UNIVERSITY OF CAPE COAST

DETERMINANTS OF EXCHANGE RATE VOLATILITY IN GHANA:
EVIDENCE FROM GLOSTEN, JAGANNATHAN AND RUNKLE MODEL
AND QUANTILE REGRESSION.

BY

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in Finance.

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# DECLARATION

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

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**Supervisors' Declaration**

We hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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## ABSTRACT

Exchange rate volatility is a major problem facing developing countries, especially Ghana. The issue of exchange rate volatility is too disturbing and over the years has become a source of great concern to policy analysts, policy makers and domestic as well as foreign investors. The study estimated the determinants of exchange rate volatility in Ghana using monthly data from 1990 to 2017. The study focused on interest rate, inflation rate, current account balance and money supply as the main determinants of exchange rate volatility in Ghana. In addition, the study was based on the positivism research paradigm, quantitative approach and used explanatory research design. Quantile Regression Model and Ordinary Least Square Regression Model were used to estimate the determinants of exchange rate volatility, and also to point out some differences among them. Exchange rate volatility was measured using the Glosten, Jagannathan and Runkle Model. The regression analysis revealed that interest rate, current account balance and money supply have negative and statistically significant effect on exchange rate volatility in Ghana. However, inflation rate exerts positive and statistically significant impact on exchange rate volatility in Ghana. The study also revealed that quantile regression model is robust than the classical ordinary least square regression model. In view of these findings, it is recommended that to stabilize exchange rate in Ghana, the central Bank of Ghana should increase interest rate on financial assets and maintain a low inflation rate. Also, the Bank of Ghana should put in place appropriate policies to improve the current account balance. Additionally, the Bank of Ghana must adopt a monetary policy mix that will help stabilize exchange rate in Ghana.

**KEY WORDS**

Exchange Rate

Volatility

Ghana

Quantile Regression Model

Ordinary Least Square Regression Model

Gross Domestic Product

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## DEDICATION

To my parents: Mr. James Kyeame and Mrs. Florence Kyeame.

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| | |
|---|---|
| ADF | Augmented Dickey Fuller |
| AIC | Akaike Information Criterion |
| ARCH | Autoregressive Conditional Heteroscedasticity Model |
| BoG | Bank of Ghana |
| CAB | Current Account Balance |
| CBN | Central Bank of Nigeria |
| ERVOL | Exchange Rate Volatility |
| GARCH | Generalized Autoregressive Conditional Heteroscedasticity Model |
| GDP | Gross Domestic Product |
| GH¢ | Ghana Cedi |
| GJR | Glosten, Jagannathan and Runkle Model |
| INF | Inflation Rate |
| INT | Interest Rate |
| JPY | Japanese Yen |
| KES | Kenyan Shilling |
| LM | Lagrangian multiplier |
| LRM | Linear Regression Model |
| MAPE | Mean Absolute Percentage Error |
| MPR | Monetary Policy Rate |
| MS | Money Supply |
| MSE | Mean Square Error |
| OLS | Ordinary Least Square Regression |
| PLS-SEM | Partial Least Square Structural Equation Model |

PP                    Phillip Perron

QRM                   Quantile Regression Model

REER                  Real Effective Exchange Rate

SC                    Schwarz Criterion

SIC                   Swartz Information Criterion

US$                   United States Dollar

USA                   United States of America

VECM                  Vector Error Correction Model

# CHAPTER ONE

# INTRODUCTION

Exchange rate volatility is a major problem facing developing countries, especially Ghana. The issue of exchange rate volatility is too disturbing and over the years has become a source of great concern to policy analysts, policy makers and domestic as well as foreign investors. Although Ghana has undergone several financial and economic reforms over the last few decades with the view to stabilize exchange rate, volatility in the exchange rate still remains an issue. As a result, the importance of stability in exchange rate cannot be understated. According to Alagidede and Ibrahim (2017), economic and employment growth can be achieved when critical attention is given to stabilizing exchange rate in Ghana. This study contributes to existing literature on determinants of exchange rate volatility in Ghana by adopting a dynamic and more robust econometric approach base on quantile regression to estimate the determinants of exchange rate volatility, using monthly data to properly address the behaviour, dynamics and micro-structure in the variables used for the study, and Glosten, Jagannathan and Runkle (GJR) model to measure exchange rate volatility. Practically, this study will be crucial for policy decision makers as they coordinate effort to stabilizing exchange rate in Ghana.

## Background to the Study

According to Alagidede and Ibrahim (2017), exchange rate volatility is defined as the excessive or persistent fluctuations of exchange rate in an economy. Governments, particularly in developing countries have adopted varying exchange rate management policies over the years with the notion to

achieve a stable exchange rate but they have experienced volatility in their exchange rate more than before (Mordi, 2006).

In Ghana, the emergence of the Financial Sector Adjustment Programme – a component of the Structural Adjustment Programme - introduced major reforms in the financial sector including the abolishment of the fixed exchange rate regime in favour of the free-floating regime in the 1980s. This transition was done to curb the boom and bust syndrome in the exchange rate and also to turn the country towards a direction of growth. However, since the adoption of the flexible exchange rate regime, the value of the Ghana Cedi has experienced higher volatility and mostly depreciated relative to major currencies especially the United States (US) Dollar and the British Pound (Alagidede & Ibrahim, 2017).

In the same vein, the move to redenominate the Ghana Cedi (GH₵) on July 2007 also triggered the volatility and depreciation of the value of the cedi relative to other major currencies in most part of its existence. When the cedi was redenominated, US$1 was exchanged for GH¢0.93. However, overtime this led to a depreciation of the cedi. This was largely due to heavy dependence on import. As a result, the US$1 was exchanged for GH¢1.49 by April 2010. This represents a depreciation of about 60.21% within about two and half years after the redenomination of the cedi (Alagidede & Ibrahim, 2017).

Also, in recent times the cedi/dollar exchange rate has been unstable or volatile. For example, at the start of January 2014, US$1 was exchanged for GH¢2.21 and at the end of September 2014, the cedi/dollar exchange rate stood at GH¢3.20. This represents a depreciation of about 44.65% (Bank of Ghana,

2015). According to Enu (2017), the most alarming of the volatility and depreciation of the Ghana Cedi against the US Dollar was recorded in 2016 and 2017 when US$1 was exchanged for GH¢3.992 and GH¢4.552 respectively. At the end of April 2019, the exchange rate stood at GH¢5.211.

The Economist Intelligence Unit in April 2019 revealed that exchange rate in Ghana is expected to be more volatile. Their report further revealed that the cedi will depreciate against the dollar and by the year 2023 US$1 will be exchange for GH¢6.5. From the foregoing discussion, it can be deduced that exchange rate is very unstable in Ghana and it seems unending. It can also be generalized that exchange rate volatility and currency instability are some of the problems associated with adopting a free-floating exchange rate regime.

Exchange rate volatility is indisputably a major problem facing Ghana. Excessive volatility in the exchange rate has led to a situation where international investment, international trade, employment growth and economic activities, in general, are affected negatively. It has created uncertainty about revenue to be earned on international transactions, threatened financial market stability and made it difficult to attain monetary policies in Ghana. Frequent fluctuations in the exchange rate have also undermined confidence in the Ghanaian economy (Alagidede & Ibrahim, 2017; Enu, 2017; and Insah & Chiaraah 2013).

According to Alagidede and Ibrahim (2017), the volatility in exchange rate in Ghana is connected to instability of macroeconomic variables and other factors. These include interest rate, inflation rate, government expenditure, export, import, money supply, trade openness, gross fixed capital formation and so on. However, Bonser-Neal (1996) argued that interest rate, inflation rate,

current account balance, money supply, income and speculation are the factors affecting exchange rate volatility because the level of exchange rate is a function of these fundamentals.

This study seeks to critically examine the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility in Ghana. This is done by adopting a dynamic and more robust econometric approach base on quantile regression model to estimate the determinants of exchange rate volatility; monthly data to properly address the behaviour, dynamics and micro-structure in exchange rate volatility, interest rate, inflation rate, current account balance and money supply; and Glosten, Jagannathan and Runkle (GJR) model to measure exchange rate volatility.

**Statement of the Problem**

Base on the background of the study, it can be deduced that exchange rate volatility exists in Ghana and it has a harmful effect on the Ghanaian economy. The study seeks to analyse the impact of interest rate, inflation rate, current account balance and money supply (as proposed by Bonser-Neal, 1996) on exchange rate volatility in Ghana.

There are also limited efforts made to examine the factors behind exchange rate volatility in Ghana. In fact, discussions about the instability of exchange rate are most often made at public speeches on the economy with little empirical contents (Alagidede & Ibrahim, 2017).

Also, extant studies on determinants of exchange rate volatility in Ghana such as Alagidede and Ibrahim (2017), Adusei and Gyapong (2017), Nortey, Ngoh, Doku-Amponsah and Ofori-Boateng (2015), and Insah and Chiaraah

(2013) used low frequency data such as annual data in their analysis. However, annual data does not properly address the behaviour, dynamics and micro-structure in exchange rate volatility, interest rate, inflation rate, current account balance and money supply (Buabin, 2016; and Dobrev & Szerszen, 2010). Also, according Adascalitei (2015) low frequency data like annual data does not improve the accuracy of volatility models. This study employs monthly data in its analysis to properly address the behaviour, dynamics and micro-structure in exchange rate volatility, interest rate, inflation rate, current account balance and money supply. Also, the study employs monthly data to improve the accuracy of Glosten, Jagannathan and Runkle model as a measure of exchange rate volatility.

The use of Standard Deviation by Adu-Gyamfi (2011) as a measure of exchange rate volatility does not capture past information of exchange rate volatility. Also, the adoption of Generalized Autoregressive Conditional Heteroscedasticity (GARCH) by Adusei and Gyapong (2017), Alagidede and Ibrahim (2017) and Nortey et al. (2015) does not capture leverage effect and asymmetric effect. The study employs Glosten, Jagannathan and Runkle (GJR) model to measure exchange rate volatility because it is an asymmetric model that captures past information of exchange rate volatility, captures leverage effect and asymmetric effect as indicated by Tsay (2010).

Also, Adeoye and Saibu (2014), Kibiy and Nasieku (2016) and Odera (2015) employed ordinary least square regression (OLS) in their analysis. However, OLS is not robust to outliers (sensitive to outliers) and does not provide the full conditional distributional characteristics of the dependent or response variable. Adusei and Gyapong (2017) also employed PLS-SEM in

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their analysis. PLS-SEM often create large mean square errors during the estimation of path coefficient loading (Adam, 2017). The study however, employs quantile regression model (QRM) as an estimation technique. This is because QRM is more robust to outliers, able to reduce weighted sum of the absolute value of the residuals in its computation and is capable of providing full conditional distributional characteristics of the dependent variable (Huang, Zhang, Chen & He, 2017).

**Purpose of the Study**

To estimate the determinants of exchange rate volatility in Ghana.

**Research Objectives**

- To examine the impact of interest rate on exchange rate volatility in Ghana.

- To determine the impact of inflation rate on exchange rate volatility in Ghana.

- To analyse the impact of current account balance on exchange rate volatility in Ghana.

- To assess the impact of money supply on exchange rate volatility in Ghana.

**Research Hypotheses**

- $H_0$: Interest rate has no impact on exchange rate volatility in Ghana.

  $H_1$: Interest rate has an impact on exchange rate volatility in Ghana.

- $H_0$: Inflation rate has no impact on exchange rate volatility in Ghana.

  $H_1$: Inflation rate has an impact on exchange rate volatility in Ghana.

- $H_0$: Current account balance has no impact on exchange rate volatility in Ghana.

  $H_1$: Current account balance has an impact on exchange rate volatility in Ghana.

- $H_0$: Money supply has no impact on exchange rate volatility in Ghana.

  $H_1$: Money supply has an impact on exchange rate volatility in Ghana.

**Significance of the Study**

The study adds to existing literature and knowledge by adopting a dynamic and more robust econometric approach base on Quantile regression model to estimate the determinants of exchange rate volatility, monthly data to properly address the behaviour, dynamics and micro-structure in exchange rate volatility, and Glosten, Jagannathan and Runkle (GJR) model to measure exchange rate volatility.

The findings of the study will help the government to properly manage interest rate, inflation rate, and current account balance, and also adopt appropriate monetary policies in order to stabilize the exchange rate. The study will also guide policy makers to adopt an exchange rate policy framework that will stabilize exchange rate in Ghana.

**Delimitation of the Study**

The study is based on the economy of Ghana over 336 monthly periods. That is, between January 1990 and December 2017. The aim is to capture the period within which the economy experienced a high exchange rate volatility. Also, variables such as interest rate, inflation rate, current account balance and money supply were used for the study because of their availability. Variables

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like commodity prices and debt servicing were not included in the study because data on them were not available.

**Limitations of the Study**

It was very difficult to get monthly data on current account balance and money supply all expressed as a percentage of Gross Domestic Percentage (% of GDP). As a result, the data available on these variables were transformed into monthly data using Econometrics View (Eviews) software.

**Organization of the Study**

The study is organized into five chapters. Chapter one, presents introduction, background to the study, statement of the problem, objectives of the study, research hypotheses, significance and scope of the study as well as organization of the study. Chapter two presents the literature review, both theoretical and empirical that underpins the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility. Chapter three presents the procedure followed in conducting the study. Chapter four presents and discusses the results in relation to the objectives and hypotheses of the study with reference to the empirical literature reviewed. Chapter five finally presents the summary, conclusions and recommendations of the study.

**CHAPTER TWO**

**LITERATURE REVIEW**

**Introduction**

This chapter presents and explains the concept of exchange rate volatility and the review of literature, both theoretical and empirical that underpins the impact of interest rate, inflation rate, current account balance and money supply (independent variables) on exchange rate volatility (dependent variable) in Ghana. The first section discusses the concept of exchange rate volatility in connection with the independent variables, the second section presents the theoretical review, the third section presents the empirical review, and the fourth and last sections present the research gaps, contribution of the current study to existing studies and the chapter summary respectively.

**The Concept of Exchange Rate Volatility**

According to Hassan, Abubakar and Dantama (2017) exchange rate volatility involves a swing or fluctuations in exchange rate over a period of time or deviations from a benchmark or equilibrium exchange rate. Exchange rate is notable of fluctuating on hourly, daily and weekly basis with no limit to its variability. This fluctuation makes the value of currencies (including the Ghana Cedis) very unstable and difficult to ascertain.

The volatility of exchange rates and its associated risks have become an increasingly important component of international financial management since the breakdown of the Bretton Woods fixed exchange rate system in the early 1970s in terms of formulating suitable macroeconomic policies (Bauwens & Sucarrat, 2006). According to Jeong (2000), volatility in exchange rates was initially perceived to be temporary. However, it has persisted and varied

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considerably over time and across countries. Therefore, the delay in depressing exchange rate volatility in its earlier stages makes it excessive and uncontrollable.

Excessive exchange rate volatility leads to delays in investment decisions, causing uncertainty in the economy. The uncertainty that is caused by volatility also negatively affects economic growth by affecting investment and investor confidence, productivity, consumption and international trade and capital flows (Alagidede & Ibrahim, 2017; Insah & Chiaraah, 2013 and Oaikhenan & Aigheyisi, 2015).

Finding reasons for real exchange rate volatility due to its negative effects is important in terms of developing appropriate economic policies to minimize fluctuations. Although there is no consensus on the causal factors of exchange rate volatility, many factors have been identified in literature.

The transition from the fixed exchange rate regime to the flexible or free-floating exchange rate regime brought a larger volatility in both the nominal and real exchange rate as indicated by Alagidede and Ibrahim (2017), Al Samara (2009), Insah and Chiaraah (2013) and Oaikhenan and Aigheyisi (2015).

Hook and Boon (2000), also indicated that increase cross-border flows that have been facilitated by the trend towards liberalization of the capital account, the advancement in technology and currency speculation have caused exchange rate to fluctuate excessively.

According to Oaikhenan and Aigheyisi (2015) and Stancik (2007), the factors affecting exchange rate volatility are country specific. Thus the causes

of volatility in exchange rate differs from country to country. They went further and stated that the extent to which each factor affects exchange rate movements depends on the method used, the period of analysis and the economic conditions prevailing in each country.

Ayhan (2016) stated that changes in the major economic factors make the exchange rates more volatile by causing unexpected changes in the exchange rate level. In addition, changes in these factors can lead to further growth of the volatility, by exceeding the target for the long-term equilibrium exchange rate in the short term. Some of these economic factors are interest rate, inflation rate, money supply, balance of payment and so on.

Bonser-Neal (1996) also argued that interest rate, inflation rate, current account balance, money supply, income and speculations are the factors affecting exchange rate volatility because the level of exchange rate is a function of these fundamentals.

According to Bergan (2010), interest rate differentials between countries causes exchange rate volatility. This is because when interest rate in a foreign country is greater than that of the domestic country, it leads to an arbitrage opportunity. That is, higher interest rates offer lenders in the foreign country a higher return relative to lenders in domestic country. Investors in the domestic country take advantage of the higher interest rate in the foreign country by purchasing assets to earn higher returns.

This arbitrage opportunity puts much pressure on the foreign exchange rate to increase and causing a depreciation of the domestic country's currency value against that of the foreign country. The opposite relationship exists for

decreasing interest rates, that is, lower interest rates tend to decrease exchange rates (Bergen, 2010). Therefore, changes in interest rate resulting from an arbitrage opportunity causes an excessive fluctuation in exchange rate. Inflation rate is also known to be highly correlated with interest rate. To a large extent, higher inflation means that higher interest rate in an economy. Hence, interest rate becomes a factor causing exchange rate volatility (Irungu, 2017).

Inflation rate differentials between countries also results in volatility of exchange rate. When inflation rate is higher in the domestic country than in a foreign country and vice versa, it also causes exchange rate volatility. Thus, when domestic price levels are higher than a foreign country's price levels, economic agents in the domestic country decide to purchase from the foreign economy.

This puts much pressure on the foreign exchange rate to increase and causing a depreciation of the domestic country's currency. The opposite relationship exists for decreasing inflation rate which tends to increase exchange rate, leading to an appreciation and depreciation in domestic and foreign country's currency respectively. When this persist for a long-time exchange rate becomes more volatile (Irungu, 2017; Dewing, 2015).

The current account balance which is a component of the balance of payment also causes exchange rate volatility. According to Odili (2014), an unfavourable balance (a deficit) in the current account balance causes excessive fluctuations in the exchange rate of a country leading to the depreciation of its currency's external value. On the other hand, a surplus in the current account

balance stabilizes the exchange rate of the country and subsequently causing an appreciation in the external value of its currency.

