STATISTICAL ANALYSIS OF THE EFFECT OF INFLATION AND EXCHANGE RATE ON STOCK MARKET RETURNS IN GHANA

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL ACTUARIAL SCIENCE DEGREE

JUNE 2015
DECLARATION

Candidate’s Declaration

This is to certify that, this thesis is the result of my own research 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 certify that this thesis was prepared from the candidate’s own work and supervised in accordance with guidelines on supervision of thesis laid down by the University of Ghana.

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ABSTRACT

The study examined the effect of exchange rate and inflation on stock market returns in Ghana. Monthly inflation and exchange rate data obtained from the Bank of Ghana and monthly market returns computed from the GSE all-share index from January 2000 through to December 2013 was used. The Autoregressive Distributed Lag (ARDL) cointegration technique, the Error correction parametization of the ARDL model and Markov transition probabilities were used in unveiling this dynamics. The ARDL and its corresponding error correction model were used in establishing the long and short run relationship between the Ghana Stock Exchange (GSE) market returns, inflation and exchange rate. The study revealed that there exist a significant long run relationship between GSE market returns and inflation. However, there existed no significant short run relationship between them. The result also showed a significant long and short run relationship between GSE market returns and exchange rate. Furthermore, due to the existence of the long run relationships, Markov transition probabilities were used to determine the long run distributions of inflation and exchange rate. The study also revealed that in the long run there is a high probability that the cedi will depreciate against the dollar and also there is a high probability that inflation will lie between 10% and 20% inclusive in the long run.
DEDICATION

This work is dedicated to the Almighty God, my mother Mrs. Beatrice Taylor and my siblings Janet Kwofie, Vida Kwofie and Peter Ehomah.
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LIST OF ABREVIATIONS

GSE……………………………….. Ghana Stock Exchange

GDP……………………………….. Gross Domestic product

US……………………………….. United States

USD……………………………….. United States Dollar

ARDL……………………………… Autoregressive Distributed Lag

ECM……………………………… Error Correction Model

VECM……………………………… Vector Error Correction Model

VAR……………………………… Vector Autoregressive

CPI……………………………….. Consumer Price Index

NEER……………………………… Nominal Effective Exchange Rate

BD……………………………….. Budget Deficit

SEC……………………………….. Security Exchange Commission

GCF……………………………… Gross Capital Formation

IR……………………………….. Interest Rate

E……………………………….. Exchange Rate

I……………………………….. Inflation Rate
MD …………………………… Money Demand

FDI …………………………… Foreign Direct Investment

GEX …………………………… Government Expenditure

GARCH ……………………… Generalized Autoregressive Conditional Heteroscedastic

ADF …………………………… Augmented Dickey-Fuller

AIC …………………………… Akaike Information Criteria

SBC …………………………… Schwartz Bayesian Criteria

HQ …………………………… Hannan-Quinn

CUSUM ………………………… Cumulative Sum of Recursive Residuals
CHAPTER ONE
INTRODUCTION

1.0 Background of study

The establishment of the Ghana Stock Exchange (GSE) was necessitated due to the recommendations of the economic reforms in the 1980s to stimulate an achievable economic growth and development in the country. Boateng (2004) observes that, after many years of experiment with state interventions in the economy, it was concluded that for the realization of a more dynamic economic growth in the country, stock markets have a role to play since they are necessary for enhancing private sector access to capital. This invariably means that the growth and sustainability of the stock market are of relevance to the government, institutions and individual investors.

Majority of investors invest in stocks with the idea of maximizing the returns on their investment. However, these decisions are made without taking into account the effect that macroeconomic variables such as inflation and exchange rate can have on the stock prices of the listed companies they are investing into (Kuwornu and Owusu-Nantwi, 2011). Hussain et al., (2009) argued that stock markets have an essential role to play in the economy. According to them, stock markets serve as a source for the mobilization of resources for productive investments. They further stated that, to perform this role the stock market must have a significant relationship with the economy. Inflation, defined as the sustained, ongoing process of continuously rising level of general prices, is arguably a common concern to any government since it serves as a proxy to determining how well its economy is doing. According to Ibrahim and Agbaje (2013), inflation rate has been increasingly unsteadily despite some stringent policies and efforts made by governments to control and fine-tune its values to a satisfactory stationary
single digit number. They also argued that, factors such as income, high nominal wages, fluctuations in revenue and the payment of debt are factors that can largely influence inflation in an economy. Over the years, changes in prices are a visible characteristic of the Ghanaian economy, hence the non-constant inflation rates.

According to Ibrahim and Agbaje (2013), the stability of prices is vital in establishing whether the level of inflation will be constant or unstable in an economy. They also argued that inflation is the constant increase in prices over a period of time. According to Ibrahim and Agbaje (2013), inflation fluctuations can create uncertainty in an economy. This uncertainty, according to them can make both local and foreign investors unwilling to invest due to the effect they could have on their returns. These uncertainties can however cause an increase or decrease in price of stocks which may affect the demand and supply of stocks in general. The consequence of this instability in price level is that it may affect potential investor’s decision to invest and in turn has a negative impact on the total returns on stocks at large.

Exchange rate is the money value of a nation’s currency in relation to another currency. Per the definition, an exchange rate has two components, the local currency and the foreign currency.

An intensifying related relationship has emerged between stock markets of countries and some trading currencies. This is due to increasing flows of capital between the financial markets of different countries across the world. The determination of the relationship between stock prices and exchange rates is of great importance, especially from the perspective of emerging markets (Tian and Ma, 2010).
Tian and Ma (2010) looked at the dependency between exchange rate and returns of stocks by examining the two main theories that explain the dynamism between share price and exchange rate. That is the goods market theory and the portfolio balance theory. They argued that the goods market theory states that the depreciation of foreign currencies against the domestic currency hurt its exporters causing the shares of such companies to become less attractive and hence affecting the overall share market in any country that is export-orientated. This means that exchange rate and share markets are negatively correlated. The authors also argued that the portfolio balance theory stipulates that there is causality from share market to exchange rate.

An alternate explanation of the two theories is also provided by Muhammed and Rasheed (2002). The authors argued that the portfolio balance models of exchange rate determination postulate a negative relationship between stock prices and exchange rates and that the causation runs from stock prices to exchange rates. Their explanations to the portfolio balance model are that as individuals hold domestic and foreign assets, including currencies, in their portfolio, an increase in domestic stock prices lead individuals to demand more domestic assets. To buy more domestic assets local investors would sell their foreign assets, causing local currency appreciation. Also an increase in wealth due to a rise in domestic asset prices will lead investors to increase their demand for money, which in turn raises domestic interest rates. This again leads to appreciation of the domestic currency by attracting foreign capital. However, they again argued that, the asset market approach treats exchange rate as the price of an asset. The consequence of this is that, exchange rate changes are determined by expected future exchange rate values. Any factor that affects future values of exchange rate will affect current exchange rate.
According to Nath and Samanta (2003), the depreciation of the domestic currency has the tendency of making the exportation of goods appealing to investors leading to an increase in foreign demand. This they said would help provide resources for firms causing stock prices to increase as a result. The appreciation of the local currency in relation to foreign currencies can cause a decrease in profits for an exporting firm since it can result in the decrease of its products by foreigners. According to them, the influence of exchange rate changes to an exporting firm is opposite to that of an importing firm. Nath and Samanta (2003), further argued that the influence of exchange rate variation on stock market returns can be largely attributed to the significance of a country’s international trade and the extent of its trade imbalance.

Bhole and Mahakud (2009) explained the portfolio balance approach by stressing the essence of capital account transaction. They stipulated that, exchange rate changes are determined by the forces of demand and supply condition of the market. They explained that a performing stock market has the tendency of attracting capital flows from foreign investors, therefore causing an increase in the demand for the country’s currency. They concluded that increases in stock prices would lead to the appreciation of the local currency in relation to foreign currencies and vice versa. Furthermore, changes in stock prices have the tendency of influencing money demand, which can result in fluctuations in exchange rate and inflation since investors’ wealth depend on the performance of the stock market.

Clearly, macroeconomic factors such as exchange rate and inflation have the tendency of either affecting the returns of a stock market positively or negatively.
1.1 Problem statement

Various programs and policies have been implemented by the government with the aim of achieving a more favourable macroeconomic environment to promote private sector investment and growth. The present government with its better Ghana agenda sees the stabilization of macroeconomic factors such as exchange rate and inflation as critical for the stabilization of the economy (Enyaah, 2011). The impact of inflation is reliant on the degree in which it is correctly anticipated or not. If inflation is unanticipated, it can negatively impact on the saving ability of the citizens. The consequence of this can be low saving ability of citizens which can lead to a fall in the demand for stocks and equities as financial wealth. The decrease in demand for stocks and equities can cause its prices to fall thereby reducing returns on stocks and equities. Fluctuation in prices of stocks also creates uncertainty for investors. This in turn can affect the demand and supply of stocks (Ibrahim and Agbaje, 2013). Therefore, the increase or decrease in price levels can affect potential investor’s decision to invest which could have a negative impact on the returns of stocks in an economy. Therefore a statistical proof of how inflation and exchange rate can affect returns of stock is important so as to inform investors as to whether to invest or not based on the prevailing inflation and exchange rates. Also, since conditions could be favourable at present and different in the future, it is also necessary to know the long run relationships between these variables to better inform investor’s in their decisions. As such this study will be looking at the short and the long run effect of inflation and exchange on the Ghanaian stock market returns and an estimation of the long run distributions of these variables.
1.2 Objective of the study

The main objective of this study is to identify the effect of macroeconomic indicators on the Ghanaian stock market (GSE index). Specifically the project seeks to;

i. Examine the effect of inflation and exchange rate on stock market returns in Ghana.

ii. Establish the short and long run relationship between inflation and exchange rate on the Ghanaian stock market using cointegration techniques; Autoregressive distributed Lag model (ARDL) and error correction model (ECM).

iii. Determine the long run distribution of inflation and exchange rate using Markov transition probabilities.

1.3 Research Questions

The study seeks to find answers the following questions:

i. What is the effect of inflation and exchange rate on the returns of the Ghana Stock exchange?

ii. What is the long run distribution of inflation if it exists?

iii. What is the long run distribution of exchange rate if it exists?

1.4 Significance of the study

Apart from appreciating how the knowledge of statistics explores and reveals information from data, this study wishes to adequately describe the behavior of inflation and exchange rate, which is important information for government policies. Investors and potential investors will get to understand whether changes in inflation and exchange rate affects returns on the stock market and to what extent does it affect it. It will also assist local firms to identify periods that may be conducive to get listed on the stock market as well as assist investors to make good investment.
decisions. In addition to being useful as a source of information, it may also arouse interest for further studies in this or related areas.

1.5 Data collection and source

All the three data sets to be used in the study are secondary. The inflation and exchange rates were obtained from the research department of bank of Ghana and the GSE all share indexes were also obtained from the Ghana stock exchange. The table below gives a summary of the time period in which the monthly data were obtained.

<table>
<thead>
<tr>
<th>Data</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation rates</td>
<td>From January 2000 to December 2013</td>
</tr>
<tr>
<td>Exchange rate (GHC/US$)</td>
<td>From January 2000 to December 2013</td>
</tr>
<tr>
<td>GSE all share index</td>
<td>From January 2000 to December 2013</td>
</tr>
</tbody>
</table>

1.6 Organization of the study

The rest of the thesis is organized into four chapters. Chapter two presents the review of related literature on the topic, chapter three looks at the methodology that was adopted in analyzing the data. Chapter four focuses on the analysis and the discussion of the results while chapter five includes summary of findings, conclusion, limitations and recommendations of the study.
CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

This part of the study dwells on a review of studies that investigates the relationship between some macroeconomic factors such as inflation and exchange rate on stock returns. Researchers to a large extent have studied the relationship between macroeconomic variables on stocks in different countries with different econometric and statistical methodologies. Below are some reviewed articles that are relevant to this study.

2.1 Evidence from the world

According to Fama (1981), stock prices reflect macroeconomic variables such as money supply, exchange rate, real GDP, interest rate, industrial production and capital expenditures.

Using autoregressive distributed lag model approach to cointegration, Hassan and Hisham (2010) tested the relationship (long run) between macroeconomic variables and equity returns in Jordan. The authors established that, money supply, foreign exchange reserves and oil prices are essential macroeconomic variables which have long run consequences on the stock market of Jordan. They argued that their findings are consistent with other similar studies carried out in other emerging economies.

Yusof and Majid (2007) established that exchange rate, industrial production index, money supply and federal funds rate are very important factors that contribute to the stabilization of the Malaysian stock market. They also established that changes in the US monetary policy as measured by the changes federal rate have a significant impact on the Malaysian stock market.
As such, they argued that any changes in the US monetary policy may affect the Malaysian stock market in the short and long run. They established these relationships by using the autoregressive distributed lag model.

In investigating the causal relation between macroeconomic variables and stock prices in the open economy of Jordan, Maghayereh (2003) employed Johansen’s cointegration methodology. He examined the possible long run effect of some selected macroeconomic variables and the Jordanian stock prices using data from 1987 to 2000. The study concluded that the macroeconomic variables affected stock prices in the Jordanian capital market. The macroeconomic variables used were exports, interest rates, inflation, foreign reserves and industrial production.

Cai (2011) analysed the cointegration relation of final consumption, investment, export, import and gross domestic product on the Swedish national account. They realized that only final consumption and gross domestic product had an effect on the Swedish national account.

Maysami and Koh (2000) examined the long-term equilibrium relationships between some selected macroeconomic variables and the Singapore stock index and as well as among stock indices of the United States and Japan using vector error-correction models. They detected that changes in exchange rates and interest rate contribute significantly to the cointegrating relationship while that of price levels and money supply do not. The authors, however, argued that the Singapore stock market is interest rate and exchange rate sensitive. Additionally, they
concluded that the stocks of the United States and Japan are positively cointegrated the Singapore stock market indexes.

Tabak (2006) conducted a study to analyze the dynamic relationship between exchange rate and stock prices in the Brazilian economy using the Granger causality. The result showed no long-term relationship among the variables. Banny and Enlaw (2000) analysed the link between the Malaysian Ringgit in relation to the USD and prices of stock in Kuala Lumpur Stock Exchange (KLSE) through the application of single and multi-index models. The study showed that a negative relationship exists between exchange rate and KLSE stock prices.

