KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY-

KUMASI

EFFECT OF EXCHANGE RATES VOLATILITY ON STOCK PRICES: EVIDENCE FROM THE GHANA STOCK EXCHANGE

BY

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DECLARATION

I hereby declare that this research is my own work towards Master of Science degree in Industrial Mathematics and that, to the best of my knowledge, this work contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

This study looked at the effect of exchange rate volatility on stock prices in Ghana. The Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model was used to establish the relationship between exchange rate volatility and stock prices. It was revealed that there is a negative relationship between stock prices movements and exchange rates volatility and the relationship is weak and insignificant. This implies that an increase in exchange rate volatility will lead to a decrease in stock market volatility. It is therefore recommended that policy makers should focus on other macroeconomic variables such as inflation, and interest rates so as to simulate growth in the local economy through investments in the Ghana Stock Exchange.

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LIST OF ACRONYMS

ADF	–	Augmented Dickey Fuller
AMEX	–	American Stock Exchange
APARCH	–	Asymmetric Power ARCH
ARCH	–	Autoregressive Conditional Heteroskedasticity
ARDL	–	Autoregressive Distributed Lag
ARMA	–	Autoregressive Moving Average
ASML	–	Accra Stock Market Limited
CLRM	–	Classical Linear Regression Model
CPI	–	Consumer Price Index
DF	–	Dickey-Fuller
EGARCH	–	Exponential Generalized Autoregressive Conditional Heteroskedasticity
GARCH	–	Generalized Autoregressive Conditional Heteroskedasticity
GCB	–	Ghana Commercial Bank
GJR	–	Glosten-Jagannathan-Runkle
GSE	–	Ghana Stock Exchange
GSE-CI	–	GSE Composite Index
GSE-FSI	–	GSE Financial Stocks Index
ICT	–	Information and Communication Technology
IMF	–	International Monetary Fund
MENA	–	Middle East and North African
NTHC	–	National Trust Holding Company Limited
NYSE	–	New York Stock Exchange
OLS	–	Ordinary Least Squares
OTC	–	Over The Counter
PPI	–	Producers Price Index
PPP	–	Purchasing Power Parity
RMSE	–	Root Mean Square Error
TARCH	–	Threshold Autoregressive Conditional Heteroskedasticity
VAR	–	Vector Autoregressive
VEC	–	Vector Error Correction
VECM	–	Vector Error Correction Model

DEDICATION

To my daughter, Keziah

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

This chapter contains basic information on the stock market and the foreign exchange market. Details of the research problem, significance, objectives and methodology are provided in this chapter.

1.1 Financial Markets

The financial system is a significant segment of every economy. According to Amevor (2005), financial markets play a critical role in the proper functioning of capitalistic economies because they serve as avenues for the release of funds from investors to borrowers. Also, Ross (2004) noted that, economic development is highly correlated with the level and efficiency of financial markets.

Advances in Information and Communication Technology (ICT) have greatly impacted on financial systems globally. Technology has facilitated an expansion of international financial transactions and the efficiency of global financial markets. Financial markets are exposed to external risks as a result of global economic integration through ICT. One major risk factor of great concern to investors is exchange rates volatility.

1.1.2 Foreign Exchange Market

Foreign exchange rate is said to be "the price of one unit of a country's currency in terms of another country's currency" (Fortura et al, 2007). In other words, "exchange rate is the number of units of a nation's currency that equals one unit of another nation's currency" (Tucker, 2005). According to Montiel (2009), "exchange rate is the domestic-currency price of foreign currency (units of domestic currency per units of a foreign currency), or the foreign-currency price of domestic currency (units of foreign currency per units of domestic currency)". He views exchange rates as an equilibrium price which is determined in the foreign exchange market. The equilibrium price determines the terms on which units of the foreign and domestic currencies can be exchanged for each other.

Two types of exchange rates exist: nominal exchange rate and real exchange rates. Real exchange rate is the price of a unit of foreign money in terms of domestic money, divided by the home consumer price index to the foreign consumer price index. Foreign exchange is usually traded over the counter (OTC) through a spatially de-centralized dealer network. Foreign currencies are mainly bought and sold by dealers housed in large money center banks located around the world. Dealers hold foreign exchange inventories and aim to earn trading profits by buying low and selling high. The foreign exchange market is highly liquid and trading volume is quite large.