Also, changes in money supply is another important determinant of exchange rate volatility. This lies in the fact that, money supply has an impact on price levels. This means that should money supply rise, price level will rise and exchange rate depreciates. On the other hand, when money supply declines exchange rate appreciates. This changes in money supply causes volatility in exchange rate (Irungu, 2017).

**Theoretical Review**

This section deals with the review of theoretical literatures linking exchange rate volatility with interest rate, inflation rate, current account balance and money supply. This section begins with the review of theoretical literature on the impact of interest rate on exchange rate volatility followed by the impact of inflation rate on exchange rate volatility, the impact of current account balance on exchange rate volatility and finally that of the impact of money supply on exchange rate volatility.

**Interest Rate and Exchange Rate Volatility**

**International Fisher Effect Theory**

The International Fisher Effect states that exchange rates changes are balanced out by interest rate changes. The Fisher theory simply argues that real interest rates across countries are equal due to the possibility of arbitrage opportunities between financial markets, which generally occurs in the form of capital flows. According to Irungu (2017) real interest rate equality implies that the country with the higher interest rate should also have a higher inflation rate,

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which, in turn, makes the real value of the country's currency decrease over time.

Nominal interest rate differentials between two countries tend to cause exchange rate volatility (Fisher, 2006). Thus, in the process of achieving equilibrium between interest rate of two countries, exchange rate tends to fluctuate rapidly. According to Al Samara (2009), variations in interest rate causes exchange rate volatility. Specifically, a country with a high interest rate experiences a stable exchange rate and subsequently a currency appreciation whilst a country with a low interest rate experiences persistent exchange rate volatility and subsequently a currency depreciation.

**Inflation Rate and Exchange Rate Volatility**

**Purchasing Power Parity Theory (PPP)**

This theory takes its root from the "law of one price" which expresses that identical products ought to be sold at identical prices. The PPP theory in this way expresses that over the long run, identical products and services in various nations should cost the equivalent in those nations. This depends on the assumption that the exchange rate will change in accordance with and wipe out arbitrage opportunity (Madura, 2011). However, in the process of wiping out any arbitrage opportunity exchange rate fluctuate excessively or exchange rate becomes more volatility.

There are two variations of this theory: the absolute form and the relative form. The absolute form of PPP expresses that the exchange rate between the currencies of two nations is equivalent to the ratio of the price levels in the two nations. Relative form of PPP theory also states that the percentage change in

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the exchange rate between two currencies over any period of time is equivalent to the difference between the percentages of change in the price levels of goods over that same time period. Relative form of PPP therefore translates absolute form of PPP from a statement about price and exchange rate levels into one about price and exchange rate changes (Lafrance & Schembri, 2002).

The exchange rate between two nations is equivalent to the ratio of the price levels within the two nations. Hence, PPP predicts that the level of exchange rates are dictated by relative prices, and adjustments in relative prices will result in exchange rate volatility. A nation with high inflation would encounter a high exchange rate volatility and subsequently a currency depreciation whilst a nation with low inflation will experience a stable exchange rate and subsequently a currency appreciation (Hill, 2008). From the foregoing discussion, it can be deduced that changes in the price levels in a country leads to exchange rate volatility.

**Current Account Balance and Exchange Rate Volatility**

**Elasticity Approach to Exchange Rate Determination**

This approach of exchange rate determination emphasizes that the behaviour of exchange rate is determined by trade flows. This approach links the excessive fluctuation of exchange rate to the demand for foreign goods and services. The balance of payment, particularly the current account balance component, is used as a measure of the forces of demand and supply of foreign exchange. This approach stresses that merchandise items such as the import and export are the predominant factors in the balance of payment that contributes to the demand and supply of foreign exchange. As a result, imbalances in the current account causes excessive exchange rate movements (Odili, 2014).

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In short, excessive movements in exchange rate is caused by the position of the balance of payment, particularly the current account balance of a country. According to Odili (2014), an unfavourable balance (a deficit) in the current account balance causes excessive fluctuations in the exchange rate of a country leading to the depreciation of its currency's external value. On the other hand, a surplus in the current account balance stabilizes the exchange rate of the country and subsequently causing an appreciation in the external value of its currency.

**Money Supply and Exchange Rate Volatility**

**Dornbusch Exchange Rate Overshooting Model**

According to Dornbusch (1976), unanticipated monetary policy shocks are able to generate disproportionately large fluctuations in the exchange rates. This is normally referred to as "overshooting effect". In this context, nominal shocks are neutral in the long-run but change the real exchange rate in the short-run. In contrast, persistent real shocks have a permanent effect on the real exchange rate.

According to the Dornbusch model, after money supply rise, the exchange rate fluctuates or changes more in the short-run than its long-run changes, therefore the exchange rate is said to be overshooting when its immediate response to a disturbance is greater than its long-run response (Dornbusch, 1976). Exchange rate overshooting is an important phenomenon because it helps explain why exchange rates change so sharply or excessively from day to day. Overshooting in exchange due to price stickiness, contributes to explaining the high volatility displayed by exchange rate (Al Samara, 2009). Therefore, the Dornbusch exchange rate overshooting model postulates that an

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increase in money supply increases exchange rate volatility whilst a decrease in money supply decreases exchange rate volatility.

**Empirical Review**

This section deals with the review of empirical literature on the determinants of exchange rate volatility in Ghana. This part begins with the review of empirical works on the impact of interest rate on exchange rate volatility followed by the impact of inflation rate on exchange rate volatility, the impact of current account balance on exchange rate volatility and finally that of the impact of money supply on exchange rate volatility.

**Interest Rate and Exchange Rate Volatility**

Benita and Lauterbach (2007), analysed the links between policy factors and exchange rate volatility by comparing panel data and specific country analysis. The authors examined the daily volatility of the exchange rate between 43 other currencies and the US dollar for the period of 1990 to 2001. The results obtained showed that with the cross-country difference, interest rate positively impact exchange rate volatility.

Investigation of the macroeconomic determinants of exchange rate volatility in India was conducted by Mirchandani (2013). The study was carried out using yearly data spanning over the period of 1991 to 2010. The results from the analysis revealed that interest rate has a negative impact on exchange rate volatility. Likewise, Ajao and Igbokoyi (2013) examined the degree of influence of productivity, trade openness, government expenditure, real interest rate and money supply on real exchange rate volatility in Nigeria. The empirical results indicated that real interest rate has negative and significant impact on exchange rate volatility in Nigeria.

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In another development, Ali, Mahmood and Bashir (2015) also looked into the impact of interest rate, inflation rate and money supply on exchange rate volatility in Pakistan. The authors used monthly data for a period 10 years. The results of the study demonstrated that interest rate has a positive impact on exchange rate volatility in Pakistan. However, Mpofu (2016) analyzed the determinants of exchange rate volatility in South Africa. The author employed monthly data and measured exchange rate volatility using the GARCH model. The outcome of the study revealed that interest rate prevents persistent fluctuations in exchange rate in South Africa.

Also, an assessment of the impact of short-term interest rate on exchange rate volatility in Turkey was done by Sarac and Karagoz (2016). Using monthly data for the period of 2003 to 2015, the authors found no evidence that a higher interest rate causes the weakening of exchange rate. But in terms of volatility, a higher interest rate serves as a protective mechanism for restraining an increase in exchange rate volatility. Hence, interest rate negatively impacts exchange rate volatility in Turkey.

Kibiy and Nasieku (2016) looked into the determinants of exchange rate volatility of the Kenyan Shilling (KES) against world major currencies such as the Japanese yen (JPY), United States (US) dollar and Euro. The authors employed monthly data for a period of 10 years. The results obtained from the regression analysis revealed that interest rate has a positive and significant effect on KES/JPY exchange rate volatility. Also, Hassan, Abubakar and Dantama (2017) analysed the determinants of exchange rate volatility in Nigeria. The authors used quarterly data from 1989 to 2015 and employed Autoregressive Conditional Heteroscedasticity (ARCH) model in modelling exchange rate

volatility. Their findings revealed that interest rate has positive and significant impact on exchange rate volatility in Nigeria.

In Ghana, Nortey et al. (2015) modelled inflation rate and exchange rates volatility by using interest rate as a control variable. The authors employed multivariate GARCH model to estimate volatility and annual time series data from 1990 to 2013. The outcome of the examination revealed that interest rate has a positive impact on exchange rate volatility. Notwithstanding, Alagidede and Ibrahim (2017) reviewed the causes and effects exchange rate volatility in Ghana. The authors used annual time series data from 1980 to 2013. They also employed the GARCH model to measure exchange rate volatility. The results from the Vector Error Correction model (VECM) analysis revealed that interest rate has no impact on exchange rate volatility in Ghana.

In a nutshell, a larger number of the studies above support the assertion that interest rate positively influences exchange rate volatility (Ali et al., 2015; Benita & Lauterbach, 2007; Hassan et al., 2017 and Kibiy & Nasieku, 2016). However, Ajao and Igbokoyi (2013) and Mirchandani (2013) found evidence of a negative effect of interest rate on exchange rate volatility. Alagidede and Ibrahim (2017) also found no impact of interest rate on exchange rate volatility. Results from the different studies are not identical due to differences in economic conditions, periods of analysis volatility measures and analytical techniques.

**Inflation Rate and Exchange Rate Volatility**

Haque and Boger (2011) examined the causes and effects of the volatility of the dollar/ yen exchange rate. The authors used United States of

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America (USA) and Japan for the study. The outcome of the examination demonstrated that both USA and Japan inflation rates have a positive impact on the volatility of dollar/ yen exchange rate. As opposed to Bobai, Ubangida and Umar (2013) who evaluated the relationship between exchange rate volatility and inflation rate in Nigeria by employing yearly time series data from 1986 to 2010. The conclusion from the test conducted showed that inflation rate negatively affects exchange rate volatility in Nigeria.

Kurihara (2013) also added to literature by conducting a research to assess whether the adoption of inflation targeting reduce exchange rate volatility and enhance economic growth. The author used panel data from twenty-eight (28) countries. The outcome of the examination revealed that inflation has a positive and insignificant impact on exchange rate volatility. Likewise, Adeniji (2013) explored exchange rate volatility and inflation upturn in Nigeria using annual time series data for 27 years. The author employed Vector Error Correction Model (VECM). The results acquired from VECM showed that inflation rate has a positive impact on exchange rate volatility.

Ali et al. (2015) also investigated into the impact of interest rate, inflation rate and money supply on exchange rate volatility in Pakistan. The authors used monthly data for a period of 10 years. Their empirical results revealed that inflation rate has a positive impact on exchange rate volatility in Pakistan. Similarly, Fabris and Vujanovic (2017) revealed that a higher inflation rate causes financial dollarization in Serbia. Financial dollarization eventually puts much pressure on the domestic currency and thereby increasing exchange rate volatility.

Kibiy and Nasieku (2016) as well looked into the determinants of exchange rate volatility of the Kenyan Shilling (KES) against world major currencies such as the Japanese yen (JPY), US dollar and Euro. The authors employed monthly data from 2006 to 2015. The results obtained from the regression analysis showed that inflation rate has a positive and significant effect on KES/JPY exchange rate volatility.

Obiekwe and Osubuohien (2016) investigated exchange rate pass-through, exchange rate volatility and inflation rate in Nigeria. The authors employed GARCH model to measure exchange rate volatility. The results obtained indicated that inflation rate has a negative and positive impact on exchange rate volatility in the short run and the long run respectively. However, Gidigbi, Babarinde and Lawan (2018) looked into the relationship between inflation and exchange rate volatility pass-through in Nigeria. Their estimation revealed that inflation rate has no impact on exchange rate volatility during the period of the study.

In Ghana, Nortey et al. (2015) modelled inflation and exchange rates volatility in Ghana. The authors employed multivariate GARCH model to estimate volatility and annual time series data from 1990 to 2013. The outcome of the study revealed that inflation rate has a positive impact on exchange rate volatility. However, Adusei and Gyapong (2017) researched the impact of microeconomic variables on exchange rate volatility in Ghana. The authors used the partial least square structural equation modelling approach and annual data for the period of 1974 to 2014. The authors found that inflation rate has a negative impact on the cedi-dollar exchange rate volatility.

Alagidede and Ibrahim (2017) reviewed the causes and effects exchange rate volatility in Ghana. The authors used annual time series data from 1980 to 2013. They also employed the GARCH model to measure exchange rate volatility. The outcome of the study revealed that inflation rate has no impact on exchange rate volatility in Ghana. Notwithstanding, Tweneboah (2015) revealed that financial dollarization resulting from increased inflation rate increases exchange rate volatility in Ghana.

In conclusion, the nature of the effect of inflation rate on exchange rate volatility as shown by most some country specific studies were positive (Adeniji, 2013; Ali et al., 2015; Kibiy & Nasieku, 2016; and Kurihara, 2013) whilst others demonstrated a negative impact (Bobai et al., 2013; and Haque & Boger, 2011) and yet still others found no impact (Gidigbi et al., 2018). But these differences in result are most likely due to varying economic conditions, periods of analysis, volatility measures and analytical techniques.

**Current Account Balance and Exchange Rate Volatility**

Bank of Uganda (2011) conducted a research on the economic growth-exchange rate volatility nexus in Uganda. The findings of the study revealed that Uganda has experienced high exchange rate volatility as a result of excessive unfavourable balance recorded in the current account in recent years and this has led to a depletion of the economic growth of the country. However, the analysis conducted further showed that current account balance restrains exchange rate volatility for the period of the study.

Haque and Boger (2011) examined the causes and effects of the volatility of the dollar/ yen exchange rate. The authors used United States of

America (USA) and Japan for the study. The current account balance of USA was included in a stepwise regression. The result of the study revealed that USA current account balance has a significant negative impact on the dollar/ yen exchange rate volatility.

Razi, Shafiq, Ali and Khan (2012) also added to literature by examining the determinants of exchange rate volatility and its impact on Pakistani economy. Using time series data for the period of 2001 to 2011, they found out that current account balance significantly and positively impacts exchange rate volatility. However, an investigation of the macroeconomic determinants of exchange rate volatility in India was conducted by Mirchandani (2013). The study was carried out using yearly data. The empirical results of the study showed that current account balance has no impact on exchange rate volatility.

In a study by Twarowska and Kakol (2014), who analysed the factors affecting volatility in the exchange rate of Pokish Zloty against Euro, revealed that the movements in the current account balance contributes to the excessive volatility of the zloty/exchange rate volatility. The outcome of the investigation revealed that a surplus in the current account balance negatively impact exchange rate volatility. As opposed to Urbanovsky (2017), who found that an increase and a decrease in the current account balance, causes excessive volatility of the exchange rate. Likewise, frequent changes in the exchange rate also affect the current account balance. This indicates a bidirectional impact among these variables. Thus, the two variables granger causes each other. This result is in line with the study conducted by Faroque and Veloce (1990) and Kim and Kim (2010).

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In Ghana, Adusei and Gyapong (2017) investigated the impact of microeconomic factors on exchange rate volatility in Ghana. The authors employed the partial least square structural equation modelling approach and annual data for the period of 1975 to 2014. The outcome of the study showed that current account balance has a negative impact on the cedi-dollar exchange rate volatility.

In summary, most of the empirical studies reviewed in this regard showed a negative influence of current account balance on exchange rate volatility (Adusei & Gyapong, 2017; Bank of Uganda, 2011; Haque & Boger, 2011; and Twarowska & Kakol, 2014) whereas others found a positive impact (Razi et al., 2012), yet still Mirchandani (2013) found no impact and Urbanovsky (2017) found bidirectional effect between them. The variations in the results above are due to differences in trade policies among the countries used for the study, volatility measures, period of analysis and analytical techniques.

**Money Supply and Exchange Rate Volatility**

An investigation into the determinants of exchange rate volatility in Pakistan was done by Saeed, Awan, Sial and Sher (2012). The authors utilized monthly data from 1982 to 2010. The empirical results obtained showed that money supply affects exchange rate volatility positively. The authors recommended that policy makers should put in place appropriate monetary measures to restrain the excessive increase in exchange rate volatility. Likewise, Kilicarslan (2018) analysed the macroeconomic determinants of exchange rate volatility in Turkey. The author used data for the period from 1974 to 2016 and also employed the GARCH model to measure exchange rate volatility. The

outcome of the analysis revealed that an increase in money supply results in an increase in real effective exchange rate volatility. Hence, money supply has a positive impact on exchange rate volatility in Turkey.

In another development, Ajao and Igbokoyi (2013) examined the degree of influence of productivity, trade openness, government expenditure, real interest rate and money supply on real exchange rate volatility in Nigeria. The empirical results indicated that money supply has no impact on exchange rate volatility. Notwithstanding, Adeoye and Saibu (2014) investigated monetary policy shocks and exchange rate volatility in Nigeria. The authors employed the ordinary least square regression and the Engle-Granger approach to analyse the data and to conduct pairwise analysis respectively. The outcome of the study showed that money supply has a positive and significant impact on exchange rate volatility.

Ali et al. (2015) investigated the impact of interest rate, inflation rate and money supply on exchange rate volatility in Pakistan. The authors used monthly data for the period from 2000 to 2009. The discoveries of the investigation revealed that a high money supply increases the price level and eventually raises exchange rate volatility. Therefore, money supply has a positive impact on exchange rate volatility.

As opposed to Ajao (2015) who analysed the determinants of real exchange rate volatility in Nigeria. The author measured volatility by the use of the GARCH model. The empirical analysis revealed that money supply has a significant negative impact on real exchange rate volatility in the short run. The author recommended that the Central Bank of Nigeria (CBN) should put in

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place monetary policies that will reduce the magnitude of exchange rate volatility.

Odera (2015) analysed the effect of external public debt on exchange rate volatility in Kenya. The author used money supply as one of the control variables for the study, employed quarterly data for the period from 1993 to 2013, measured volatility using the standard deviation of the second order of the moving average and used ordinary least square regression technique. The findings of the study revealed that money supply does not have any significant impact on exchange rate volatility in Kenya.

Notwithstanding, Kibiy and Nasieku (2016) looked into the determinants of exchange rate volatility of the Kenyan Shilling against world major currencies such as the Japanese yen, US dollar and Euro. The authors employed monthly data from 2006 to 2015. The outcome of the regression analysis revealed that money supply has a negative and significant effect on KES/JPY exchange rate volatility.

Malovic, Ozer and Zdravkovic (2017) studied the impact of dollarization on exchange rate volatility and the rational choice of currency regime in two European Union Candidate countries. These countries were Serbia and Turkey. The authors utilized monthly time series data for a period of 10 years and employed the GARCH model to measure volatility. The result of the study unveiled that money supply in Serbia positively influences the dinar/euro exchange rate volatility, whereas in Turkey, money supply has a negative impact on exchange rate volatility.