Muhammed Rasheed (2002) used Granger causality tests and vector error correction to examine the long and short run association between exchange rates and stock prices using monthly data from four South Asian countries (Sri Lanka, Pakistan, India and Bangladesh). The findings of the research showed no short run relationship between the variables for all the countries. Also, the study showed no long run relationship between exchange rates and stock prices for India Pakistan. However, there was a bi-directional causality between exchange rate and stock prices for both Bangladesh and Sri Lanka.

In investigating the relationship between the stock market and foreign exchange reserves, exchange rate and trade balance in India, Bhattacharya and Mukherjee (2003) applied cointegration techniques and the Granger non-causality test. They used the Bombay Stock Exchange (BSE) index and three macroeconomic indicators and concluded that there is no causal relationship between the three macroeconomic indicators and stock prices. On the other hand, Banerjee and Adhikary (2009) concluded that there is a bi-directional causality between
exchange rate and stock prices in the short-run. The study however showed no long-term relationship between the other two macroeconomic variables and stock prices.

The interaction between exchange rate and stock prices in Bangladesh was investigated by Rahman and Uddin (2008) using monthly exchange rates of the Euro, the US dollar, the British pounds, the Japanese yen and stock exchange index of Dhaka from 2003 to 2008. They applied the Johansen multivariate procedure to test for the existence of any possible cointegrating relationship. The result of the study showed no cointegration relationship between exchange rate and the stock prices.

Georgantopoulos & Tsamis (2011) examined the effect of Budget Deficits in economy of Greece using vector autoregressive and vector error correction model. They investigated the causal relationship between Gross Domestic Product (GDP), Consumer Price Index (CPI), Nominal Effective Exchange Rate (NEER) and budget deficit (BD) using data from 1980-2009. The study showed that the variables exhibited cointegrating relationships with a one-way causality. The causality was seen to run from BD to GDP and from NEER to BD. There was also a bidirectional causal relationship between CPI and NEER. However, the study found no significant link between BD and inflation.

Zia and Rahman (2011) studied the causality between stock prices and foreign exchange in Pakistan using 181 monthly closing values of the exchange rate and stock market index and from 1995 to 2010. The cointegrating technique of Engle-Granger was used to test the long-run relationship between the two variables and it was shown that there is the absence of long run
relationship between them. The Granger causality test was also used to check if there is any causation in the relationship between the variables with the results showing no such relationship.

Morley (2009) used ARDL to establish the relationship between exchange rate and stock prices in the long and short run. The result of the study showed the existence of a long run relationship between the two variables for the currencies of Japan, UK and the Switzerland in relation to the US dollar.

Lean et al., (2006) analysed the linkage between stock prices and the exchange rates of eight Asian countries using Granger causality tests by using data from 1991 to 2005. They tested for the existence of cointegration and causality for all the countries. The authors used the Gregory and Hans (1996) cointegration test. The results showed that only the exchange rate and stock prices in Korea were cointegrated over the study period. The result for Korea further showed a weak one directional long-run Granger causality between the variables. This causality runs from exchange rate to stock prices. However, there was no evidence of causality for the other seven countries.

According to Dritsakis (2011), there exist a long run relationship between the demand for money and inflation, real income and exchange rate using ARDL cointegration technique. The author established that there exists a stable, long-run relationship between monetary aggregate, real income, inflation and exchange rates. He also discovered a positive coefficient of real income elasticity while that of inflation and exchange rate were negative.
Tian and Ma (2010) employed the cointegration technique of ARDL to study the relationship between exchange rate and the Chinese share market. The result of the study showed the existence of cointegration between the share index of Shanghai and exchange rate (that is Renminbi against the US dollar). The result of the study showed that stock price is influenced positively by both exchange rate and money supply. The impact of interest rates, exchange rates and inflationary changes on stock prices were studied by Solnik (1987) using data from nine different countries. The data were from the UK, USA, Germany, Japan, Canada, Switzerland, Belgium, Netherlands and France. They established in the study that inflationary changes and depreciation had an insignificant positive impact on the USA stock market. The results from the other countries were however significant.

Qiao (1997) established the relationship between the stock prices of Tokyo, Hong Kong and Singapore and exchange rate using Granger causality. The result of the study showed that exchange rate changes significantly affected stock prices in Japan and Hong-Kong but not Singapore. There was, however the existence of a long run relation between exchange rates and stock prices for all three markets.

Aggrawal et al., (2010) used data from 2007 to 2009 to examine the relationship between stock returns and exchange rate (Indian rupee-US Dollar). The result of the study showed that the two variables are cointegrated with a one directional causality from the returns to exchange rate changes.
Aggarwal (1981) used monthly exchange rate and stock prices from 1980 to 1986 to examine the relationship between exchange rate and stock prices. Using simple linear regression, he established that changes in the US dollar rate in relation to other currencies are positively related to stock prices in the United States.

However, Soenen and Hennigar (1988) discovered that the relationship between stock prices and the US dollar is significant and negative. The periods of study were, however different, although the variables were the same and from the same country.

According to Ahmed et al., (2013), nominal wage rate and domestic credit exhibit a positive relation with price level both in the short and long run. They applied ARDL for their estimation by using data from the fiscal year 1975 to 2010. Budha (2012) also investigated the demand for money in Nepal using the Autoregressive Distributed Lag (ARDL). The results of the test revealed that there exist a cointegration relationship among real money aggregates, real income, inflation and interest rate. The author also discovered that the elasticity of real income was positive while that of inflation is negative. By applying the error correction models he concluded that deviations from the long-run equilibrium are short-lived.

Amare and Moshin (2000) used the stock prices from nine Asian countries to establish if they have a long running relationship with exchange rate. The nine countries were Hong Kong, Thailand, Taiwan, Philippines, Singapore, Malaysia, Japan, Korea and Indonesia. The cointegration techniques were used for this study. The period of the study was from 1980 to 1998. The authors used monthly exchange rate and prices. The outcome of the study showed that
only results from the Philippines and Singapore showed the existence of a long run relationship while that of the other countries did not show such relationship.

Broome and Morley (1998) investigated the relationship between stock prices and interest rate using cointegration technique. The result of their study showed that stock prices and interest rates show a short run relationship, but do not exhibit a long run common trend. They used Johansen maximum likelihood test for cointegration in establishing this relationship using data from the G-7 countries. Similarly, Nieh and Lee (2001) studied the relationship between stock prices and exchange rates for the G-7 countries from 1993 to 1999. They explained that there existed no long run relationship between the variables. However, the authors established that there exists a short-run significant relationship. They also argued that no significant correlation exists between the stock prices in the United States and the other G-7 countries.

Wu (2000) established that in the 1990s, the appreciation of the currency of Singapore against the United States dollar and the Ringgit of Malaysia led to an increase in stock prices in the long term. However, the appreciation of the currency of Singapore against the Indonesian rupiah and Japanese yen leads to a decrease in prices of stocks. The study adopted the Johansen cointegration technique.

Ramasamy and Yeung (2001) studied the causality between two stock markets and exchange rates using granger causality. They analysed this relationship between the economies of two countries in East Asia. The authors established the presence of cointegration and found that the direction of causality tends to exhibit a hit and run behaviour and returns to equilibrium according to the duration of the period of study.
In examining the causal relationship between some selected macroeconomic indicators and the Kazakhstan stock exchange index, Oskenbayev et al., (2011) employed the bound testing approach, within the Autoregressive Distributed Lag (ARDL) model framework, Johansen Cointegration test, Engel-Granger two-step approach and Granger causality test approaches. They realized that the main determinants of the Kazakhstan stock exchange index were per income per capita, inflation and the exchange rate. Their results indicate the existence of cointegration between these series. They argued that the results of the study are in compliance not only with theory, but also with issues in practice.

In establishing the movement of stock returns and inflation, Yeh and Chi (2009) used quarterly data. The study confirmed the presence of both short and long run relationship between stock prices and inflation. They further argued that the result confirms the existence of an inverse movement and the existence of a long run relationship between the two variables. Hence from their study it can be deduced that stock prices are depressed by increases in inflation rates.

Bello (2013) investigated the effects of exchange rate of four United States trading partners on the United States stock market and on ten sectors of the United States economy using data from the year 2000 to 2012. It was realised that the Chinese Yuan was the least volatile of the four currencies and the euro was the most volatile; however, the euro appreciated the most during the study period. The result showed that the association between the Japanese yen and the U.S. stock market were significant and negative while the euro and the pound were positively and significantly associated with U.S. stocks.
The relationship that exists between economic growth and stock market in Pakistan was investigated by Shahbaz et al., (2008). They used data set from 1971 to 2006. In determining the order of integration of the understudy variables, the Phillip Perron test was used. The ARDL methodology was used to establish the presence of cointegration between the variables. Also, in investigating the long run relationships, short run dynamics; ARDL and Engle-Granger causality were respectively applied. After determining the order of integration, the study concluded that there exists a strong positive relationship between economic growth stock market changes. Bidirectional long run causality between stock market and economic growth was established by the Engle Granger-Causality technique. Also, the study showed a one way short run causality that runs from stock market development to economic growth.

Özlen and Ergun (2012) examined the relationship between stock returns and five macroeconomic variables. The study employed the Autoregressive distributed lag methodology using data from 2005 to 2012. The effect of exchange rate, inflation rate, current account deficit, interest rate, and unemployment rate on stock returns was investigated. The returns of forty five (45) companies were used for the study. The result showed the existence of long run relationships between the variables.

Butt et al., (2010) examined the effect of stock returns variation in relation to some economic variables by using a multi-factor model. A ten year data consisting of financial variables were used for the study. Data was collected from the textile and banking sectors because according to the author they have available data and also they are part of the best performing sectors on the Karachi Stock Exchange. The data were analysed using GARCH and the result showed that the
Karachi stock market returns are accounted for by the variation in the stock returns of the banking and textile industries. According to the author, the inclusion of industry related variables and macroeconomic variables to the study added extra power in describing the variation in stock returns. The authors presented a very important fact that industry level economic exposure is higher than at firm level.

Zhang and Zhang (2009) conducted a study on the forecasting of stock market trends using stochastic analysis. They transition the behaviour of stocks into a three state Markov process and were able to come out with the long run distribution of stock prices in China.

### 2.2 Evidence from Africa

In examining the effect of inflation on capital market performance in Nigeria, Usman and Adejare (2013) used multiple linear regression. They used secondary data from the Nigeria’s central bank and Security Exchange Commission (SEC) spanning from 1970 to 2010. The variables used for the study were multiple regressions were inflation rate, market capitalization, All-Share index, market volume and market turnover, and Gross Domestic Product. They found that that inflation accounted for 18.2% of the variation in the influence of the capital market performance and they also realized that there was a weak correlation between inflation and the performance of Nigerian capital market is weak. So they finally concluded that a negative relationship exists between inflation and capital market performance.

Ayidogbon et al., (2013) examined the relationship between real Money Demand function (MD), Gross Capital Formation (GCF), Interest Rate (IR), Inflation rate (I), Exchange rate (E) and Government Expenditure (GEX). From their co-integration tests they observed that, in the long
run, interest rate impact negatively on MD while GCF, exchange rate and GEX on the other hand have a positive impact on MD in Nigeria. Also, in the short run they established through a vector error correction model that, MD, GCF, I and E have a negative relationship with MD.

According to Subair and Salihu (2010), volatility of exchange rate impacts negatively on the Nigeria Stock markets. They conducted this study by using data from 1981 to 2007 comprising of the variables GDP, annual stock market capitalization, interest rate, inflation and exchange rate volatility. Using the Error Correction Model (ECM), they examined the effects of exchange rate volatility on the Nigerian stock market. They, however, observed that inflation and interest rate did not exhibit any long run relationship with stock market capitalization.

A study conducted by Ibrahim and Agbaje (2013) showed the existence of long run relationship between inflation and stock market returns in Nigeria. They adopted the Autoregressive Distributed Lag procedure for the study. The data for the study consist of the Nigerian consumer price index and the Nigeria all share price index. There existed a significant short run relationship with a moderate speed of convergence to equilibrium for changes in consumer price index. They argued that the existence of the short run relationship could be due to the instability of prices of stocks in Nigeria over time.

Oskooee and Sohrabian (1992) investigated the relationship between exchange rate and stock prices in the short and long run using cointegration. They also examined the casual relationship between the two variables using Granger causality. The authors concluded from the study that
there exists a dual causal relationship between exchange rate and stock prices and in the short-run. However, the study found no long run relationship among the variables in question. According to Bartov and Bodnar (1994), changes in the dollar rate in relation to the local currency have little power in explaining stock returns. They established this relationship by using regression.

Ajayi and Mougoue (1996) showed that the depreciation of the Nigerian Naira in relation to the US dollar has a negative short run effect on stock prices in Nigeria. They established this by using monthly stock prices and exchange rate data.

### 2.3 Evidence from Ghana

By examining the existence of causality between five macroeconomic variables (interest rate, money supply, inflation, exchange rate and Foreign Direct Investment (FDI)) and stock returns in Ghana, Issahaku et al., (2013) used Granger causality and vector error correction model. The result of the study showed that there exist a significant short run relationship between inflation, exchange rate and stock returns in Ghana. They also established that the Ghanaian stock market will take approximately 20 months to return to equilibrium in the event of changes in any of the macroeconomic variables involved in the study. Their study made use of all the variables used in this research except that the methodologies are different.

Adjasi et al. (2008) analysed the repercussions of exchange rate volatility on the Ghanaian stock market. They used data spanning from 1995 to 2005 to explain this effect. The outcome of the
study showed that there is a negative relationship between exchange rate and the Ghanaian stock market returns. The methodology employed was the GARCH.

Adam and Tweneboah (2008) used the Johansen cointegration technique and accounting techniques to measure the impact of macroeconomic variables on stock prices in Ghana. They looked at how consumer price index, Treasury bill rate and exchange rate could impact on stock returns. Their study showed that stock prices in Ghana have a significant long run relationship with the macroeconomic variables under study.