According to Isard (1995), "markets for exchanging different monetary instruments have ancient origins. Coins made of gold and silver have particularly long histories as monetary units, and arrangements for trading the coins used by different societies were perhaps the earliest foreign exchange markets. Specific references to the practices of exchanging coins at rates reflecting their different metallic contents have been found in scattered documents from Egypt, Mesopotamia, and the Greek city states". Transactions of foreign nature are either in terms of international trade or international investment activities. This makes the foreign exchange market, the largest and technically advanced market among the global financial markets. In the view of Isard (1995), investment-related foreign transactions have impacted tremendously on the growth of the financial system in recent times. This trend is as a result of portfolio diversification of investments internationally. Most large foreign exchange transactions involve transfers of funds between different bank deposits. This involves funds being deposited in a foreign-currency bank account and debited from a domestic-currency account.

Foreign Exchange Transaction Types

Foreign exchange transactions are divided into three categories (Nelson, 2001). The first are spot transactions for immediate delivery. Spot exchange rates are the prices at which foreign currencies trade in the spot market.

Second, swap transactions are agreements in which a currency sold (bought) today is to be repurchased (sold) at a future date. The price of both the current and future transaction is set today. The swap rate is the difference between the repurchase (resale) price and the original sale (purchase) price. The swap rate and the spot rate together implicitly determine the forward exchange rate.

The third category of foreign exchange transactions are outright forward transactions. These are current agreements on the price, quantity, and maturity or future delivery date for a foreign currency. The agreed upon price is the forward exchange rate. Standard maturities for forward contracts are 1 and 2 weeks, 1, 3, 6, and 12 months. When the forward rate exceeds the spot rate in domestic terms, it is normally said that the forward currency trades at a premium otherwise it trades at a discount.

Exchange Rate Determination

Exchange rate is mainly determined by demand and supply for a foreign currency in relation to a domestic currency. The demand for foreign currencies is a derived demand. The demand for foreign currencies depends on the demand for foreign goods and services or for foreign assets and it's therefore considered as a derived demand. An increase in demand for foreign goods increases the demand for the foreign currencies to purchase the goods and services.

Models for the Determination of Exchange Rates

Various models have been developed for the determination of exchange rates or the equilibrium prices between different currencies. According to Mumuni and Afriyie (2004), the portfolio balance and the monetary approaches are the most widely used models in determining exchange rates. The monetary model was first developed to analyze balance of payment adjustments under fixed exchange rates but was later modified into a theory of nominal exchange rate determination after the breakdown of the Breton Woods system in 1973. Ian (2009) posited that the quantity theory of money and the Keynesian theory are the main theories factored into the construction of the current monetary model of exchange rates determination.

Another well known model of exchange rate determination is the Purchasing power parity (PPP). The purchasing power parity has played a pivotal role in studies on exchange rates since it was developed in the early 1800s by Wheatly and Ricardo (Nelson, 2001). This theory states that prices should be internationally arbitraged so that they are the same in all location when expressed in a common currency (absolute PPP). Also known as the Commodity-Arbitrage approach, the absolute PPP was also proposed by Samuelson (1964). It uses Producers Price Index (PPI) since it is more skewed towards traded goods than Consumer Price Index (CPI) which includes items that are not traded internationally.

Exchange Rate Regimes in Ghana

Ghana currently operates a floating exchange rates regime with occasional interventions by the central bank. In 1983, a payment policy was implemented by the Ghanaian government with an objective of moving away from direct control of the exchange rate market and move towards a reliance on the market dynamics to determine the exchange rates (Osei, 1996).

The government of Ghana licensed 180 forex bureaus to operate in the country in 1990 (Bhasin, 2004). Subsequently, the two-window exchange system was unified in 1992 and the market started operating an interbank whole sale system (Jebuni, 2006).

Role of Bank of Ghana on Monetary System

The Bank of Ghana, among other things, is responsible for maintaining price stability in the Ghanaian economy. The Bank's intervention in the operations of the foreign exchange market is on discretionary basis for purposes of controlling price volatility in line with its monetary objectives.

The Bank of Ghana Law gives the Bank of Ghana the independence in the discharge of its monetary activities. This implies that the Bank can use whatever tools are available at its disposal in achieving its primary objective of price stability.