Meanwhile, Pham (2018) assessed the relationship between liquidity/money supply and exchange rate volatility. The author employed panel

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data and the empirical results obtained revealed that money supply has a positive impact on exchange rate volatility in developing countries. But the result is otherwise under the influence of financial market development.

In Ghana, Insah and Chiaraah (2013) also added to literature by investigating the sources of real exchange rate volatility in the Ghanaian economy. The authors employed annual data for the period 1980 to 2012. The result of the study indicated that money supply does not contribute too much to real exchange rate volatility. They discovered that money supply negatively impacts real exchange rate volatility but not significant. As opposed to, Alagidede and Ibrahim (2017) who reviewed the causes and effects exchange rate volatility in Ghana, and discovered that money supply has positive effect on exchange rate volatility.

In conclusion a significant number of the studies above support the assertion that money supply positively impacts exchange rate volatility (Adeoye & Saibu, 2014; Alagidede & Ibrahim, 2017; Ali et al., 2015; Kilicarslan, 2018; Pham, 2018; and Saeed et al., 2012;). Whilst others found a negative impact (Ajao, 2015; Insah & Chiaraah, 2013; and Kibiy & Nasieku, 2016), yet still Ajao and Igbokoyi (2013) and Odera (2015) found no impact of money supply on exchange rate volatility. These disparities in the outcomes are due to differences in monetary policies, periods of analysis, data frequencies, volatility measures and analytical techniques.

**Gaps in Existing Studies**

The study seeks to fill the following gaps in the empirical studies reviewed. First and foremost, in the Ghanaian context, all the studies reviewed

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measured exchange rate volatility by using either GARCH model or Standard Deviation (for instance Insah & Chiaraah, 2013; Alagidede & Ibrahim, 2017; and Adu-Gyamfi, 2011 respectively). According to Tsay (2010), GARCH model do not capture leverage effect and asymmetric effect (positive and negative shocks) in regard to conditional variance of real effective exchange rate. However, Coffie (2018) modelled and forecasted the volatility of the Botswana and Namibia stock market returns using GJR and Exponential GARCH model which is very good.

Furthermore, standard deviation does not capture the past information of real effective exchange rate (Alagidede & Ibrahim, 2017). The study therefore employed the Glosten, Jagannathan and Runkle (GJR) Model which is a conditional heteroscedastic asymmetric model to measure exchange rate volatility. This is because GJR model captures leverage effect, asymmetric effect and past information of exchange rate volatility.

Also, in the Ghanaian context, all the studies reviewed employed annual time series data in their analysis (Adusei & Gyapong, 2017; Alagidede & Ibrahim, 2017; Insah & Chiaraah, 2013; and Nortey et al., 2015). However, according to Buabin (2016) and Dobrev and Szerszen (2010), annual time series data, which is a low frequency data does not adequately address the behaviour, dynamics and micro-structure in exchange rate volatility but a high frequency data like monthly or weekly or daily data does. The study employs monthly time series data in its analysis to properly address the behaviour, dynamics and miro-structure in exchange rate volatility, interest rate, inflation rate, current account balance and money supply. Notwithstanding, Coffie and Chukwulobelu (2014)

employed intra-day data in measuring and forecasting stock market return and they are commended for that.

In addition, in a general context, the empirical works reviewed either used Ordinary Least Square Regression (OLS) model or the Partial Least Square Structural Equation Modelling (PLS-SEM) approach as an analytical technique (Adeoye & Saibu 2014; Kibiy & Nasieku, 2016; Odera, 2015; and Adusei & Gyapong, 2017 respectively). OLS is not robust to outliers and does not enhances the full conditional distributional characteristics of the dependent variable.

Also, with the use of PLS-SEM, there is the possibility that large mean square errors will be created during the estimation of path coefficient loading as indicated by Adam (2017). The study, therefore, employed Quantile Regression Model (QRM) to analyse the data due to its robustness to outliers, ability to minimize weighted sum of the residuals in its computation and provide full conditional distributional characteristics of the dependent variable.

Knowing exchange rate volatility at the different quantiles of the distribution is not just limited to knowing the impact of the covariates on the response variable at the lower tail, median and higher tail of the distribution. But, also helps to understand the intensity of the strategies to put in place when exchange rate volatility is low or high.

**Contribution to Existing Studies**

The current study contributes to existing studies in the Ghanaian context by employing Glosten, Jagannathan and Runkle (GJR) model to measure exchange rate volatility. Also, with respect to the Ghanaian context, the current

study fills another gap in literature by using monthly data in its analysis to properly address the behaviour, dynamics and micro-structure in exchange rate volatility, interest rate, inflation rate, current account balance and money supply. Finally, with respect to the general context, the current study adds to existing literature by employing Quantile Regression model in analysing the data.

**Chapter Summary**

This chapter discussed the concept of exchange rate volatility and reviewed the theoretical and empirical literatures for the variables used for the study. The theory linking exchange rate volatility to interest rate, inflation rate, current account balance and money supply are International Fisher Effect Theory, Purchasing Power Parity Theory, Elasticity Approach to Exchange Rate Determination and Dornbusch Exchange Rate Overshooting Model respectively. It also came to light that the results on the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility vary among the works reviewed. These disparities in the outcome were due to differences in economic conditions, trade policies monetary policies, study periods, measures of volatility and analytical techniques.

It finally brought to bear the gaps that need to be filled based on the empirical literature reviewed. These include the use Glosten, Jagannathan and Runkle model, which is an asymmetric conditional heteroscedastic model that captures leverage effect, asymmetric effects and past information of exchange rate volatility to measure or model exchange rate volatility. Using monthly data to properly address the behaviour, dynamics and micro-structure in exchange rate volatility, interest rate, inflation rate, current account balance and money

supply. Finally, using quantile regression model to estimate the determinants of exchange rate volatility in order to provide a full conditional distributional characteristic of the dependent variable and among others.

## CHAPTER THREE

## RESEARCH METHODS

**Introduction**

This chapter deals with the systematic procedures used to explain the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility in Ghana. Particularly, this chapter presents the research paradigm, research design, research approach, data collection procedures, source and measurement of variables with empirical justifications, model specifications and analytical technique. Finally, this chapter presents the estimation techniques and diagnostics tests.

**Research Paradigm**

Research paradigm refers to the philosophy underpinning a scientific research and the scientific approach that is regarded appropriate to the reason, context and focus of the research work (Hallebone & Priest, 2008). This is in accordance with the positivism research paradigm. According to Saunders and Lewis (2012), the propounders of the positivism research paradigm are of the view that the positivist approach to scientific research involves researching into an observable social reality and making law-like generalizations as done by physical and natural scientists.

The fact that such social reality is obvious means that it can be measured and quantified into variables. Thus, the use of the positivism paradigm involves collecting data on variables, analyzing data by using statistical test of significance and affirming or rejecting hypotheses to make generalizations. Positivism paradigm of research produces generalizable findings which are

normally reported quantitatively, and also allows for the possibility of making predictions about general phenomena (Hallebone & Priest, 2008).

The study adopts the positivism research paradigm because it involves collection of data on exchange rate, interest rate, inflation rate, current account balance and money supply, analysis of the data to establish relationships by using statistical test of significance and finally accepting or rejecting hypotheses to establish whether interest rate, inflation rate, current account balance and money supply have an impact on exchange rate volatility in Ghana.

**Research Design**

According to Saunders and Lewis (2012), research design can be exploratory, descriptive or explanatory. The study employed the explanatory research design. The empirical studies that seeks to establish cause and effect relationships between variables may be termed as explanatory (Saunders & Lewis, 2012). Explanatory research design is employed in the study to explain the impact or effect of interest rate, inflation rate, balance of payment and money supply on exchange rate volatility in Ghana.

**Research Approach**

There are three main approaches to research, namely, the quantitative approach, the qualitative approach and the mixed approach (Creswell, 2014). According to Saunders and Lewis (2012), positivism research paradigm makes use of the quantitative research approach and therefore the quantitative research method is adopted for this study. Creswell (2014) explained that the quantitative research approach involves seeking for causal explanations so that it could be used for predictions.

The study employs the quantitative approach because hypotheses will be deduced from theories and models will be constructed base on these hypotheses. Since quantitative approach to research makes use of statistical analysis, the study employs inferential statistics (particularly regression) to analyze the data.

**Data Collection Procedures**

The study estimates and explains the determinants of exchange rate volatility in Ghana. This is done by analysing the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility. Base on this purpose, secondary monthly data for the period of 1990 to 2017 on interest rate and inflation rate are obtained from the Bank of Ghana Website whilst current account balance and money supply are sourced from the World Bank Website. Data on real effective exchange rate is obtained from Bruegel Website.

The motivations for selecting those variables are that they are the major indicators determining exchange rate volatility in Ghana. Also, due to availability of data on those variables. Furthermore, the selection of the period for the study is based on the fact that, it is the timeframe that the cedi/dollar exchange rate experienced rapid volatility. The study employs monthly data in its analysis due to the following reasons:

Firstly, according to Adascalite (2015) high frequency data such as monthly, weekly or intraday data improves the accuracy of volatility measures. Therefore, monthly data is used for the study to improve the accuracy of Glosten, Jagannathan and Runkle model as a measure of exchange rate volatility. Thus, the use of annual data by Alagidede and Ibrahim (2017), Insah

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and Chiaraah (2013), and Adusei and Gyapong (2017) does not improve the accuracy of volatility measures.

Dobrev and Szerszen (2010) also posited that the use of high frequency data such as monthly or weekly or intraday data eliminates forecasting bias. Therefore, monthly data is used for this study to prevent forecasting bias that may arise. Dobrev and Szerszen further indicated that, high frequency data such as monthly or weekly or intraday data helps to capture and understand market behaviour, dynamics and micro-structures. The study, therefore, employs monthly data to understand the behaviour, dynamics and micro-structures in exchange rate volatility, interest rate, inflation rate, current account balance and money supply for the period of analysis.

Ters and Ferrari (2017) argued that monthly or weekly or intraday data captures a large amount of information regarding exchange rate quotes and prices. They concluded by revealing that such data help researchers to easily identify the effect of precisely timed shocks on market quotes. Therefore, monthly data is used for this study to enable us obtain large amount of information on the variables and to know precisely the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility.

**Measurement of Variables**

The adoption of a measurement for all the variables is determined by the fact that those measures have been largely used in literature. Exchange rate is measured and defined as the Real Effective Exchange Rate (REER) between the Ghana Cedi and the US Dollar (GH¢/US$). REER is used in international trade

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to determine how much of a foreign good can be acquired with a unit of a domestic good (Rates, 2007).

Interest rate (INT) is the 91-Day Treasury bill rate. Thus, it is the interest rate on a short-term investment usually with a 91-day period offered by the Bank of Ghana on behalf of the government (Bank of Ghana, 2018). According to Abakah (2009), 91-Day Treasury bill rate is used as a benchmark or standard for interest rate in the money market.

The inflation rate (INF) variable is the overall consumer price index which comprises both food and non-food price indexes. Current account balance (CAB) comprises the balance of trade in goods and services, net income, direct transfers and asset income.  The CAB is measured as a percentage of GDP. The reason for this is that CAB expressed as a percentage of GDP is a yardstick for determining international competitiveness of developing countries (Wanjau, 2014).

Money supply (MS) is the broad money supply (M2) taken as the sum of M1 and near money. M1 includes cash and checking deposits, while near money refers to savings deposits, money market securities, mutual funds and other time deposits. M2 is therefore measured as a percentage of GDP.

 Table 1 shows how the variables were measured, their source and the empirical justifications for their measurements.

**Table 1: Description of Variables, Sources and Empirical Justifications**

| Variable | Measurement | Source | Empirical Justification |
|---|---|---|---|
| Exchange Rate Volatility | Glosten Jagannathan and Runkle (GJR) Model | | Musa, Tasi'u and Bello (2014); Tsay (2010) |
| Exchange Rate | Real Effective Exchange Rate (GH¢/US$, CPI-Based) | Bruegel Website | Buabin, (2016); Iyke and Ho (2017) |
| Interest Rate | 91-Day Treasury Bill Rate | Bank of Ghana (BoG) Website | Parveen, Khan and Ismail (2012); Kuwornu (2012); Ajao (2013); Mirchandani (2013); Abakah (2009) |
| Inflation Rate | Overall Consumer Price Index (Non-food and Food) | Bank of Ghana (BoG) Website | Mbulawa (2015); Takyi and Obeng (2013); Naceur and Ghazouani (2007); Kuwornu (2012) |
| Current Account Balance | Current Account Balance (% of GDP) | World Bank Website | Adusei and Gyapong (2017); Twarowska and Kakol (2014); Razi, Shafiq, Ali and Khan (2012) |
| Money Supply | Broad Money Supply (M2) (% of GDP) | World Bank Website | Zwanzeger (2008); Ineichen (2010); |

Source: Field Survey, Odoom (2019)

**Model Specification**

The study adopts the Quantile Regression Model and Ordinary Least Square Regression Model to capture the impact of interest rate, inflation rate, money supply and current account balance on exchange rate volatility. As a result, the results obtain by these regression estimators will be compared to point

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out some differences between them. The Quantile Regression Model and the

Ordinary Least Square Regression Model are shown in model 1 and model 2.

$$ERVOL_t = \beta_0^{(P)} + \beta_1^{(P)}INT_t + \beta_2^{(P)}INF_t + \beta_3^{(P)}CAB_t + \beta_4^{(P)}MS_t + \varepsilon_t^{(p)} \ldots\ldots\ldots\ldots.. (1)$$

$$ERVOL_t = \beta_0 + \beta_1 INT_t + \beta_2 INF_t + \beta_3 CAB_t + \beta_4 MS_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots........ (2)$$

Where,

- ERVOL is Exchange Rate Volatility

- INT is Interest Rate

- INF denotes Inflation Rate,

- CAB denotes Current Account Balance

- MS also denotes Money Supply

- $\beta$ represents the coefficients

- $\varepsilon$ represents error term

- p is percentile/quantile (where $0 < p < 1$ indicates the proportion of the population having scores below the quantile at $p$)

- t also represents time

**Modelling Volatility**

The study employs the Glosten, Jagannathan and Runkle (GJR) model to generate time varying conditional variance of real effective exchange rate (REER) as a standard measure of exchange rate volatility. According to Tsay (2010), GJR is a class of an asymmetric conditional heteroscedastic models that captures leverage effect and asymmetric effect (positive and negative shocks) in regard to conditional variance of real effective exchange rate (REER).

GARCH model employed by Alagidede and Ibrahim (2017), Adusei and Gyapong (2017), Insah and Chiaraah (2013) and Nortey et al. (2015) assumes that positive and negative shocks have the same impact on volatility. Therefore, both negative and positive shocks (that is bad and good news) are treated the same by the GARCH model. However, in practice, this assumption does not hold (Drachal, 2017). The use of asymmetric model like Glosten, Jagannathan and Runkle (GJR) has the ability to capture both negative and positive news and treat them accordingly.

The use of standard deviation as a measure of exchange rate volatility by Adu-Gyamfi (2011) does not capture past information of exchange rate volatility. This makes standard deviation an undesirable approach in measuring exchange rate volatility. Empirical studies indicate that current exchange rate volatility is affected by its own past values. However, the motivation for the use of Glosten, Jagannathan and Runkle model in this study, is that, it captures past values of exchange rate volatility in its estimation.

Therefore, the study employs GJR (2, 1) to measure exchange rate volatility. This is because the Ljung-Box Statistic of the Squared Standard Residuals with ten (10) lags and the Engle LM test for the presence of ARCH effect in Appendix B and C respectively show that the GJR (2, 1) has fully and sufficiently captured autocorrelation, heteroscedasticity and volatility clusters in the sample. This is due to the fact that we fail to accept the null hypothesis of the presence of ARCH effect in the series. The GJR (2, 1) is shown in model 3.

$$\sigma^2_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \varepsilon^2_{t-2} + \gamma_1 s_{t-1}\varepsilon^2_{t-1} + \beta_1 \sigma^2_{t-1} \dots\dots\dots\dots\dots\dots\dots (3)$$

Where,

- $\sigma^2{}_t$ represents conditional variance

- $\alpha_1, \alpha_2$ and $\beta_1$ are non-negativity parameters

- $\gamma_1$ non-negativity parameter representing leverage or asymmetric effects (if $\gamma_1 > 0$ it indicates the presence of leverage effect; and asymmetric effect if $\gamma_1 < 0$ )

- $\varepsilon^2_{t-1}$ and $\varepsilon^2_{t-2}$ represents one and two periods lag(s) information about real effective exchange rate volatility respectively.

- $\sigma^2_{t-1}$ connotes one period lag of the forecast error variance and

- $s_{t-i}$ is a dummy variable $= \begin{cases} 1 \text{ if } \varepsilon_{t-i} < 0 \\ 0 \text{ if } \varepsilon_{t-i} \geq 0 \end{cases}$

**A Priori Expectations**

Table 2 shows the expected sign of the independent variables based on the theoretical literature discussed in chapter 2.

**Table 2: A Priori Expected Signs of the Independent Variables**

| Variable | Expected Sign |
|---|---|
| Interest Rate | - |
| Inflation Rate | + |
| Current Account Balance | _ |
| Money Supply | + |

Source: Field Survey, Odoom (2019)

**Data Analysis Technique**

The study employs Quantile Regression Model (QRM) and Ordinary Least Square (OLS) Regression Model to estimate or analyze the determinants of exchange rate volatility in order to point out some differences between these estimators. In the mid-18th century, Boscovich proposed the conditional-median regression model to address the limitations of the conditional-mean

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estimate of the Linear Regression Model (LRM) or Ordinary Least Square Regression Model (OLS). The median-regression model examines the impacts of an independent variable on the conditional median of the dependent variable. Therefore, the conditional median represents the central location even when the distribution is skewed (Hao & Naiman, 2007).

However, according to Hao and Naiman (2007), to model location shifts and shape shifts, Koenker and Bassette (1978) proposed a more general form than the median-regression model called the quantile-regression model (QRM). In recent times, QRM is gaining more popularity than the classical LRM. This is because given a set of independent variables, the LRM models the conditional mean of a dependent variable without considering the full conditional distributional characteristics of the dependent variable. Notwithstanding, QRM enhances the analysis of the full conditional distributional characteristics of the dependent variable (Huang et al., 2017).

