6):1938-1943.

Pesaran MH, Shin Y, Smith RJ (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics 16(3):289-326.

Seabra F, Flach L (2005). Foreign direct investment and profit outflows: A causality analysis for the Brazilian economy. Economics Bulletin 6(1):1-15.

Sundqvist E (2002). An empirical investigation of the International Fisher Effect (Dissertation). Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-56062

Toda HY, Yamamoto T (1995). Statistical inference in vector autoregressions with possibly integrated processes. Journal of Econometrics 66:225-250.

Zettelmeyer J (2004). The impact of monetary policy on the exchange rate: evidence from three small open economies. Journal of Monetary Economics 51(3):635-652.