Impact of Exchange Rate Volatility on the National Economy

Exchange rate volatility is said to have implications for the financial system of a country especially the stock market. Changes in exchange rates have pervasive effects, with consequences for prices, wages, interest rates, production levels, and employment opportunities, and thus with direct or indirect implications for the welfare of virtually all economic participants. Accordingly, large and unpredictable changes in exchange rates present a major concern for macroeconomic stabilization policy. Given the effects that changes in exchange rates can have on economic conditions, policy makers naturally want to understand what can be done to limit exchange rate variability, and with what consequences.

At the national level, it is difficult to say whether depreciation is actually good news or bad news. The stock index consists of several firms from diverse businesses such as exporters and importers whose transactions are affected by exchange rate changes in different ways.

In the view of Fortura et al (2007), a strong currency is a mixed blessing. They started that a strong currency is good because:

- It lowers the prices of imports and makes trips to foreign countries less expensive.
- Lower prices on foreign goods and helps to keep inflation in check.
- A strong domestic currency also make investment in foreign financial markets (foreign stocks and bonds) relatively cheaper.

However, on the flip side, a strong currency makes domestic exports expensive. Therefore foreigners will buy fewer goods from that country. The net effect of this trade imbalance is a fall in exports and rise in imports.

1.1.3 The Stock Market

The stock market is very crucial for the development of financial systems. It is a place where stocks, bonds and other securities are bought and sold. The stock market allows individuals to become part owners of businesses. On the other hand, this is a market where businesses raise needed capital from local and international investors to finance their operations. As stated by Cherif and Gazdar (2010) this particular market provides an important indicator for information sharing among investors, for company valuation, and the prospects of macroeconomic fundamentals.

Ghana Stock Exchange

The stock market is a market where equities (shares) are traded. They provide the avenue for both government and businesses to raise needed capital by selling securities (shares and bonds). Investors with excess funds are able to invest and earn returns thereby enhancing their welfare. Diversification of risk is made possible by stock markets through their operations by allowing both domestic and international investors to do transactions across borders. The Ghana Stock Exchange (GSE) was incorporated in July 1989 as a private company limited by guarantee under Ghana companies' code, 1963 (Act 179). Its status was later changed to a public company limited by guarantee in April 1994. Trading on the floor of the Exchange commenced in November 1990.

Efforts to establish a stock exchange in Ghana dates back to 1968, when a study conducted by the government indicated that the establishment of a stock Exchange in the country would contribute immensely to the nation's economic advancement. Subsequently, a stock market Act was enacted in 1971 which gave grounds for the Accra Stock Market Limited (ASML) to be established in the same year.

Even though the Accra Stock Market Limited never operated, Over-The-Counter (OTC) trading in shares of some foreign companies took place in the late 1970s. This followed a government of Ghana "investment Policy Decree" in 1975 which culminated in the establishment of the National Trust Holding Company Limited (NTHC) and the National Stockbrokers Limited. This decree required foreign firms in Ghana to divest themselves of not less than 40% of their equity capital to indigenous Ghanaians. Since its establishment, the Ghana Stock Exchange has performed creditably. Its performance in recent times shows that it is an emerging market to contend with in both Africa and in the World at large.

For instance, the GSE recorded a year to date gain of 58.06% on the index by 31st December, 2008 even though 2008 was an election year with its attendant problems. The GSE All-share index ended the year with 10,431.64 points compared to 6,599 points in 2007. This gain was well above 24.66% interest equivalent on 91-day treasury-bills. The US dollar in 2008 rose by 24% against the Ghana cedi. Therefore, the market outperformed Treasury-bills, bank fixed deposits and investments in the US dollar.

Another millstone in the 2008 financial year was the licensing of a securities depository at the GSE by the Securities and Exchange Commission. The GSE was granted a license in November 5, 2008 to operate a securities depository by the Securities and Exchange Commission. This was to enable a fast and efficient delivery and settlement system on the market. This frees investors from handling physical certificates since the system records, maintains and registers the transfer of securities by book-entry without a physical movement or endorsement of certificates.

On the other hand, the GSE had its worse performance in 2009 becoming the least performing market in Africa. This 2009 abysmal performance of the GSE has been attributed to the financial crisis and the migration from paper certification to electronic book entry securities under a new automated trading system. The GSE recorded -46.58%

in the All-share index whereas Tunisia led the African market with a return on index of 46.60%.

