ASHESI UNIVERSITY

ECONOMETRIC ANALYSIS OF RELATIONSHIP BETWEEN EXCHANGE RATE AND INFLATION: A CASE STUDY OF GHANA

Undergraduate Thesis Report submitted to the Department of Business Administration, Ashesi University in partial fulfilment of the requirement for the award of Bachelor of Science degree in Business Administration

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DECLARATION

I hereby declare that this dissertation is my original study and that none of its parts have been presented for another degree in this university or elsewhere.

Candidate's signature…….

Candidate's name: Francisca Arthur Adu

Date: 11th May 2020

I hereby declare that the submitted dissertation and presentation of it were supervised in accordance with the guidelines on supervision of thesis laid down by Ashesi University.

Supervisor's signature: …….

Supervisor's name: Dr. Stephen Emmanuel Armah

Date: 11th May 2020

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LIST OF ACRONYMS

Acronym	**Meaning**
ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lag
AIC	Akaike Information Criteria
BOP	Balance of Payments
CPI	Consumer Price Index
GHS	Ghanaian Cedi
RER	Real Exchange Rate
USD	United States Dollar

DEFINITION OF TERMS

BALANCE OF PAYMENT: The balance of payment keeps track of all funds that go in and out of a country.

BALANCE OF PAYMENT DEFICITS: A balance of payment deficit means a country has a trade deficit. In other words, the imports of the country exceed its exports.

BROAD MONEY SUPPLY (M2): M1is the local currency of a country, including demand deposits, traveller's checks, and other checkable deposits. Broad money supply is M1 plus retail money market mutual fund balances, saving deposits (including money market deposit accounts), and small-time deposits (Mankiw, 2010).

CURRENT ACCOUNT SURPLUS: The current account is a recording of all foreign transactions that do not create liabilities. A current account surplus arises when total value of exported goods and services in a nation exceeds imported total value of goods and services.

FISCAL IMBALANCES: A government is said to experience a fiscal imbalance when all its future income streams do no match its entire future debt requirements.

HYPERINFLATION: This is commonly known as inflation that surpasses 50 percent each month and is just over one percent per day (Mankiw, 2010).

INTEREST RATE PARITY: This theory holds that investors cannot take advantage of differences in interest rates in other countries, to make abnormal profits because countries with high interest rate is as a result of currency depreciation (Wu & Chen, 1998).

MONETARISTS: These are economists with the school of thought that instability in money supply leads detriments on growth in the short run, and price levels in the longer run. Hence, the argue that the only way to make sure that output, employment and prices are stable to keep money supply slow and steady (Mankiw, 2010).

STRUCTURALISTS: Structuralists hold the view economic structures like specialization pattern in international trade, the capacity of technology of the economy, the labour force's educational level, the nature and development basis of institutions, etc. (Missio et al., 2015) have a massive influence on the economic growth of a country.

ABSTRACT

The purpose of this study is to predict inflation rates for Ghana, based on past exchange rate data. The project was motivated by the instability of general price levels in Ghana and the detrimental effects it has on the economy. The study seeks to determine if inflation rates in Ghana be predicted based on past exchange rate data. Forecasting inflation rates will aid the government to devise more precise policies to tackle the expected rates and assist individuals with contingent planning.

The study uses a quantitative research method to examine the subject matter, in the form of a time series regression analysis. The data employed has a monthly frequency and spans from 1999 to 2018. Quantitative data for the intended analysis was retrieved from the World Bank and Bank of Ghana, however data from past literature journals, reports, and books were also analysed and discussed.

A negative correlation between exchange rate and inflation is expected from the analysis such that an appreciation; increase in the value, of the Ghanaian Cedi would yield lower inflation rates.

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CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

The relationship between exchange rate and inflation is a very significant one as they are both relevant instruments of macroeconomic performance. Inflation can be defined as a persistent rise in price levels in an economy (Mankiw, 2011).

The relationship between inflation and growth is complicated and may differ in the short run compared to the long run. In the short-run there is the well-documented and negative Phillips curve relationship between inflation and unemployment implying that higher levels of employment are consistent with job growth and economic growth (Osiakwan & Armah, 2013). In the longer run, lower levels of inflation are probably beneficial as it may correspond with growth, employment and debt settlement. Extremely high levels on the other hand (typically called hyper-inflation), can be detrimental to the development of an economy in either run. Hyperinflation devalues the currency of the country, which subsequently corrodes the purchasing power of consumers and in turn lowers spending. Cost of living is increased as a result of high inflation rate, and this increase can possibly decrease standard of living if there is no proportional increase in income (Osiakwan & Armah, 2013). This affects other stakeholders like firms and the government because hyperinflation leads to a permanent reduction in per capita income (making them unable to settle debts), as well as fall in investment and production efficiency (Osiakwan & Armah, 2013). Hence when price levels are relatively stable, monetary policymakers are said to be doing a good job (Sobel et al., 2006)

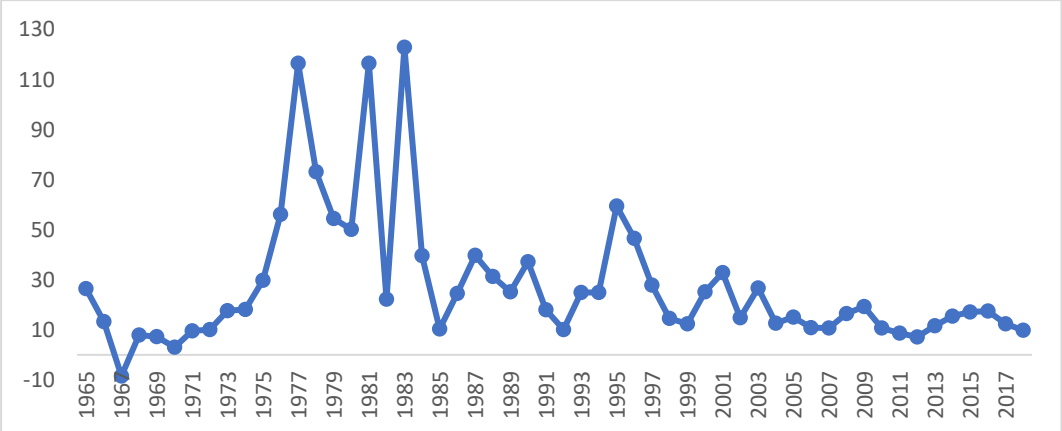
Exchange rate on the other hand is the value of a country's currency in terms of another country's currency (Mankiw, 2011). Exchange rate can be broken down into two concepts; real and nominal exchange rate. Nominal exchange rate is the relative price of two currencies; that is, the price of a foreign currency expressed in terms of a home or domestic currency (Feenstra & Taylor, 2014). Hence, say the nominal exchange rate between the dollar and the cedi is six, then one dollar would purchase six cedis. The real exchange rate, however, looks at the price of foreign goods relative to the price of domestic goods. For a home country, a high normal rate may give the impression of their currency will be able to afford several foreign goods, nonetheless, it is the real exchange rate that determines that. This proves that besides prices of domestic goods, imports and exports prices are also key drivers of growth and development.

The forces of demand and supply of money determine exchange rates. This concept is well explained by the concept Interest Rate Parity. The Interest Rate Parity looks at the equilibrium state of the relationship between exchange rate and interest rate of two countries. When deposits of all currencies conceive an equal expected rate of return, then the foreign market is said to be equilibrium. The condition with which any two currencies expected returns on deposits correspond when measured in the same currency is known as the interest parity condition. This infers that probable holders of foreign currency deposits see them as assets that are equally advantageous, given that expected rates of return are equal. Hence, if for instance, the expected return on the British Pound deposits is five percent greater than that on the Ghanaian cedi deposits, individuals would not be interested in holding Ghana cedi deposits, creating an excess supply of the Ghanaian cedi and on the other hand, excess demand for British Pound on the foreign exchange market (Krugman et al., 2012).

In monetary economics, one of the main issues is the relative benefits of various methods for achieving price stability (Hernandez-Verme, 2004) and in many open economies, consideration of this problem involves weighing out fixed and flexible exchange rate regimes. This was affirmed by one Obadan in 2007, who further explained that choosing the suitable exchange rate regime that would favour positive exchange rate levels is always a crucial decision for open economies because of effects like the standard of living, income distribution, balance of payments and others (Obadan, 2007). In 1976, Dornbusch stipulated that when exchange rate is defined as the rate of change between the currencies of two countries, an increase in exchange rate will lead to a rise in general price levels, and when the exchange rate falls, specifically the home country's currency appreciates, then price levels are expected to decline as well (Dornbusch, 1976). In developing countries, the inflation rate has been double that of advanced countries since 1980 (Obiekwe & Osabuohien, 2016), emphasizing the need to implement real exchange rate policies that would take inflation into account. (WHY HOW)

1.2 PROBLEM STATEMENT

Figure 1: Ghana Historical Inflation Rates



Source: Author's Plot using Data from the World Bank

The main objective of the Central Bank of Ghana is to maintain stability of general price levels (*Our Monetary Policy Framework*, n.d.). Figure 1 above however proves that this has not been the case for decades in Ghana, as there have been very fluctuating levels of price over the years, starting from significantly low levels, to peak values, then back to moderately low levels. In an open economy, businesses determine consumer preferences by paying attention to changes in relative prices of goods and services, in order to determine the right production mix to supply. The instability of price levels obscures the perceptibility of these changes in relative prices of goods and services, hence hindering firms and individuals to clearly interpret market signals conveyed by the changes. This also leads to inefficient allocation of resources and subsequently, decline in growth and development. Although, presently, Ghana boasts of single-digit inflation rate, the problem has been how to make this low number beneficial to the lives of citizens in the country, as currently, low inflation as a remedy for development and growth issues is feeble at best and will actually result in lack of jobs for citizens in the short run, because low inflation stalls job production and deters production (Osiakwan & Armah, 2013).