Kuwornu and Owusu-Nantwi (2011) showed that consumer price index has a significant positive effect on stock returns in Ghana. They also established that exchange rate and Treasury bill rate changes have a negative impact on the Ghanaian stock market. However, crude oil prices were not seen to have any significant impact on stocks. The authors adopted the full information maximum likelihood estimation procedure.

A study by Kuwornu (2012) investigated how the Ghanaian stock market can be impacted by changes in some macroeconomic variables. They used monthly data from 1992 to 2008 and also employed the Johansen cointegration technique in analyzing the data. The macroeconomic variables involved in the study were consumer price index, exchange rate, 91 day Treasury bill rate and crude oil price. The results of the study revealed that there exist a significant long run equilibrium relationship between the four macroeconomic variables and stock returns in Ghana.

According to Mettle et al., (2014), share prices on the Ghana stock exchange can be modeled as Markov chains with finite states. They transitioned the price changes into a three state Markov
chain to form a three state transition matrix and used it to estimate the limiting distributions of some selected companies listed on the Ghana stock exchange.

2.4 Review of some theoretical models in the literature

2.4.1 Johansen’s approach to testing for cointegration

The Johansen methodology is based on the Vector Autoregressive representation and referred to as a maximum likelihood approach. This is because the underlying estimation method which provides the Johansen test statistics is in fact maximum likelihood. The appropriate lag length is identified using the Akaike Information Criterion (AIC) or Schwartz Bayesian information criterion (SBC) to ensure white noise errors. An unrestricted statistical analysis with a reduced form stated as follows then begins:

\[ Y_t = \alpha + \sum_{i=1}^{p} \Pi Y_{t-i} + \eta_t; \quad \eta_t \sim N(0,\sigma); \quad i = 1,2,\ldots,n \]  

Where \( Y_t \) is a three by one vector with order I(0) and \( \alpha \) is a three by one vector of constraints. Assuming \( \Delta Y_t = Y_t - Y_{t-1} \) then the above equation can be written as:

\[ Y_t = \alpha + \sum_{i=1}^{p-1} \psi \Delta Y_{t-i} + \Pi Y_{t-1} + \eta_t \]  

The long run matrix \( (\Pi) \) with a rank of \( r \) determines the number of linear combinations of \( Y_t \) that are stationary since \( \eta_t \) is stationary. The hypothesis for the existence of cointegrating vectors is written as \( H_0 : \Pi = \alpha \beta' \) where both \( \beta \) and \( \alpha \) are matrices of dimension \( nxr \). The adjustment parameter in the system is \( \alpha \) and \( \beta \) is the correlation of the error mechanism of the cointegration vectors. In testing the hypothesis of cointegrating vectors, the first thing to be
determined is the order of the cointegration vectors. In determining the order of the cointegrating vectors \((r)\) we compute the trace statistics \(\lambda_{\text{trace}}\) and then estimate the values of the characteristic roots or eigenvalue \(\lambda_{\text{max}}\). The computations for each procedure is as follows:

2.4.1.1 The trace test

The trace test is used in testing the null hypothesis of \(r\) cointegrating vectors. The alternative hypothesis for the test is the absence of cointegrating vectors \((r \leq 1)\). The test statistic of the trace statistics is given by

\[
\lambda_{\text{trace}} = -T \sum_{i=r+1}^{q} \ln(1-\hat{\lambda}_i),
\]

(2.3)

\(T\) is the size of the sample and \(\hat{\lambda}_i\) is the \(i^{th}\) largest canonical correlation.

2.4.1.2 The maximum eigenvalue

Similar to the trace test the maximum eigenvalue test, tests the null hypothesis of \(r\) cointegrating vectors. However, the null hypothesis for this test is the presence of \((r + 1)\) cointegrating vectors. The test statistic for this test is given by;

\[
\lambda_{\text{max}} = -T \ln(1-\hat{\lambda}_{r+1})
\]

(2.4)

Similarly the null hypothesis is stated as \(r = q\) cointegrating vectors with \((q = 0, 1, 2, \ldots)\) against the alternate hypothesis of the existence of an additional cointegrating vector that is \((r \leq q + 1)\).
According to the Johansen-Juselius procedure, both the trace test \((\lambda_{\text{trace}})\) and maximum
eigenvalue test \((\lambda_{\text{max}})\) should be conducted. According to Johansen-Juselius (1992), for in case
of conflicting outcomes between these tests, the \(\lambda_{\text{max}}\) test should be chosen for inference.

### 2.4.2 The multiple regression model

Suppose that we are interested in the relationship between a dependent variable \((Y)\) and \(k\)
independent Variables, \(X_1, X_2, \ldots, X_k\). Then, if the independent variables take the specific values
\(x_{i1}, x_{i2}, \ldots, x_{ik}\), then the multiple regression expresses the corresponding value of the dependent
variable \(Y_i\) as:

\[
Y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik}
\]

(2.5)

Where \(\beta_0, \beta_1, \ldots, \beta_k\) are the regression coefficients which represents the average change in \(Y\) for
a unit in the corresponding independent variable and \(\epsilon_i\) is a random error term with mean 0.

The sample multiple regression for the model above with \(i = 0, 1, 2, \ldots, n\) can be written in matrix
form as:

\[
\begin{pmatrix}
Y_1 \\
Y_2 \\
\vdots \\
Y_n
\end{pmatrix} = 
\begin{pmatrix}
1 & x_{11} & x_{11} & \ldots & x_{11} \\
1 & x_{12} & x_{11} & \ldots & x_{11} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
1 & x_{in} & x_{11} & \ldots & x_{11}
\end{pmatrix} 
\begin{pmatrix}
\beta_0 \\
\beta_1 \\
\vdots \\
\beta_k
\end{pmatrix} + 
\begin{pmatrix}
\epsilon_1 \\
\epsilon_2 \\
\vdots \\
\epsilon_n
\end{pmatrix} \iff Y = \mathbf{X}\beta + \epsilon
\]

(2.6)

### 2.4.2.1 Estimation of multiple regression parameters

The regression parameters are estimated using the Ordinary Least Squares (OLS) of estimation
of parameters. The OLS method provides estimates that best minimize the sum of squares due to
the error (SSE).
\[
SSE = \sum_{i=1}^{n} e_i^2 = e'e = (Y-Y')(Y-Y) = (Y-X\beta)'(Y-X\beta)
\]
\[
= YY' - \beta'X'Y' - Y'X\beta + \beta'XX\beta
\]
\[
= YY' - 2\beta'X'Y + \beta'XX\beta
\]
(2.7)

By ordinary Least squares criterion

\[
\frac{\partial SSE}{\partial \beta} = 0 \iff -2XY + 2XX\beta = 0
\]
(2.8)

Substituting the estimates \(\hat{\beta}\) for \(\beta\), equation (2.8) become;

\[
XX\hat{\beta} = XY \iff \hat{\beta} = (XX)^{-1}XY
\]
(2.9)

Under the assumptions of the regression model it can be shown that the joint confidence region

for all \(k\) of the \(\beta_i\) regression parameters, with confidence coefficient \((1-\alpha)\) is:

\[
\frac{(\hat{\beta} - \beta)'XX(\hat{\beta} - \beta)}{kMSE} \leq F_{(1-\alpha),k,n-k}
\]
(2.10)

2.4.3 The Two-step Engle-granger cointegration test

Engle and Granger (1987) introduced a two-step estimator for models involving co-integrated variables. In the first step, the parameters of the cointegrating vector are estimated by running the static regression in the levels of the variables. In the second step, these are used in the error-correction form. Both steps require only OLS, and the results may be shown to be consistent for all the parameters. Let the long-run (cointegrating) regression be;

\[
Y_t = \beta X_t + \mu_t
\]
(2.11)

Where \(Y_t\) and \(X_t\) are non-stationary variables and of order one. That is both the dependent and independent variables are integrated of order one. For \(Y_t\) and \(X_t\) to be cointegrated, the required condition is that the residuals from the equation above should be stationary (that is \(\mu_t \sim I(0)\)).
The second step involves the use of error-correction model (ECM) to estimate the short-run terms using the ordinary least square procedure. The Granger theorem states that, if a number of variables, such as $Y_t$ and $X_t$, are cointegrated, then there exist an Error correction model that relates these variables and vice versa.

2.5 Conclusions

The various studies above clearly show that results differ from country to country since they have different economic conditions. This is supported by Zucchi (2013), who argues that several studies have examined the impact of inflation on stock returns but unfortunately these studies have produced conflicting results when factors such as geography and time period is taken into consideration. She also argues that the result of most studies shows that inflation can either impact stocks positively or negatively. This she said depends on the ability to hedge and also depends on monetary policy government.

None of the reviewed papers so far provide an estimate of the long run distributions after establishing the existence of long run relationships. For the Ghanaian certain, only few studies have so far used the ARDL methodology. Hence, after establishing the long and short run relationships, the long run distribution was estimated using Markov transition probabilities to help investors make a decision based on the direction of the effect of each variable that will be established.
CHAPTER THREE

METHODOLOGY

3.0 Introduction

This study seeks to analyse the relationship between the Ghana Stock Exchange (GSE) market returns, the exchange rate (Ghana Cedi against the US dollar) and the Inflation rate. This chapter is concerned with the description of the dataset and the statistical models (the Autoregressive distributed Lag (ARDL), the Error Correction parametization of the ARDL Model and Markov transition probabilities) that will be used in unveiling the dynamism between the variables.

3.1 Data Collection and Source

The study made use of secondary data collected from the period, January 2000 to December 2013 consisting of monthly observations for each variable. The stock prices were sourced from the Ghana Stock exchange (GSE) whereas the inflation and exchange rate were obtained from the Bank of Ghana.

3.2 Description and transformation of data

In carrying out the ARDL methodology, we used GSE market returns, exchange rate and inflation. In order to obtain the market returns from the GSE index, we use the formula

$$R_i = \frac{P_i - P_{i-1}}{P_i} \times 100$$

where $P_i$ is the stock price at time $i$ and $P_{i-1}$ is the stock price at time $i - 1$.

However, for inflation and exchange rate we use the actual values obtained from the bank of Ghana. Before applying the statistical models, each data set was checked for stationary (that is if
the mean and variance is constant over time). We check this stationarity by using the Augmented Dickey Fuller (ADF) test for stationarity. Any dataset that is not stationary is differenced using the formula $\Delta Y_t = Y_t - Y_{t-1}$. Every non-stationary dataset was difference until it became stationary.

In building the Markov transition probability matrix, each inflation data point was given a label based on the ranges provided at the later phase of this chapter, whereas the exchange rate data were also labeled based on the immediate past value. The procedure for testing for stationarity and the statistical models used are discussed below.

### 3.3 Unit root test (Test for stationarity)

Generally macroeconomic time series variables are found to be non-stationary. A time series data is stationary if its mean and variance are constant over time, while the value of the covariance between two time periods depends only on the gap between the periods and not the actual time at which this covariance is considered. If one or both of these conditions are not satisfied, then the process is said to be non-stationary (Charemza and Deadman, 1992). The stationarity of a time series data can be investigated using the Augmented Dickey-Fuller Test (ADF), Phillips-Perron test or the KPSS test, which can be applied as a counterpart of ADF and Phillips and Perron test.

Several studies have shown that many time series variables are non-stationary or integrated of order 1 (that is their first difference is stationary). In this study, the time series variables considered are the GSE market returns, exchange rate and inflation. To apply the ARDL methodology, we first perform the unit root test on the three time series variable in the study to establish whether they are stationary or not. For this study, the Augmented Dickey-Fuller (ADF)
unit root test was used for this purpose. In the application of the ADF test, three regression forms are generated:

\[
\Delta Y_t = \alpha_t Y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \epsilon_t \tag{3.1}
\]

\[
\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \epsilon_t \tag{3.2}
\]

\[
\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 t + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \epsilon_t \tag{3.3}
\]

Where \( \epsilon_t \) are white noise errors. The extra lagged terms are included in the model to ensure that errors are uncorrelated. The ADF test is based on the hypothesis below:

\[ H_0: Y_t \text{ is not } I(0) \text{ or } Y_t \text{ is non-stationary} \]
\[ H_1: Y_t \text{ is } I(0) \text{ or } Y_t \text{ is stationary} \]

To conclude on the test, we compare the calculated ADF statistics with the critical values from Fuller’s table. If the test statistic is less than the critical value, then the null hypothesis \( H_0 \) is not rejected and we conclude that the series is non-stationary or not integrated of order zero. The p-value of the test can also be compared to the level of significance for drawing this conclusion. If a variable is stationary without differencing, we say it is integrated of order zero and if it is stationary only after first difference we say it is integrated of order one.

### 3.4 Cointegration

Variables are cointegrated if there is a linear combination of them that is stationary. If the variables in question are found to have unit roots (non-stationarity), and are of the same order, then the cointegrating relationship (that is the tendency of the variables to move together)
between the variables in the long run can be studied either by the Engle-Granger (1987), the Johansen-Juselius (1992) procedure or the ARDL approach. However the Engle-Granger and Johansen-Juselius procedure can only be used if the variables are integrated of the same order while the ARDL can be used if the variables are integrated of unequal order. However, in this study, the ARDL methodology was used since the order of integration of variables were different.

3.5 ARDL Approach to cointegration

In estimating the ARDL model, the best lag-length (p) is selected by using the Final Prediction Error (FPE) criterion, Akaike Information Criterion (AIC) or Schwarz Bayesian criterion (SBC) while ensuring that the errors are white noise. Time series ($H_t$) is called white noise if ($H_t$) is a sequence of identically distributed and independent random variables with constant mean and variance. After the determination of the appropriate lag length, the ARDL model can then be specified and estimated. Below is a description of the ARDL model both in the simple and generalized form.