The QRM and LRM are identical somehow or another, as every one of them deal with a continuous endogenous variable that is linear in an undisclosed parameter, nevertheless the two models model distinctive quantities and rely upon different assumptions about the error term. Outlined below are the reasons why QRM is preferable to LRM so far as the study is concern:

In the first place, LRM assumes that a distribution is normal. Accordingly, calculated probability values (p-values) rely upon the normality presumption. The infringement of this condition causes biases in p-values, thus leading to invalid hypothesis testing. It can likewise cause inaccuracy in standard errors. The QRM, notwithstanding, is flexible in light of the fact that

the distribution of the outcome does not need to be strictly specified as a parametric assumption. The QRM's inferential statistics is thus, distribution free (Koenker & Hallock, 2001).

Also, when dealing with a distribution that is asymmetric in nature and heavy tailed of which the data used for the study is no exception, the mean is not an appropriate measure of central tendency. Hence, as indicated by Hung et al. (2017), conditional-median regression gives a better measure of centrality for modelling location shifts than conditional-mean regression.

Furthermore, QRM gives more far reaching statistical modeling than the customary LRM. It is additionally capable of minimizing asymmetrically weighted absolute residuals. QRM makes no assumptions on the form of the error term, which makes it flexible (Koenker and Bassette, 1978). But inferences drawn from QRM models are challenging, particularly when the data characteristics are complicated, as criticized by Huang et al. (2017).

The use of Autoregressive Distributive Lag (ARDL) model and Vector Error Correction model (VECM) by Insah and Chiaraah (2013) and Alagidede and Ibrahim (2017) respectively is also problematic. This is because according to Peterson and Adam (2017) the use of ARDL model requires that all the variables used for the study must be strictly integrated at order zero (i.e. I (0)) or order one (i.e. I(1)). Likewise, the use of VECM requires that all the variable in the study must be strictly integrated at order one (i.e. I(1)).

According to Peterson and Adam (2017) it is impossible to use ARDL and VECM in a situation where some or all the variables are integrated beyond order one. Quantile regression model can be used irrespective of the order of

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integration of the variables or irrespective of whether the variables are differenced more than once. Peterson and Adam also posited that ARDL model is used when dealing with small sample size. However, in the context of this study ARDL model is not an ideal approach because the data points use are large (about 336 monthly periods). QRM can be used irrespective of the number of data points or sample size for a study.

**Estimation Techniques**

The study begins by showing the descriptive statistics of the variables employed. This gives us a good idea of the data and the nature of the estimations and diagnostics to be carried out. It also provids the correlation coefficients to reveal the strengths and direction of the relationships between the variables. The investigation of the time series properties of the data was done using the Augmented Dickey-Fuller (ADF) and Phillip Perron Tests. The unit root test is used to check the stationary properties of the data. The study then proceeds to conduct diagnostics tests such as serial correlation, heteroscedasticity and normality tests on the error term of the OLS model.

**Descriptive statistics and Correlation analysis**

According to Adam (2017) the purpose of descriptive statistics is to summarise, arrange and present a set of data in a way that facilitates interpretation. Descriptive statistics includes the construction of graphs, charts and tables. It also includes calculation of various descriptive measures and measures of variation. The study provides information about mode, mean, standard deviation, kurtosis and skewness of the variables. The purpose of this is to give an idea about the patterns in the data and the nature of diagnostics and estimations to be carried out (Adam). The study also conducts correlation

analysis to examine the strength and direction of the linear relationships between exchange rate volatility and its determinants.

**Unit root test**

According to Nelson and Plosser (1982) macroeconomic time series data are most often not stationary and it is very essential to test for the stationary properties of the data. This testing requires the test of the order of integration of the data set which is known as the unit root tests. According to Gujarati (2012) a time series is stationary if its mean, variance, and autocovariances are not influenced by time.

A stationary series that achieves stationarity after it is being differenced (d) times is said to be integrated of order (d). According to literature, non-stationary variables in a model tend to produce spurious regressions and make the test statistics (F, t, $R^2$ and DW) unreliable (Al-Yousif, 2002). A stationary series is achieved when the non-stationary series variables are differenced properly. Also, the order of integration is known as the appropriate number of differencing.

In accordance with empirical literature, the study tests for the stationarity characteristics of the variables in the model using the Augmented Dickey-Fuller (ADF) and the Phillip Perron (PP) tests. The ADF and PP tests are conducted to ensure that the series enter the model to be estimated in non-explosive form and to deal with the issue of tests with low power. In the case of this test, the optimal lag length is selected base on the Swartz Information Criterion (SIC). ADF and PP involve two separate steps. First of all, they test

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the model with intercept only, and secondly, test with intercept and trend in order to assess the degree of integration of the data series.

The ADF and PP are identical but they are different with regard to how they correct autocorrelation in the residuals. The ADF and PP tests, tests the null hypothesis of the variables that they have unit root as against the alternative hypothesis of no unit root. The formulation of the ADF and PP are given in model 4 and 5 as:

$$\Delta Y_t = \mu + \delta_t + \rho Y_{t-1} + \sum_{i=1}^{p} \psi_i \ \Delta Y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\Delta Y_t = \mu + \delta_t + \rho Y_{t-1} + \psi_i Y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where,

- $Y_t$ denote the series at time t

- $\Delta$ is the difference operator

- $\mu$, $\delta$, $\rho$, and $\psi$ are the parameters to be estimated

- $\varepsilon$ is the error term.

The hypothesis testing is given as:

$H_0$: $\rho = 0$ (series contain unit root – non stationary)

$H_1$: $\rho \neq 0$ (series contain no unit root – stationary)

If the computed t-value for the variables are lesser in absolute terms (or less negative) than the critical DF values we accept the null hypothesis ($H_0$) and conclude that the series has unit root or the series/variables are integrated beyond order one i.e. I(1). On the other hand, if the computed t-value of the variables are greater in absolute terms (or more negative) than the critical DF values we reject $H_0$ in favour of the alternative hypothesis ($H_1$) and conclude

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that the series has no unit root or the series/variables are not integrated beyond order one i.e. I(1).

**Diagnostic test**

It is crucial to examine the assumptions of the LRM particularly the OLS model for a time series data. This is to determine the extent to which estimated results of the LRM can be relied upon (Irungu, 2017). Therefore, the diagnostic tests considered important for time series data are explained in the subsequent sub-headings.

**Serial correlation test**

One of the assumptions of the LRM particularly the OLS model is that the residuals of the regression ought not to correlate with its lagged values. The coefficients obtained from the regression analysis is unreliable when this assumption is violated (Peterson & Adam, 2017). As a result, the study tests for serial correlation by using the Breusch-Godfrey Lagrange Multiplier (LM) test.

The LM test tests the null hypothesis of no serial correlation against the alternative hypothesis of the presence of serial correlation in the error term. If the probability value of the F-statistic is more than 5% significance level, the null hypothesis is accepted and thus confirm that there is no serial correlation in the error term (Peterson & Adam, 2017).

**Heteroscedasticity test**

Another assumption of the classical LRM, particularly the OLS model according to Peterson and Adam (2017), is that the error term should have a constant variance. Also known as homoscedasticity of the error term. Heteroscedasticity is therefore said to be exist when the residual term do not

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have a constant variance. The study tests for heteroscedasticity using the Breusch-Pagan test.

The null hypothesis of the error term is homoscedasticity and the alternative hypothesis of heteroscedasticity of the error term is to be tested. If the probability value of F-statistic is more than 5% significance level, the null hypothesis of homoscedasticity is accepted. Whereas if the probability value of the F-statistic is less than the 5% significance level the alternative hypothesis is accepted (Peterson & Adam, 2017).

**Normality test**

According to Peterson and Adam (2017), the residuals of the linear regression must also be normally distributed to make it robust. The study uses the Jarque-Bera normality test to test the normality of the residuals. The null hypothesis of normality of the residuals and alternative hypothesis of non-normality of the residual term is to be tested.

If the probability value of the Jarque-Bera statistic is more than 5% significance level, the null hypothesis of normality of the residual term is accepted. Whereas if the probability value of the Jarque-Bera statistic is less than the 5% significance level the alternative hypothesis is accepted (Peterson & Adam, 2017).

**Chapter Summary**

This chapter presented the research methods employed in conducting the study. The study is based on the positivism research paradigm and the quantitative research approach. The study also employed explanatory research design as it seeks to explain the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility in Ghana.

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It must be noted that the study employed monthly data from 1990 to 2017 due to availability of data. The chapter also highlighted the source, measurement and empirical justification of the measurement of the variables.

Also, Glosten, Jagannathan and Runkle (GJR) model was employed to measure exchange rate volatility. Specifically, exchange rate volatility was measured using GJR (2, 1) specification. This is because GJR (2, 1) specification fully captures autocorrelation, heteroscedasticity and volatility clusters in the sample. The study mainly employed Quantile Regression and Ordinary Least Square Regression as estimation techniques in order to point out some differences between them.

Descriptive and correlation analysis were conducted to know the patterns in the data, and the strength and directions among the variables respectively. Unit root test was conducted using Augmented Dickey-Fuller (ADF) and Phillip Perron (PP) tests in order to check the order of integration of the variables.

Finally, diagnostic tests such as serial correlation, heteroscedasticity and normality tests were conducted. This was to ensure that the error term in the ordinary least square regression is free from serial correlation, it is homoscedastic and normally distributed.

## CHAPTER FOUR

## RESULTS AND DISCUSSIONS

### Introduction

This chapter presents and discusses the estimation results. The chapter starts by displaying the descriptive statistics of the variables, the estimation of exchange rate volatility, trend analysis of exchange rate volatility, correlation analysis, Augumented Dickey Fuller and Phillip Perron unit root tests and diagnostic tests such as serial correlation, heteroscedasticity and normality tests. Finally, the results for both quantile regression and ordinary least square regression are presented and discussed in relation to the objectives and hypotheses of the study with reference to the empirical literature reviewed in Chapter 2.

### Descriptive Statistics

In this section, the basic features or characteristics of the variables used for the study are examined. As a result, the mean which indicates the average of each of the variables, the median which represents the middle observation for each of the variables, standard deviation which indicates the variability within each of the variables, the skewness and kurtosis represent the distribution of each variable, the maximum and minimum values which is the range, measures variability within each variable; are discussed.

From table 3, Real Effective Exchange Rate (REER) computed based on consumer price indices and trade weight of trading partners has an average of approximately 103.3% and lies within the ranges of 53.4% and 162.7%. Interest Rate (INT) measured using 91-Day Treasury bill rate has an average of approximately 25.8% and lies within the limits of 9.1% and 47.9%. Inflation

Rate (INF) measured using consumer price index has an average of approximately 143.9% and lies within the ranges of 5.4% and 1401.1%.

Current Account Balance measured as a percentage of Gross Domestic Product (% GDP) has an average of approximately -6.6% and lies within the limits of -12.9% and 2.1%. Finally, Money Supply (MS) measured as a percentage of Gross Domestic Product (% GDP) has an average of approximately 25.6% and lies within the ranges of 13.9% and 34.3%.

Also, inflation rate is the variable that has experienced greater fluctuation over the period of the study with a standard deviation of approximately 138.3%. Real effective exchange rate and interest rate are the second and third most volatile variables with standard deviations of approximately 23.7% and 11.1% respectively. Over the period of the study, current account balance and money supply are the least volatile variables with standard deviations of approximately 3.3% and 4.9% respectively.

Furthermore, it can be observed that real effective exchange rate, interest rate, inflation rate and current account balance are positively skewed with skewness of approximately 0.7%, 0.4%, 2.7% and 0.3% respectively. Positive skewness indicates that the tail on the right-hand side of the distribution of each of these variables is longer than the tail on the left-hand side of the distribution of each of these variables.

This implies that the bulk of the values or observations of real effective exchange rate, interest rate, inflation rate and current account balance are greater than their mean and lie to the right of their mean. However, money supply is

negatively skewed. This means that the bulk of the values or observations of money supply are less than its mean and lie to the left of its mean.

Kurtosis measures the peakedness of a distribution. According to Hill, Griffiths and Lim (2012), the Jarque-Bera normality test assumes that a perfectly symmetrical series should have a kurtosis of three (3), skewness of zero (0) and probability value that is greater than any significant level specified. From Table 3, the values of kurtosis for real effective exchange rate, interest rate, current account balance and money supply are slightly less than three (3). This means that the distributions of each of real effective exchange rate, interest rate, current account balance and money supply are flatly shaped.

On the other hand, the value of kurtosis for inflation rate is far greater than three (3). This suggests that the distribution of inflation rate is peaked shaped. Also, the probability values of the Jarque-Bera statistic for real effective exchange rate, interest rate, inflation rate and money supply are less than the 5% significance level. As a result, the null hypothesis of normality of real effective exchange rate, interest rate, inflation rate and money supply is rejected in favour of the alternative hypothesis of non-normality of real effective exchange rate, interest rate, inflation rate and money supply. Notwithstanding, the probability value of the Jarque-Bera statistic for current account balance is greater than the 5% significance level. This implies that current account balance is normally distributed.

The maximum and minimum values of real effective exchange rate, interest rate, inflation rate and money supply are far from each other. This

indicates the presence of outliers in the series. This serves as a motivation for the use of Quantile Regression as an estimation or analytical technique.

**Table 3: Summary Statistics of the Variables**

|  | REER | INT | INF | CAB | MS |
|---|---|---|---|---|---|
| Mean | 103.2614 | 25.8077 | 143.9662 | -6.6339 | 25.5611 |
| Median | 103.2614 | 24.7000 | 126.1500 | -6.5556 | 25.7711 |
| Maximum | 162.6857 | 47.9300 | 1401.100 | 2.0635 | 34.3485 |
| Minimum | 53.3962 | 9.1300 | 5.3600 | -12.9237 | 13.9794 |
| St. Dev. | 23.7047 | 11.1106 | 138.3197 | 3.2544 | 4.9965 |
| Skewness | 0.7336 | 0.4082 | 2.6890 | 0.2669 | -0.3110 |
| Kurtosis | 2.7072 | 2.2645 | 21.8700 | 2.8560 | 2.5941 |
| Jarque-Bera | 31.3394 | 16.9036 | 5390.018 | 4.2781 | 7.7237 |
| P-value | (0.0000) | (0.0002) | (0.0000) | (0.1178) | (0.0210) |

Note: St. Dev. Represents Standard Deviation. REER=Real Effective Exchange Rate, INT=Interest Rate, INF=Inflation Rate, CAB=Current Account Balance and MS=Money Supply. Shown in the brackets are the Probability Values of the Jarque-Bera Statistic.
Source: Field Survey, Odoom (2019)

**Estimation of Exchange Rate Volatility (ERVOL)**

The study employs the Glosten, Jagannathan and Runkle (GJR) model; a form of Conditional Heteroscedastic Models to measure exchange rate volatility. According to Tsay (2010), to measure volatility using any of the conditional heteroscedastic models, it is crucial to test for the presence of ARCH effect in the series. The study employs the Langrangian Multiplier (LM) test as shown in Appendix A to check for ARCH effect in the real effective exchange rate series.

An examination of Appendix A shows that there is the presence of profound ARCH effects in the real effective exchange rate series. This is evident by the significance of the F-statistic at 5% significance level. As a result, the null hypothesis of no ARCH effect is rejected in favour of the alternative hypothesis of the presence of ARCH effect. Therefore, we can estimate exchange rate volatility using the Glosten, Jagannathan and Runkle model. The study, therefore, employs GJR (2, 1) to generate the conditional variance or exchange rate volatility. This is because GJR (2, 1) specification fully captures autocorrelation and heteroscedasticity in the variance of the sample as indicated in Appendix B and C.

Thus, from the Ljung-Box statistic of the squared standardized residuals in Appendix B, the probability values for the Autocorrelation, Partial Autocorrelation and the Q-Stat are not statistically significant at 5% and 10%. Likewise, from the Engle LM test for the presence of ARCH effect in Appendix C, the probability value of the F-statistic is also not statistically significant at 5% and 10%. This means that there is no autocorrelation and heteroscedasticity in the sample respectively.

The equation for the conditional variance with its parameters derived from Appendix D is given as:

$$\sigma^2_t = 1.6558 + 0.2255\varepsilon^2_{t-1} + 0.3468\varepsilon^2_{t-2} - 0.2429s_{t-1}\varepsilon^2_{t-1} + 0.41828\sigma^2_{t-1}$$

From the variance equation and Appendix D, previous information about exchange rate volatility represented by one lagged of the squared error ($\varepsilon^2_{t-1}$) and two lagged of the squared error ($\varepsilon^2_{t-2}$) has coefficients of 0.2255 and 0.3468 respectively. These coefficients are statistically significant at 10% and 5%

significant level respectively. This means that current exchange rate volatility is affected by its own past shocks or volatilities. This is in line with the results obtained by Alagidede and Ibrahim (2017) and Alam and Rahman (2012) who found that past volatilities of exchange rate affect its current volatility in Ghana and Malaysia respectively. Also, the significance of the one lagged of the square error and two lagged of the squared error is consistent with the Langrangian Multiplier test of the error term of exchange rate. This therefore indicates that GJR (2, 1) specification is appropriate for measuring exchange rate volatility.

The coefficient $\gamma_1$, has a value of -0.2429. This coefficient represents asymmetric effect and is statistically insignificant at 5% significance level. According to Musa and Bello (2014), asymmetric effect is a stylized fact in financial market which means that negative shocks tend to have a different effect on volatility of exchange rate compared to positive shocks. Since the coefficient is insignificant, the stylized fact 'asymmetric effect' is not present in Ghana. This is in line with the result obtained by Jabeen and Khan (2014) who found that the parameter $\gamma_1$, which represents asymmetric effect is negative and statistically insignificant for the Pak Rupee/US Dollar, Pak Rupee/Japanese Yen and Pak Rupee/British Pound exchange rates respectively.

Also, from Appendix D, persistence which is 0.8691 (computed as $0.2255 + 0.3468 - \frac{0.5726}{2} + 0.4182$) is less than 1. This implies that volatility shocks are high in Ghana. And it will remain so for a long time until equilibrium is established. This further suggests that there is the presence of volatility clustering. Volatility clustering is a stylized fact in financial market which illustrate a period in which large changes in exchange rate are followed by large

changes and small changes in exchange rate are followed by small changes as indicated by Musa and Bello (2014).