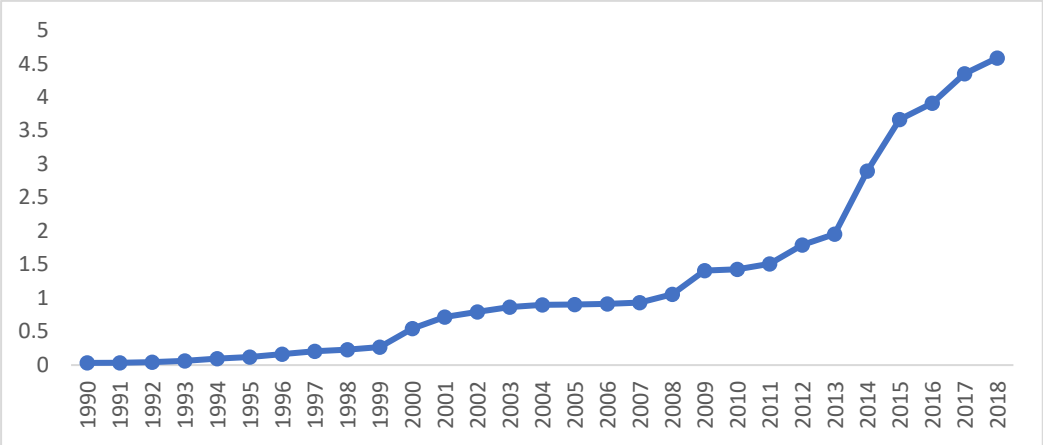
A factor that obscures the concept of inflation in Ghana, is the lack of association between Ghana's exchange rate and inflation rates, especially during the periods of low inflation (Osiakwan & Armah, 2013). In 2010 to 2012 for instance, the value of the cedi still depreciated against major currency pairs nevertheless, Ghana recorded low inflation rates. This was the same in 2018 as well. Theoretically, an inverse relationship is expected between inflation rate and nominal exchange rate (Mankiw, 2011), however, this has not been the case for Ghana, hence emphasizing the need for an empirical examination of the exact relationship between these variables.

As such, in this study, we determine if there is a significant relationship or causal effect of exchange rate on inflation rates in Ghana, and consequently economic growth and hence, if inflation rates can be forecasted based on exchange rate data. This is necessary as a country's general performance is reliant on economic growth and development and instruments like inflation and exchange rate, among others, deeply affect growth and should concern policymakers and economists. A persistent rise in inflation would have negative repercussions that would interfere with the goals of the country.

1.2.1 EXCHANGE RATE

A significant role of exchange rate is how it connects price systems of different countries, hence allowing direct comparison of prices (Bobai et al., 2013). To examine the relationship of exchange rate and inflation, the historical pattern or trend of the exchange rate; USD/GHS, to be precise, must also be examined. The Figure below shows that the Ghanaian Cedi has shown features of unceasing instability over the years. The figure looks at exchange rate data from 1990 to 2018 and the upward trend depicts a depreciation in the value of the Ghanaian Cedi against the United States Dollar over these years. The Figure shows that the Ghanaian Cedi was initially depreciating at a slower rate until 2008, when there was a slightly sharp rise in the value of the United States Dollar against the Ghanaian Cedi. The magnitude of the drop was the highest since the country's currency redenomination in 2007 (Arthur, 2014). This sudden surge was repeated from 2013 to 2015. In this two-year period alone, the US dollar had appreciated by approximately 87.7%, against the Ghanaian Cedi.

Figure 2: USD/GHS Historical Exchange Rate



Source: Author's Plot using Data from the World Bank

The currency of the country witnessed a significant depreciation in value since it was changed from the Cedi to the Ghana Cedi (Arthur, 2014). From July 2007, when the new currency was introduced, to the end of that year, the value of the cedi among major currency pairs fell by 5.1%, despite The Central Bank of Ghana's attempts to push it up by increasing money supply by USD 288 million (Arthur, 2014). In the subsequent year, there was massive surge of 25.3% in depreciation and this was as a result of rising monetary growth, increasing rate of inflation and fiscal deficit, fall in foreign reserves and weak economic fundamentals (Arthur, 2014). Unfortunately, this continued in 2009, leading to a further depreciation of 13.6% by the end of the year (Arthur, 2014). Additionally, the liberalization of capital markets to foreigners which allows them to buy and sell bonds such that by December 2008, foreign investors held 46% of short-term government securities and 87% of long-term government securities (Arthur, 2014). The risk of selling these securities back to the locals is so high that it puts inflationary pressure on the domestic currency (Arthur, 2014).

The continuous fall in the value of the cedi is also a result of rising balance of payment and current account deficit in the country. The country has had balance of

payment deficits since mid-1970 (Boateng & Ayentimi, 2013). Since Ghana heavily relies on imports, this does not help improve its balance of payments, as to pay the importer, more foreign denominations are purchased with the Ghanaian Cedi (Arthur, 2014), leading to its devaluation. In 1980, Ghana experienced a deterioration in current account surplus, to a deficit of 3.8% of Gross Domestic Product, and although the government made several efforts to stabilize its balance of payments, the country continued to record further increase in the deficit, such that by 2008, current account deficit was at 24.7% of Gross Domestic Product (Boateng & Ayentimi, 2013).

1.3 RESEARCH QUESTION

Can we forecast Ghana's inflation rates with past exchange rate data?

1.4 RESEARCH OBJECTIVES

In order to determine if Ghana's inflation rate can be forecasted using exchange rate data, the objectives in the course of this study are:

i. To identify and analyze the empirical effect real exchange rate has on domestic price levels in the Ghanaian economy, from 1990 to 2018.
ii. Establish other dominant macroeconomic variables that have causal effects on inflation in Ghana.
iii. To add to existing literature on the dynamic causal relationship between exchange rate and inflation. A purpose of this study is to contribute ideas and critique works that have already been done to show the relationship between inflation and exchange rate.
iv. To recommend strategies for policies that will be particularly beneficial to policymakers to measure and manage inflation, as well as exchange rates Ghana. This paper aims to contribute to policy making effectively by evidently analyzing

the effect of exchange rate on inflation and hence, economic growth Ghana, to make recommendations concerning the measurement, control and reporting of the statistic.

1.5 HYPOTHESES

H_0: There is no relationship between exchange rates and inflation.

H_1: There is a relationship between exchange rates and inflation.

1.6 RELEVANCE OF STUDY

Over the past few years, Ghana has had a single digit inflationary rate and the government is particular about maintaining this. In February 2018, The Institute of Economic Affairs asked the Central Bank to re-assess its inflation-targeting regime if they want inflation rates to remain significantly low. They believed that while currently the policy may seem helpful, inflation rates have not been stable in a while and the economic costs incurred by the country are massive and are having great repercussions on the economy (Bruce, 2018). Since 2007, the country has been using an inflation-targeting regime, which has been of no benefit to price levels. Between the periods of 2007 to 2017, inflation surpassed the announced target by at least 10% on average (Bleaney et al., 2018).

There have been several studies that have tried to model inflation rates in Ghana based on factors like Cost Push, Demand Pull and Expansionary Monetary Policies, mostly employing the constant variance assumption model, based on a single variable analysis of inflation rates. Nevertheless, not many have looked at the parallel movements of exchange rate and inflation rates, or whether predictions can be made by comparison of historical data. As mentioned in Section 1.2, the lack of a clear association between exchange rate and inflation rate in Ghana has proven to be a

major complication in inflation issues in the country, hence, the evaluation of movement of exchange rate and its effect on price levels is very relevant especially since Ghana heavily relies on imports and to a large extent is driven by the external sector. The exchange rate affects prices of raw materials like oil, hence in the case of a depreciation prices of imported inputs rise, as well as exportables, and this puts pressure on wages because of the increased cost of living. Hence mechanically, a conflict between inflation and depreciation immediately forms as a result of implicit or explicit wage indexation. When this happens, a major driver of inflation will now be real depreciation.

Forecasting inflation rates will aid the government to devise more precise policies to tackle the expected rates. Hence, in the case where rates are expected to be high for instance, there might be the need for contractionary fiscal or monetary policies and vice versa when rates are low. Additionally, if individuals are aware of expected price levels, they can make contingency plans and prepare budgets based on these rates to avoid any disasters in the future.

CHAPTER TWO: LITERATURE REVIEW

OVERVIEW OF CHAPTER

In this chapter, a literature pertinent to the study are reviewed. The first part of the chapter looks at the theoretical literature establishing the relationship between inflation and exchange rate, the second segment is empirical framework that explores this relationship, and the last part is an empirical analysis of inflation modelling studies of Ghana.

2.1 THEORETICAL FRAMEWORK

2.1.1 MONETARY AND STRUCTURALIST THEORIES

The argument of the main causes of inflation has been a major debate between monetarists and structuralists since time. Monetarists believe that excess money supply such that it exceeds productivity, is the main cause of inflation in an economy. They contend that, without a corresponding growth in supply of money beyond that of real output, secular inflation cannot persevere. Hence, inflation can only be curbed if growth in money supply is decelerated which would subsequently lead to stable price levels as well as a more balanced economy.

Contrarily, the structuralists hold the view that inflation can persist autonomously, that is, regardless of monetary instruments. In their regard, money supply is an effect of inflation and not a cause. They believe that inflation has two main causes; food supply rigidities and the inconsistency in exports purchasing power (B. Fischer & Mayer, 2007). They argue that in a dual economy, where there are two distinct sectors in the economy; manufacturing and agricultural sectors, supply of food is inelastic and as such, there’s flexibility in prices with regards to changes in demand and resources shifts between these two sectors when needed. During industrialization,

resources shift from the agricultural sector to the manufacturing sector which result in rigidities in supply in the agricultural sector. Say these blockages in the agricultural sector detrimentally affect food production, coupled with inadequacies in purchasing power of exports resulting in low food imports, prices of food would increase respectively, which would in turn affect cost of living and wages. Hence to them, "if prices of food or exports react more rapidly than prices in the rest of the economy then the inflation rate will be affected not only by the excess supply of money, but also by the change of relative prices reflecting sectoral excess demand" (B. Fischer & Mayer, 2007). Barriers in sectors lead to low productivity which subsequently increases prices and then result in an increase in money supply.