3.5.1 A simple ARDL model

The ARDL (1,1) model is given by:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \epsilon_t$$

(3.4)

Where it is assumed that $\epsilon_t \sim iid(0,\sigma^2)$ and $|\alpha_1|<1$. The coefficients are interpreted as the long run effects. ARDL (1,1) means that both the dependent and independent variable have a lag of one. In long-run equilibrium, we expect that $y_t = y_{t-1}$ and $x_t = x_{t-1}$, so we can write equation (3.4) as:
\[ y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x \iff (1 - \alpha_1) y_t = \alpha_0 + (\beta_0 + \beta_1) x \] (3.5)

Thus the long-run response to \(y\) of a change in \(x\) is given by

\[ k = \frac{\beta_0 + \beta_1}{1 - \alpha_1} \] (3.6)

Now in establishing the connection between the ARDL model and the error correction model (ECM), subtract \(y_{t-1}\) from both sides of equation (3.4) and then add and subtract \(\beta_0 x_{t-1}\) on the right-hand side to get

\[ y_t - y_{t-1} = \alpha_0 + (\alpha_1 - 1) y_{t-1} + \beta_0 (x_t - x_{t-1}) + (\beta_0 + \beta_1) x_{t-1} + \epsilon_t \] (3.7)

And substituting

\[ \beta_0 + \beta_1 = k(1 - \alpha_1) \] from equation (3.6) and \(\Delta y = y_t - y_{t-1}\) and \(\Delta x = x_t - x_{t-1}\) into equation (3.7)

We get

\[ \Delta y_t = \alpha_0 + (\alpha_1 - 1)(y_{t-1} - kx_{t-1}) + \beta_0 \Delta x_{t-1} + \epsilon_t \] (3.8)

Thus equation (3.8) is the ECM that is implied by the ARDL (1,1) model. There are other transformations that have been considered in estimating the error correction model.

### 3.5.2 Generalization of the ARDL model

An ARDL\((m,n)\) model with \(p\) exogenous variables, which can also be written as ARDL\((m,n;p)\), is given by:

\[ y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i y_{t-i} + \sum_{j=1}^{p} \sum_{i=0}^{n} \beta_{ij} x_{j-i} + \epsilon_t \] (3.9)

Where \(\epsilon_t \sim iid(0, \sigma^2)\). We might also write this, using the lag operator \(L^i z_t = z_{t-i}\), as

\[ \alpha(L) y_t = \alpha_0 + \sum_{j=1}^{p} \beta_j (L) x_j + \epsilon_t \] where \(\alpha(L) = 1 - \sum_{i=1}^{m} \alpha_i L^i\) and \(\beta_j (L) = \sum_{j=1}^{n} \beta_{ij} L^j\)
However, in the case of only one and two independent variable (ie ARDL(m,n;1) and ARDL(m,n;2)) as in the case of this project, equation (3.9) can be written as:

\[
y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_m y_{t-m} + \beta_{01} x_{t} + \beta_{11} x_{t-1} + \ldots + \beta_{n1} x_{t-n} + \varepsilon_t \tag{3.10}
\]

\[
y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_m y_{t-m} + \beta_{01} x_{t} + \beta_{11} x_{t-1} + \ldots + \beta_{n2} x_{t-n} + \varepsilon_t \tag{3.20}
\]

As before, there are a number of possible transformations of this equation which, because they do not add or remove any linearly independent columns from the data matrix, are equivalent projections of the dependent variable on to the data. Again, given joint stationarity in long-run equilibrium we expect \( y_t = y_{t-1} \) and \( x_t = x_{t-1} \). So we can write equation (3.9) as

\[
y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i y_{t} + \sum_{j=1}^{p} \sum_{i=0}^{n} \beta_{ij} x_{jt} \tag{3.12}
\]

\[
\left(1 - \sum_{i=1}^{m} \alpha_i \right) = \alpha_0 + \sum_{j=1}^{p} \sum_{i=0}^{n} \beta_{ij} x_{jt} + \varepsilon_t \tag{3.13}
\]

Thus the long-run response to \( y \) of a change in \( x \) is given by

\[
k = \frac{\sum_{j=1}^{p} \sum_{i=0}^{n} \beta_{ji}}{\left(1 - \sum_{i=1}^{m} \alpha_i \right)} = \frac{\sum_{j=1}^{p} \beta_{j(1)}}{\alpha(1)} \tag{3.14}
\]

Where \( \alpha(1) \) and \( \beta_{j(1)} \) represent the substitution of unity for the lag operator \( L \) in the lag polynomials.

\[3.5.2.1 \text{ Test statistic for the co-integration test}\]

Shin (1994) proposed the following test statistic for the null hypothesis of co-integration
\[ C = n^{-2} \sum_{i=1}^{n} \frac{S_i^2}{\hat{\sigma}_e^2} \]

Where \( n \) is the sample size, \( S_i = \sum_{i=1}^{t} \hat{\varepsilon}_i^2 \) and \( \hat{\sigma}_e^2 \) are the estimators of the long-run variance of \( \varepsilon_t \).

### 3.5.3 The error correction parametization of the generalized ARDL model

Error correction models in time series econometrics provides a way of capturing adjustments in a dependent variable which depend on the extent to which an explanatory variable deviate from an equilibrium relationship with the dependent variable. It measures the speed at which a dependent variable \( Y \) returns to equilibrium after a change in an independent variable \( X \). We can derive a generalized error correction model (ECM), corresponding to the \( ARDL(m, n; p) \) model with \( p \) exogenous variables \( x_1, x_2, \ldots, x_p \) by steps similar to those used in the specific cases above. The result, which allows us to specify directly a general dynamic regression model in the form of an ECM, is (for \( r \leq m \)):

\[
\Delta y_t = \alpha_0 + \sum_{i=1}^{r} \eta_i \left( y_{t-i} - \sum_{j=1}^{p} x_{j,t-i} \right) + \sum_{j=1}^{p} \beta_{j0} \Delta x_{jt} + \sum_{j=1}^{p} \sum_{i=1}^{r} \xi_{ji} x_{jt-i} + \sum_{j=1}^{p} \sum_{i=r+1}^{m} \beta_{ji} x_{jt-i} + \sum_{i=r+1}^{m} \alpha_i y_{t-i} + \varepsilon_t \quad (3.15)
\]

with

\[
\eta_i = \alpha_i - 1, \quad \eta_i = \alpha_i \quad i = 2, \ldots, r \quad r = \min(m,n)
\]

\[
\xi_{ji} = \alpha_i - 1 + \beta_{j0} + \beta_{ji}, \quad \xi_{ji} = \alpha_i + \beta_{ji} \quad i = 2, \ldots, r
\]

and \( \Delta x_{jt-i} = (x_{jt-i} - x_{jt-i-1}) \)

We might ask what its distinguishing feature is. The answer is that in the ECM formulation, parameters describing the extent of short-run adjustment to disequilibrium are immediately provided by the regression. The error-correction mechanism will be of particular value where the extent of an adjustment to a deviation from equilibrium is especially interesting.
3.5.4 ARDL Model specification as applied to the variables under study

Three ARDL models will be specified and estimated. The first is between GSE market returns and inflation, the second between the GSE market returns and exchange rate (Dollar rate against the Cedi) and the third model is between GSE market returns on both Exchange rate and inflation.

The ARDL specification of the relationship between the GSE market returns and inflation is given as:

$$ R_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i R_{t-i} + \sum_{i=1}^{n} \beta_i I_{t-i} + \varepsilon_t $$

(3.16)

Also, the ARDL specification of the relationship between the GSE market returns and exchange rate is given as:

$$ R_t = \beta_0 + \sum_{i=1}^{m} \alpha_i R_{t-i} + \sum_{i=1}^{z} \phi_i E_{t-i} + \epsilon_t $$

(3.17)

Lastly, the ARDL specification of the relationship between GSE market returns, exchange rate and inflation is given as:

$$ R_t = \gamma_0 + \sum_{i=1}^{m} \alpha_i R_{t-i} + \sum_{i=1}^{n} \beta_i I_{t-i} + \sum_{i=1}^{z} \phi_i E_{t-i} + \omega_t $$

(3.18)

Where $R = \text{GSE market returns}$

$I = \text{Inflation Rate}$

$E = \text{Exchange rate}$

$m, n \ and \ z$ are lag length of GSE market returns, inflation and exchange rate respectively.

$\varepsilon$ and $\epsilon$ are white noise error terms

$\alpha_0, \beta_0 \ and \ \gamma_0$ are drift components
In investigating the presence of long run relationships between the GSE market returns and inflation or GSE market returns and exchange rate, the bound testing procedure under Pesaran et al. (2001) was used. This testing procedure is based on the F-test. The test hypothesis is a test of no cointegration among the variables against the existence or presence of cointegration among the variables. The hypotheses are similarly stated as:

\[ H_0: \alpha_1 = \alpha_2 = 0 \]
\[ H_1: \alpha_1 \neq \alpha_2 \neq 0 \]

The two equations above are to test whether stock returns and inflation rate are co-integrated while the ones below show that of stock returns and exchange rate.

\[ H_0: \beta_1 = \beta_2 = 0 \]
\[ H_1: \beta_1 \neq \beta_2 \neq 0 \]

The ARDL bound testing procedure is based on a Wald-test (F-statistic). The wald statistics is distributed under the null hypothesis of no cointegration among the variables. Pesaran et al. (2001) provided two critical values (lower and upper bounds) for testing cointegration relationship between variables. According to the values provided by Pesaran, the lower critical value assumes that all the variables are I(0) meaning that there is no cointegrating relationship between the variables under study. However, the upper bound assumes that all the variables are I(1) implying that there is a cointegrating relationship between the variables. If the computed F-statistic from the test is greater than the upper critical value, then \( H_0 \) is rejected (meaning the variables are cointegrated). However, if the F-statistic is below the lower bound critical value, then \( H_0 \) cannot be rejected (meaning there is no cointegration among the variables). Also, if the
computed F-statistics falls between the lower and upper bound values of the critical values then the results are inconclusive.

After establishing the existence of cointegration relationship, the estimates of the long run coefficients between the variables are computed. After the parameters of the short run parameters can then be estimated using the error correction model. The most appropriate models are selected based on the Schwarz Bayesian Criteria in relation to the lags of each variable. The error correction model was used to help capture the speed of adjustment to equilibrium among the variables affecting GSE market returns.

### 3.5.5 ECM specification as applied to the variables under study

The ECM specification of the relationship between the GSE market returns and inflation, GSE market returns and exchange rate are given as follows:

\[
R_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i R_{t-i} + \sum_{i=1}^{n} \beta_i I_{t-i} + \lambda_1 ECM_{t-1} + \epsilon_t \tag{3.19}
\]

\[
R_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i R_{t-i} + \sum_{i=1}^{z} \beta_i E_{t-i} + \lambda_2 ECM_{t-1} + \epsilon_t \tag{3.20}
\]

The equation below is also the ECM specification for GSE market returns, inflation and exchange rate.

\[
R_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i R_{t-i} + \sum_{i=1}^{n} \beta_i I_{t-i} + \sum_{i=1}^{z} \phi_i E_{t-i} + ECM_{t-1} + \omega_t \tag{3.21}
\]

### 3.6 Model Selection Criteria

Several selection criteria have been proposed to help select the most appropriate model in relation to the lag order of the models. Some of these selection criteria are the Akaike
Information Criteria (AIC), Schwarz Bayesian criterion (SBC) and Hannan-Quinn (HQ). The competing models in the study based on the appropriate lags are ranked according to the values of the AIC, SBC or HQ with the model being the one with the lowest information criterion. If two or more competing models have the same or similar AIC, SBC or HQ values, then the principle of parsimony is applied to select the most appropriate model. The principle of parsimony states that a model with fewer parameters is usually better than a complex model.

3.6.1 Akaike Information Criterion (AIC)

The Akaike Information Criterion (AIC) was introduced by Hirotogu Akaike in 1973. It was the first model selection criterion to gain widespread acceptance. The AIC was an extension to the maximum principle and consequently the maximum likelihood principle which is applied to estimate the parameters of the model once the structure of the model has been specified. The AIC is defined as;

\[
\text{AIC} = 2(N) - 2(\text{loglikelihood}),
\]

where \( N \) is the number of parameters in the model.

Given a family of competing models of various structures, the maximum likelihood estimation is used to fit the model and the AIC is computed based on each model fitted. The selection of the most appropriate model is then made by considering the model with the minimum AIC. The first term of the AIC equation above measures the model goodness of fit whereas the second term is called the penalty function. It is called the penalty function because it penalizes a competing model by the number of parameters it contains.
3.6.2 Schwarz Bayesian Information Criterion

The Schwarz Bayesian criterion (SBC) is related to the Bayes factor and is useful for selecting the most appropriate model out of a candidate of families of models. The BIC is obtained by replacing the $2(N)$ in the AIC equation by $N\ln(n)$. Hence, the BIC is defined as

$$BIC = k\ln(n) - 2(\text{likelihood})$$

Where $k$ denotes the number of parameters in the model, $n$ is the length of the time series or the sample size. Again, the maximum likelihood estimation is used to fit the model and the BIC is computed for each of the models in a family of competing models and the fitted model with the minimum BIC is considered to be the most appropriate model.

3.7 Model diagnostic checks

The model diagnostic checks are performed to determine the adequacy or goodness of fit of a chosen model. The model diagnostic checks are performed on residuals. According to the ARDL model, the residuals are assumed to be independently and identically distributed with non-constant variance and serially uncorrelated errors.

3.8 Diagnostic tests for the ARDL model

To investigate how good the ARDL model is, we conducted some diagnostic and stability tests. The diagnostic tests conducted were the serial correlation test of residuals, normality and heteroscedasticity test in relation to the residuals. The stability test conducted was the cumulative sum of recursive residuals (CUSUM) to determine if there were significant breaks with the sampled period.
3.8.1 Lagrange multiplier (LM) test for Serial correlation

The LM statistic is useful in identifying serial correlation, not only of the first order, but of higher orders as well. In carrying out the test we first estimate the regression model (in this case the ARDL model) by ordinary least squares and compute its estimates residuals \( (e_i) \). After we regress the errors \( (e_i) \) against the independent variable \( x_{1t},...,x_{kt} and e_{t-1} \). The test statistic is

\[
LM = (n-1)R^2_e
\]

Where \( R^2_e \) is the R-square from the regression model. We reject the null hypothesis of no serial correlation \( (\rho = 0) \) in favour of the alternative that \( (\rho \neq 0) \) if \( (n-1)R^2_e > \chi^2_{1-\alpha} \). If the test shows that there is serial correlation in the residuals, then we would expect \( e_t \) to be related to \( e_{t-1} \).