The GSE was however able to scale up its performance in 2010 and 2011. The trading volume values for 2010 were 330.13 million shares and GH₵151.13 million respectively, while the trading volume and values for 2011 were 419.79 million shares and GH₵446.56 million respectively. This shows that the volume of shares traded went up by 27% while the value of shares traded in 2011 represented 29.5% over that of 2010. The 2011 performance followed a number of major changes implemented by the GSE. To complement the automated trading regime, the GSE extended its trading hours to afford dealers increased contact hours with their clients during the trading day and also to afford non-resident investors in time zones different from Ghana, greater opportunity to reach out to their local brokers. The new trading hours became 09.30hours GMT to 15.00 hours GMT from the existing 09.30hours GMT to 13.00hours GMT. This was expected to also help improve liquidity in the market place. (GSE, 2013).

The Ghana Stock Exchange (GSE) also introduced a new method of calculating closing prices of equities on the market. Closing prices of listed equities from January 4, 2011 were calculated using the volume weighted average price of each equity for every given trading day. Formally, closing price was based on the last transaction price of listed equities. Two new indices were introduced on January 4, 2011 to replace the GSE All-Share Index which tracks price changes in the listed equities. The new indices were the GSE Composite Index (GSE-CI) and the GSE Financial Stocks Index (GSE-FSI).

1.2 STATEMENT OF PROBLEM

Financial markets are avenues for both lenders and borrowers to engage in mutual trade. However, there are a lot of uncertainties or risks associated with investments in the financial markets. These uncertainties are the result of the impact of various economic variables on business operations in the economy.

One of the economic variables that can impact on stock investments is exchange rates. This is because exchange rates affect both the internal financial environment and external trade.

There is no consensus among researchers on the impact of exchange rates volatility on stock returns. In Ghana particularly, few studies have highlighted this relationship. For this reason, policy makers may not be able to confidently determine which regulation is appropriate for the Ghanaian economy since certain interventions on the foreign exchange market could be counter productive to businesses in the country. This research is to ascertain the linkage between exchange rates volatility and stock returns of listed companies at the Ghana Stock Exchange (GSE) with a keen attention on the period after 2007 when Ghana undertook a redenomination of its currency. The uncertainty regarding the relationship between these variables posses serious challenges to financial decision markers. This challenge can be considered as a policy dilemma.

1.3 OBJECTIVE OF THE STUDY

The main purpose of this research is to establish the 'effect of exchange rates volatility on stock prices'. The study shall endeavor to achieve the following specific objectives:

1. Determine the relationship between exchange rates volatility and stock returns.
2. Forecast the stock returns volatility of the Ghana Stock Exchange using the GARCH (1, 1) model.

1.4 METHODOLOGY

The model used for this study is the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model which was developed by Bollerslev (1986). The GARCH model comes from the Autoregressive Conditional Heteroskedasticity (ARCH) family of model developed by Engle (1982).

The data used for this study are secondary data obtained from the Ghana Stock Exchange, the Ghana Statistical Service and the Bank of Ghana quarterly bulletins. This research is based on monthly data for the period January, 2000 to March, 2013. The Ghana Cedi (GH¢) and US Dollar ($) interbank exchange rates was used as a proxy for exchange rate volatility analysis in this project. Eviews and Microsoft Excel software were used to capture and analyze the data at all material times. The Kwame Nkrumah University of Science and Technology online Library, the internet and the University of Ghana library were the main sources of reading material for the study.

1.3 SIGNIFICANCE OF THE STUDY

A vibrant stock market offers great prospects for economic development of an economy. However, researchers have reported mixed findings on the impact of exchange rates on stock prices. The results of this study will therefore add to the body of knowledge regarding the relationship between exchange volatility and stock prices for the formulation of policies that will ensure a conducive business environment in Ghana.

Additionally, the findings of this study will be instrumental in decision and policy making by various stakeholders:

- Financial managers will use the findings to determine the magnitude of exchange rate risk to factor into asset prices to maximize their returns to investments.
- The findings of this research will aid monetary authorities to formulate appropriate policies for growth in targeted sectors of the economy.
- The risk management department of the bank of Ghana will use the findings of this research to estimate the impact of exchange rate exposure on local businesses and thereby develop strategies to mitigate the risk.
- Prospective investors in the Ghana Stock Exchange will be able to ascertain the extend of market risk their investments are exposed to.