2.1.2 THE NEO LIBERAL "CRISIS OF CONFIDENCE" MODEL

In neoclassicism, there is the belief that inflation, especially hyperinflation, is due to a loss in confidence in the store of value of the country. This is usually as result of a crisis where the government needs to take any necessary action to ensure victory, like civil wars, severe internal conflicts, warfare, capital flight, contagions, etc. In such situations, expenses cannot be significantly reduced, and it may difficult to take fiscal measures like tax increases, hence leading to deficits. Thus, in the "Crisis of Confidence" model, speculators and producers start to believe that there is a high perceived risk associated with holding the currency and hence start increasing prices. Typically, such deficits will be financed through loans however circumstances do not allow for that so to try and salvage the problem, the government would usually increase domestic money supply. The Chinese hyperinflation of 1939 to 1945, is a typical example of this theory, where the government printed more money in order to make up for the deficits and costs incurred by the civil war. In the end, the lack of confidence causes an increase in money supply which in turn leads to inflation.

2.1.3 PURCHASING POWER PARITY MODEL

When the Purchasing Power Parity theory holds, then the relationship between exchange rate and inflation can be established. The origins of the Purchasing Power Parity can be traced to the sixteenth century, by the Salamanca School in Spain, however its contemporary usage could be attributed to Gustar Cassel, a Swedish economist who recommended the theory as a way of amending the exchange rate parities in pre-World War I, for countries who were to return to the gold standard system after the fights (Adedoyin et al., 2016). Nevertheless, modifications to the theory was required as countries still experienced different rates of inflation during and after the war. The most practical form of the Purchasing Power Parity; absolute PPP, was then devised based on the law of one price. It stipulates that due to arbitrage, exchange rate would adjust such that the price of baskets of goods of services between two countries would be equal. Hence, the main argument proposed by Cassel was that relative price levels are necessary to determine exchange rate and a change in price level would result in a change in exchange rate consequently.

2.1.4 TRADITIONAL FLOW MODEL

The major argument with the Traditional Flow approach is that the flow of imports and exports is held in equilibrium when Balance of Payments of a country is equilibrated as well. Wherefore, exchange rate is defined as the relative price of various national outputs. As such, for a country to gain a current account surplus, it must acquire foreign financial assets, or a capital outflow, whereas to finance a current account deficit, a capital inflow is required or a sale of foreign financial assets. With this in mind, an assumption that current account is a function of changes in real income and relative prices is derived.

2.2 EMPIRICAL FRAMEWORK

2.2.1 EMPIRICAL STUDIES: DEVELOPED MARKETS

Montiel (1989) investigates the high inflation episodes in Brazil, Argentina and Israel using unrestricted vector autoregressions and quarterly data. His work estimates the dynamic relationship among price, base money and nominal exchange rate, however, to reduce the chances of extreme misspecification, he includes nominal wage and real output in the model. This also gave room for an estimation of the effect of base money on nominal exchange rates in these countries. Although typically involvement of more variables to a model could lead to result biases and undefined errors, all five variables employed were very significant as they highly influence price behaviour. His findings showed that in Argentina and Brazil, exogenous shocks in exchange rate and base money were the main causes of inflation for the periods examined though in Israel the major cause was nominal wage. Hence the results seemed to side with the balance of payments view of the causes of high inflation in the countries under study (Montiel, 1989).

Montiel (1989) in his work, used ordering assumptions to assess the relative contribution of the causal variables (Dornbusch et al., 1990), nevertheless, using data from the same countries, Dornbusch, Sturzenegger and Wolf (1990) in their paper "Extreme Inflation: Dynamics and Stabilization" investigate the process of high inflation by looking at its sources, catalysts and behaviour, as well as the important prescriptions for stabilization using a structures, but instead, they follow Olivier Blanchard and Danny Quah by including restrictions based on economic theories for their VAR model (Dornbusch et al., 1990). They include factors like exchange rate, and justify this with the explanation that the external sector plays a serious role in the

inflationary process because real exchange rates are not constant (Dornbusch et al., 1990), and the purchasing power parity assumption is not empirically justifiable, hence, real exchange rate shocks can accelerate high inflation (Dornbusch et al., 1990). Three main restrictions were made; the assumption that innovations in the budget and inflation rate do not affect real exchange rate in the long run and the assumption that shocks to budget deficit affect the real exchange rate with a lag in the short run (Dornbusch et al., 1990).

Employing a granger causality test and variance decompositions in a structured VAR framework they find that budget or real exchange shocks hasten the inflation process, and should that happen, steady adjustments to policies would not be enough to control the inflation. Such periods were classified as an era of “extreme inflation” and they stipulated that after this period, a country would lose its ability to keep inflation rates at 5 or 10 percent per month (Dornbusch et al., 1990).

Likewise, Fisher, Sahay and Végh (2002) in their paper “Modern Hyper- and High Inflations” did not favour the fiscal view of causes of inflation either. To ensure consistency in their results, a condition that countries included in the sample should have at least ten annual observations for each variable during the period 1960 to 1995, was introduced (S. Fischer et al., 2002). The model employed five variables; inflation as the dependent variable, and reserve money, broad money, fiscal balance, and nominal GDP as the independent variables. In addition to these panel regressions, the study included subsamples containing the countries with high inflation to determine the coefficients during their high-inflation episodes and how it differed from low-inflation periods. Their findings showed that in the long run, there is a strong negative relationship between money growth and inflation, however in periods of high

inflation, the relationship was found to be stronger than that of low inflation. In the short run, the relationship remained strong for countries with high inflation however, was insignificant for those with low inflation (S. Fischer et al., 2002). The study also revealed no significant relationship between fiscal deficits and inflation but showed that periods of high inflation were coupled with terrible macroeconomic performance. Their research showed that exchange rate-based stabilizations often resulted in an initial growth in consumption and real GDP and stabilization policies that were not built on exchange rate appeared to have insignificant effects on output, consumption and investment.

Contrarily, Catao and Terrones (2003) used a simple intertemporal optimization model to demonstrate the relationship between fiscal deficits and inflation based on forty-two years' worth of data from 107 countries. This time around, their research favoured the "fiscal view" of causes of inflation. Unlike many econometric specifications, the relationship was modelled nonlinearly, where fiscal deficit was scaled by narrow money and not GDP (Catão & Terrones, 2003). Countries were segmented into two groups; advanced and developing countries, to allow for a clear determination of the relationship between the variables. No significant relationship was found between fiscal deficits and inflation for developed countries with low inflation, however in the case of advanced countries with moderate inflation and developing countries, the relationship was strong and positive.

2.2.2 EMPIRICAL STUDIES: DEVELOPING AND EMERGING MARKETS

Klau (1988) looked at the effect real exchange movements and exchange rate policies have on inflation in twenty-two sub-Saharan African countries using panel regressions. Countries were grouped into two; Communauté Financière Africaine

franc countries with fixed exchange rate regimes, and those with floating exchange rate regimes. The essence of the categorization was to demonstrate that even with similarities in economic structure and history, their reactions to supply shocks have been different due to the diversity in exchange rate regimes. The framework used for the analysis was an improved version of Kamin (1996) which showed an empirical relationship between inflation rate and the real exchange rate level in a number of Latin American and Asian countries (Kamin, 1996). Klau's (1998) work also confirmed this empirical relationship for the selected sub-Saharan African countries. For the CFA Franc countries, keeping real exchange rate highly appreciated allowed them to maintain low levels on consumer price index than the Non-CFA countries (Klau, 1998). This also proved that the capability of the non-CFA countries to manage a relatively competitive exchange rate did come at a high inflationary cost to them, and a weaker monetary governance. The work showed the dilemma policymakers usually face as they are stuck between the trade-off of improving domestic inflation or keeping external competition high through currency depreciation (Klau, 1998). Additionally, in both groups, Klau (1998) discovered that in the short and long run, currency devaluations had positive effects on economic growth, and this differed from findings in Kamin and Klau (1997).

In December 2001, Prakash Loungani and Phillip Swagel studied the sources of inflation in fifty-three developing countries, with major focus on the effect of exchange rate regime on average price levels. Sources of inflation were put into four major groups; fiscal imbalances, balance of payment deficits, exchange rate depreciation, and government budget constraints. Additionally, countries were also grouped into their respective regions to allow for a clearer analysis. A modified version on Montiel's (1989) Vector Autoregressions model was employed where

instead of estimating individual VAR for each country like he did, Loungani and Swagel (2001) combined the data across the different countries. The results from their study proved that in many African and Asian countries, sources of inflation are quite diverse. The most dominant were fiscal variables; money growth and exchange rates in high inflation countries however other instruments like oil and non-oil commodities prices as well as output gap had moderate effects on inflation in these regions (Loungani & Swagel, 2001). In many low to moderate inflation, inertial inflation was more significant, and a recommendation given was for countries to focus on structural matters like labour market rigidities and inflation forecasting schemes when building anti-inflationary policies (Loungani & Swagel, 2001). It was also discovered that for developing countries with fixed exchange rate regimes, money growth seemed to be the major source of inflation compared to those with floating exchange rate regimes.

Onyekachi and Onyebuchi (2016) examined the relationship between exchange rate and inflation in Nigeria, using the Johansen co-integration test, Vector Error Correction Model and a Correlation coefficient analysis. The dependent variable under study was inflation whereas exchange rate, money supply and real gross domestic product were the explanatory variables employed. Their findings from the Johansen co-integration test revealed that in the long run, there is an equilibrium relationship between the dependant and independent variables and the Vector Error Correction Model estimated that on average, a 1% increase in exchange rate would lead to a decline in inflation rate by 24.9% in Nigeria, however this result was rendered statistically insignificant (Onyekachi & Onyebuchi, 2016). The partial correlation coefficient analysis also demonstrated a weak negative correlation between the predicted variable and exposure variables. Based on their findings, they highly recommended that policymakers pay attention to the parallel movement of

exchange rate and inflation when trying to stabilize price levels and overall, improve macroeconomic performance.

Asel Isakova (2007) also modelled and forecast inflation in developing countries, using Central Asia as a case study and data from 1994 to 2006. The region was chosen because of their periods of high and severe economic recessions. The data was further grouped using a unit root test to determine the direction of integration. Additionally, the time series were also segregated into the three groups of inflation; cost-push, monetary and imported inflation. Unfortunately, her research was rather inconclusive as limitations in the data made it a challenging task.

In 2014, Blessing Mandizha also looked at the relationship between inflation and exchange rate depreciation using data from Zimbabwe's periods of hyperinflation, that is from 2001 to 2005. Her results showed that in the short run, increases in consumer price index was in fact as a result of depreciation in the local currency however the granger causality test proved a statistically significant positive correlation between exchange rate depreciation and average price levels only in the short run. In the long run, there was only a "feedback" relationship between inflation and exchange rate (Mandizha, 2014). The findings also showed that instruments like interest rate and inflation have are positively correlated to economic growth, hence an increase or decrease in either variable would correspond to a respective change in growth in the economy.