3.8.2 Testing for Heteroscedasticity

To test the null hypothesis of homoscedasticity against the null hypothesis of heteroscedasticity we apply the Lagrange Multiplier test for homoscedasticity. The test either uses the F-statistic which is dependent on the goodness of fit measure from the entire model or the Lagrange multiplier statistic which is an easier approach. The test statistic for the Lagrange Multiplier test is given by:

\[
LM = n \times R^2_{e_{LM}}
\]

The LM statistic is distributed as \( \chi^2_k \), where \( k \) is the number of regressors. It makes use of the residuals of the ordinary least square regression of the variables in question.

3.9 Stochastic processes

A stochastic process is a collection of random variables, representing the evolution of some random values over time. Define a family of random variables \( \{x(t), t \geq 0\} \) indexed by the time
parameter $t$. The process $x(t)$ is called a stochastic process. The value assumed by the process is
called the states, and the set of possible values is called the state space. The set of possible values
of the indexing parameter is called, the parameter space, which can be either discrete or
continuous. The project seeks to analyse the Markov properties of inflation and exchange rate
which are stochastic time series variables by converting them into a three state transition
probability matrix with discrete parameter and state spaces.

When a stochastic process has a discrete parameter and state spaces, we may define the transition
probabilities as; $p_{ij}^{(m,n)} = p(X_n = j|X_m = i)$ for $n \geq m$. A stochastic process $\{x(t), t \in T\}$ is
said to be time homogenous if the transition distribution function depends only on the difference
between the time intervals of the process. That is if $F(x_0, x; t_0, t_0 + t) = F(x_0, x; 0, t)$ for $t \in T$,
where $F$ is the probability distribution of the process.

3.9.1 Markov’s process

First-order dependence is the simplest type of dependence in an underlying stochastic process.
This is called the Markov-dependence. The following is the definition of Markov dependence.

Considering a set of points $(t_0, t_1, ..., t_n, t)$, $t_0 < t_1 < t_2 < ... < t_n < t$ and $t, t_r \in T (r = 0, 1, ..., n)$ which
are finite, $T$ is the parameter space of the process $\{X(t)\}$. The dependence exhibited by the
process $\{X(t), t \in T\}$ is said to be a Markov-dependence if the conditional distribution of $X(t)$
for given values of $X(t_1), X(t_2), ..., X(t_n)$ depends only on $X(t_n)$ which is the immediate known
past value of the process. That is if;
Therefore a discrete stochastic process is said to exhibit Markov Dependence if
\[ p(X_n = j | X_{n_1} = i_1, X_{n_2} = i_2, ..., X_{n_k} = i_k) = p(X_n = j | X_{n_1} = i_1) \] (3.25)

\[ \forall n > n_1 > n_2 > \ldots > n_k, t_1, t_2, ..., t_m \in T \text{ and } i_1, i_2, ... j \in S \]

A stochastic process satisfying (3.25) is called a Markov process. In a Markov process if the state space is known for any specific value of the time parameter \( t \), that information is sufficient to predict the behavior of the process beyond it. This is the Markov property. Whenever the parameter and state spaces are discrete, we call such a Markov process a Markov chain. This project will seek to compute the \( n \)-step transition probabilities. The “\( n \)-step” transition probability is defined as \( P_{ij}^{(n)} = P(X_n = j | X_0 = i) \). Where the term “\( n \)-step” refers to the time interval between observations. When \( n=1 \) we write \( P_{ij}^{(1)} = P_{ij} \). The one-step transition probability \( (P_{ij}) \) is computed to form the transition (stochastic) matrix for the determination of the long run stationary (steady state or limiting) distribution of the variables under study.

### 3.9.2 Transition stochastic matrix

Let \( S \) be a finite discrete state space containing states \( i \) and \( j \). Suppose a process \( X \) is in state \( i \) at discrete time \( t \) then the probability of the process moving from state \( i \) to state \( j \) in the next step at time \( t + 1 \) is called the first transition probability and is denoted by \( P_{ij} \).

Mathematically, \( P_{ij} = P(X_{t+1} = j | X_t = i) \). In time-homogeneous Markov chain \( P_{ij} \) is true for all \( t \in T \). Consider a time-homogeneous process, the probability of moving from state \( i \) to state \( j \) in \( n \) time steps is \( P_{ij}^{(n)} = p(X_n = j | X_0 = i) = p(X_{t+n} = j | X_t = i) \).
Let \( P = p_{ij} = \begin{pmatrix}
p_{00} & p_{01} & \cdots & p_{0k} \\
p_{10} & p_{11} & \cdots & p_{1k} \\
\vdots & \vdots & \ddots & \vdots \\
p_{k0} & p_{k1} & \cdots & p_{kk}
\end{pmatrix} \) be the matrix of all possible first step transitions from state \( i \) to \( j \) \( \forall i, j \in S = \{0, 1, 2, \ldots, k\} \). Using the Chapman-Kolmogorov equation, 

\[
p_{ij}^{(n)} = \sum_{r \in S} p_{ir}^{(k)} p_{rj}^{(n-k)}
\]

(3.26)

It can be shown by induction that;

\[
p^n = p^{(n)} \text{ i.e. } \begin{pmatrix}
p_{00} & p_{01} & \cdots & p_{0k} \\
p_{10} & p_{11} & \cdots & p_{1k} \\
\vdots & \vdots & \ddots & \vdots \\
p_{k0} & p_{k1} & \cdots & p_{kk}
\end{pmatrix}^n = \begin{pmatrix}
p_{00}^{(n)} & p_{01}^{(n)} & \cdots & p_{0k}^{(n)} \\
p_{10}^{(n)} & p_{11}^{(n)} & \cdots & p_{1k}^{(n)} \\
\vdots & \vdots & \ddots & \vdots \\
p_{k0}^{(n)} & p_{k1}^{(n)} & \cdots & p_{kk}^{(n)}
\end{pmatrix}
\]

For \( n=1 \), the matrix above is called a one-step transition probability. After computing the one-step probabilities, the long run distribution can be determined if it can be shown that the states communicate, they are irreducible and aperiodic.

### 3.9.3 Communication, reducibility and periodicity of Markov chains

A state \( j \) is said to be **accessible** from a state \( i \) if \( j \) can be reached from state \( i \) in a finite number of steps. That is if there is a non-zero probability that a process in state \( j \) can transition into state \( i \). Also, if two states \( i \) and \( j \) are accessible to each other, then there are said to communicate. Probabilistically these definitions imply that:
\[ i \rightarrow j ( \text{\textit{j accessible from} \textit{i}}) \text{ if for some } n \geq 0, \ P_{ij}^{(n)} > 0 \]
\[ j \rightarrow i ( \text{\textit{i accessible from} \textit{j}}) \text{ if for some } n \geq 0, \ P_{ji}^{(n)} > 0 \]
\[ i \leftrightarrow j (\text{\textit{i and} \textit{j communicate}}) \text{ if for some } n \geq 0, \ P_{ij}^{(n)} > 0 \text{ and for some } m \geq 0, \ P_{ji}^{(m)} > 0 \]

We say a set \( S \) which is a set of states is a **communicating class** if every pair of states contained in \( S \) communicates with each other. It can be shown that communication is an equivalence relation. The set of all states of a Markov chain that communicates with each other can therefore be grouped into a single equivalence class. However, a Markov chain may have more than one set of equivalence class. If a Markov chain has more than one such class, then it is not possible to have communicating states in the different equivalent classes. It is however possible to have communicating states in one class that are accessible from another class. A Markov chain is **irreducible** if its state space has a single communicating class; in other words, if all its states belong to only one equivalence class.

A state \( i \) is said to have a **period** \( k \) if any return to state \( i \) must occur in multiples of \( k \) time steps. Formally, the period of a state is defined as \( k = \gcd\{n: P(X_n = i|X_0 = i) > 0\} \). If the value of \( k \) is however one \((k = 1)\) then the state is said to be **aperiodic**.

### 3.9.4 Ergodicity long-run stationary distribution

A state is **ergodic** if it is aperiodic and positive recurrent. A state \( i \) is said to be recurrent if and only if beginning from state \( i \), the eventual return to state \( i \) is certain. If all the states in an irreducible Markov chain are aperiodic then it is said to be ergodic. If an \( n \)-state time-homogeneous Markov chain is ergodic then it has a long-run stationary distribution \( \lim_{n \to \infty} P^n = \pi \) where \( \pi \) is the stationary matrix with same row probability vectors. A finite irreducible
Markov chain can be shown to be ergodic if it is aperiodic. If there's a finite number \( m \) such that any state can be reached from any other state in exactly \( n \) steps then the model is said to be ergodic.

Given the transition probability matrix \( P \) of an aperiodic, irreducible, \( m \)-state finite Markov chain, there exists a unique probability vector \( \pi = (\pi_1, \pi_2, \ldots, \pi_m) \) such that \( \pi P = \pi \) with 
\[
\sum_{i=1}^{n} \pi_i = 1 \quad \text{and} \quad \Pi = \lim_{n \to \infty} P(X_n = i) \quad \text{where} \quad \lim_{n \to \infty} P^n = \Pi = [\pi \quad \pi \quad \cdots \quad \pi]
\]
The probability vector \( \pi \) gives the stationary distribution or long run distribution of the process.

### 3.9.5 Classification of Inflation and exchange rate as a three state Markov process

To model inflation rates (a continuous variable) as a discrete Markov chain, we would first classify inflation into three mutually exclusive and exhaustive states, namely Low, Medium and High. Grouping of inflation rates into states would be based on what most economists view as:

- **Low (0)** → single digit inflation (less than 10%)
- **Medium (1)** → moderate inflation (10% - 20%) acceptable for economic development and
- **High (2)** → inflation values that distort economic stability (inflation above 20%).

Also, to model exchange rate as a discrete Markov chain, we would again classify exchange rate into three mutually exclusive and exhaustive states, namely appreciated, stable and depreciate of the Ghanaian currency against dollar. Therefore the grouping of exchange rate will be as follows:

- **Appreciated (state 0)**
Stable (state 1)

Depreciate (state 2)

Each monthly inflation and exchange rate from January 2000 to December 2013 would be assigned to a state according to its grouping and the number of first step transitions recorded for each $i \rightarrow j, i \neq j \in S = \{0,1,2\}$

The stochastic matrix $P = p_{ij}$ is estimated using the sample estimates of the first passage probabilities given by;

$$p_{ij} = \frac{\text{Frequency of first step transitions from state } i \text{ to state } j}{\text{Total number of first step transitions from state } i}$$

(38)
CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.0 Introduction

This chapter presents the analysis and the discussion of the results obtained from the study. The data used for the study consist of monthly inflation rates, exchange rate (US dollar rate) and Ghana Stock Exchange (GSE) market returns. The chapter begins with a diagnostic analysis of the stationarity of the three variables (returns, inflation and exchange rate) in the study. This is then followed by the Autoregressive Distributed Lag (ARDL) and Error correction model (ECM) methodology, which was used in determining the short and long run relationships between the variables and lastly the estimation of the long run (steady state or limiting) distribution of exchange rate and inflation using Markov transition probabilities. MINITAB 16 was used to obtain the various graphs due to its pictorial clarity; MICROFIT 5.0 was used for the ARDL methodology while the transition matrices were developed using excel.

4.1 Preliminary analysis

Figure 4.1.1: Time series plot of the monthly stock market returns in Ghana (2000-2013)
Figure 4.1.1 above shows the time series plot of the monthly GSE market returns for the period January 2000 to December 2013. From the figure, it appears that the monthly return rate is characterized by a constant mean and a stable variance which is an indication of the stationarity of the return rates. To confirm the presence of this stationarity, the Augmented Dickey-Fuller (ADF) test was performed. The p-value of the test was less than 0.05 hence we reject the null hypothesis of unit root (non-stationarity) at 5% level of significance and thus conclude that the return rates are stationary over the period January 2000 to December 2013. The result of the Augmented Dickey-Fuller (ADF) test is shown in Table 4.1.1. This means that the return rates are integrated of order zero (I(0)) since it is stationary without differencing it.

Table 4.1.1: Augmented Dickey-Fuller (ADF) Unit root Test for the monthly Rates of Inflation, Exchange rate (Dollar rate) and GSE market returns in Ghana (2000-2013)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation rate</td>
<td>Constant</td>
<td>-1.545</td>
<td>-2.879</td>
<td>0.508</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-2.523</td>
<td>-3.437</td>
<td>0.317</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-0.712</td>
<td>-1.943</td>
<td>0.407</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>Constant</td>
<td>0.658</td>
<td>-2.879</td>
<td>0.991</td>
</tr>
<tr>
<td>(dollar rate)</td>
<td>Constant + Trend</td>
<td>-0.868</td>
<td>-3.437</td>
<td>0.956</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>3.003</td>
<td>-1.943</td>
<td>0.999</td>
</tr>
<tr>
<td>Stock returns</td>
<td>Constant</td>
<td>-11.604</td>
<td>-2.879</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-11.677</td>
<td>-3.437</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-11.385</td>
<td>-1.943</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

Table 4.1.1 also shows the ADF test of stationarity for inflation and exchange rate. The p-values show that the two variables are not stationary. Figure 4.1.2 clearly confirms this since the plot of the level values of inflation and exchange rate (US dollar against Ghana Cedi) shows that the mean and variance are not constant over time. This called for a transformation of the data. There
are several transformations that are usually used to achieve stationarity in a time series data. Examples of such transformations include ordinary differencing, taking of natural logarithms, taking square roots, etc. The ordinary differencing was used in this study. Hence inflation and the dollar rate values were differenced. Figure 4.1.2 also shows a plot of the differenced values. The plot shows that the mean and variance of the first difference of inflation (d(inflation)) and exchange rate (d(Dollar)) appears to be constant over time. This is confirmed by the ADF test of stationarity. Since the p-values from Table 4.1.2 are each less than 0.05 we conclude that the variables are stationary. Hence this shows that after first difference, inflation and exchange rate between became stationary. This means that inflation rate and exchange rate are both integrated of order one I(1).