This finding is consistent with the empirical result obtained by Alagidede and Ibrahim (2017) who found out that exchange rate in Ghana exhibits some degree of volatility clustering. The issue of volatility clustering in the exchange rate is evident from the exchange rate volatility trend graph shown in Figure 1.
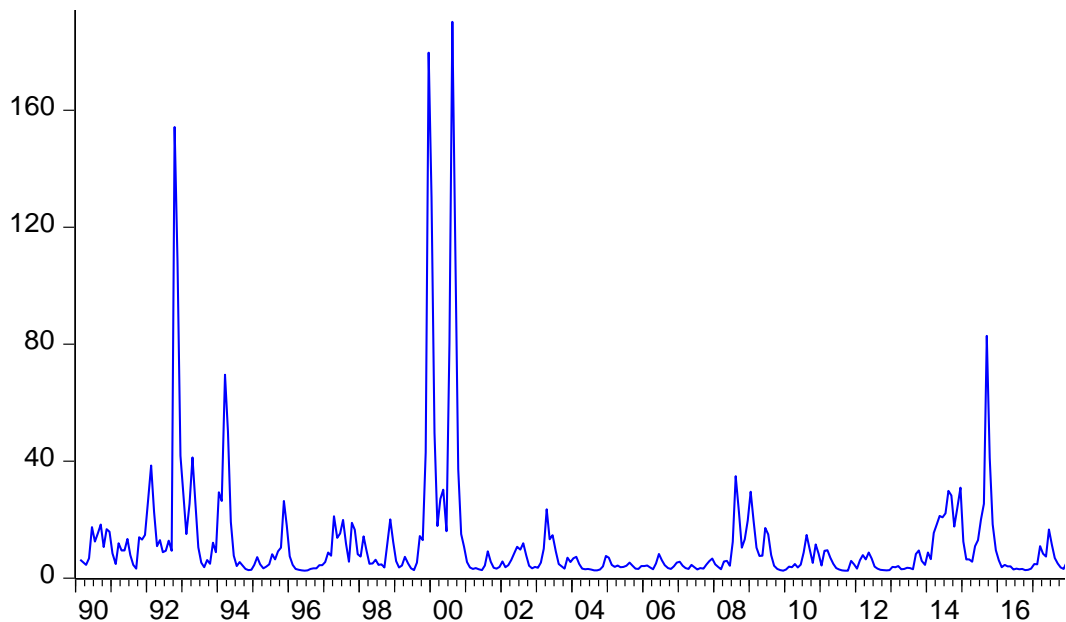


*Figure 1*: A Graph Showing Trend Analysis of Exchange Rate Volatility
Note: The graph in Figure 1 shows exchange rate volatility measured using GJR (2, 1). The variable on the vertical axis is exchange rate volatility whilst the variable on the horizontal axis is years in months.

From Figure 1, it can be observed that between 1990 and 2000 exchange rate volatility was extremely high. This higher level of volatility demonstrates a general pattern of depreciation of the cedi against the dollar. This was after the gradual changeover from the fixed exchange rate regime to the free-floating exchange rate regime in the early 1980s. During this period (i.e., between 1990 and 1998) prices of goods and services in the economy experienced a critical

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increment. This higher pattern in inflation rate were generally credited to extreme money supply (excess liquidity) and constrained food supply. Interest rate (e.g. the 91-day Treasury bill) was also trending downwards during this period. Inflation rate rose strongly in the year 2000 because of pressures from external and fiscal sectors of the economy.

The high rate of inflation in the year 2000 was as a result of higher expenditure incurred by the previous government during the election period resulting in increased money supply and a higher inflation rate. Inflation rate declined relentlessly in August 2001 into double digit and at the same time interest rate rose up. These led to a stability in the exchange rate between 2001 and 2006. In July 2007 the cedi was redenominated and it became one of the highly valued currencies from the least valued hitherto. During this period US$1was exchanged for GH¢0.92.

The move to the redenomination of the cedi caused the depreciation of the cedi against the dollar but at a lower rate between 2008 and 2009. This was because of overdependence on import, high inflation rate differentials and excess liquidity. Between the periods of 2010 and 2013 the exchange rate was moderately stable because of a decline in inflation rate to a single digit of 9.2%, and stringent fiscal and monetary strategies that were set up (Fosu, 2010).

The cedi/dollar exchange rate instability encountered a sharp spike between the periods of 2014 and 2015. This was because of a surge in import and thus putting pressure on the exchange rate thereby depreciating the cedi by a whopping 40%. In recent years the exchange rate has been volatile and it seems unending. According to the Economist Intelligence Unit, the cedi/dollar

exchange rate is expected to be more volatile and subsequently depreciate further against the US dollar by the year 2023.

**Correlation Analysis**

Table 4 depicts the correlation coefficients between exchange rate volatility and its determinants on one hand and among the determinants of exchange rate volatility on the other hand. These correlation coefficients range from -1 to +1 and measure the strength of the linear relationship between the variables. Shown in the brackets are probability values which test the statistical significance of the coefficients. Probability values which are below 5% show significance at 95% confidence level.

An examination of Table 4 reveals that there is a negative, significant and very strong correlation between exchange rate volatility and money supply. This implies that the higher the supply of money in the economy, the lower the volatility of exchange rate. Also, there is a positive, significant and strong correlation between exchange rate volatility and inflation rate. This means that the higher inflation rate, the higher the volatility of exchange rate in the economy.

However, the correlation between exchange rate volatility and interest rate is statistically significant, weak and negative. Alagidede and Ibrahim (2017) also found out that exchange rate volatility correlates weakly and negatively with interest rate. Likewise, exchange rate volatility negatively and weakly correlates with current account balance.

Among the independent variables, inflation rate correlate negatively and strongly with interest rate. Also, money supply correlates positively and strongly with inflation rate. Money supply weakly and negatively correlates

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with interest rate and current account balance. A critical examination of the correlation coefficients reveals that none of them is above 0.9. This means that there is no multicollinearity among the variables (Adam, 2017).

**Table 4: Correlation Coefficients among the Variables**

| Variables | ERVOL | INT | INF | CAB | MS |
|---|---|---|---|---|---|
| ERVOL | 1 | | | | |
| INT | -0.2302 (0.0000) | 1 | | | |
| INF | 0.4923 (0.0000) | -0.5509 (0.0000) | 1 | | |
| CAB | -0.1187 (0.0295) | 0.2563 (0.0000) | -0.3906 (0.0000) | 1 | |
| MS | -0.7378 (0.0000) | -0.2759 (0.0000) | 0.4851 (0.0000) | -0.1579 (0.0037) | 1 |

Note: ERVOL = Exchange Rate Volatility, INT= Interest Rate, INF= Inflation Rate, CAB= Current Account Balance and MS= Money Supply. The Probability values are in brackets.
Source: Field Survey, Odoom (2019)

**Unit root test**

Unit root test was conducted for time series data in order to prevent spurious regression. Spurious regression occurs when the regression result obtained is misleading and as a result it cannot be a basis to draw sound conclusions (Peterson & Adam, 2018). Also, according to Koenker and Xiao (2004), the use of quantile regression in time series analysis requires that all the variables used for the study should have a mean of zero and a constant variance (i.e. they should be stationary). This therefore requires unit root testing.

As a result, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were applied to all the variables in levels and in first difference so as to formally build up their order of integration and to ensure that they are

stationary. To be sure of the order of integration of all the variables, the test was done, firstly with constant only and secondly with constant and time trend in the model. The ideal number of lags incorporated into the test was based on automatic selection by Schwarz-Bayesian Criterion (SBC).

The study utilized the P-values in the brackets in tables 5, 6, 7 and 8 to settle on the unit root decision, (i.e., rejection or acceptance of the null hypothesis that the series contain unit root) which arrived at similar conclusion with the critical values. The outcomes of ADF test and PP test for unit root with intercept only and with intercept and trend in the model for every one of the variables are exhibited in Tables 5, 6, 7, and 8 respectively. The null hypothesis is that the series is non-stationary, or contains unit root. The rejection of the null hypothesis for the test depends on the MacKinnon (1991) critical and probability values.

Therefore, from Table 5, it can be deduced that all the variables are not stationary at levels for the ADF test at constant. This is because the probability values of the various variables at levels are greater than 1% significance level. As a result, the alternative hypothesis that the series does not contain unit root is rejected in favour of the null hypothesis that the series contain unit root. However, when all the variables were differenced for the first time, they became stationary at 1% significance level. That is, the alternative hypothesis that the series or variables does not contain unit root is accepted and the null hypothesis that the series contain unit root is rejected. This implies that all the variables are integrated at order one.

**Table 5: Results of Unit Root Test with constant only: ADF Test**

| Levels | | | | First Difference | | |
|---|---|---|---|---|---|---|
| Variables | ADF-Statistic | Lag | Variables | ADF-Statistic | Lag | $I(0)$ |
| lnERVOL | -2.9422[0.0417] | 1 | ΔlnERVOL | -15.1707[0.0000]*** | 0 | $I(1)$ |
| lnINT | -1.9707[0.2998] | 1 | ΔlnINT | -10.8176[0.0000]*** | 0 | $I(1)$ |
| lnINF | -2.0899[0.2490] | 9 | ΔlnINF | -5.4777[0.0000]*** | 7 | $I(1)$ |
| CAB | -2.5122[0.1135] | 13 | ΔCAB | -6.0947[0.0000]*** | 12 | $I(1)$ |
| lnMS | -3.0614[0.0306] | 14 | ΔlnMS | -4.8980[0.0000]*** | 13 | $I(1)$ |

Note: *** shows the rejection of the null hypothesis of non-stationary at 1% level of significance, Δ indicates first difference, and $I(0)$ is the order of integration. The values in brackets are the Probability values.
Source: Field Survey, Odoom (2019)

**Table 6: Results of Unit Root Test with constant and trend: ADF Test**

| Levels | | | | First Difference | | |
|---|---|---|---|---|---|---|
| Variable | ADF-Statistic | Lag | Variables | ADF-Statistic | Lag | I(0) |
| lnERVOL | -3.2818[0.0711] | 1 | ΔlnERVOL | -15.1599[0.0000]*** | 0 | $I(1)$ |
| lnINT | -2.6949[0.2394] | 1 | ΔlnINT | -10.8222[0.0000]*** | 0 | $I(1)$ |
| lnINF | -1.0314[0.9370] | 9 | ΔlnINF | -6.2413[0.0000]*** | 8 | $I(1)$ |
| CAB | -2.3446[0.4082] | 13 | ΔCAB | -6.1555[0.0000]*** | 12 | $I(1)$ |
| lnMS | -2.4821[0.3369] | 14 | ΔlnMS | -5.2252[0.0000]*** | 13 | $I(1)$ |

Note: *** shows the rejection of the null hypothesis of non-stationary at 1% level of significance, Δ indicates first difference, and $I(0)$ is the order of integration. The values in brackets are the Probability values.
Source: Field Survey, Odoom (2019)

From Table 6, it can be observed that all the variables are not stationary at levels for the ADF test with constant and time trend. This is because the probability values of the various variables at levels are greater than 1% significance level. As a result, the alternative hypothesis that the series does not contain unit root is rejected in favour of the null hypothesis that the series contain unit root. However, when all the variables were differenced for the first time, they became stationary at 1% significance level. That is, the alternative

hypothesis that the series or variables does not contain unit root is accepted and the null hypothesis that the series contain unit root is rejected. This implies that all the variables are integrated at order one.

**Table 7: Results of Unit Root Test with constant only: PP Test**

| Levels | | | | First Difference | | |
|---|---|---|---|---|---|---|
| Variables | PP-Statistic | Bwd | Variables | PP-Statistic | Bwd | I(0) |
| lnERVOL | -2.6789[0.0788] | 5 | ΔlnERVOL | -14.9084[0.0000]*** | 11 | *I*(1) |
| lnINT | -2.0270[0.2752] | 11 | ΔlnINT | -11.2156[0.0000]*** | 8 | *I*(1) |
| lnINF | -2.1371[0.2303] | 9 | ΔlnINF | -25.3651[0.0000]*** | 4 | *I*(1) |
| CAB | -2.7896[0.0608] | 12 | ΔCAB | -14.2256[0.0000]*** | 11 | *I*(1) |
| lnMS | -2.6178[0.0903] | 12 | ΔlnMS | -14.2225[0.0000]*** | 11 | *I*(1) |

Note: *** shows the rejection of the null hypothesis of non-stationary at 1% level of significance, Δ indicates first difference, and *I*(0)  is the order of integration. The values in brackets are the Probability values.
Source: Field Survey, Odoom (2019)

Table 7 depicts the unit root test using the Phillip Perron test with constant only. It can be observed that all the variables are not stationary at levels. This is because the probability values of the various variables at levels are greater than 1% significance level. As a result, the alternative hypothesis that the series does not contain unit root is rejected in favour of the null hypothesis that the series contain unit root. However, when all the variables were differenced for the first time, they became stationary at 1% significance level. That is, the alternative hypothesis that the series or variables does not contain unit root is accepted and the null hypothesis that the series contain unit root is rejected. This implies that all the variables are integrated at order one.

**Table 8: Results of Unit Root Test with constant and trend: PP Test**

| Levels | | | | First Difference | | | |
|---|---|---|---|---|---|---|---|
| Variable | PP-Statistic | Bwd | Variables | PP-Statistic | Bwd | I(0) | |
| lnERVOL | -2.9767[0.1404] | 4 | ΔlnERVOL | -14.9005[0.0000]*** | 12 | $I(1)$ | |
| lnINT | -2.7303[0.2250] | 11 | ΔlnINT | -11.2151[0.0000]*** | 8 | I(1) | |
| lnINF | -1.1692[0.9142] | 6 | ΔlnINF | -25.3104[0.0000]*** | 7 | $I(1)$ | |
| CAB | -2.7046[0.2355] | 12 | ΔCAB | -14.2311[0.0000]*** | 11 | $I(1)$ | |
| lnMS | -2.1791[0.4992] | 12 | ΔlnMS | -14.2894[0.0000]*** | 11 | $I(1)$ | |

Note: *** shows the rejection of the null hypothesis of non-stationary at 1% level of significance, Δ indicates first difference, and $I(0)$ is the order of integration. The values in brackets are the Probability values.
Source: Field Survey, Odoom (2019)

Finally, Table 8 depicts the unit root test using the Phillip Perron test with constant and time trend. It can be observed that all the variables are not stationary at levels. This is because the probability values of the various variables at levels are greater than 1% significance level. As a result, the alternative hypothesis that the series does not contain unit root is rejected in favour of the null hypothesis that the series contain unit root. However, when all the variables were differenced for the first time, they became stationary at 1% significance level. That is, the alternative hypothesis that the series or variables does not contain unit root is accepted and the null hypothesis that the series contain unit root is rejected. This implies that all the variables are integrated at order one.

**Serial Correlation test**

The Breusch-Godfrey serial correlation LM test was applied to the error term in the ordinary least square regression model. This was done in order to test the null hypothesis of no serial correlation as against the alternative

hypothesis of serial correlation. Presented in Table 9 is the result of the serial correlation test.

**Table 9: Breusch-Godfrey Serial Correlation Test for the OLS Model**

| F-statistic | 1.6160 | Prob. F(2,326) | 0.2003 |
|---|---|---|---|
| Obs*R-squared | 3.2788 | Prob. Chi-Square(2) | 0.1941 |

Source: Field Survey, Odoom (2019)

Presented in Table 9 is the result of the serial correlation test for the ordinary least square regression model. The F-statistic of 1.6160 has a probability value of 0.2003. This probability value is more than the 5% significance level. This implies that the null hypothesis of no serial correlation in the residual term is accepted whereas the alternative hypothesis of serial correlation in the residual term is rejected. Also, the Durbin Watson statistic of 1.91 in table 11, which is approximately 2 provides further evidence that there is no serial correlation in the residual term.

**Heteroscedasticity test**

In order to find out whether the variance of the residual term in the ordinary least square regression model is constant, Breusch-Pagan-Godfrey heteroscedasticity test was applied to the error term. The null hypothesis of homoscedasticity of the residual term whilst the alternative hypothesis of heteroscedasticity of the error term were tested and presented in Table 10.

**Table 10: Breusch-Pagan-Godfrey Heteroscedasticity Test for the OLS Model**

| F-statistic | 0.7477 | Prob. F(5,328) | 0.5886 |
|---|---|---|---|
| Obs*R-squared | 3.7618 | Prob. Chi-Square(5) | 0.5842 |
| Scaled explained SS | 10.5522 | Prob. Chi-Square(5) | 0.0610 |

Source: Field Survey, Odoom (2019)

From the result presented in Table 10, the F-statistic of 0.7477 has a probability value of 0.5886. This probability value is more than the 5% significance level. This implies that the null hypothesis of homoscedasticity in the residual term is accepted whereas the alternative hypothesis of heteroscedasticity in the residual term is rejected. Therefore, there is no heteroscedasticity in the residual term

**Normality test**

To check whether the error term in the ordinary least square model is normally distributed, the Jarque-Bera normally test was applied to the residual term. The null hypothesis of normality of the residual term whilst the alternative hypothesis of non-normality of the residual term were tested and presented in Appendix E.

From Appendix E, it can be observed that the Jarque-Bera statistic of 3.7754 has a probability value of 0.1514. This probability value is greater than the 5% significance level. This implies that the null hypothesis of normality of the residual term is accepted whereas the alternative hypothesis of non-normality of the residual term is rejected. It is also evident from the classical bell-shaped, symmetric histogram with most of the frequency counts dying off out in the tails in Appendix E that the error term is normally distributed.

**Regression Analysis**

Regression analysis was conducted to assess the magnitude and direction of the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility. By so doing, the results obtained by the Quantile Regression estimator was compared to that of the Ordinary Least Square Regression estimator in order to point out some differences

between them. Note that before the regression analysis was conducted the natural logarithms of all the variables except current account balance were taken in order to reduce the variability within the series. The natural logarithm of current account balance was not taken because most of the values in the series were negative; and we cannot take logarithm of negative numbers.