2.2.3 EMPIRICAL STUDIES: GHANAIAN CONTEXT

Chibber and Shafik (1990) modelled inflation and found out that inflationary surge was not as a result of official devaluation, as this rather had a positive effect on government budget in the country. This was because prices in Ghana had already

reflected the parallel exchange rate (Chhibber & Shafik, 1990). Emphasis was on placed on inflation mostly being a monetary phenomenon although past inflation rates had been as a result of structural deficiencies in the economy (Chhibber & Shafik, 1990). Nonetheless, Dordunoo (1994) stipulated that depreciation of exchange rate in a rapid manner, as well as hikes in prices of imports, were inflationary in nature and hence should not be left out when looking at the factors that influence average price levels in an economy.

Ocran (2007) modelled inflation rates in Ghana within the time period of 1960 to 2003 using the Johansen Co-integration test to determine the long-term relationship between inflation and other macro-economic variables, and an Error Correction Model to aid explain the relationship (Ocran, 2007). His findings showed that exchange rate, price of foreign goods and terms of trade were the main drivers of inflation in Ghana in the long run (Ocran, 2007). Nevertheless, he failed to establish a relationship between money supply and inflation rate in the country in the long run (Ocran, 2007). Per his research however, in the short run the main causes of inflation in Ghana are money growth, inflation inertia, changes in interest rates and exchange rate, with inflation inertia being the dominant determinant (Ocran, 2007).

In 2002, Akoena showed that inflation in Ghana is as a result of innovation in output using Granger Causality tests and a Vector Error-Correlation model (as cited in Alnaa & Abdul-Mumuni, 2005, p.11). He argues that although theoretically, rate of inflation relies on short-run changes in money and long-run disequilibrium, his results established no causal relationship between inflation and changes in money growth in the short run (as cited in Alnaa & Abdul-Mumuni, 2005, p.11).

Nortey, Ngoh, Doku-Amponsah and Ofori-Boateng modelled inflation and exchange rate in Ghana using multivariate GARCH, DCC and BEKK models and found a positive correlation, both conditionally and unconditionally, between inflation and exchange rates, between interest rate and inflation rates, and lastly between exchange rate and interest rates (Nortey et al., 2015). Their analysis proved that when there is stability in general price levels, interest rates are expected to stable as well (Nortey et al., 2015). Nevertheless, with exchange rate and inflation rate, when price levels are stable, depreciation in the Ghanaian Cedi is expected, but at a slower rate (Nortey et al., 2015). Generally, they discovered that a positive performance of the Cedi would yield positive inflation and interest rates in the long run.

2.3 CONCLUSION

The discussions above, outlining the empirical works of the relationship between exchange rate and inflation rate have showed diverse conclusions. For developed and developing countries, there is no clear conclusion on the exact relationship between these two macroeconomic variables in either case. The results from the research conducted on Ghana shows the need for more extensive and strong analysis of the variables as much attention has not been paid attention to it.

CHAPTER THREE: METHODOLOGY

OVERVIEW OF CHAPTER

This Chapter discusses the research methods, data collection and analysis tools and techniques that were employed in this study, as well as the limitations of the methodology.

3.1 RESEARCH DESIGN

The approach used in this study is a causal research design, also known as an explanatory research design. The aim of causal research is to empirically examine cause-and-effect relationships among variables, and hence usually involves more than one explanatory variables and their relationship to one dependant variable (Oppewal, 2010). Given that the main objective of this study is to determine if Ghana's inflation rate can be forecasted using past exchange rate data, the most fitting research design to test the hypothesis was a causal research design approach. These relationships are established through statistical and econometrical methods, nevertheless, conclusions made about causality are usually stronger if they are based on "designed" experiments (Oppewal, 2010).

3.2 RESEARCH SCOPE

The country of study here is Ghana, in West Africa. As stated by BBC News, it is known to be one of the most stable countries in the region, with a fast-growing economy ('Ghana Country Profile', 2018). It is one of few African countries to have uncovered oil quite recently and has since been working on ways of retrieving and sustaining the resource. The discovery of oil has also created a boost in foreign direct investment. The peace and tranquillity in the country also makes it a very safe place to conduct business. Currently, the government of Ghana is running an initiative titled

"The Year of Return", to encourage Ghanaians in the diasporas to return to the country and invest in it. In order to give a true reflection of the population, data that was used for this study was not sampled but focused on the entire country.

3.3 SAMPLE SIZE

For a time series dataset, the sample size is the number of time periods over which variables of interest would be observed (Wooldridge, 2013). As such, for each variable, the sample size was originally twenty, covering a time range from 1999 to 2018 inclusive. This is mainly because in this time period, most of the variables under study underwent significant changes due to Ghana's currency redenomination as well as the global financial crisis of 2007-08. To make up for the short timeframe, monthly data for each variable was used to increase the frequency of collection of observation, and hence increase the number of relevant data points from twenty to 20*12 = 320. Per the Law of Large Numbers, more data allows for more robust estimation of relationships.

3.4 DISCUSSION OF VARIABLES

The dependent variable is inflation. The main explanatory variables investigated here were exchange rates, interest rates and money supply. Bawumia and Atta-Mensah (2003) predicted that broad money supply, growth rate (OF WHAT) and depreciation of exchange rate are the major causes of high rates of inflation in Ghana (Atta-Mensah & Bawumia, 2003). This was also empirically confirmed by Alnaa and Abdul-Mumuni (2005), who inferred that money supply, interest rate and exchange rate are the main predictors of inflation in Ghana (Alnaa & Abdul-Mumuni, 2005). A key finding that also influenced the variables used in this investigation is that of Ocran (2007) whose findings proved that exchange rate, price of foreign goods

and terms of trade were the main causes of inflation in Ghana in the long run (Ocran, 2007). Based on these studies, these variables were chosen as the key variables substantially influence inflation rates and added to the econometric model to be employed in this study.

3.4.1 INTEREST RATES

A negative correlation between interest rate and inflation is expected here. This is simply because should interest rates fall in an economy, borrowing by individuals and firms would increase which would in turn increase spending as well. This would lead to a rise in aggregate demand and growth in the economy as well as a rise in inflation. On the other hand, an increment in the interest rate would dampen spending but encourage savings as higher returns would be expected which would lead to lower disposable income. This decelerates growth in the economy, leading to a fall in inflation. Irving Fisher was one of the first people to make the claim that interest rates are governed by inflation expectations (Levine & Kaplan, 1981). Nevertheless, empirical evidence has shown that although the relationship exists, it is weak in nature (Levine & Kaplan, 1981). For the purpose of this study, the risk-free rates on the 91-day Treasury bill in Ghana were used to indicate nominal interest rates because it is the rate used for most valuation projects.

3.4.2 MONEY SUPPLY

Demand and supply of money determines the relationship between growth in money and rate of inflation, in the long run. In an economy where supply of money increases faster than growth in real output, inflation would also rise. Simply put, the increase in supply of money with real output constant shows that there is more money to in the system for purchases but number of goods available for purchase remains

unchanged and as such firms are forced to increase prices to mitigate the rise in monetary pressure. The quantity theory of money examines the direct relationship between these two variables. The formula MV = PT, where M represents money supply, V is the velocity of money circulation, P measures the average price level and T looks at the volume of transactions (Osiakwan & Armah, 2013), shows that when velocity of money circulation and volume of transactions are held constant, price level is proportionally related to money supply growth. The right hand side of the equation represents total spending in the economy and this can also be equated to Gross Domestic Product (Sinah, 2017). Hence the equation can be rewritten as MV = GDP to show that money supply can be found by dividing gross domestic product by velocity of money circulation (Sinah, 2017). Money supply was measured by broad money supply.

3.4.3 EXCHANGE RATES (USD/GHS)

Exchange rate is defined as the price of one currency in terms of the currency of another country. Changes in exchange rates of both tradable and non-tradable would have large effects on the price levels in an economy. Hence stability of exchange rate is needed to ensure stability in prices (Bobai et al., 2013). An increase in foreign exchange rate, or a depreciation in the home currency causes exports to be cheaper, leading to a rise in demand for exports of the home country. This would subsequently result in an increase in price which would cause a growth in the inflation rate (Monfared & Akın, 2017). Svensson (2000) showed that exchange rate can impact inflation rate in three ways:

i. In an open economy, changes in exchange rate affects relative prices of both domestic and foreign goods such that net exports have an effect on the total demand of goods and indirect inflation (Monfared & Akın, 2017).

ii. Contrarily, domestic prices of imported final goods are directly affected by changes in the exchange rate such that it directly affects consumer price index as well and the effect of this change is very pertinent in the short run than the net export effect (Monfared & Akın, 2017).

iii. Lastly, nominal wages are also affected by changes in exchange rate because of the effect of prices of imports on the Consumer price index and the combination of these two effects would cause the rate of inflation to be affected by cost of domestic production (Monfared & Akın, 2017).

Based on this theory, a positive relationship between exchange rate and inflation is expected. The USD/GHS exchange rate was used to measure the changes in exchange rate.

3.4.4 INFLATION RATES

Generally, inflation refers to a persistent rice in average price levels, however it can also be defined as an increase in money supply. When money supply in an economy increases, it usually results in higher price levels (Sa'ad et al., 2018). Inflation rate was measured based on percentage changes in Consumer Price Index.

3.5 JUSTIFICATION OF THE EMPIRICAL MODEL

For this study, a time series regression model was used to examine if inflation rates can be forecasted based on past exchange rate data. This empirical model is fitting for this study because it is a statistical method for forecasting a future response built on historical data and the data sample to be employed here is made up of a

sequence of stochastic variables indexed by time. Although forecasting is simply an application of regression analysis, it differs slightly from just the estimation of causal effects (Wooldridge, 2013). The concept of autocorrelation is also explored under time series regression, where the time series has a linear correlation with its lagged versions, and these are established through autoregressive models. Nevertheless, Wooldridge (2013) shows that predictions made from autoregressions can be improved upon if other variables and their lags are added to the autoregression to give an autoregressive distributed lag model (Wooldridge, 2013).