Figure 4.1.2: Time Series plot of monthly Inflation, exchange rate and their first difference in Ghana (2000-2013)
Table 4.1.2: Augmented Dickey-Fuller Unit Root Test for the monthly Rates of Inflation and Exchange rate (Dollar rate) in Ghana (2000-2013) after first difference

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation rate</td>
<td>Constant</td>
<td>-5.196</td>
<td>-2.880</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-5.281</td>
<td>-3.439</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-5.096</td>
<td>-1.943</td>
<td>0.000*</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>Constant</td>
<td>-5.508</td>
<td>-2.879</td>
<td>0.000*</td>
</tr>
<tr>
<td>(dollar rate)</td>
<td>Constant + Trend</td>
<td>-5.58</td>
<td>-3.437</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-4.526</td>
<td>-1.943</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

4.2 The Autoregressive Distributed Lag Model (ARDL)

The ARDL test according to Pesaran et al., (2001) can be adopted for cointegration analysis irrespective of whether the regressors are purely I(0), purely I(1) or a mixture of I(0) and I(1). The results above shows that the stock market returns is integrated of order zero I(0) and inflation and exchange rate are each integrated of order one I(1), hence the ARDL model can be applied in this case. The analysis that follows is in three folds. A separate ARDL model was built for the GSE market returns and inflation to ascertain how inflation affects returns followed by another model for GSE market returns and exchange rate. However, in both models market returns was the dependent variable while the other becomes the independent variable. This was done to ascertain how each of inflation and exchange rate could affect stock returns separately or individually. The last ARDL model was developed using both exchange rate and inflation as independent variables to ascertain how they both affect the GSE market returns. The separate analysis were again done to ascertain the individual effects when only one independent variable is involved and the relative effect when both are included in the same model.
4.2.1 ARDL model for GSE Market Returns and Inflation

The results in Table 4.2.1 show the estimates of the ADRL model describing the relationship between exchange rate and GSE market returns. We investigate both the short and long run relationships and effects.

Table 4.2.1: Testing for the existence of a level relationship among variables in the ARDL model

<table>
<thead>
<tr>
<th>Number of regressor(s)</th>
<th>Value of statistic K=1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computed F-statistic</td>
<td>11.0325</td>
</tr>
<tr>
<td>5% critical value</td>
<td></td>
</tr>
<tr>
<td>Lower bound value:</td>
<td>4.94</td>
</tr>
<tr>
<td>Upper bound value:</td>
<td>5.73</td>
</tr>
</tbody>
</table>

The critical bound values were extracted from Pesaran et al. (2001) while F-statistic is based on the researchers own calculation from field data.

The result of the ARDL bound test for cointegration between the GSE market returns and exchange rate is presented in Table 4.2.1. From the table above, the computed F-Statistic is 11.0325. The value is above the upper bounds critical value of 5.73 at the 5% level of significance. This means that the null hypothesis of no cointegrating relationship is rejected according to (Pesaran et al., 2001). This means that stock market returns and inflation are cointegrated. The results imply that there exists a long-run relationship between the variables.

Next we compute the estimates of the ARDL long-run coefficient for the model and that of the Error correction model (ECM) as well. Table 4.2.2 contains the long run estimates while Table 4.2.3 contains the estimates of the corresponding ECM.

The coefficient of the long-run relationship and the error correction model estimates are also provided in the tables below. ARDL(0,1) means that the dependent variable (GSE market
returns) has a lag of zero while that of the independent variable (inflation) is one. Inflation with a lag of one implies that its current value depends on only the previous value. This means that month on month dependencies can occur as time increases into the distant future (long run).

Table 4.2.2: Estimated Long Run coefficients: ARDL (0,1) selected based on Schwarz Bayesian Criterion

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>0.001013</td>
<td>0.86187</td>
<td>0.11759</td>
<td>0.005*</td>
</tr>
<tr>
<td>Constant</td>
<td>0.9947</td>
<td>7.0064</td>
<td>2.8538</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

The long run relationship between inflation and stock returns in Table 4.2.2 shows that the coefficient of inflation is positive and significant. This means that inflation has a positive impact on stock returns since the p-value is less than 0.05. The coefficient of inflation shows that a one percent rise in inflation will lead to approximately 0.101% increase in the GSE market returns in the long run. The positive relationship between stock returns and inflation in the long run is consistent with Kuwornu (2000). This means that investors on the Ghanaian stock market are compensated for increases in inflation in the long run.

Table 4.2.3: Error Correction representation of the selected ARDL model: ARDL (0,1) selected by Schwarz Bayesian Criterion

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>d(Inflation)</td>
<td>0.0039716</td>
<td>0.033891</td>
<td>0.118</td>
<td>0.907</td>
</tr>
<tr>
<td>ECM(-1)</td>
<td>-0.039186</td>
<td>0.028056</td>
<td>-2.1703</td>
<td>0.0116*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

The Error Correction coefficient of -0.039186 (0.0116) is significant and has a correct (since it must lie between 0 and -1) sign. This shows a moderate speed of convergence of GSE market
returns to equilibrium after inflation changes become stable. The result also shows that a change in one period lagged value of inflation has a positive effect on changes in stock returns. However the p-value of 0.907 shows that it is not significant at 5%. This means that there is no significant short run relationship between inflation and stock market returns.

4.2.1.1 Diagnostic tests for returns against inflation model

The R-square value of the ARDL model was 0.5250. This shows that the model fits reasonably well. The Lagrange Multiplier test for heteroscedasticity which is distributed as chi-square has a value of 0.00499 (p-value=0.480) and the Lagrange Multiplier test for Serial correlation also had a value of 0.01513 (p-value=0.130). Also the Shapiro Wilks test of normality had a chi-square value of 0.45 (p=0.104) meaning the assumption of normality of errors is satisfied. This shows that the diagnostic tests for serially uncorrelated errors, normality and heteroscedasticity are satisfied at 5% level of significance. Recursive estimation of the errors also suggests that the regression coefficients are generally stable over the sampled period. This is because the Cumulative Sum (CUSUM) plot based on the recursive residuals given in Figure 4.2.1 does not show evidence of statistically significant breaks.

The CUSUM plot below shows the stability of the stock return function. It shows whether the ARDL model has shifted over time. As can be observed from Figures 4.2.1, the parameters of the model were stable during the sample period (2000-2013) as the plot is contained in the bound.
4.2.2 ARDL model for GSE Market Returns and Exchange rate

Similarly, we estimate an ARDL model to analyse the relationship between exchange rate and stock returns. We investigate both the short and long run effects.

Table 4.2.4: Testing for the existence of level relationship among variables in the ARDL model

<table>
<thead>
<tr>
<th>Number of regressor(s)</th>
<th>Value of statistic K=1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computed F-statistic</td>
<td>26.4832</td>
</tr>
<tr>
<td>5% critical value</td>
<td></td>
</tr>
<tr>
<td>Lower bound value:</td>
<td>4.94</td>
</tr>
<tr>
<td>Upper bound value:</td>
<td>5.73</td>
</tr>
</tbody>
</table>

The critical values are extracted from Pesaran et al. (2001)

The result of the ARDL bound test for cointegration between the GSE market returns and exchange rate is shown in Table 4.2.4. From Table 4.2.4, the calculated F-Statistic is 26.4832. The value of the F-statistic is greater than the upper bound value of 5.73 at the 5% significance level. This means that the null hypothesis of no cointegrating long-run relationship is according
to Pesaran et al. (2001). That is, stock market returns and exchange rates are cointegrated. The result also means that there is a long-run relationship between them.

Table 4.2.5 contains the long run estimates while Table 4.2.6 also contains the estimates of the corresponding Error correction model.

The long run coefficients estimate and Error Correction Model estimates are provided in the tables below. The result shows that the exchange rate has a lag of one while that of GSE market returns is zero.

Table 4.2.5: Estimated Long Run coefficients: ARDL (0,1) selected by Schwarz Bayesian Criterion

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate</td>
<td>-0.0013670</td>
<td>0.0024662</td>
<td>-5.5432</td>
<td>0.005*</td>
</tr>
<tr>
<td>Constant</td>
<td>0.92839</td>
<td>0.025067</td>
<td>37.0364</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

The long run relationship between exchange rate and stock return results are presented in Table 4.2.5 above. It shows that the estimated coefficient of exchange rate is negative and significant. This means that exchange rate has a negative impact on stock returns since the p-value is less than 0.05. The coefficient shows that 1% appreciation in the dollar rate against the Cedi will lead to an approximately 0.13670% decrease in stock return in the long run. This invariably means that a fall in the Cedi against the dollar leads to a reduction in the GSE market returns.
Table 4.2.6: Error Correction representation of the selected ARDL model: ARDL (0,1) selected by Schwarz Bayesian Criterion

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>d(exchange rate)</td>
<td>-0.0007847</td>
<td>0.000141</td>
<td>-5.529</td>
<td>0.005*</td>
</tr>
<tr>
<td>ECM(-1)</td>
<td>-0.057400</td>
<td>0.0078624</td>
<td>7.3006</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

The error correction coefficient of -0.057400 (p-value=0.000) is significant and shows that the speed of convergence to equilibrium after a change in exchange rate is 0.0057%. The result also shows that a change in one period lagged value of the dollar rate has a negative effect on changes in stock returns. This result implies that an increase in the dollar rate of the previous month has a negative influence on the changes noticed in the GSE market returns in the current month. This means that there exist a negative short run relationship between GSE market returns and exchange rate.

4.2.2.1 Diagnostic tests for returns against exchange rate model

Similarly, the R-square value of the ARDL model was 0.59340. This shows that the model fits reasonably well. The Lagrange Multiplier test for heteroscedasticity which is distributed as a chi-square has a value of 0.0335 (p-value=0.530) and the Lagrange Multiplier test for Serial correlation also had a value of 0.0071 (p-value=0.058). Also the Shapiro Wilks test of normality had a chi-square value of 0.75(p-value=0.345) meaning the assumption of normality of errors is satisfied. This shows that the diagnostic tests for serially uncorrelated errors, normality and heteroscedasticity are satisfied at 5% level of significance. Recursive estimation of the errors also suggests that the regression coefficients are generally stable over the sampled period. The Cumulative Sum (CUSUM) of plot based on the recursive residuals is given in Figure 4.2.2. The plot does not show evidence of statistically significant breaks.
Figure 4.2.2 shows the test of stability in GSE market returns changes in relation to the dollar rate over time. It shows that the parameters of the estimated ARDL model are stable over the sampled period.

![CUSUM test for stability](image)

Figure 4.2.2: CUSUM test for stability

### 4.2.3 ARDL model for GSE Market Returns against Inflation and Exchange rate

The results below show the estimates of the ARDL model describing the relationship between GSE market returns, inflation and exchange rate. We investigate both the short and long run relationships and effects.

<table>
<thead>
<tr>
<th>Number of regressors</th>
<th>Value of statistic</th>
<th>5% critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computed F-statistic</td>
<td>5.964</td>
<td>Lower bound value: 3.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper bound value: 4.85</td>
</tr>
</tbody>
</table>

The critical bound values were extracted from Pesaran et al., (2001) while F-statistic is based on the researchers own calculation from field data.
The result of the ARDL bound test for cointegration between the GSE market returns, inflation and exchange rate is presented in Table 4.2.7. From the table above, the calculated F-Statistic is 5.964. This value is above the upper bounds critical value of 4.85 at the 5% significance level. This means that the null hypothesis of no cointegrating relationship can be rejected according to (Pesaran et al., 2001). This implies that stock market returns are cointegrated with inflation and exchange rate. The results also imply that there exists a long-run relationship between the variables.

Next we compute the estimates of the ARDL long-run coefficient for the model and that of the Error Correction Model (ECM) as well. Table 4.2.8 contains the long run estimates while Table 4.2.9 contains the estimates of the corresponding ECM. The long run coefficients and the error correction model estimates are also provided in the tables below. ARDL(0,1,1) means that the dependent variable (GSE market returns) has a lag of zero whiles each independent variable (inflation and exchange rate) has a lag of zero.

Table 4.2.8: Estimated Long Run coefficients: ARDL (0,1,1) selected by Schwarz Bayesian Criterion

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>0.0527</td>
<td>0.7446</td>
<td>2.0519</td>
<td>0.005*</td>
</tr>
<tr>
<td>Dollar</td>
<td>-0.0513</td>
<td>0.1923</td>
<td>-5.4651</td>
<td>0.000*</td>
</tr>
<tr>
<td>Constant</td>
<td>0.234</td>
<td>0.03451</td>
<td>6.7806</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

The result of the long run relationship between GSE market returns, exchange rate and inflation in Table 4.2.8 shows that the coefficient of inflation and exchange rate have a positive and negative significant impact on stock returns respectively since their p-values are less than 0.05.
This means that inflation and exchange rate have an aggregate significant long run effect on GSE market returns.

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>d(Inflation)</td>
<td>0.023466</td>
<td>0.123885</td>
<td>1.842</td>
<td>0.670</td>
</tr>
<tr>
<td>d(Exchange rate)</td>
<td>-0.036477</td>
<td>0.1419</td>
<td>-2.578</td>
<td>0.002*</td>
</tr>
<tr>
<td>ECM(-1)</td>
<td>-0.04365</td>
<td>0.028056</td>
<td>-2.324</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

The error correction coefficient of -0.04365 (p-value=0.015) is significant and suggests a moderate speed of convergence to equilibrium. The result above again clearly shows that inflation has no significant short term effect on GSE stock returns while that of exchange rate has a short term effect on returns.

**4.2.3.1 Diagnostic tests for returns against inflation and exchange model**

Again, the R-square value of the ARDL model was 0.6220. This shows that the model fits reasonably well. The Lagrange Multiplier test for heteroscedasticity which is distributed as chi-square has a value of 0.04195 (p-value=0.517) and the Lagrange Multiplier test for Serial correlation also had a value of 0.03026 (p-value=0.082). Also the Shapiro Wilks test of normality had a chi-square value of 0.82 (p-value=0.622) meaning the assumption of normality of errors is satisfied. This shows that the diagnostic tests for serially uncorrelated errors, normality and heteroscedasticity are satisfied at 5% level of significance. Recursive estimation of the errors also suggests that the regression coefficients are stable over the sampled period. This is because the Cumulative Sum (CUSUM) plot based on the recursive residuals given in Figure
4.2.3 does not show evidence of statistically significant breaks. The CUSUM plot below shows the stability of the stock return function.