Dependent variable: Exchange rate volatility (ERVOL)
**Table 11: Regression Analysis**

| Variable | | | Model 1 QR | | | Model 2 OLS |
|---|---|---|---|---|---|---|
| | 10th | 35th | 50th | 75th | 95th | |
| Constant | -0.5591** | -0.0890** | -0.0019 | 0.1956** | 0.8681** | -0.0050 |
| | (0.0712) | (0.0215) | (0.0212) | (0.0263) | (0.0834) | (0.0293) |
| lnINT | -1.3771** | -0.1625 | -0.4305 | -1.5163* | -1.4029** | -0.5649 |
| | (0.6007) | (0.4110) | (0.5573) | (0.8124) | (0.6131) | (0.4559) |
| lnINF | 0.0030 | 0.3846** | 0.3359** | 0.1740 | 1.1584** | 0.1392 |
| | (0.0586) | (0.0859) | (0.1205) | (0.1314) | (0.1321) | (0.2338) |
| CAB | -0.1066 | -0.1050** | -0.0944** | -0.1362** | -0.0646 | -0.1086* |
| | (0.0657) | (0.0382) | (0.0399) | (0.0558) | (0.0751) | (0.0570) |
| lnMS | -1.6754 | -2.6613** | -2.2306* | -4.7185** | -0.8840 | -1.9901 |
| | (1.5030) | (1.1117) | (1.1786) | (0.8619) | (1.7686) | (1.6004) |
| R Squared | | | | | | 0.04 |
| Pseudo R Squared | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | |
| DW | | | | | | 1.91 |

Note: QR=Quantile Regression, OLS=Ordinary Least Square, lnINT= Log of Interest Rate, lnINF=Log of Inflation Rate, CAB=Current Account Balance, lnMS=Log of Money Supply and DW=Durbin Watson, ** and * denote significance levels at 5% and 10% respectively. Shown in ( ) are the standard errors.
Source: Field Survey, Odoom (2019)

Table 11 presents the regression results obtained for the impact of interest rate, inflation rate, current account balance and money supply on exchange rate volatility. The results presented in Table 11 is based on two baseline models. Model 1 in the second column of Table 11 provides the

coefficients of the independent variables obtained from the quantile regression estimate. Whilst Model 2 in the third column of Table 11 provides the coefficients of the independent variables obtained from the ordinary least square regression estimate. In fact, Model 1 indicated by the quantile regression provides the coefficients of each of the independent variables at the 10th, 35th, 50th, 75th and 95th percentiles of the dependent variable (exchange rate volatility).

Table 11 also provides some crucial indicators of both Model 1 (quantile regression) and Model 2 (ordinary least square regression). These include Pseudo R squared for each of the percentiles/quantiles of the dependent variable (for the quantile regression model), Durbin Watson statistic and R squared (for the ordinary least square model). Also, shown in the parenthesis are the standard errors.

Form Table 11, it can be observed that the coefficients for the variables at various quantiles of exchange rate volatility differs. This is so, because the quantile regression estimator ranks the observations in the dependent variable (exchange rate volatility) from the lowest to the highest. Thereafter, it segregates the observations into quantiles as specified by the researcher. From then, the impact of the covariates or independent variables (interest rate, inflation rate, current account balance and money supply) are assessed on each of the quantiles of the dependent variable (exchange rate volatility) as indicated by Koenker and Hallock (2001). Unlike ordinary least square regression which assesses the impact of the regressors on the average or mean of the dependent variable. However, according to Koenker and Hallock the magnitude of the observations representing each quantile differs for the various quantiles. This

makes the coefficients for the variables at various quantiles on exchange rate volatility differs.

**Regression result obtained for the impact of Interest Rate on Exchange Rate Volatility in Ghana.**

This section discusses the outcome of the impact of interest rate on exchange rate volatility in Ghana. From the results presented in Table 11, it is observed that for the quantile regression estimate (Model 1), the coefficient of interest rate is negative and statistically insignificant at 35th percentile and 50th percentile of exchange rate volatility at both 5% and 10% significant levels. Interest rate has coefficients of approximately -0.16 and -0.43 at 35th percentile and 50th percentile of exchange rate volatility respectively.

Likewise, interest rate is negative and statistically insignificant at both 5% and 10% significant levels for the ordinary least square regression estimate (Model 2) with coefficient of approximately -0.56. This indicates that interest rate does not have any significant impact on exchange rate volatility at the 35th percentile, 50th percentile and for the ordinary least square estimate. This connects to the findings of Alagidede and Ibrahim (2017), who found that interest rate does not have any significant impact on exchange rate volatility in Ghana.

However, at the 10th percentile, 75th percentile and 95th percentile of exchange rate volatility, interest rate is negative and statistically significant at 5%, 10% and 5% significant levels respectively. Besides, interest rate has coefficients of approximately -1.37, -1.5163 and -1.40 at the 10th percentile, 75th percentile and 95th percentile of exchange rate volatility respectively. As result, 1% increase in interest rate will lead to approximately 1.37%, 1.52% and

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1.40% decrease in exchange rate volatility at the 10th, 75th and 95th percentiles respectively. Interest rate therefore has negative and statistically significant impact on exchange rate volatility at most of the quantiles of exchange rate volatility.

The negative impact of interest rate on exchange rate volatility links to the findings of Mpofu (2016). According to Mpofu, an increase in interest rate attracts foreign investors and a greater amount of capital inflows. This prevents the persistent fluctuations in exchange rate and the depreciation of the domestic currency caused by increased demand of foreign currencies than supply of foreign currencies. It also arrests speculative attacks on the exchange rate.

This also links to the findings of Sarac and Karagoz (2016), who found that a higher interest rate serves as a protective mechanism for restraining an increase in exchange rate volatility in Turkey. Also, Ajao and Igbokoyi (2013) revealed that a rise in interest rate contributes immensely to a reduction in exchange rate volatility in the Nigerian economy. Similarly, Mirchandani (2013) found out that interest rate negatively influences exchange rate volatility in India.

However, the result of this study is not consistent with the results obtained by Nortey et al. (2015) in Ghana who argued that interest rate has a positive effect on exchange rate volatility. Likewise, it contradicts with the result obtained Hassan et al. (2017) in Nigeria, who found that interest rate has a positive impact on exchange rate volatility.

It can be observed that impact of interest rate on exchange rate volatility tends to be higher at the upper tail (specifically the 75th and 90th percentiles) than at the lower tail. The result obtained for the impact of interest rate on

exchange rate volatility differs considerably from other studies especially the Ghanaian studies. This is because the analytical technique, frequency of the data used, economic conditions of the period of the study and the data span used in this study differs from the existing studies.

The negative impact of interest rate on exchange rate volatility is therefore in accordance with the priori expectation for the study based on the theoretical literature discussed in Chapter 2. Also, based on the outcome of this study, the null hypothesis that interest rate has no impact on exchange rate volatility in Ghana is rejected in favour of the alternate hypothesis that interest rate has an impact on exchange rate volatility in Ghana.

**Regression result obtained for the impact of Inflation Rate on Exchange Rate Volatility in Ghana.**

This section discusses the effect of inflation rate on exchange rate volatility in Ghana. From the quantile regression estimate (Model 1) in Table 11, the coefficient of inflation rate is positive and statistically insignificant at both 5% and 10% significance levels at the 10th percentile and 75th percentile of exchange rate volatility respectively. Also, interest rate has coefficients of approximately 0.003 and 0.17 at the 10th percentile and 75th percentile of exchange rate volatility respectively. Similarly, from the ordinary least square regression estimate (Model 2) inflation rate is positive and statistically insignificant at both 5% and 10% significance levels with coefficient of approximately 0.14

This implies that inflation rate does not contribute to exchange rate instability or volatility at the 10th percentile and 75th percentile of exchange rate volatility, and for the ordinary least square estimates (on the average of

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exchange rate volatility). This result is consistent with the outcome of the study conducted by Kurihara (2013), who found out that inflation rate has positive and statistically insignificant impact on exchange rate volatility for all the 28 countries included in the study. Likewise, Gidigbi et al. (2018) found that inflation rate has no impact on exchange rate volatility in Nigeria.

Notwithstanding, inflation rate is positive and statistically significant at 5% significance level at the 35th percentile, 50th percentile and 95th percentile of exchange rate volatility with coefficients of approximately 0.38, 0.34 and 1.15 respectively. This means that 1% increase in inflation rate will increase exchange rate volatility by approximately 0.38%, 0.34% and 1.15% at the 35th percentile, 50th percentile and 95th percentile of exchange rate volatility respectively. Thus, inflation rate contributes to instability in exchange rate at majority of the percentiles of exchange rate volatility.

This finding is in accordance with the result obtained by Adeniji (2013), who found out that inflation rate has a positive impact on exchange rate volatility in Nigeria. According to Kibiy and Nasieku (2016), the persistence increase in exchange rate volatility is due to a rise in the general price level in Kenya. Therefore, increase in inflation rate (representing a rise in general price level) causes an increase in exchange rate volatility. Also, Obiekwe (2016) revealed that the persistence increments in inflation rate which leads to excessive fluctuation in exchange rate in Nigeria, is due to excess liquidity in the economy. The volatile behavior of exchange rate in Nigeria therefore weakens the value of the Naira, which makes people loss confidence in the Nigerian currency as a store of value and a medium of settlement.

Besides, a study conducted by Fabris and Vujanovic (2017) in Serbia revealed that a higher rate of inflation causes financial dollarization. Financial dollarization occurs when a foreign currency (especially in US dollars) is used as a medium of exchange and a store of value in the domestic economy. As a result, Tweneboah (2015), argued that financial dollarization resulting from increased inflation rate increases exchange rate volatility in Ghana.

Therefore, frequent fluctuations of exchange rate in Ghana can also be attributed to financial dollarization resulting from a higher inflation rate.  The implication is that continuous demand of foreign currency in Ghana increase instability in exchange rate and puts more downward pressure on the cedi which eventually leads to its depreciation. Similarly, Nortey et al. (2015) in Ghana and Ali et al. (2015) in Pakistan also found that inflation rate has a positive influence on exchange rate volatility.

The outcome of this study contradicts with the findings of Adusei and Gyapong (2017) and Obiekwe and Osubuohien (2016) who argued that inflation rate negatively influences exchange rate volatility in Ghana and Nigeria respectively. That is, an increase in inflation rate decreases exchange rate volatility.

It can be observed that inflation rate has a higher impact on exchange rate volatility at the upper tail of the distribution (specifically at the 95th percentile) than at the lower tail. The results obtained for the impact of inflation rate on exchange rate volatility differs considerably from other studies especially the Ghanaian studies. This is because the analytical technique, frequency of the data used, economic conditions of the period of the study and the data span used in this study differs from the existing studies.

However, the positive impact of inflation rate on exchange rate volatility matches with the priori expectation for the study based on the theoretical literature discussed in Chapter 2. Also, base on the regression result, the null hypothesis that inflation rate has no impact on exchange rate volatility in Ghana is rejected in favour of the alternate hypothesis that inflation rate has an impact on exchange rate volatility in Ghana.

**Regression results obtained for the impact of Current Account Balance on Exchange Rate Volatility in Ghana.**

This section discusses the outcome of the impact of current account balance on exchange rate volatility. From the regression result in Table 11, the coefficient of current account balance is negative and statistically significant at 5% significant level at the 35th percentile, 50th percentile and 75th percentile of exchange rate volatility for the quantile regression estimate. Current account balance therefore has coefficients of approximately -0.11, -0.09 and -0.14 at the 35th percentile, 50th percentile and 75th percentile of exchange rate volatility respectively.

This means that 1% increase in current account balance will decrease exchange rate volatility by approximately 0.11%, 0.09% and 0.14% at 35th percentile, 50th percentile and 75th percentile of exchange rate volatility. It can therefore be observed that current account balance is negative and statistically significant at most of the quantiles of exchange rate volatility.

Also, the coefficient of current account balance is negative and statistically significant at 10% significance level for the ordinary least square regression estimate with coefficient of approximately -0.11. This implies that

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on the average, 1% increase in the current account balance will lead to approximately 0.11% decrease in exchange rate volatility.

This result is in line with the findings of Bank of Uganda (2011). The result of their study revealed that current account balance restrains exchange rate volatility in Uganda. Also, Haque and Boger (2011) revealed that current account balance negatively impacts the volatility of the dollar/yen exchange rate. In Ghana, Adusei and Gyapong (2017) found that current account balance reduces exchange rate volatility.

Notwithstanding, the coefficient of current account balance is negative and statistically insignificant at both 5% and 10% significance levels at the 10th percentile and 95th percentile of exchange rate volatility. This implies that current account balance has no impact on exchange rate volatility at the 10th percentile and 95th percentile of exchange rate volatility. This result is in line with that of Mirchandani (2013) who found that current account balance has no impact on exchange rate volatility in India.

However, the negative impact of current account balance on exchange rate volatility is not consistent with Razi et al. (2012). They found in their study that an increase in current account balance increases exchange rate volatility. The authors argued that when import is greater than export, the outcome is a deficit in the current account balance. When a country therefore records persistent deficit in its current account balance overtime, it translates into persistent movements in its exchange rate (exchange rate volatility) thereby leading to a depreciation of its currency.

It can be observed that current account balance tends to have a greater impact on exchange rate volatility at the upper tail of the distribution

(specifically at the 75<sup>th</sup> percentile) than at the lower tail. The result obtained for the impact of current account balance on exchange rate volatility differs considerably from other studies. This is because the analytical technique, frequency of the data used, economic conditions of the period of the study and the data span used in this study differs from the existing studies.

The negative impact of current account balance on exchange rate volatility is in accordance with the priori expectation for the study base on the theoretical literature discussed in Chapter 2. In addition, base on the regression result, the null hypothesis that current account balance does not have any impact on exchange rate volatility in Ghana is rejected in favour of the alternate hypothesis that current account balance has an impact on exchange rate volatility in Ghana.

**Regression result obtained for the impact of Money Supply on Exchange Rate Volatility in Ghana.**

This section discusses result of the impact of money supply on exchange rate volatility in Ghana. Here, a very interesting and surprising result is obtained. It can be observed from Table 11 that the coefficient of money supply is negative and statistically insignificant at both 5% and 10% significance levels on the 10th percentile and 95th percentile of exchange rate volatility. Money supply therefore has coefficients of approximately -1.68 and -0.88 on the 10th percentile and 95th percentile of exchange rate volatility respectively.

Likewise, the coefficient of money supply is negative and statistically insignificant at both 5% and 10% significance levels for the ordinary least square regression estimate with a coefficient of approximately -1.99. This means that money supply does not have any impact on exchange rate volatility

at the 10th percentile, 95th percentile and for the ordinary least square regression (average) estimate.

This result conforms to the findings of Odera (2015) and Ajao and Igbokoyi (2013) who found that money supply does not have any significant impact on exchange rate volatility in Kenya and Nigeria respectively. Also, Insah and Chiaraah (2013) in their study, found that the coefficient of money supply was negative but do not have any significant impact on exchange rate volatility in Ghana.

However, the coefficient of money supply is negative and statistically significant at 5%, 10% and 5% significance levels at the 35th, 50th and 75th percentiles respectively. And also, with coefficients of approximately -2.66, -2.23 and -4.72 at the 35th, 50th and 75th percentiles of exchange rate volatility respectively. This implies that 1 percent increase in money supply will reduce exchange rate volatility by approximately 2.66%, 2.23% and 4.72% at the 35th, 50th and 75th percentiles of exchange rate volatility respectively. From the quantile regression estimate, money supply significantly and negatively influences exchange rate volatility at most of the quantiles. Therefore, money supply has the ability to significantly decrease exchange rate volatility in Ghana.

This result is in accordance with Pham (2018), who found out that money supply has the tendency to reduce exchange rate volatility in developing countries. The author argued that money supply will decrease exchange rate volatility in developing countries when their financial markets are developed extensively.   Pham also claimed that money supply negatively impacts exchange rate volatility in developed countries when their financial institutions

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are enhanced. Ajao (2015) also supported the claim that money supply negatively impacts exchange rate volatility in Nigeria.

However, the result does not conform to the findings of Adeoye and Saibu (2014) Ali et al. (2015) and Kilicarslan (2018) who argued that increased money supply raises general price levels (causes inflation) and eventually accelerates exchange rate volatility. That is, they found that money supply has a positive impact on exchange rate volatility.

It can be observed that money supply tends to have a greater impact on exchange rate volatility at the upper tail of the distribution (specifically at the 75th percentile) than at the lower tail. The result obtained for the impact of money supply on exchange rate volatility differs considerably from other studies especially the Ghanaian studies. This is because the analytical technique, frequency of the data used, economic conditions of the period of the study and the data span used in this study differs from the existing studies.

The negative impact of money supply on exchange rate volatility is not in line with the priori expectation for the study base on the theoretical literature discussed in Chapter 2. Also base on the regression result, the null hypothesis that money supply does not have any impact on exchange rate volatility in Ghana is rejected in favour of the alternate hypothesis that money supply has an impact on exchange rate volatility in Ghana.

From Table 11, the Pseudo R squared indicates that 2% of the variations in exchange rate volatility is explained by interest rate, inflation rate, current account balance and money supply at the 10th, 35th, 50th and 75th percentiles respectively. Also, 3% of the variations in exchange rate volatility is also

explained by interest rate, inflation rate, current account balance and money supply at the 95th percentile.

Again, from the ordinary least square regression estimates (Model 2), the R squared implies that about 4% of the variations in exchange rate volatility are explained by interest rate, inflation rate, current account balance and money supply. Also, the R squared value of 0.04 is less than the Durbin Watson statistic of 1.91. This provides further evidence that there is no serial correlation in the error term in the ordinary least square regression model.

It can be seen from Table 11 that all the variables are significant at most of the quantiles of exchange rate volatility. Also, the quantile regression estimates (Model 1) are different from the ordinary least square regression estimates (Model 2) for all the variables. This indicates that the conditional distributional effects of the quantile regression model provide a more comprehensive picture than the "average" ordinary least square regression effects. This implies that using ordinary least square regression model alone does not provide a complete picture of the effect of the independent variables on the dependent variable.

In addition, it is evident from Table 11 that the standard errors produced by the quantile regression model estimate (Model 1) at most of the quantiles are less than those obtained by the ordinary least square regression model estimate (Model 2). This means that quantile regression has the ability to reduce as much as possible absolute errors in its computation than ordinary least square regression.

Furthermore, quantile regression model (Model 1) is more robust to outliers than the ordinary least square regression (Model 2). This is because

quantile regression is able to rank all the observation in the dependent variable from the lowest to the highest and then segregate them into quantiles of interest. The segregation is done to ensure that each quantile contains observations that have similar characteristics. And the effect of the independent variables on the respondent variable is assessed separately for each quantile. As a result, when there are outliers in the respondent variable, quantile regression deals with them separately at different quantile(s). This task cannot be performed by the ordinary least square regression model and the results obtained by it are adversely affected by outliers.

Also, quantile regression model (Model 1) does not make any assumption of the error term in the regression model (assumption free). It is evident from the study that no diagnostics tests like normality test, serial correlation test and heteroscedasticity test are done on the error term in the case of quantile regression. Quantile regression is thus simple and straight forward.

It can also be deduced that quantile regression model is more robust than ordinary least square model because it is not sensitive to the violation of the model distribution assumptions.

The results obtain for this study especially the regression result differs from existing studies particularly Ghanaian studies. This is because the analytical technique used, the period of analysis and economic conditions prevailing in the period of this study differs from that of the existing studies.

Finally, it is observe that quantile regression allows us to know the impact of the covariates at the lower tail, median and higher tail of the distribution of the response variable. But the ordinary least square regression just shows the impact of the covariates on the average of the response variable.