Generally, there are two time series model that are used by many econometricians and statisticians to conduct time series analysis and are the Static Models and the Finite Distributed Lag Models (Wooldridge, 2013). The Static Model is based on the theory that relationship between the dependent and independent variable being modelled, is a contemporaneous one, such that a change in the explanatory variable at a particular time period is said to have an instant effect on the response variable (Wooldridge, 2013). An example of the static model is the Phillip Curve;

$$inf_t = \beta_0 + \beta_1 Unem_t + u_t,$$

Where inf_t represents inflation rate on an annual basis and $Unem_t$ is the annual unemployment rate. The assumption made under the Phillip Curve is a constant natural rate of unemployment and inflationary expectations, making it a good model to be used to investigate the contemporaneous tradeoff between unemployment and inflation (Wooldridge, 2013). A static model can have more than one explanatory variable, and such a model is used to determine the ceteris paribus effect of an explanatory variable on the response variable. Mathematically, a static model of x relating to y is represented as:

$$y_t = \beta_0 + \beta_1 x_t + u_t,\ t = 1, 2, \ldots, n$$

In the Finite Distributed Lag Model, one or more independent variables are allowed to affect the dependent variable with a lag (Wooldridge, 2013). It is mathematically represented as:

$$y_t = \beta_0 + \beta_0 x_t + \beta_1 x_{t-1} + \ldots + \beta_q x_{t-q} + u_t,\ t = 1, 2, \ldots, n$$

and the reasoning here is to investigate if in the aggregate the response variable is linked to the explanatory variable. The equation takes into account the fact that changes in the response variable would not always immediately result from changes in the independent variable (Wooldridge, 2013). The sum of the coefficients is the long-run change in the response variable given a permanent rise in the explanatory variable and is known as the long-run propensity (Wooldridge, 2013).

This study employs more than one independent variable hence, a multivariate time series approach was used here, and the equation for the model is:

$$inf_t = \beta_0 + \beta_1 exch_{t-1} + \ldots + \beta_{12} exch_{t-12} + \alpha_1 inrst_{t-1} + \ldots + \alpha_{12} inrst_{t-12} + \delta_1 ms_{t-1} + \ldots + \delta_{12} ms_{t-12} + u_t$$

Where $\beta_0, \ldots, \beta_{12}, \alpha_1, \ldots, \alpha_{12},$ and $\delta_1, \ldots, \delta_{12}$ are unknown coefficients, u_t is the error term which captures all other lurking variable which could affect rate of inflation, *exch* is the annual exchange rate measured by USD/GHS rates, *inrst* represents annual interest rate over the time period, *ms* is broad money supply over the time period and *inf* is annual inflation rates indicated by percentage changes in Consumer Price Index.

3.5.1 TIME SERIES REGRESSION ASSUMPTIONS

For the model to stand, the following Gauss-Markov time series regression assumptions are necessary:

i. Time Series Assumption 1: Linear in Parameters

This assumption states that the time series process, which is stochastic in nature, follows a model that is linear in its process such that;

$$Y_t = \beta_0 + \beta_1 x_{t1} + \beta_{kx} t_k + u_t$$

Where β_j are the parameters to be estimated, u_t is the sequence of errors and n is the number of time periods or observations (Wooldridge, 2013).

ii. Time Series Assumption 2: No perfect Collinearity

No independent variable in the sample is constant, neither are they a perfect linear combination of others. This assumption allows for correlation among the independent variable, however it rules out **perfect** correlation in the sample (Wooldridge, 2013).

iii. Time Series Assumption 3: Zero Conditional Mean

Given the independent variables for all time periods under study, the expected value of the error term u_t for each t, is zero. Such that;

$$E(u_t \mid X) = 0, t = 1, 2, \ldots, n \quad \text{(Wooldridge, 2013)}$$

iv. Time Series Assumption 4: Homoskedasticity

This assumption states that the error term must have a constant variance for all observations. Mathematically, this is represented as

$$Var(u_t \mid X) = Var(u_t) = \sigma^2, t = 1, 2, \ldots, n$$

If this assumption does not hold, then the errors or disturbances are said to be heteroskedastic (Wooldridge, 2013).

v. Time Series Assumption 5: No Serial correlation

Conditional on X, the disturbances or errors in two separate time periods are not correlated (Wooldridge, 2013), such that

$$Corr(u_t, u_s|X) = 0, \text{ for all } t \neq s \text{ (Wooldridge, 2013)}$$

vi. Time Series Assumption 6: Normality

The error term or disturbances are independent of the explanatory variables and are also independently and identically distributed as normal (Wooldridge, 2013).

3.6 ETHICAL CONSIDERATIONS

Data retrieved from the various sources were not manipulated just so it falls in line with the models used in the study. Furthermore, the findings from this study were strictly from the analysis made and as such interpretations, conclusions and recommendations were also be based on these results, regardless of the opinions of the author.

CHAPTER FOUR: RESULTS

OVERVIEW OF CHAPTER

This chapter is a presentation of the results from the statistical analysis of the data collected. The chapter contains a detailed discussion of the findings in line with the objectives of this study. The chapter enables the reader to understand the results based on the empirical literature.

4.1 DESCRIPTIVE STATISTICS

Table 4.1: Summary statistics of macroeconomic variables

Variables	*Mean*	*Standard Deviation*	*Min*	*Max*	*Median*
Money supply (in billion GHS)	13.48	16.14	0.32	60.43	5.96
Interest Rate (GHS)	21.12	9.04	9.25	46.75	22.64
Exchange Rate (USD/GHS)	1.78	1.33	0.24	4.82	1.24
Inflation Rate (GHS)	16.01	7.30	8.39	41.95	14.24

Notes: The figures shown are monthly data for macroeconomic variables gathered from the Bank of Ghana.
Source: Author's estimations using R statistical software.

The results presented above in Table 4.1 are the descriptive statistics of the macroeconomic variables discussed in the study, for the period 1999 to 2018. Over this period, the average inflation rate for Ghana, measured by the Consumer Price Index, was 16.01 percent with a standard deviation of ±7.3, showing the huge spread or dispersion among the values. Additionally, the mean statistic proves that on average, within the time period under study, the Central Bank of Ghana did not meet its single digit target inflation, emphasizing the ineffectiveness of the country's present inflation-targeting system employed. Additionally, the Ghanaian Cedi also

experienced consistent depreciation over the years, with a minimum of GHS 0.24 per US Dollar in early 1999, and a maximum of GHS 4.82/USD in late 2018. Money supply, measured by M2, that is broad money supply, averaged at GHS 13.48 billion over the time period, with a minimum of GHS 320 million, and an all-time high of GHS 60.43 billion and lastly, interest rates, represented by 91-day treasury bill rates, averaged at 21.12 percent during the period with a standard deviation of ±9.04. The interest rate statistics shows the failures of the country's Central Bank's attempts to decrease interest rates and push real economic activity.

4.2 TEST FOR TIME SERIES REGRESSION ASSUMPTIONS

This section discusses results from the investigation of the Gauss-Markov time series regression assumptions discussed in section 3.5 above, necessary for the model to stand. A few tests were conducted to examine the likely violations of these assumptions and to evaluate the efficiency and robustness of the model used, other post-estimation tests were also conducted.

4.2.1 TEST FOR NORMALITY

4.2.1.1 SHAPIRO-WILK (1965) TEST FOR NORMALITY

The Shapiro-Wilk Test invented in 1965, is a test to investigate the composite hypothesis that the data from a sample of real-valued observations are independent and identically distributed, as well as normal (Shapiro & Wilk, 1965). Many statistical methods like the T-test and ANOVA assume normality among variables, however if variables are not normally distributed, there would be the need to employ other nonparametric methods. There are two test statistics related with this test; W for Wilk, and p-value. The decision rule is to reject the null hypothesis and accept the alternate, if the P-value is less than 0.05. The value computed for the W test statistic always

satisfies the condition $0 < W \leq 1$, and is calculated "by dividing the square of an appropriate linear combination of the sample order statistics by the usual symmetric estimate of variance" (Shapiro & Wilk, 1965). The following hypothesis were investigated using the Shapiro-Wilk (1965) test.

H_0: Sample is normally distributed.

H_α: Sample is not normally distributed.

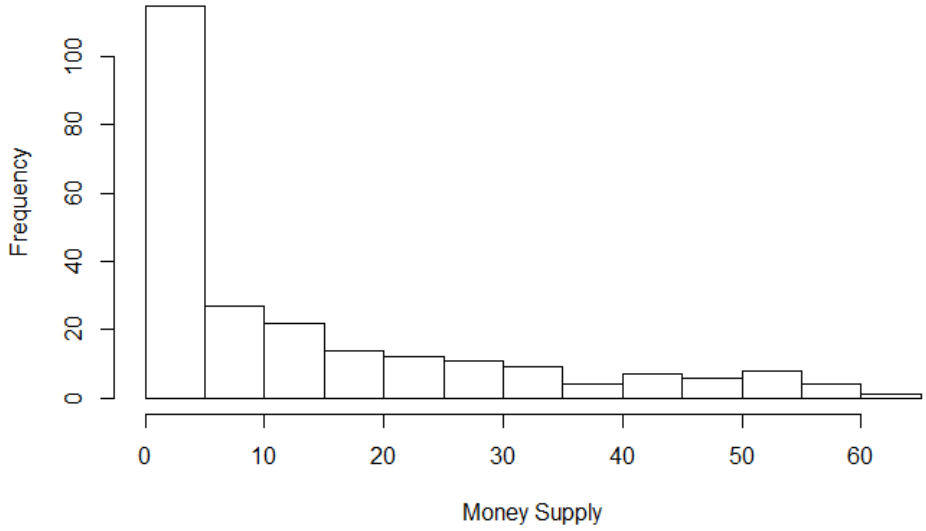
Table 4.2: Results of the Shapiro-Wilk (1965) Test for normality

Variables	*W*	*P-Value*
MS	0.79	0.00
INRST	0.92	0.00
EXCH	0.82	0.00
INF	0.80	0.00

Source: Author's estimations using R statistical software

Table 4.2 above depicts the results generated from the Shapiro-Wilk (1965) Test. From the table above, all variables satisfy the condition of the W test statistic, as discussed early on. Additionally, the P-values computed for all variables, were less than 0.05, proving that the results are statistically significant given as such the data provides significant evidence to reject the null hypothesis and accept the alternate, that the sample is not normally distributed. Nevertheless, to ensure that the variables of study were normally distribution, its logarithmic versions were used.