![CUSUM test for stability](image)

Figure 4.2.3: CUSUM test for stability

The ARDL methodology helped establish that there is a long run relationship between GSE market returns and inflation as well as GSE market returns and exchange rate. Depending on this relationship, if the long run estimates of inflation and exchange rate are determined it can help inform investors as to whether to invest in the long run or in the short run. However, the long run estimates of these variables were not estimated by the ARDL so Markov chains were used to estimate them as follows.

4.3 Three-state stochastic Markov chain of inflation

The table below gives the categorical groups and frequencies of the three-state inflation. Starting from January 2000, monthly inflation values were tagged as 0, 1 or 2 through to December 2013 based on the classifications below. From the data set, the number of inflation rates below 10%,
from 10% to 20% inclusive and above 20% was counted. After, the various states to state one-step transitions were then tracked and also counted manually.

Table 4.3.1: Categorization of inflation into three states

<table>
<thead>
<tr>
<th>State of inflation</th>
<th>Classification of state (%)</th>
<th>Representation of state</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Below 10</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Medium</td>
<td>From 10 to 20</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>High</td>
<td>Above 20</td>
<td>2</td>
<td>47</td>
</tr>
</tbody>
</table>

Source: Calculations based on the researchers own calculation from field data

Table 4.3.2 shows the frequencies that were observed by counting the number of times of moving from one state to the other throughout the data from January 2000 to December 2013.

Table 4.3.2: Frequencies of one-step transitions for inflation

<table>
<thead>
<tr>
<th>One step transition from state 0</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 → 0</td>
<td>30</td>
</tr>
<tr>
<td>0 → 1</td>
<td>1</td>
</tr>
<tr>
<td>0 → 2</td>
<td>0</td>
</tr>
<tr>
<td>Total transitions from state 0</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>One step transition from state 1</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 → 0</td>
<td>1</td>
</tr>
<tr>
<td>1 → 1</td>
<td>86</td>
</tr>
<tr>
<td>1 → 2</td>
<td>3</td>
</tr>
<tr>
<td>Total transitions from state 1</td>
<td>90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>One step transition from state 2</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 → 0</td>
<td>0</td>
</tr>
<tr>
<td>2 → 1</td>
<td>3</td>
</tr>
<tr>
<td>2 → 2</td>
<td>44</td>
</tr>
<tr>
<td>Total transitions from state 2</td>
<td>47</td>
</tr>
</tbody>
</table>
Table 4.3.2 shows that the number of times Ghana recorded a low inflation in a particular month and a low inflation in the next within the sampled period was 30. The table also shows that, there was no time within the sampled period in which high inflation was recorded when that of the previous month was low. Similarly, there was no transition from state two to state zero. The highest state to state transition was from state one to state one. This means that there is going to be a high probability of Ghana recording a medium inflation when that of the previous month is also medium. The future monthly inflation depends largely on the immediate past monthly inflation rates. Thus, it exhibits Markov dependence.

The frequencies above were used to calculate sample estimates of the first transition probabilities $p_{ij}$’s using the formula:

$$p_{ij} = \frac{\text{Frequency of first step transitions from state } i \text{ to state } j}{\text{Total number of first step transitions from state } i}$$

Where $p_{ij}$ is the probability of moving from state $i$ to state $j$ in the next month.

The transition probabilities are:

$p_{00} = \frac{30}{31}$ \hspace{1cm} $p_{01} = \frac{1}{31}$ \hspace{1cm} $p_{02} = 0$

$p_{10} = \frac{1}{90}$ \hspace{1cm} $p_{11} = \frac{86}{90}$ \hspace{1cm} $p_{12} = \frac{3}{90}$

$p_{20} = 0$ \hspace{1cm} $p_{21} = \frac{3}{47}$ \hspace{1cm} $p_{22} = \frac{44}{47}$

From the probabilities above the first step transition probability matrix is given by:
\[ P = \begin{pmatrix} p_{00} & p_{01} & p_{02} \\ p_{10} & p_{11} & p_{12} \\ p_{20} & p_{21} & p_{22} \end{pmatrix} = \begin{pmatrix} 30/31 & 1/31 & 0 \\ 1/90 & 86/90 & 3/90 \\ 0 & 3/47 & 44/47 \end{pmatrix} \]

The second step transition matrix \( p_{ij}^{(2)} \), third step \( p_{ij}^{(3)} \) up to \( n \)-steps \( p_{ij}^{(n)} \) transition matrices are also obtained recursively according to the Chapman-Kolmogorov equations. The step to step transition probabilities for exchange rate can also be found in the appendix. The same step transition for each matrix was used to plot the graph below. The figure shows a plot of \( n \)-step transition probabilities for inflation rates for state zero to zero \( p_{00}^{(n)} \), one to one \( p_{11}^{(n)} \) and two to two \( p_{22}^{(n)} \) for ten months \( (n=1, 2, \ldots, 10) \) to give a trend of the behaviour as \( n \) increases. It shows the various transition probabilities from a given state to the same state for ten months. It clearly shows that the probabilities keep decreasing as \( n \) increases. It is however not so clear how the line will keep moving as \( n \) increase further hence it suffices to determine the long run distribution.

![Figure 4.3.1: n-step transition probabilities for inflation rates in Ghana](http://ugspace.ug.edu.gh)
In determining the long run distribution (stationary distribution) of inflation, we need to show that the three state transition probability matrix $P$ is geometrically ergodic.

Hence it suffices to show that the process is irreducible and aperiodic by theorems on ergodicity.

A Markov graph can be used to show if the process is irreducible by showing that all the states communicate.

![Markov graph](image)

Figure 4.3.2: Markov graph

The graph above shows that you can move from one state to the other. Hence it is evident from the Markov graph; the state space $S = \{0,1,2\}$ is irreducible since all the three states communicate (i.e. you can move from one state to the other). You can move from state two to state zero through state one.

Also $P_{00} \neq 0$ implies that state 0 has period 1. Now, since all states $S = \{0,1,2\}$ belong to one equivalent class and from the fact that periodicity is a class property, it implies that the chain is aperiodic. Now, since the process is aperiodic and irreducible it implies that the process is geometrically ergodic having a long-run stationary distribution $\pi$ with $\pi = \lim_{n \to \infty} P^n$. From theory the relationship between the long run distribution and the transition probability matrix is given by $\pi = \pi P$ where $\pi = (x \ y \ z)$ with the constraint $x + y + z = 1$. 
The computation of the long run distribution was done in two ways. The first procedure was
done by iteratively multiplying the transition matrix by subjecting it to powers until the values
become stationary for each state. The second procedure was done by using the definition straight
away. The two results are presented in the appendix. The difficulty with the second method is
that we are unable to estimate the time in which the stationarity is observed. According to the
recursive method which was done in excel, we expect stationarity after 567 months. The result of
the two procedures resulted in the same estimates. From the two procedures, the long run
distribution of inflation is given by:

\[
\begin{align*}
x &= \frac{31}{168} = 0.18452381 \\
y &= \frac{90}{168} = 0.53571429 \\
z &= \frac{47}{168} = 0.27976190
\end{align*}
\]

\[\pi = (0.18452381 \ 0.53571429 \ 0.27976190) \text{ or } \pi = (18.45\% \ 53.57\% \ 27.98\%)\]

The values of the limiting distribution show that, in the long run there is a 53.57% chance that
inflation rate will lie between 10 and 20%, inclusive, 27.98% chance that it will be greater than
20% while there is only 18.45% chance that it will be a single digit inflation.

4.4 Three-state stochastic Markov chain of exchange rate

Table 4.4.1: Categorization of the dollar rate into three states

<table>
<thead>
<tr>
<th>Classification of state</th>
<th>Representation of state</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appreciate</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Stable</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Depreciate</td>
<td>2</td>
<td>144</td>
</tr>
</tbody>
</table>

Source: Calculations based on the researchers own calculation from field data
Table 4.4.1 also gives the categorical groups and frequencies of the three-state dollar rate. Again starting from January 2000, monthly inflation values were tagged as 0, 1 or 2 through to December 2013 based on the classifications in Table 4.4.1. From the table, the number of times the cedi appreciated was thrice, it was stable on 141 different occasions (i.e. month on month) while it depreciated 24 times during the sampled period.

Table 4.4.2: Frequencies of one-step transitions for exchange rate

<table>
<thead>
<tr>
<th>One step transition from state 0</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 → 0</td>
<td>11</td>
</tr>
<tr>
<td>0 → 1</td>
<td>0</td>
</tr>
<tr>
<td>0 → 2</td>
<td>13</td>
</tr>
<tr>
<td>Total transitions from state 0</td>
<td>24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>One step transition from state 1</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 → 0</td>
<td>0</td>
</tr>
<tr>
<td>1 → 1</td>
<td>0</td>
</tr>
<tr>
<td>1 → 2</td>
<td>3</td>
</tr>
<tr>
<td>Total transitions from state 1</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>One step transition from state 2</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 → 0</td>
<td>13</td>
</tr>
<tr>
<td>2 → 1</td>
<td>3</td>
</tr>
<tr>
<td>2 → 2</td>
<td>125</td>
</tr>
<tr>
<td>Total transitions from state 2</td>
<td>141</td>
</tr>
</tbody>
</table>

Table 4.4.2 shows the various frequencies of moving from one state to the other. It shows that there were times that the dollar appreciated for two or more consecutive months within the sampled period (that is transition from zero to zero). There was no transition from state zero to state one that is there was no time within the sampled period that the dollar appreciated and later
become stable. The highest frequency recorded was 125, which is the number of times the Cedi depreciated against the dollar for consecutive months.

Using the frequencies from the above table, the transition probabilities are given by:

\[ p_{00} = \frac{11}{24}, \quad p_{01} = 0, \quad p_{02} = \frac{13}{24} \]

\[ p_{10} = 0, \quad p_{11} = 0, \quad p_{12} = 1 \]

\[ p_{20} = \frac{13}{141}, \quad p_{21} = \frac{3}{141}, \quad p_{22} = \frac{125}{141} \]

Therefore the first step transition probability matrix is given by:

\[
\begin{pmatrix}
    p_{00} & p_{01} & p_{02} \\
    p_{10} & p_{11} & p_{12} \\
    p_{20} & p_{21} & p_{22}
\end{pmatrix} = \begin{pmatrix}
    \frac{11}{24} & 0 & \frac{13}{24} \\
    0 & 0 & 1 \\
    \frac{13}{141} & \frac{3}{141} & \frac{125}{141}
\end{pmatrix}
\]

Figure 4.3.3 also shows the n-step transition probabilities for exchange rate from state zero to zero (\( p_{00}^{(n)} \)), one to one (\( p_{11}^{(n)} \)) and two to two (\( p_{22}^{(n)} \)) for ten months (\( n=10 \)). It does show that the probabilities decreased up to some point and then appear to be stabilizing after some time as \( n \) increases (that is on a month to month basis). It looks as though the long run distribution can be obtained after a few number of transitions. The lines are wide apart with the probability of being in state two being very high. Hence we would expect that the probability of the state being in state two to be high in the long run.
Again from the transition matrix above, we can estimate the long run distribution by showing whether the transition matrix $P$ is geometrically ergodic. To justify this, it suffices to again show that the process is irreducible and aperiodic by theorems on ergodicity.

Figure 4.3.4: Markov graph

Again, the graph above shows that you can move from one state to the other. Hence it can from the directed-multigraph; the state space $S = \{0,1,2\}$ is irreducible since all the three states communicate.
Also \( P_{00}^1 = \frac{11}{24} > 0 \) implies that state 0 has period 1. Now since all states \( S = \{0,1,2\} \) belong to one equivalent class and from the fact that periodicity is a class property, it implies that the chain is aperiodic. Now, since the process is aperiodic and irreducible it implies that the process is geometrically ergodic having a long-run stationary distribution \( \pi \) with \( \pi = \lim_{n \to \infty} P^n \). Again, the computation of the long run distribution is given was done iteratively and by using the definition. The result of both procedures can also be found in the appendix. According to the recursive procedure, we expect exchange rate to stabilize in twenty one months from the time of the study with the cedi depreciating against the dollar since the probability of state three is higher than the other states. From the two procedures, the long run distribution of exchange rate is given by:

\[
\begin{align*}
x &= 0.14385714 \\
y &= 0.01785714 \\
z &= 0.8392857
\end{align*}
\]

\( \pi = (0.143, 0.018, 0.839) \) or \( \pi = (14.3\% \ 1.8\% \ 83.9\%) \)

The values of the limiting distribution shows that, in the long run there is 83.9\% chance that the cedi will depreciate, 14.3\% chance that the cedi will remain stable while there only a 1.8\% chance that the cedi will appreciate against the dollar in the long run.
CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

The chapter presents a summary of the findings from the study as well as the conclusions, recommendations and the areas for future research. Thus the main results and findings of the models used in the study are presented. To satisfy the objectives of this study, five-fold analysis was carried out. The first was the ARDL model for GSE market returns and inflation to determine if there exist long and short run relationships between them. The second was also an ARDL model between GSE returns and exchange rate to also determine if there is also a long and short run relationship between them. The third is also an ARDL model for GSE market returns, inflation and exchange rate, where inflation and exchange rate are both used as independent variables. The fourth and fifth is the determination of the long-run stationary distribution of inflation and exchange rate. This was necessary to help investors to envisage the behavior of inflation and exchange rate as they were seen to have a long run relationship with stock returns.

5.1 Summary

The order of integration of the variables under study was investigated using graphs and the ADF test. It was realized that the GSE market returns was stationary at level without differencing meaning that GSE market return is integrated of order zero. However, inflation and exchange rate were non-stationary at level. Inflation and exchange rate become stationary after first difference, implying that they are each integrated of order one.
The bounds test of the ARDL model showed that the GSE market returns and inflation are co-integrated. The result also showed the existence of significant positive long-run relationship between the GSE market returns and inflation. The coefficient of inflation showed that a one percent rise in inflation can lead to approximately 0.101% increase in stock market return in the long run. The positive relationship between GSE market returns and inflation in the long run is consistent with the result obtained by Kuwornu (2000) who examined the relationship between macroeconomic variables and stock market returns in Ghana from 1992 to 2008. The result means that investors are rewarded for inflation increases in the long run.