**Chapter Summary**

In this chapter, the time series properties of all the variables used for the study were examined, presented and discussed. This was done to prevent spurious regression in both quantile and ordinary least square regression models. As a result, both Augumented Dickey Fuller and Phillip Perron tests were conducted and the results showed that all the variables were to be differenced once to attain stationarity. This means that all the variables were integrated at order one.

Autocorrelation, heteroscedasticity and normality tests on the residual term in the ordinary least square regression model were also carried out. The results revealed that the error term does not correlate with their lags. Also, the error term is homoscedastic. And finally, the error term is normally distributed.

The results obtained by the ordinary least square regression in part and the quantile regression as a whole revealed that interest rate, current account balance and money supply exert negative and statistically significant impact on exchange rate volatility in Ghana. Whereas inflation rate has positive and significant impact on exchange rate volatility in Ghana.

Also, the results obtained by the regression analysis showed that the quantile regression model (QRM) estimates are different than ordinary least square (OLS) regression estimates. This is because, in terms of conditional distributional effects, quantile regression provides more comprehensive picture than ordinary least square regression.

From table 11, it can be observed that the quantile regression estimates provides information about the impact of the covariates on the lower tail, median and upper tail of the distribution of the response variable.

In addition, quantile regression is able to minimize absolute errors in its computation than ordinary least square regression.

Lastly, quantile regression does not require diagnostic test such as normality, autocorrelation and heteroscedasticity tests on the error term. It does not also have any assumptions underpinning it (assumption free). It is simple and straight forward than ordinary least square.

## CHAPTER FIVE

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

**Introduction**

This chapter presents the summary of the entire study. The chapter also presents a summary of the findings, conclusions, recommendations as well as the suggestions for further research.

**Summary of the Research**

Exchange rate volatility is a major problem facing most developing countries especially Ghana. According to literature various forms of factors determine exchange rate volatility. However, the study emphasized interest rate, inflation rate, current account balance and money supply. This is because the aforementioned variables are the major economic indicators influencing exchange rate volatility in Ghana. Also, the level of exchange rate is a function of the aforementioned variables. As a result, the study finds out whether these actors encourage or discourage exchange rate volatility in Ghana.

The theories linking exchange rate volatility to the aforementioned variables are the International Fisher Effect Theory, Purchasing Power Parity Theory, Elasticity Approach to Exchange Rate Determination and Dornbusch Exchange Rate Overshooting Model. The empirical review also posited that the impact of the aforementioned factors on exchange rate volatility differs from country to country. This is because of varying economic conditions, estimation techniques, frequency of data used, study periods and economic policies.

The study was based on the positivism research paradigm and quantitative research approach. The study also adopted the explanatory research

design to estimate the various models. Furthermore, the study employed monthly data on all the variables for the period of 1990 to 2017. The study also developed five baseline models. The first and second model specifications which are quantile regression and ordinary least square regression models respectively sought to establish the effect of the independent variables on dependent variable and also to point out the differences between the results obtained by these estimators. The third model sought to measure exchange rate volatility. Finally, the fourth and fifth models are Augmented Dickey Fuller and Phillip Perron unit root test models respectively.

Descriptive statistics was presented to display the characteristics of each of the variables. Trend analysis of exchange rate volatility was shown and interpreted in order to know the level of fluctuations that have occurred in the exchange rate over the period of the study. Correlation analysis was done to assess the direction and the strength among the variables. Unit root test was conducted using Augumented Dickey Fuller and Phillip Peron tests to ensure that the variables are stationary, know the order of integration of the variables and also to prevent spurious regression.

Diagnostics tests such as serial correlation, heteroscedasticity and normality tests on the error term in the ordinary least square regression model were performed. These were done because the study employed time series data in its analysis and also to ensure that the ordinary least square regression is appropriate in establishing the effects of the independent variables on dependent variable.

**Summary of Findings**

Several insightful and significant results that have good economic implications emerged from the findings of this study. The first objective of the study was to examine the impact of interest rate on exchange rate volatility in Ghana. The second objective determined the impact of inflation rate on exchange rate volatility in Ghana whiles the third objective analyzed the impact of current account balance on exchange rate volatility in Ghana. Finally, the fourth objective was to assess the impact of money supply on exchange rate volatility in Ghana.

**Table 12: Summary of Results on the Hypotheses**

| Hypotheses | Confirmation |
|---|---|
| $H_0$: Interest rate has no impact on exchange rate volatility in Ghana. | Rejected |
| $H_0$: Inflation rate has no impact on exchange rate volatility in Ghana. | Rejected |
| $H_0$: Current account balance has no impact on exchange rate volatility in Ghana. | Rejected |
| $H_0$: Money supply has no impact on exchange rate volatility in Ghana. | Rejected |

Source: Field Survey, Odoom (2019)

From the results on the first objective, a strong evidence was found that interest rate had a significant negative impact on exchange rate volatility in Ghana. This means that an increase in interest rate will reduce exchange rate volatility. Also, based on the second objective, inflation rate had a significant positive impact on exchange rate volatility. This implies that a rise in inflation rate will increase exchange rate volatility.

Results on the third objective indicated that current account balance had a significant negative impact on exchange rate volatility in Ghana. This signifies

that a favourable increase in current account balance will contribute to a reduction in exchange rate volatility. Finally, the results on the fourth objective proved that money supply had a significant negative impact on exchange rate volatility. That is, money supply has the tendency to reduce exchange rate volatility in Ghana.

The trend analysis revealed that the cedi/dollar exchange rate has been highly volatile over the period of the study. The correlation analysis also revealed that there was a strong negative and statistically significant correlation between exchange rate volatility and money supply. However, inflation rate correlated with exchange rate volatility positively, highly and statistically significantly. However, both interest rate and current account balance negatively, weakly and significantly correlated with exchange rate volatility.

The results from the unit root test obtained from both Augmented Dickey Fuller and Phillip Perron tests revealed that all the variables were differenced once in order to attain stationarity. Also, the diagnostics tests conducted on the error term in the ordinary least square regression showed that it was free from serial correlation, heteroscedasticity and it was normally distributed.

The study further pointed out some differences between quantile regression and ordinary least square regression. The results obtained indicated that quantile regression estimates are different from the ordinary least square regression estimates. This was because, in terms of conditional distributional effects, quantile regression was able to provide a comprehensive picture than ordinary least square. This is because quantile regression provides results for

the impact of the regressors on the lower tail, median and higher tail of the distribution of the response or dependent variable.

In addition, quantile regression is simple and straight forward. That is, it does not have any underlying assumptions and does not involve any diagnostic tests such as serial correlation, heteroscedasticity and normality tests on the error term. Quantile regression is also more robust to outliers than ordinary least square regression. Because quantile regression is able to model for observations that have similar characteristics and the outlier cases at the same time. Also, unlike ARDL and VECM, quantile regression can be used for estimation irrespective of the order of integration of the variables. Thus, even if the variables are integrated beyond order one or are differenced more than once, quantile regression can be used as an analytical technique.

The results obtained for this study especially the regression results, differ considerably from existing studies, particularly the Ghanaian studies. This is because the analytical technique employed, economic conditions that prevailed, the frequency of the data used and the period of analysis considered in this study differ from existing studies.

**Conclusions**

Base on the results, the conclusion on the first objective is that an improvement in interest rate depress exchange rate volatility in Ghana because interest rate has a significant negative effect on exchange rate volatility. Also, the conclusion on the second objective is that inflation rate has a positive impact on exchange rate volatility. Hence, an enhancement in the inflation rate in Ghana encourages volatility in the exchange rate.

In relation to the third objective, the study concludes that current account balance has a negative impact on exchange rate volatility. As a result, current account balance depresses exchange rate volatility in Ghana. Finally, on the fourth objective, it is concluded that money supply has a negative impact on exchange rate volatility. Hence, money supply restrains exchange rate volatility in Ghana.

The study also concludes that quantile regression model is more robust than ordinary least square regression model. This is because quantile regression is insensitive to outliers and the violation of model distributional assumptions.

Base on the results, the conclusion on the first hypothesis is that interest rate has an impact on exchange rate volatility in Ghana. In relation to the second hypothesis, it is concluded that inflation rate has an impact on exchange rate volatility in Ghana.

In relation to the third hypothesis, it is concluded that current account balance has an impact on exchange rate volatility in Ghana. Finally, on the fourth hypothesis, it is concluded that money supply has an impact on exchange rate volatility in Ghana.

**Recommendations**

In relation to the first objective, the Bank of Ghana should increase interest rate on financial assets such as Treasury bill rate, bonds and so on. Success in this regard will stabilize exchange rate in Ghana.

Base on the second objective, a low inflation rate is required to ensure that a stable exchange rate is achieved. This is because an increase in inflation rate will trigger serious threat in maintaining a stable exchange rate in Ghana.

In relation to the third objective, current account balance must be improved to stabilize exchange rate in Ghana. The Bank of Ghana should put in place policies that tend to improve the current account balance. Measures to improve the current account balance include, increasing duties and tariffs on imported products that can equally be produced in Ghana.

The Ghana Export Promotion Council should also support local industries in areas such as packaging and standardization of locally manufactured product. This will help locally made products to withstand keen competition in the international market thereby increasing their demand to improve the current account balance and stabilize exchange rate.

Also, based on the result obtained for the fourth objective, the central Bank of Ghana has a part to play in stabilizing exchange rate in Ghana. So they should adopt a monetary policy mix that seeks to restrain volatility of exchange rate.

Finally, it is also recommended that quantile regression should be used more often because it is simple, precise, accurate and comprehensive in terms of assessing the impact of the covariates on the distribution of the response variable than ordinary least square regression model. Also, both quantile regression model and ordinary least square regression model can be used to provide a further comprehensive result.

**Suggestions for Further Research**

First of all, other studies can extend this current study by examining the impact of political regime and commodities prices such as cocoa, gold, crude oil and cereal prices on exchange rate volatility in Ghana. Also, further studies

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can examine the effect of exchange rate volatility on debt servicing and consumption in Ghana.

Again, other studies can use a higher frequency data such as weekly and daily data in their analysis. They can also use other asymmetric models such as Integrated GARCH, Student t-GARCH, GARCH in the Mean, Exponential GARCH, Threshold GARCH and Dynamic Conditional Correlation GARCH to measure exchange rate volatility.

# REFERENCES

Adam, M. A. (2017). *Statistics for Business Research*. Ghana: Global Research Publishers.

Abakah, E. (2009). *Impact of monetary policy on stock prices in Ghana.* (Master's thesis, Kwame Nkrumah University of Science and Technology). Retrieved July 10, 2019, from ir.knust.edu.gh/handle/ 123456789/585

Adascalitei, S. (2015). *The importance of high frequency data on the financial markets. Proceedings from International Academic Conference.* International Institute of Social and Economic Sciences.

Adeniji, S. (2013). Exchange rate volatility and inflation upturn in Nigeria: Testing for Vector Error Correction Model. *Munich Personal RePEc Archive*, 1-19.

Adeoye, B. W., & Saibu, O. M. (2014). Monetary policy shocks and exchange rate volatility in Nigeria. *Asian Economic and Financial Review, 4*(4), 544-562.

Adu-Gyamfi, A. (2011). *Assessing the impact of exchange rate volatility on economic growth in Ghana* (Master's thesis, Kwame Nkrumah University of Science and Technology). Retrieved July 15, 2019, from ir.knust.edu.gh/xmlui/ handle/123456789/4682

Adusei, M., & Gyapong, E. Y. (2017). The impact of macroeconomic variables on exchange rate volatility in Ghana: The partial least squares structural equation modelling approach. *Research in International Business and Finance*, *42*, 1428-1444.

Ajao, M. G. (2015). The determinants of real exchange rate volatility in Nigeria. *Ethiopian Journal of Economics*, *24*(2), 43-62.

Ajao, M. G., & Igbekoyi, O. E. (2013). The determinants of real exchange rate volatility in Nigeria. *Academic Journal of Interdisciplinary Studies*, *2*(1), 459-471.

Al Samara, M. (2009). The determinants of real exchange rate volatility in the Syrian economy. *Exchange Organizational Behavior Teaching Journal*, 1-36.

Alagidede, P., & Ibrahim, M. (2017). On the causes and effects of exchange rate volatility on economic growth: Evidence from Ghana. *Journal of African Business*, *18*(2), 169-193.

Alam, M. Z., & Rahman, M. A. (2012). Modelling volatility of the BDT/USD exchange rate with GARCH model. *International Journal of Economics and Finance, 4*(11), 193-204.

Ali, T. M., Mahmood, M. T., & 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.

Al-Yousif, Y. K. (2002). Financial development and economic growth: Another look at the evidence from developing countries. *Review of Financial Economics*, *11*(2), 131-150.

Ardalan, K. (2005). The monetary approach to balance of payments: A review of seminal long-run empirical research. *Journal of Economics and Economic Education Research*, *6*(1), 37-73.

Ayhan, F. (2016). *Döviz kuru oynaklığı, dış ticaret ve istihdam ilişkisi: Türkiyeuygulaması* (Doctoral disse rtation, Selçuk Üniversitesi Sosyal Bilimler Enstitüsü). Retrieved September 23, 2019, from https://sch olar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Ayhan%2C+F.+% 282016%29%2C+Döviz+Kuru+Oynaklığı%2C+Dış+Ticaret+ve+İstih dam+İlişkisi%3A+Türkiye+Uygulaması%2C+%28Yayımlanmamış+Y üksek+Lisans%2FDoktora+Tezi%29.+Selçuk+Üniversitesi+Sosyal+Bi limler+Enstitüsü%2C+Konya.&btnG=p0df.

Bank of Ghana. (2015). *Monetary Policy Report.* January 2015. Accra: Bank of Ghana.

Bank of Ghana. (2018). *Monetary Policy Report.* January 2018. Accra: Bank of Ghana.

Bank of Uganda. (2011). *Annual Report 2010/11.* Kampala: Bank of Uganda.

Bauwens, L., D., & Sucarrat G. (2006). Exchange rate volatility and the mixture of distribution hypothesis. *Empirical Economics, 30*(5), 889-911.

Benita, G., & Lauterbach, B. (2007). Policy factors and exchange rate volatility. *International Research Journal of Finance and Economics*, *7*(8), 7-23.

Bergen, J. V. (2010). Factors that influence exchange rates. *Exchange Rates and Corporate Performance, 11*(9), 49-59.

Bobai, F. D., Ubangida, S., & Umar, Y. S. (2013). An assessment of exchange rate volatility and inflation in Nigeria. *Journal of Emerging Issues in Economics, Finance and Banking (JEIEFB)*, *1*(4), 321-340.

Bonser-Neal, C. (1996). Does central bank intervention stabilize foreign exchange rates?. *Economic Review-Federal Reserve Bank of Kansas City*, *81*, 43-58.

Bowerman, B. L., O'Connell, R. T., & Koehler, A. B. (2005). *Forecasting, time series and regression*: *An applied approach*. Thomson Brooks/Cole.

Buabin, C. P. (2016). *Effect of exchange rate volatility on economic growth in Ghana: An empirical investigation* (Masters Dissertation, University of Cape Coast). Retrieved June 4, 2019, from https://erl.ucc.edu.gh/jspui/handle/12 3456789/3290.

Coffie, W. (2018). Modelling and forecasting volatility of the Botswana and Namibia stock market returns: Evidence using GARCH models with different distribution densities. *Global Business and Economics Review*, *20*(1), 18-35.

Coffie, W., & Chukwulobelu, O. (2014). Modelling stock return volatility: Comparative evidence from selected emerging African and Western developed markets. *International Journal of Management Practice, 7*(4), 366-379.

Creswell, J. W. (2014). *A concise introduction to mixed methods research*. Sage Publications.

Dewing, D. (2015). *Determinants of exchange rate volatility in South Africa* (Master's dissertation, University of Fort Hare). Retrieved July 3, 2019, from http://libdspace.ufh.ac.za/bitstream/handle/20.500.11 837/973/Desiree%20Dewing%20Masters%20Dissertation%20PDF.pdf ?sequence=1&isAllowed=y.

Dobrev, D., & Szerszen, P. J. (2010). *The information content of high-frequency data for estimating equity return models and forecasting risk. Proceedings from the first International Finance Discussion.* Board of Governors of the Federal Reserve System (US).

Dornbusch, R. (1976). Expectations and exchange rate dynamics. *Journal of Political Economy*, *84*(6), 1161-1176.

Dornbusch, R. (1985). Purchasing power parity. *National Bureau of Economic Research,* (1591), 1-34.

Drachal, K. (2017). Volatility clustering, leverage effects and risk-return trade off in the selected stock markets in the CEE countries. *Romanian Journal of Economic Forecasting*, *20*(3), 37-53.

Enu, P. (2017). The key drivers of exchange rate depreciation in Ghana. *Journal of Basic and Applied Research International, 22*(4), 132-147.

Fabris, N., & Vujanović, N. (2017). The impact of financial dollarization on inflation targeting: Empirical Evidence from Serbia. *Journal of Central Banking Theory and Practice*, *6*(2), 23-43.

Faroque, A. & Veloce, W. (1990). Causality and structure of Canada's balance of payments. *Empirical Economics, 15*, 267-283.

Ferrari, M. M., & Ters, K. (2017). The benefits of using large high frequency financial datasets for empirical analyses: Two applied cases. *IFC Bulletins Chapters*. *43*, 1-21.

Fisher, I. (2006). The Theory of Interest. New York, NY: MacMillan.

Fosu, A. K. (2001). Emerging Africa: The case of Ghana. *Africa Economic Research Consortium.* Nairobi.

Friedman, M. (1989). Quantity theory of money. In *Money* (pp. 1-40). Palgrave Macmillan, London.

Gidigbi, M. O., Babarinde, G. F., & Lawan, M. W. (2018) Inflation and exchange rate volatility pass-through in Nigeria. *Journal of Management, Economics, and Industrial Organization, 2*(3), 18-40.

Gujarati, D. N. (2012). *Basic Econometrics*. Tata McGraw-Hill Education.

Hallebone, E., & Priest, J. (2008). *Business and management research: Paradigms and practices*. Macmillan International Higher Education.

Hao, L., Naiman, D. Q., & Naiman, D. Q. (2007). *Quantile regression* (No. 149). Sage.

Haque, M. A., & Boger, G. (2011). The volatility of the dollar yen exchange rate: Cause and effect. *Journal of Economics and Economic Education Research*, *12*(1), 55-60.

Hassan, A., Abubakar, M. I., & Dantama, Y. (2017). Determinants of exchange rate volatility: New estimates from Nigeria. *Eastern Journal of Economics and Finance*, *3*(1), 1-12.