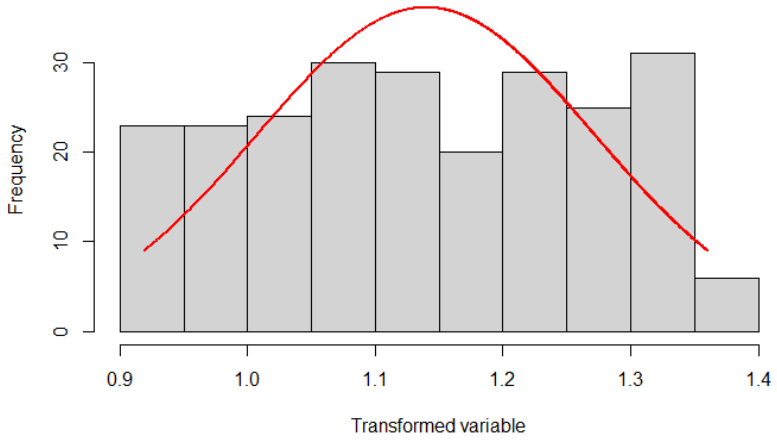
Figure 4.3: Graph showing the distribution of monthly Money Supply



Source: Author's plot using R Statistical Software.

As shown in Figure 4.1 above, the distribution of average monthly money supply was right-skewed, with huge variations in its mean, mode and median and as such, to attain a normal distribution, the data for this variable were transformed to its base ten logarithmic versions and the result of the transformation is depicted in Figure 4.2 below.

Figure 4.4:Graph showing the distribution of log transformed Money Supply

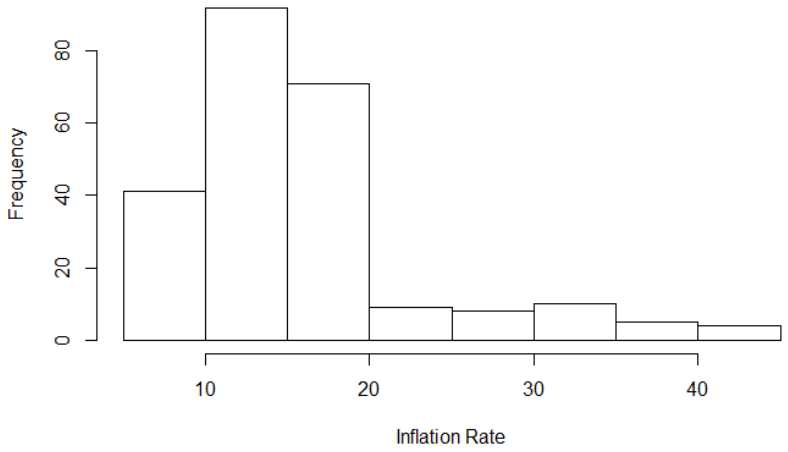


Source: Author's plot using R Statistical Software.

Additionally, the distribution for inflation rate, as shown in Figure 4.3, was also skewed to the right, with the mode being the highest point of the histogram, and

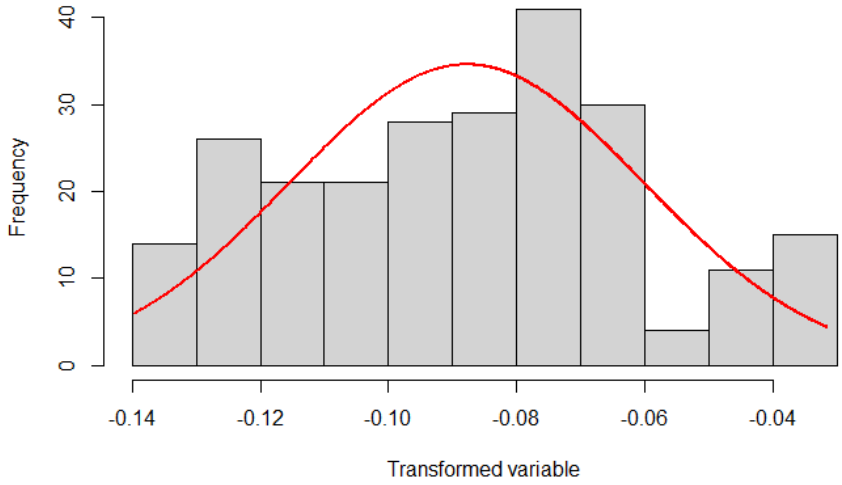
the median and mean falling in the lower tail. Transforming the variable into its logarithmic version, as shown in Figure 4.4, gave it a normal distribution.

Figure 4.5: Graph showing the distribution of monthly Inflation Rate



Source: Author's plot using R Statistical Software.

Figure 6: Graph showing the distribution of log transformed Inflation Rate



Source: Author's plot using R Statistical Software.

Exchange rate and interest rates were also transformed into their logarithmic versions to decrease the skewness in their distribution and to allow for a sensitivity analysis, that is an elasticity relationship, among the variables.

4.2.2 TEST FOR MULTICOLLINEARITY

As discussed in Section 3.5, for the model to hold, no independent variable in the sample should be constant, neither should they have perfect linear correlations. Hence the assumption allows for correlation among the independent variable, however it rules out **perfect** correlation in the sample (Wooldridge, 2013). Hence to investigate the issue of multicollinearity, a correlation matrix of all the independent variables was employed for this study.

Table 4.3: Results of correlation matrix of all the independent variables

	Money Supply	*Interest Rate*	*Exchange Rate*
Money Supply	1.00		
Interest Rate	-0.27	1.00	
Exchange Rate	0.96	-0.23	1.00

Source: The author's estimates using Microsoft Excel.

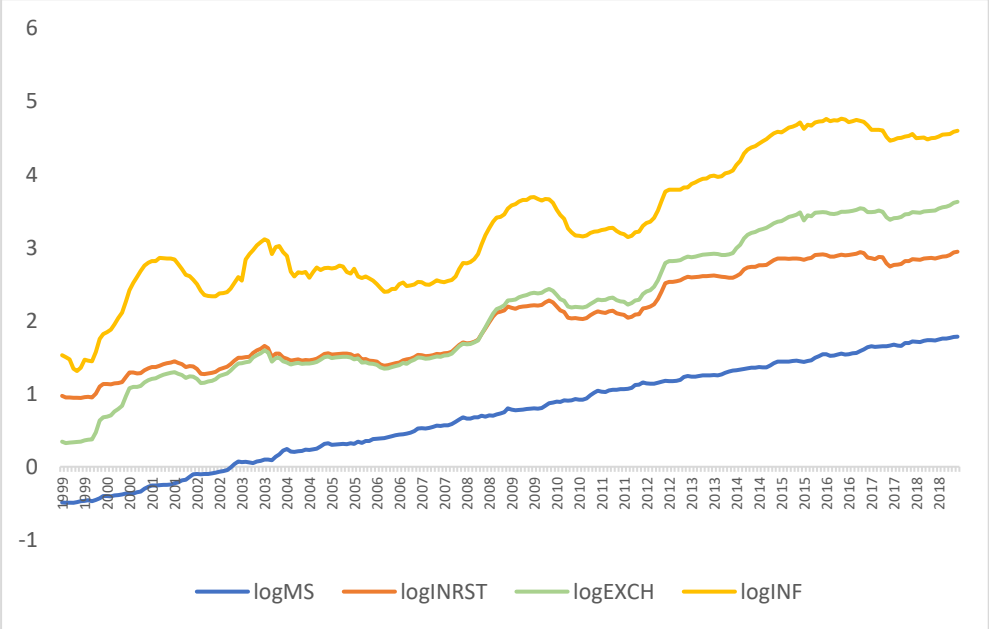
As shown in Table 4.3 above, although the explanatory variables are corelated, none of them have a perfect correlation.

4.2.3 TEST FOR STATIONARITY

The notion of stationarity plays an important role in the analysis of time series (Wooldridge, 2013). "A stationary time series process is one whose probability distributions are stable over time in the following sense: If we take any collection of random variables in the sequence and then shift that sequence ahead *h* time periods, the joint probability distribution must remain unchanged," (Wooldridge, 2013). Hence to establish and understand the relationship between variables, stability must be assumed among the variables over time otherwise should the relationship between two variables be allowed to change arbitrarily in each time period, then nothing can

be learnt about how a change in one variable affects the other variable since there is access to a single time series realization (Wooldridge, 2013).

Figure 4.7: Graph showing the line distribution of the response and explanatory variables



Source: Author's plot using Microsoft Excel

All time-series datasets have either stochastic or deterministic trends, hence it is important to conduct unit root or stationarity tests to identify the existing trends in the data (Metes, 2005). The easiest way to first identify these trends is to conduct a graphical analysis. Figure 4.5 above depicts the results from the graphical analysis and there is an upward trend in the distribution of the log transformations of Money Supply, Interest Rates, Exchange rates and Inflation rates, over the time period under study. The most important thing is to identify the presence of trend in mean, variance, autocorrelation and seasonality and the presence of any of these signifies non-stationarity (Metes, 2005). A graph with an upward trend exhibits a constant trend in the mean (Metes, 2005) whereas one with a continued downward or upward slope exhibits a non-constant mean (Metes, 2005). From Figure 4.5, the log transformations of Interest Rates, Exchange rates and Inflation rates generally depict an upward trend with a few fluctuations hence proving the

need to include a constant and trend condition in the stationarity test, nevertheless, the log transformation of Money Supply shows a sustained upward trend, implying that a non-constant should be included in the stationarity test.

4.2.3.1 AUGMENTED DICKEY FULLER TEST

The Augmented Dickey-Fuller test is used to test the assumption of serial correlation for time series data. It is an improved and powerful version of the Dickey-Fuller test and can be used on more complex models, hence making it highly recommended. The test statistic computed, namely the DF_T statistic, is used in comparison with a tabulated critical value as shown in Table 4.4 below.