The coefficient of the error correction model of -0.039186 (p=0.0116) is significant with its value, suggesting a moderate speed of convergence to equilibrium. The coefficient of inflation in the error correction model showed no significant short-run relationship between GSE market returns and inflation. This means that there is no short run relationship between GSE market returns and inflation.

The result of the long-run relationship between the GSE market returns and exchange rate showed a significant negative relationship. The coefficient shows that 1% appreciation in the Ghana Cedi against the dollar will lead to an approximately 0.1367% increase in stock return in the long run. This may be due to the fall in demand of foreign stocks as the cedi appreciates against the dollar. The error correction coefficient estimated at -0.057400 (p=0.000) was also statistically significant. The result also showed a negative short run relationship between stock market returns and exchange rate. This means that in the short run changes in exchange rate can have a significant impact on the GSE market returns.
When inflation and exchange rate were both used as independent variables in the third model, the coefficient of the error correction model increased in absolute terms compared to the other two models. This means that the GSE market returns sets back to equilibrium faster when inflation and exchange rate are stable than when only one of the two is stable.

Due to the significant long run relationships between the variables, the Markov transition matrices were developed to determine the long run distribution of inflation and exchange rate to inform investors who are interested in making long term investments.

After classifying the inflation rates into three states, namely, Low (below 10% or single-digit inflation), Medium (from 10% to 20%) and High (above 20%), it was found to be an ergodic Markov process (that is aperiodic, irreducible) with a long-run stationary distribution;

\[ \pi = (0.1845 \ 0.5357 \ 0.2798) \text{ or } \pi = (18.45\% \ 53.57\% \ 27.98\%) \]

Also, after classifying the exchange rate into three states, namely, appreciate, stable and depreciate (that is the Cedi against the dollar) and it was also found to be an ergodic Markov process (that is aperiodic, irreducible) with a long-run stationary distribution;

\[ \pi = (0.143 \ 0.018 \ 0.839) \text{ or } \pi = (14.3\% \ 1.8\% \ 83.9\%) \]

These results thus confirm that inflation and exchange rate have long run distributions.

**5.2 Conclusions**

The objectives of the study were to examine the short and long run relationship between the GSE market returns, inflation and exchange rate in Ghana. This study adopted the ARDL bounds
testing approach to establish these relationships. The study showed that there exist a significant positive long run relationship between the GSE market returns and inflation, but the short run relationship was not statistically significant. Also the study showed the existence of a statistically significant long and short run relationship between the GSE market returns and exchange rate (USD against the Ghana Cedi). Upon the establishment of these long run relations, Markov transition probabilities was used to estimate the long-run stationary distributions of inflation and exchange (that is the long run behavior of inflation and exchange rate). It was realized that in the long run there is a high probability that inflation rate will lie between 10% and 20% inclusive whereas there is also a high probability that the Cedi will depreciate against the dollar in the long run.

The speed of adjustment estimated by the error correction model for inflation and exchange rate in relation to the GSE market returns shows that the GSE market returns adjusts faster to inflation than to exchange rate changes. This means that exchange rate changes can have a lasting impact on GSE market returns than inflation. This result implies that inflation and exchange rate are essential macroeconomic variables that influence the flow of investment.

The long run distributions of inflation and exchange rate that were estimated using Markov transition probabilities are to serve as a yard stick for advising potential investors whether to invest in stock in the long run or not. The study showed that inflation impact positively on stock returns in the long run hence it is laudable to invest in the foreseeable future since it was realised that inflation will increase in the future whereas the opposite is for exchange rate.
5.3 Limitations of the study

Despite the benefits provided by this study, there are certain limitations which may hinder a hundred percent accuracy of findings. Some of these limitations are as follows:

- There is no proven theorem that makes comparisons of long run distributions from Markov transition matrices in a case where the length of time for transitions are different even for the same data. Example for a given daily and monthly exchange rate data, is the estimates of the long run distribution going to be the same with some specified error margin for the same study period?

- The project is also limited in terms of recent data as the 2014 data was not readily available as at the time of request.

5.4 Recommendations

Due to the relationship that exists between inflation, exchange rate and market returns it is highly recommendable that Potential investors pay attention to both exchange rate and inflation rate changes in relation to their decision to invest on the GSE market returns. It is also necessary that investors pay attention to other macroeconomic factors in making investment decisions as they could also affect their returns. Again, Investors, apart from the fundamental factors should also consider firms specific factors in their decision to purchase a firm’s stock.

Also, in order to achieve better stock performance, policy makers of the Ghana Stock Exchange must also put in place measures to ensure better corporate performance by listed firms since investors would like to know the performance of the stock market before investing.
It is also essential on the part of Government to ensure that prudent measures are put in place to ensure the cedi is stable against the US dollar and other currencies to attract both local and foreign investors on the stock market to boost the economy.

It is recommended to future researchers that the effect of other macroeconomic variables on the GSE market returns are investigated using more than one statistical methodology for comparison of estimates.
REFERENCES


APPENDICES

Appendix A

Inflation

Iterative procedure for determining long run distribution of inflation in excel

\[
P_{ij}^{(1)} = \begin{pmatrix} 0.96774194 & 0.03225806 & 0.00000000 \\ 0.01111111 & 0.95555556 & 0.03333333 \\ 0.00000000 & 0.06382979 & 0.93617021 \end{pmatrix}
\]

\[
P_{ij}^{(2)} = \begin{pmatrix} 0.93688288 & 0.03157590 & 0.00107527 \\ 0.02136997 & 0.01310337 & 0.06305753 \\ 0.00070922 & 0.06046477 & 0.87854233 \end{pmatrix}
\]

\[
P_{ij}^{(3)} = \begin{pmatrix} 0.90735020 & 0.03098002 & 0.00307470 \\ 0.03085365 & 0.01488733 & 0.08955166 \\ 0.00202799 & 0.05744170 & 0.82649011 \end{pmatrix}
\]

\[
P_{ij}^{(4)} = \begin{pmatrix} 0.87907612 & 0.03046090 & 0.00586428 \\ 0.03963164 & 0.01648462 & 0.11315542 \\ 0.00386793 & 0.05472546 & 0.77945148 \end{pmatrix}
\]

\[
P_{ij}^{(5)} = \begin{pmatrix} 0.85199727 & 0.03001005 & 0.00932528 \\ 0.04776668 & 0.01791460 & 0.13417317 \\ 0.00615072 & 0.05228456 & 0.73692195 \end{pmatrix}
\]

\[
P_{ij}^{(6)} = \begin{pmatrix} 0.82605434 & 0.02961987 & 0.01335263 \\ 0.05531538 & 0.01919466 & 0.15287759 \\ 0.00880705 & 0.05009073 & 0.69844862 \end{pmatrix}
\]

\[
P_{ij}^{(7)} = \begin{pmatrix} 0.80119180 & 0.02928358 & 0.01335263 \\ 0.06232886 & 0.02034037 & 0.16951302 \\ 0.01177567 & 0.04811864 & 0.66362494 \end{pmatrix}
\]

\[
P_{ij}^{(8)} = \begin{pmatrix} 0.77735751 & 0.02899509 & 0.02274568 \\ 0.06885335 & 0.02136568 & 0.18429831 \\ 0.01500247 & 0.04634556 & 0.63208588 \end{pmatrix}
\]
\[ P_{ij}^{(9)} = \begin{bmatrix}
0.75450254 & 0.02874898 & 0.02795706 \\
0.07493059 & 0.02228311 & 0.19742953 \\
0.01843976 & 0.04475110 & 0.60350369
\end{bmatrix} \]

\[ P_{ij}^{(10)} = \begin{bmatrix}
0.73258086 & 0.02854040 & 0.03342391 \\
0.08059836 & 0.02310389 & 0.20908231 \\
0.02204556 & 0.04331697 & 0.57758407
\end{bmatrix} \]

After subjecting the matrix to powers, the limiting distribution was obtained as;

\[ P_{ij}^{(536)} = \begin{bmatrix}
0.18452381 & 0.53571429 & 0.27976190 \\
0.18452381 & 0.53571429 & 0.27976190 \\
0.18452381 & 0.53571429 & 0.27976191
\end{bmatrix} \]

\[ P_{ij}^{(537)} = \begin{bmatrix}
0.18452381 & 0.53571429 & 0.27976190 \\
0.18452381 & 0.53571429 & 0.27976190 \\
0.18452381 & 0.53571429 & 0.27976190
\end{bmatrix} \]

The limiting distribution was obtained at 537 steps.

Determining the long run distribution of inflation using the definition of limiting distribution.

\[ \pi = \pi p \Rightarrow (x \ y \ z) = (x \ y \ z) \begin{bmatrix}
30/31 & 1/31 & 0 \\
1/90 & 86/90 & 3/90 \\
0 & 3/47 & 44/47
\end{bmatrix} \] ................. (1)

\[ x + y + z = 1 \] ................. ................. ................. ................. (2)

From equation (1) and (2) we have:
\[ \frac{30}{31} x + \frac{1}{90} y = x \]

\[ \frac{1}{31} x + \frac{86}{90} y + \frac{3}{47} z = y \]

\[ \frac{3}{90} y + \frac{44}{47} z = z \]

Now substituting the constraint into the three equations above we have:

\[ \frac{121}{2790} y + \frac{1}{31} z = \frac{1}{31} \] \hspace{1cm} \text{.................................}(a) \]

\[ \frac{107}{1395} x + \frac{229}{2115} z = \frac{2}{45} \] \hspace{1cm} \text{.................................}(b) \]

\[ \frac{3}{47} x + \frac{137}{1410} y = \frac{3}{47} \] \hspace{1cm} \text{.................................}(c) \]

Solving equation (a), (b) and (c) simultaneously we get

\[ x = \frac{31}{168} = 0.18452381 \]
\[ y = \frac{90}{168} = 0.53571429 \]
\[ z = \frac{47}{168} = 0.27976190 \]
Appendix B

**Exchange rate**

Iterative procedure for determining long run distribution of inflation in excel

\[
P_{ij}^{(1)} = \begin{pmatrix} 0.45833333 & 0.00000000 & 0.54166667 \\ 0.00000000 & 0.00000000 & 1.00000000 \\ 0.09219858 & 0.02127660 & 0.88652482 \end{pmatrix}
\]

\[
P_{ij}^{(2)} = \begin{pmatrix} 0.26001034 & 0.01152482 & 0.72846483 \\ 0.09219858 & 0.02127660 & 0.88652482 \\ 0.12399401 & 0.01886223 & 0.85714376 \end{pmatrix}
\]

\[
P_{ij}^{(3)} = \begin{pmatrix} 0.18633483 & 0.01549925 & 0.79816592 \\ 0.12399401 & 0.01886223 & 0.85714376 \\ 0.13585803 & 0.01823710 & 0.84590487 \end{pmatrix}
\]

\[
P_{ij}^{(4)} = \begin{pmatrix} 0.15899323 & 0.01698225 & 0.82402452 \\ 0.13585803 & 0.01823710 & 0.84590487 \\ 0.14025949 & 0.01799798 & 0.84174253 \end{pmatrix}
\]

\[
P_{ij}^{(5)} = \begin{pmatrix} 0.14884579 & 0.01753244 & 0.83362177 \\ 0.14025949 & 0.01799798 & 0.84174253 \\ 0.14189307 & 0.01787654 & 0.83962411 \end{pmatrix}
\]

\[
P_{ij}^{(6)} = \begin{pmatrix} 0.14368202 & 0.01781242 & 0.83850556 \\ 0.14249934 & 0.01786234 & 0.83962411 \\ 0.14272435 & 0.01785982 & 0.83933233 \end{pmatrix}
\]
\( P_{ij}^{(9)} = \begin{pmatrix} 0.14297076 & 0.01785098 & 0.83917826 \\ 0.14280786 & 0.01785982 & 0.83933233 \\ 0.14283885 & 0.01785813 & 0.83930301 \end{pmatrix} \)

\( P_{ij}^{(10)} = \begin{pmatrix} 0.14289931 & 0.01785486 & 0.83924583 \\ 0.14283885 & 0.01785813 & 0.83930301 \\ 0.14285035 & 0.01785751 & 0.83929213 \end{pmatrix} \)

After subjecting the matrix to powers, the limiting distribution was obtained as;

\( P_{ij}^{(20)} = \begin{pmatrix} 0.14285714 & 0.01785714 & 0.83928571 \\ 0.14285714 & 0.01785714 & 0.83928571 \\ 0.14285714 & 0.01785714 & 0.83928571 \end{pmatrix} \)

\( P_{ij}^{(21)} = \begin{pmatrix} 0.14285714 & 0.01785714 & 0.83928571 \\ 0.14285714 & 0.01785714 & 0.83928571 \\ 0.14285714 & 0.01785714 & 0.83928571 \end{pmatrix} \)

Determining the long run distribution of exchange rate using the definition of limiting distribution.

\[ \pi = \pi P \Rightarrow \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 11 \\ 24 \\ 0 \\ 0 \\ 13 \\ 24 \\ 0 \\ 0 \\ 1 \end{pmatrix} \]

\[ \begin{pmatrix} 13 \\ 141 \\ 3/141 \\ 125/141 \end{pmatrix} \]

\[ x + y + z = 1 \]

Simplification of equation (1) gives the following:

\[ \frac{11}{24}x + \frac{13}{141}z = x \]

\[ \frac{3}{141}z = y \]

\[ \frac{13}{24}x + y + \frac{125}{141}z = z \]

Now substituting the constraint into the three equations above we have:
Solving equation (d), (e) and (f) simultaneously we get

\[
\frac{13}{24} y + \frac{715}{1128} z = \frac{13}{24} \quad \ldots \ldots \ldots \ldots \ldots \ldots \quad (d)
\]

\[
x + \frac{48}{47} z = 1 \quad \ldots \ldots \ldots \ldots \ldots \ldots \quad (e)
\]

\[
\frac{739}{1128} x + \frac{157}{141} y = \frac{16}{141} \quad \ldots \ldots \ldots \ldots \ldots \ldots \quad (f)
\]

Solving equation (d), (e) and (f) simultaneously we get

\[
x = 0.14385714 \quad y = 0.01785714 \quad z = 0.8392857
\]

The iterative procedure and the procedure gave the same estimates.
Appendix C

Data

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