Hill, C. (2008). International business: Competing in the global market place. *Strategic Direction*, *24*(9).

Hill, R. C., Griffiths, W. E., & Lim, G. C. (2012). *Principles of Econometrics*. John Wiley &Sons.

Huang, Q., Zhang, H., Chen, J., & He, M. (2017). Quantile regression models and their applications: A review. *Journal of Biometrics and Biostatistics, 8* (354), 2-6.

Ineichen, A. O. (2010). *Why did the South Korean won depreciate against the US dollar in the recent economic crisis and the Asian financial crisis 1997/98?:Won-dollar exchange rate movements and the role of capital flows* (Master's thesis, Georgetown University). Retrieved July 3, 2019, from https://repository.library.georgetown.edu/handle/10822/553784

Insah, B., & Chiaraah, A. (2013). Sources of real exchange rate volatility in the Ghanaian economy. *Journal of Economics and International Finance*, *5*(6), 232-238.

Irungu, E. N. (2017). *Factors that influence volatility in the foreign exchange rate in Kenya* (Doctoral dissertation, United States International University-Africa). Retrieved September 22, 2019, from https://pdfs. semanticscholar.org/bf23/5d14d41c82c6e806006c644a562c961c3e5f.p df.

Isard, P. (1995). *Exchange Rate Economics.* Cambridge: Cambridge University Press.

Iyke, B. N., & Ho, S. Y. (2017). The real exchange rate, the Ghanaian trade balance, and the J-curve. *Journal of African Business*, *18*(3), 380-392.

Jabeen, M., & Khan, S. A. (2014). Modelling exchange rate volatility by macroeconomic fundamentals in Pakistan. *International Econometric Review*, *6*(2), 58-76.

Jeong, J. (2000). "What drives exchange rates? The case of the yen/dollar Rate". *Multinational Business Review,* 31-36.

Kariuki, D. W. (2015). *The relationship between the real interest rate and the real exchange rate in Kenya*. (Master's thesis, School of Business, University of Nairobi). Retrieved July 5, 2019, from http://erepository .uonbi.ac.ke/bitstream/handle/11295/93900/Kariuki_%20The%20Relat ionship%20Between%20The%20Real%20Interest%20Rate%20And% 20The%20Real%20Exchange%20Rate%20In%20Kenya.pdf?sequence =4&isAllowed=y

Kibiy, J., & Nasieku, T. (2016). Determinants of exchange rate volatility of the Kenyan Shilling against world major currencies. *International Journal of Social Sciences and Information Technology*, *2*(11), 1181-1202.

Kilicarslan, Z. (2018). Determinants of exchange rate volatility: Empirical evidence for Turkey. *Journal of Economics Finance and Accounting*, *5*(2), 204-213.

Kim, C. H., & Kim, D. (2010). Do capital inflows cause current account deficits? *Applied Economics Letters, 18*(5), 497-500.

Koenker, R., & Bassett Jr, G. (1978). Regression quantiles: Econometrica. *Journal of the Econometric Society*, 33-50.

Koenker, R., & Hallock, K. (2001). Quantile regression: An introduction. *Journal of Economic Perspectives*, *15*(4), 43-56.

Koenker, R., & Xiao, Z. (2004). Unit root quantile autoregression inference. *Journal of the American Statistical Association*, *99*(467), 775-787.

Krugman, P. R. (2008). *International economics: Theory and policy*. India: Pearson Education.

Kurihara, Y. (2013). Does adoption of inflation targeting reduce exchange rate volatility and enhance economic growth? *Journal of World Economic Research*, *2*(6), 104-109.

Kuwornu, J. K. M. (2012). Effects of macroeconomic variables on the Ghanaian stock market returns: A co-integration Analysis. *Journal of Economics and Informatics, 4*, 1-12.

Lafrance, R., & Schembri, L. (2002). Purchasing-power parity: Definition, measurement, and interpretation. *Bank of Canada Review*, 27-33.

MacKinnon, J. G. (1991). Critical values for cointegration tests. In Eds.), *Long-Run Economic Relationship: Readings in Cointegration.*

Madura, J. (2011). *International financial management*. Cengage Learning.

Malović, M., Özer, M., & Zdravković, A. (2017). Impact of dollarization on exchange rate volatility and rational choice of currency regime: Evidence from two EU candidate countries. *Industrija*, *45*(4), 79-91.

Mbulawa, S. (2015). Determinants of economic growth in Southern Africa development community: The role of institutions. *Applied Economics and Finance*, *2*(2), 91-102.

Mirchandani, A. (2012). Analysis of macroeconomic determinants of exchange rate volatility in India. *International Journal of Economics and Financial Issues*, *3*(1), 172-179.

Mokoma, T. J. (2014). *Exchange rate volatility in South Africa: A comparative analysis of the ARCH and GARCH models.* (Master's dissertation, Mafikeng Campus of the North-West University). Retrieved January 6, 2019, from https://pdfs.semanticscholar.org/6b01/1e64230b81b1bccd7c66cd7fc9fb99bc6423.pdf

Mordi, C. N. (2006). Challenges of exchange rate volatility in economic management in Nigeria. *CBN Bullion*, *30*(3), 17-25.

Mpofu, T. R. (2016). The determinants of exchange rate volatility in South Africa. *Economic Research Southern Africa, Working Paper*, *604*.

Musa, Y., Tasi'u, M., & Bello, A. (2014). Forecasting of exchange rate volatility between Naira and US Dollar using GARCH models. *International Journal of Academic Research in Business and Social Sciences*, *4*(7), 369-381.

Musyoki, D., Pokhariyal, G. P., & Pundo, M. (2012). The impact of real exchange rate volatility on economic growth: Kenyan evidence. *Business and Economic Horizons*, *7*(1232-2016-101104), 59.

Naceur, S. B., & Ghazouani, S. (2007). Stock markets, banks, and economic growth: Empirical evidence from the MENA region. *Research in International Business and Finance*, *21*(2), 297-315.

Nelson, C. R., & Plosser, C. R. (1982). Trends and random walks in macroeconomic time series: Some evidence and implications. *Journal of Monetary Economics*, *10*(2), 139-162.

Njindan, Iyke, B., & Ho, S. Y. (2018). Real exchange rate volatility and domestic consumption in Ghana. *The Journal of Risk Finance*, *19*(5), 513-523.

Nortey, E. N., Ngoh, D. D., Doku-Amponsah, K., & Ofori-Boateng, K. (2015). Modelling inflation rates and exchange rates in Ghana: Application of multivariate GARCH models. *Springer Plus*, *4*(1), 1-10.

Oaikhenan, H. E. & Aigheyisi, O. S. (2015). Factors explaining exchange rate volatility in Nigeria: Theory and empirical evidence. *Economic and Financial Review*, *53*(2), 47-77.

Obiekwe, E., & Osabuohien, E. S. C. (2016). *Exchange rate pass through, exchange rate volatility and inflation rate in Nigeria*. Paper presented at 3rd International Conference on African Development Issues (CU-ICADI 2016).

Obioma, N. E. (2000). *Elements of International Economics* Lagos: Impresses Publishers.

Odera, Q. A. (2015). *An analysis on the effect of external public debt on exchange rate volatility in Kenya*. (Master's dissertation, University of Nairobi). Retrieved June 8, 2019, from erepository.uonbi.ac.ke /.../Odera_An%20Analysis %20On%20The%20Effect%20Of%.pdf.

Odili, O. (2014). Exchange rate and balance of payment: An autoregressive distributed lag econometric investigation on Nigeria. *Journal of Economics and Finance*, *4*(6), 21-30.

Parveen, S., Khan, A. Q., & Ismail, M. (2012). Analysis of the factors affecting exchange rate variability in Pakistan. *Academic Research International, 2*(3), 670-674.

Peterson, O. J., Adam, M. A. (2017). *Financial Econometrics: An example based handbook.* Ghana: Nova Science Corporation.

Pham, T. H. H. (2018). Liquidity and exchange rate volatility: The role of financial development. *Universite De Nantes*, 1-34.

Rates, E. (2007). Why Real? *Finance and Development Review*, *2*(4), 1-14.

Razi, A., A. Shafiq, S.A. Ali and H. Khan, 2012. Determinants of exchange rate and its impact on Pakistan economy. *Global Journal of Management and Business Research*, *12*(16), 44-48.

Saeed, A., R.U. Awan, M.H. Sial and F. Sher, 2012. An econometric analysis of determinants of exchange rate in Pakistan. *International Journal of Business and Social Sciences*, *3*(6), 184-196.

Salvatore, D. (1993). The international monetary system: Past, present and future. *Fordham L. Rev., 62*(7), 1975-1988.

Saraç, T. B., & Karagöz, K. (2016). Impact of short-term interest rate on exchange rate: The case of Turkey. *Procedia Economics and Finance*, *38*, 195-202.

Saunders, M. N., & Lewis, P. (2012*). Doing research in business & management: An essential guide to planning your project*. Pearson.

Stancık, J. (2006). Determinants of exchange rate volatility: The case of the new EU members. *Czech Journal of Economics and Finance*, *57*(9-10), 1-27.

Takyi, P. O., & Obeng, C. K. (2013). Determinants of financial development in Ghana. *International Journal of Development and Sustainability*, *2*(4), 2324-2336.

Timothy, O. T., & Chigozie, M. S. A. A. O. (2016). Exchange rate volatility and inflation: The Nigerian experience. *Journal of Economics and Sustainable Development*, *7*(10), 6-15.

Tsay, R. S. (010). Analysis of financial time series. A John Wiley & Sons. *INC,*.

Twarowska, K., & Kakol, M. (2014). Analysis of factors affecting fluctuations in the exchange rate of Polish Zloty against Euro. *Proceedings of the Management, Knowledge and Learning International Conference*. (pp. 889-898). Portoroz, Slovenia: Make learn.

Tweneboah, G. (2015). Financial dollarization and exchange rate volatility in Ghana. *Ghanaian Journal of Economics*, *3*(1), 24-88.

Urbanovský, T. (2017). The connection between the exchange rate and the balance of payments accounts in the Czech Republic: An econometric approach. *Financial Assets and Investing*, *9*(1), 58-71.

Wanaset, A. (2014). Sources of exchange rate volatility in Thailand. *Development Economic Review*, *3*(2), 17-26.

Wanjau, B. M. (2014). The relationship among real exchange rate, current account balance and real income in Kenya. *International Journal of Business and Social Science*, *5*(9), 97-118.

Zwanger, S. (2008). *Determinants of exchange rates: The case of the Chilean Peso* (Master's Thesis, University of North Carolina Wilmington). Retrieved July 15, 2019, from https://libres.uncg.edu/ir/uncw/f/zwan zgers2008-1.pdf

## APPENDICES

### A: LM test of ARCH Effect

| | | | |
|---|---|---|---|
| F-statistic | 15.15872 | Prob. F(1,333) | 0.0001** |
| Obs*R-squared | 14.58579 | Prob. Chi-Square(1) | 0.0001** |

Note: ** represents 5% significance level
Source: Field Survey, Odoom (2019)

### B: Ljung-Box of the Squared Standardised Residuals

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | P-Value |
|---|---|---|---|---|---|---|
| .\|. \| | .\|. \| | 1 | -0.032 | -0.032 | 0.3563 | 0.551 |
| .\|. \| | .\|. \| | 2 | -0.032 | -0.033 | 0.7067 | 0.702 |
| .\|. \| | .\|. \| | 3 | -0.013 | -0.015 | 0.7627 | 0.858 |
| .\|. \| | .\|. \| | 4 | -0.036 | -0.039 | 1.2156 | 0.876 |
| .\|. \| | .\|. \| | 5 | 0.006 | 0.002 | 1.2267 | 0.942 |
| .\|. \| | .\|. \| | 6 | -0.053 | -0.056 | 2.1936 | 0.901 |
| .\|. \| | .\|. \| | 7 | -0.039 | -0.043 | 2.7041 | 0.911 |
| .\|. \| | .\|. \| | 8 | 0.005 | -0.003 | 2.7138 | 0.951 |
| .\|. \| | .\|. \| | 9 | 0.007 | 0.002 | 2.7284 | 0.974 |
| .\|. \| | .\|. \| | 10 | -0.015 | -0.020 | 2.8038 | 0.986 |

Note: AC = Autocorrelation and PAC = Partial Autocorrelation
Source: Field Survey, Odoom (2019)

### C: Engle LM test of ARCH Effect

| | | | |
|---|---|---|---|
| F-statistic | 0.344267 | Prob. F(2,330) | 0.7090 |
| Obs*R-squared | 0.693347 | Prob. Chi-Square(2) | 0.7070 |

Source: Field Survey, Odoom (2019)

**D: Estimation of Exchange Rate Volatility (ERVOL)**

| Variable | Coefficient |
|---|---|
| **Mean equation** | |
| Constant | 0.3142** |
| | (0.1315) |
| | [2.3897] |
| **Variance equation** | |
| Constant | 1.6558** |
| | (0.4209) |
| | [3.9336] |
| $\alpha_1$ | 0.2255* |
| | (0.1141) |
| | [1.9761] |
| $\alpha_2$ | 0.3468* |
| | (0.1173) |
| | [2.9569] |
| Asymmetric effect | -0.2429** |
| $(\gamma_1)$ | (0.8655) |
| | [-0.2807] |
| $\beta_1$ | 0.4182** |
| | (0.1063) |
| | [3.9340] |
| | |
| AIC | 4.8698 |
| SC | 4.9381 |
| Persistence | 0.8691 |

AIC= Akaike Information Criterion, SC= Schwarz Criterion, ** and * represent 5% and 10% significance levels respectively. Shown in ( ) and [ ] are standard errors and z-statistics respectively.
Source: Field Survey, Odoom (2019)

**E: A Histogram Showing the Distribution of the Residual Term**
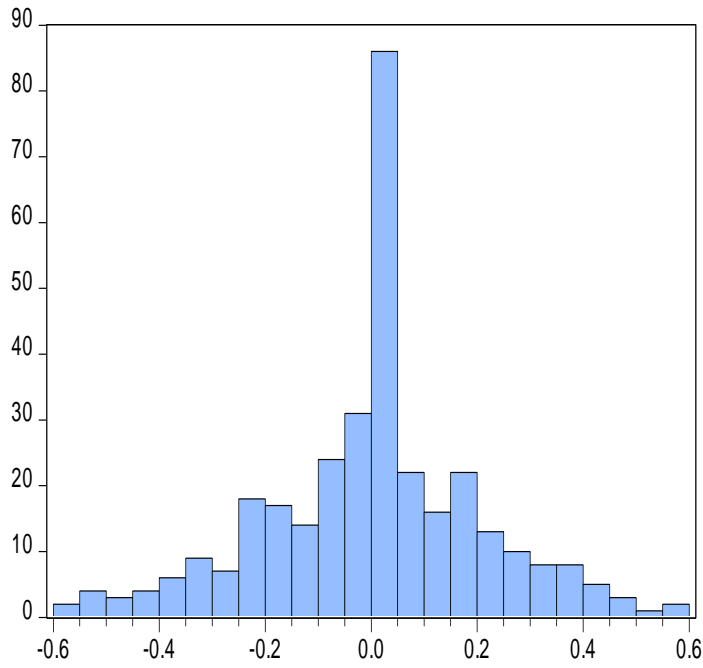


| | |
|---|---|
| Series: Residuals | |
| Sample1990M02 2017M12 | |
| Observations 335 | |
| | |
| Mean | -4.47e-18 |
| Median | 0.000000 |
| Maximum | 0.564720 |
| Minimum | -0.569509 |
| Std. Dev. | 0.206763 |
| Skewness | -0.090081 |
| Kurtosis | 3.487869 |
| | |
| Jarque-Bera | 3.775368 |
| Probability | 0.151422 |

Source: Field Survey, Odoom (2019)

Dependent variable: Exchange rate volatility (ERVOL)

**F: Regression Analysis**

| Variable | Model 1 QR | | | | | Model 2 OLS |
|---|---|---|---|---|---|---|
| | 10th | 35th | 50th | 75th | 95th | |
| Constant | -0.5591* | -0.0890* | -0.0019 | 0.1956* | 0.8681* | -0.0050 |
| | (0.0712) | (0.0215) | (0.0212) | (0.0263) | (0.0834) | (0.0293) |
| | [-7.8578] | [-4.1332] | [-0.0885] | [7.4279] | [10.4135] | [-0.1707] |
| LnINT | -1.3771* | -0.1625 | -0.4305 | -1.5163** | -1.4029* | -0.5649 |
| | (0.6007) | (0.4110) | (0.5573) | (0.8124) | (0.6131) | (0.4559) |
| | [-2.2926] | [-0.3955] | [-0.7724] | [-1.8664] | [-2.2881] | [-1.2390] |
| LnINF | 0.0030 | 0.3846* | 0.3359* | 0.1740 | 1.1584* | 0.1392 |
| | (0.0586) | (0.0859) | (0.1205) | (0.1314) | (0.1321) | (0.2338) |
| | [0.0505] | [4.4772] | [2.7867] | [1.3247] | [8.7699] | [0.5952] |
| CAB | -0.1066 | -0.1050* | -0.0944* | -0.1362* | -0.0646 | -0.10861** |
| | (0.0657) | (0.0382) | (0.0399) | (0.0558) | (0.0751) | (0.0570) |
| | [-1.6221] | [-2.7498] | [-2.3611] | [-2.4426] | [-0.8597] | [-1.9062] |
| LnMS | -1.6754 | -2.6613* | -2.2306** | -4.7185* | -0.8840 | -1.9901 |
| | (1.5030) | (1.1117) | (1.1786) | (0.8619) | (1.7686) | (1.6004) |
| | [1.1147] | [-2.3940] | [-1.8926] | [-5.4744] | [-0.4998] | [-1.2441] |
| R Squared | | | | | | 0.0387 |
| Ad R Squared | 0.0042 | 0.0077 | 0.0063 | 0.0066 | 0.0197 | 0.0241 |
| Pseudo R Squared | 0.0161 | 0.0195 | 0.0182 | 0.0185 | 0.0315 | |
| DW | | | | | | 1.9051 |
| AIC | | | | | | 1.5872 |
| SC | | | | | | 1.6557 |

Note: QR=Quantile Regression, OLS=Ordinary Least Square, lnINT= Log of Interest Rate, lnINF=Log of Inflation Rate, CAB=Current Account Balance, lnMS=Log of Money Supply and DW=Durbin Watson, AIC=Akaike Information Criterion and SC= Schwarz Criterion. ** and * denote significance levels at 5% and 10% respectively. Standard errors are in ( ) whilst t-statistics are in [ ].

Source: Field Survey, Odoom (2019)