Table 4.4: Critical Values for Dickey-fuller t-distribution

	With trend			*Without trend*		
Sample Size	1%	5%	10%	1%	5%	10%
25	−4.38	−3.60	−3.24	−3.75	−3.00	−2.63
50	−4.15	−3.50	−3.18	−3.58	−2.93	−2.60
100	−4.04	−3.45	−3.15	−3.51	−2.89	−2.58
250	−3.99	−3.43	−3.14	−3.46	−2.88	−2.57
500	−3.98	−3.42	−3.13	−3.44	−2.86	−2.57

Source: (Fuller, 1976)

The Augmented Dickey–Fuller statistic is a negative number, and, should the computed test statistic be more negative than its compared value in Table 4.4 above, the null hypothesis is rejected and the alternate accepted. The null and alternative hypothesis for the Augmented Dickey-Fuller test are as follows:

H_0: Series is non-stationary.

H_α: Series is stationary.

The table below depicts the results from the Augmented Dickey-Fuller tests of the logarithm transformations of money supply, interest rate, inflation rate and exchange rate.

Table 4.5: Results of the Augmented Dickey-Fuller Stationarity Test

	Level		*First Difference*		*Order of Integration*
	With trend	Without trend	With trend	Without trend	
logINF	-3.92**	-3.55***	-10.81***	-10.83***	*I(1)*
logINRST	-3.18*	-2.89**	-10.3***	-10.32***	*I(1)*
logEXCH	-4.04***	-0.91	-11.59***	-11.61***	*I(1)*

Source: Author's estimates from R Statistical Software.
Note: '***', '**' and '*'mean statistically significant at 1%, 5% and 10% respectively.

The Augmented Dickey-Fuller test was run in two phases; when the series includes a constant and trend, and when the series includes a constant only. As mentioned in Section 3.3, the number of observations for the study was 240 hence, the results from this test was compared to the critical values of Dickey-Fuller test for a sample size of 250 in Table 4.4. From Table 4.5, the results showed that all the variables except for exchange rate had unit roots at some significance levels. After taking the first differences, exchange rate, interest rate and inflation rate were found to be stationary with and without trend at 1%, 5% and 10% significance levels, hence all the variables became integrated of the same order at the first difference and the study can proceed to determine the long run relationship among the variables to gain better empirical results.

4.3 CO-INTEGRATION TEST

Co-integration is employed in econometrical analysis to determine the existence on a long run equilibrium relationship among variables. Hence, an existence on

cointegration implies an existence of a long run relationship among variables with unit roots (Sa'ad et al., 2018). The benefits with this method are that both long run and short run variables are estimated concurrently and can be used regardless of if all the variables have a zero or one order of integration. In the case where one of the variables is integrated of order one and the others of order zero, then the variables are not integrated of the same order and hence does not meet the conditions necessary for a cointegration test (Sa'ad et al., 2018) and the Bounds test by Pesaran (1999, 2001) is the best method to estimate long run relationships among variables, so long as none of the variables is integrated of order two (Sa'ad et al., 2018).

A selection test was first conducted to identify the optimal lag for the cointegration test. Even though several tests exist for optimal lag selection, the Akaike Information criteria (AIC) was employed here due to effectiveness in many studies, as well as its simplicity. The results of the test can be found in Table 4.6 below.

Table 4.6: Results of the Akaike Information criteria (AIC) estimation

Variables	logEXCH	logMS	logINRST	logINF
Number of lags	10	10	8	1

Source: Author's estimates from R Statistical Software.

The results from the table above show that the optimal lag length for exchange rate and money supply is ten months, whereas interest rate and inflation rate are eight months and a month respectively. This means that the historical values of all variables are important in estimating the relationship between exchange and inflation using an ARDL model.

4.3.1 JOHANSEN CO-INTEGRATION TEST

As discussed early on, all the series were integrated of order one hence the Johansen Co-integration test is a valid method to use to determine the existence of a long run relationship. A cointegration test is necessary, to determine if empirically, a model shows a viable relationship in the long run. Hence, if the results of a cointegration test does not establish this relationship, then there is the need for the differences of the variables to be used to conduct the research. The Johansen Co-integration test can be observed with the help of the Eigen test statistic and Trace Test statistic. If the test statistic computed is larger the critical value at five percent significant level, the null hypothesis is rejected, and the alternate is accepted. The null and alternative hypothesis of the cointegration test is specified below:

H_0: There is no cointegrating equation.

H_α: There is a cointegrating equation.

The results of the cointegration test are summarised in Table 4.7 below.

Table 4.7: Result of Test for Co-integration Rank

	Trace Test		Eigen Test	
Hypothesized number of CEs	Trace Value	5%	Eigen Value	5%
At most 3*	41.53	9.24	41.53	9.24
At most 2*	89.82	19.96	48.29	15.67
At most 1*	156.28	34.91	66.45	22.00
None*	317.35	53.12	161.08	28.14

Source: Author's estimates using R Statistical Software
Note: * denotes rejection of the null hypothesis at 5%.

The results depicted in Table 4.7 above suggest the existence of more than one co-integrating equation in both the Trace Statistic and Maximum Eigen statistics, as all

values of both the trace statistic and max-Eigen statistic in the estimation results is larger than that of the critical values. Per the decision rule discussed above, we reject the null hypothesis and conclude that there is presence of co-integration, hence implying that there is a long-run relationship between the variables. Note that the first difference of all variables was used for the cointegration test.

4.4 AUTOREGRESSIVE DISTRIBUTED LAG MODEL

A major objective of this research paper is to examine if there is a dynamic causal relationship between exchange rate and inflation, and subsequently if inflation rate can be forecasted based on past exchange rate data. Based on the empirical and theoretical literature reviewed in chapter two, the following hypothesis will be investigated in this section:

H_0: There is no relationship between exchange rate and inflation rates.

H_a: There is a relationship between exchange rate and inflation rates.

As mentioned in Section 3.5, a static model evaluates a contemporaneous effect between variables, such that a change in the explanatory variable at a particular time period has an instant effect on the response variable, whereas a distributed lag model considers the fact that changes in the response variable would not always immediately result from changes in the independent variable (Wooldridge, 2013). Since history plays an important role in forecasting, the static model will not be appropriate for this research since it does not consider lagged values of the variables. With that said, the Auto-regressive Distributed Lag Model is the most appropriate for this investigation since it allows for lags that will consider the possible effect of past data on future occurrences. An ARDL model of order p and n is defined for a scalar variable y_t as

$$y_t = \sum_{i=1}^{p} a_i y_{t-1} + \sum_{i=0}^{n} c_i' x_{t-1} + \varepsilon_t,$$

where $\mathcal{E}_t$ is a scalar of the error term and has a mean of zero, y_t is a vector and x_t is are variables that can either be differenced at their levels or at order one, or cointegrated. The coefficients a_i are scalars whereas c_i are row vectors (Hassler & Wolters, 2005).

Table 4.8: Results of the Estimated ADRL

Residuals:

Min	1Q	Median	3Q	Max
-0.0409	-0.00323	-0.00055	0.003472	0.03781

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.001199	0.001085	1.105	0.2705
logexch.t	0.851553	0.172157	4.946	1.63e-06 ***
logexch.1	0.078220	0.179940	0.435	0.6643
logexch.2	0.062347	0.169084	0.369	0.7127
logexch.3	0.315935	0.168778	1.872	0.0627
logexch.4	0.086418	0.168486	0.513	0.6086
logexch.5	-0.187735	0.168731	-1.113	0.2672
logexch.6	-0.164864	0.167129	-0.986	0.3251
logexch.7	-0.014184	0.168088	-0.084	0.9328
logexch.8	-0.064640	0.168671	-0.383	0.7020
logexch.9	-0.075891	0.170787	-0.444	0.6573
logexch.10	0.102880	0.173221	0.594	0.5533
logms.t	-0.186566	0.077661	-2.402	0.0172 *
logms.1	0.025012	0.077910	0.321	0.7485
logms.2	0.067467	0.076293	0.884	0.3776
logms.3	0.009916	0.078753	0.126	0.8999
logms.4	0.064117	0.080384	0.798	0.4261
logms.5	0.172028	0.078561	2.190	0.0297 *
logms.6	0.080154	0.082038	0.977	0.3298
logms.7	0.073429	0.079597	0.923	0.3574
logms.8	0.050451	0.077971	0.647	0.5184
logms.9	0.039381	0.079466	0.496	0.6208
logms.10	-0.029854	0.081771	-0.365	0.7154
loginrst.t	0.295925	0.034671	8.535	3.91e-15 ***
loginrst.1	0.067810	0.040506	1.674	0.0957
loginrst.2	0.006485	0.034680	0.187	0.8519
loginrst.3	-0.023496	0.034219	-0.687	0.4931
loginrst.4	-0.006809	0.034082	-0.200	0.8419
loginrst.5	0.019937	0.03434	0.581	0.5622

loginrst.6	0.027601	0.034226	0.806	0.4210
loginrst.7	0.015719	0.034440	0.456	0.6486
loginrst.8	0.040898	0.034792	1.175	0.2412
loginrst.9	0.010078	0.034971	0.288	0.7735
loginrst.10	-0.025618	0.034971	-0.733	0.4647
loginf.1	-0.124076	0.070898	-1.750	0.0817

Residual standard error	0.00943
Multiple R-squared	0.4929
Adjusted R-squared	0.4045
F-statistic	5.574

Source: Author's estimates using R Statistical Software
Note: '*" $p < 0.05$, '**' $p < 0.01$, '***' $p < 0.001$.

It is interesting to note from the results above, that exchange rate tends to be positively correlated to inflation rate the closer the month, and negatively correlated in the latter months. The general rule of thumb is that explanatory variables are significant if their p-values are well below 0.05 significant level. The results above show that only one coefficient of exchange rate, has a statistically significant effect on inflation rate; and since the frequency of data points is monthly, we can say that only exchange rate of current month is statistically correlated to inflation rate and since all the coefficients of the other lags of exchange rate were statistically insignificant, it signals that past monthly exchange rates do not have an impact on inflation rates in Ghana. Likewise, from the regression estimate, only one coefficient of interest rate, particularly interest rate of current month, was statistically significant, with a value of 0.2959, whereas past interest rates have no significant effect on inflation rates in Ghana. Two coefficients of money supply were also significant at a five percent significance level hence were both included in the final model.

It is worth noting that the R-squared of the Autoregressive Distributive lag model estimated is 0.4045, meaning that all the explanatory variables account for only 40.5% of the variation in inflation rates in Ghana. Unfortunately, this does not show a strong

correlation between exchange rate and inflation rate in Ghana. The F-statistic computed is 5.574, which is an extremely low value and a p-value which was not statistically significant, hence indicating that the model is not a good fit overall.

The results from the Autoregressive distributed lag model was used to derive a functional linear equation between the dependent and independent variables, and only the parameters that were statistically significant were included. The mathematical equation is detailed below:

$$inf_t = -0.1241\log inf_{t-1} + 0.8516\log exch_t - 0.1866\log ms_t + 0.1720\log ms_{t-5} + 0.2959\log inrst_t$$
$$[0.0709] \qquad [0.1722] \qquad [0.0777] \qquad [0.0786] \qquad [0.0347]$$

$$n = 240,\ r^2 = 0.4045$$

The values in parentheses are the estimated standard errors of the parameters. Per the equation above, a 1% increase in current month exchange rate, will lead to an 85% increase inflation rate, a one percent increase in current month's interest rate will lead to an increase in inflation rate by 29.6%, a one percent increase in current month's money supply will lead a decline in inflation rate by 18.7%, and a 1% increase in five month's money supply will lead to a rise in inflation rate by 17.2%.

4.5 POST ESTIMATION TESTS

This section explores the post-estimation tests conducted to test the robustness and functional ability of the model, including the Breusch-Pagan test for heteroscedasticity, the Breusch Godfrey Test and Durbin-Watson test for serial correlation, and the Ramsey RESET test.

4.5.1 TEST FOR SERIAL CORRELATION

The presence of serial correlation in the errors of a time series regression is said to invalidate goodness-of-fit measure, that is, the R-squared and adjusted R-squared

(Wooldridge, 2013). However, where data are stationary and not strongly dependent, this is not the case (Wooldridge, 2013). Serial correlation is often seen as a more significant problem than heteroskedasticity because it usually has deeper effect on standard errors and the efficiency of parameters, rather than heteroskedasticity (Wooldridge, 2013). The Breusch-Godfrey test and Durbin-Watson test were used to test for serial correlation, based on the hypothesis below.

H_0: There is no serial correlation in idiosyncratic errors

H_a: There is serial correlation in idiosyncratic errors

The p-value computed; 0.1343 per the Breusch-Godfrey test, is greater than the 0.05 significance level, hence the alternate hypothesis is rejected. Similarly, the Durbin-Watson test for serial correlation generated a p-value of 0.9235, also giving enough evidence, to fail to reject the null hypothesis. Hence the conclusion that there is no autocorrelation in idiosyncratic errors is made.

4.5.2 BREUSCH-PAGAN TEST FOR HETEROSCEDASTICITY

An infamous test used in econometrics and statistics to test heteroskedasticity is the Breusch-Pagan test. Unlike the White test which assumes that heteroskedasticity could be a linear function of all the explanatory variables, as well as a function of their squared values and their cross products, and hence permits for nonlinear effects of the independent variables on the dependent variable, the Breusch-Pagan test assumes that heteroskedasticity could be a liner function of the explanatory variables in the model. Unfortunately, this considered as a weakness of the Breusch-Pagan test. The following null and alternate hypothesis were made for the Breusch-Pagan test:

H_0: There is constant variance or homoscedasticity in residual.

H_a: There is the presence of heteroskedasticity in residual.

Table 4.9: Summary of Breusch-Pagan Test for Heteroskedasticity

Test Statistic	*Value Computed*
Breusch-Pagan (BP)	97.06
P-Value	0.88

Source: Author's estimate from R Statistical Software

The rule of thumb here is to reject the null hypothesis if the p-value is less than 0.05 and accept the alternate. However, since the P-value derived from the Breusch-Pagan test is 0.88, which is greater than the 0.05 significance level, then we fail to reject the null hypothesis and hence conclude that there is a constant variance or homoscedasticity in the residuals.

4.5.3 TEST FOR FUNCTIONAL FORM AND STABILITY

Ramsey's (1969) regression specification error test (RESET) has shown to be very suitable in distinguishing the general functional form of misspecification (Wooldridge, 2013). The idea behind Ramsey's RESET is that given that the expected value of the error term for each explanatory variable is zero, for the model derived, nonlinear functions of the explanatory variables added to the equation would not be significant (Wooldridge, 2013). Hence, this test was conducted to examine if any nonlinear variables would be necessary to better explain the relationship between inflation and exchange rate in Ghana. With that in mind, the following hypothesis were investigated:

H_0: The model has no omitted variables.

Ha: The model has omitted variables.

The p-value from the results of the test was 0.1593 with an F-statistic of 1.8113. Since the p-value is well above a 0.05 significance level, we fail to reject the null hypothesis and conclude that the functional form of the model is correctly specified.

4.6 LIMITATIONS OF THE STUDY

The sample size of twenty for each variable presented was a major limitation of this study. Per the Central Limit Theorem, the larger the sample size, the more representative the sample is of the population. Hence a small sample size makes it difficult to make statistical inference. Unfortunately, some of the variables only had limited data available for the country under study, as such 1999 was the first year with data present for all variables and hence, the starting point.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

This final section recaps the results discussed in the prior chapter and makes fitting conclusions per the findings. This chapter also provides recommendations to assist economists, individuals, firms and policymakers when addressing inflation rate concerns.

5.1 SUMMARY OF FINDINGS

This paper analysed the relationship between inflation rate and exchange rate, as well as other macroeconomic variables. A multifactor model was used to investigate the long and short run relationship by employing an Autoregressive Distributed Lag model. The results from the cointegration test suggested the existence of more than one co-integrating equation in the long-run relationship between inflation rate and the independent variables. Monthly data of each variable, that is, inflation rate measured by changes in CPI, exchange rate measured by USD/GHS, money supply measured my broad money supply, and interest rate measured by 91-day treasury bill rates, were used for the study, over the period 1999 to 2018. The following hypotheses were tested for the study:

H_0: There is no linear relationship between exchange rate and inflation rates.

H_a: There is a linear relationship between exchange rate and inflation rates.

The results from the Autoregressive Distributed Lag model showed that exchange rate in the short run is positively correlated to inflation rate, and negatively correlated in the long run. The reported adjusted R-square value of 0.406 however, showed that the independent variables employed in the study, fundamentally, are to a large extent not the most dominant factors that cause variations in inflation rate in Ghana. When it

comes to the statistical significance of each independent variable, the results from the Autoregressive Distributed Lag model showed that though all independent variables were found to be statistically significant in the model, the present values of all the explanatory variables had the most exposure on the dependent variables, as they were all significant at the 5 percent level for each independent variable. The findings also prove that inflation rate in one month in the past affects current inflation rates, whereas current month's exchange and interest rate are positively correlated to inflation rate. Present month's money supply on the other hand, has a negative effect on inflation rate while five-month lagged values of money supply affects inflation rates positively.

There were some parts of the findings that were parallel with existing literature, whereas some results were surprising. An expectation of a strong relationship was expected between the independent variables and inflation rate. The results from the Auto-regressive Distributed Lag Model however showed that the explanatory variables have no strong influence on the response variable under study. Additionally, the lagged values of the explanatory variables seemed to have no significant effect on inflation rate like the current values, as shown by the equation generated from the Auto-regressive Distributed Lag Model.

The positive relationship between inflation rate and exchange rate directly concurs with a few of the existing literature discussed in Chapter two of the research. Dordunoo (1994) stipulated that swift depreciation, where depreciation is an increase in the exchange rate, led to high inflation rates and Nortey, Ngoh, Doku-Amponsah and Ofori-Boateng (2015) proved that a positive performance of the Cedi, an appreciation or decrease in exchange rate, would cause yield lower inflation rates in the long run.

Similarly, in 2008, Adam and Tweneboah provided convincing evidence proving the existence of a positive parallel movement of exchange rate and inflation rate, in the capital market (Adam & Tweneboah, 2008). Nevertheless, research by Ansong (2013) showed that exchange rate had no significant effect on price levels in Ghana (Ansong, 2013), a direct contrast with the literature discussed in section 2.3 of this research.

The triviality of the joint effect of interest rates, exchange rate, and money supply (M2) in shaping inflation rates in Ghana, is in direct contrast to the evidence presented by Chibber and Shafik (1990), Ocran (2007), Nortey, Ngoh, Doku-Amponsah and Ofori-Boateng and Dordunoo (1994). This means that policymakers must consider other extensive macroeconomic variables when investigating possible drivers of inflation in Ghana. Furthermore, the lack of a strong influence of money supply on average price levels in Ghana, is also quite surprising due to the theoretical and empirical literature discussed above. The significance of the relationship between lagged exchange rate values and inflation rate, however, is parallel with Farooq, Keung and Kazmi (2005) who discuss that an increase in the value of a currency, increases competition among local firms which in turn raises earnings as well (Farooq et al., 2004).

5.2 CONCLUSION

Per the results of the ADRL model, it can be concluded that making inflation rate predictions based on past exchange rate data would not be the most accurate due to the moderate relationship between the two variables. Exchange rate, interest rate and money supply together explain only 40.6% of the variations in inflation rate in and hence there are other key drivers of inflation in Ghana. Current values of inflation, exchange rate, interest rate and money supply are essential catalysts of inflation rate

predictions rather than lagged values. The data therefore support the hypothesis that exchange rate has an impact on inflation rates in Ghana.

5.3 RECOMMENDATIONS

The findings show that exchange rate has a moderate effect on inflation rate in Ghana, hence I recommend that policymakers in the country tighten fiscal and monetary policies that will largely regulate changes in exchange rate. Policies like tax cuts can be employed to control economic activity and stabilize exchange rate for the betterment of the economy. Exchange rate management policies must ensure that rates are kept at an appreciable level to avoid a decline in foreign and local investment and producer loss of confidence.

5.4 SUGGESTIONS FOR FUTURE STUDIES

Future studies should pay more attention on other possible drivers of inflation besides what have been discussed in this study or perhaps conduct a further empirical analysis of inflation and exchange rate with a larger timeframe coupled with varying frequencies. Instead of monthly data, further studies can investigate daily, quarterly or even annual data and compare each frequency. Research on monthly data however can include a larger scope.

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