1.9 ORGANIZATION OF THE WORK

In the five chapters of this research work, the author has in the first chapter introduced the reader to the background of the study, the statement of the problem and the purpose and significance of the study. Also included in chapter one are the research objectives.

Chapter two contains review of some relevant and related literature to this research. Chapter three presents the methodology implored in the study including the model specification and source of the data used.

In chapter four, the researcher presents the statistical analysis of the data and findings of the study. The conclusions and recommendations drawn from the research are presented in chapter five of the work.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter discusses available literature on exchange rates and stock prices. It reviews relevant literature on the interaction between exchange rates and stock returns. It also takes a look at various methods that have been engaged by researchers in studying exchange rates and stock returns.

For the purpose of effectiveness and clarity, the review of literature is treated and discussed in two parts. Part one deals with review of empirical findings on the relationship between stock prices and exchange rates. Part two deals with the methods that researchers have used in their research on the interaction between exchange rates and stock returns.

2.1 REVIEW OF EMPIRICAL FINDINGS

The stock market is viewed as the standard of measuring the economic health of a country (Khola & Aurangzeb, 2012). This is attributable to the fact that several financial variables influence the performance of the stock market in a country. A unique variable of interest to both investors and policy markers is the exchange rate. This is because the exchange rate volatility affects both internal and international financial transaction of the country.

Numerous empirical studies have been done to determine the relationship between stock prices and macroeconomic variables like exchange rates. These studies have reported varied and mixed findings on the relationships and the direction of causality between exchange rates and stock prices. The relationship between stock prices and exchange rates has practical applications for investors. In the view of Wang and Hang (2010), investors use volatility forecast of stock prices for of portfolio selection, asset pricing and risk management (see also Engle, Focardi & Fabozzi, 2007).

Aydemir and Demirhan (2009) studied the relationship between stock prices and exchange rates in the Turkish economy. They found that there is bi-directional causal relationship between exchange rates and all other stock market indices. While negative causality exists from services, financials and industrial indices to exchange rates, there exists a positive causal relationship from technology indices to exchange rate. The research used services, financials, industrial and technology indices as stock indices covering 2001 to 2008 and employed the Granger Causality test.

Naeem and Rasheed (2002) studied the relationship between stock prices and exchange rates using the co-integration, vector error correction model and the Granger Causality test. They obtained data from the period 1994 to 2000 from Pakistan, India, Bangladesh and Sri-Lanka. The results show no short-run association between the variables for all the countries under study. There is however a bidirectional long-run causality between the variables for Bangladesh and Sri-Lanka.

The issue of which of the two variables (exchange rate or stock price) moves the other still remains to be settled. For instance, while Abdalla and Murinde (1997) and Apte

(2001) posited uni-directional causality from exchange rates to stock prices, Karabacak et al. (2010) and Simpson et al. (2009) reported a uni-directional causality running from stock prices to exchange rates.

Caporale et al. (2013), focused on the 2007 to 2010 banking crisis period in their study. They reported varied causalities ranging from country to country. Whereas the US and UK showed a uni-directional spillovers from stock returns to exchange rates, bi-directional spillovers were found in the Euro area and Switzerland. This is consistent with Azman-Saini et al. (2003), who also found a bi-directional relationship.

Due to the varied nature of findings on the causality between exchange rates and stock prices, Ramasamy and Yeung (2001) cautioned that interpreting Granger causality results should be carefully done. In their study, they found a hit-and-run behavior and switches in the causality between exchange rates and stock returns according to the length of period chosen.

Many other researchers like Stavarek (2005), and Adjasi et al. (2008) have undertaken extensive studies into the relationship between these variables; stock prices and exchange rates.

For instance, Stavarek (2005) performed analysis and test of long-run and short-run dynamics between stock prices and exchange rates in a group of nine countries from the US and EU. He found that, the direction of the relations is not uniform and differs among countries. Neither the intensity nor direction of causal relations was the same in the developed economies and the new EU-member countries. He concluded that the stock market cannot be used to forecast exchange rates in the new EU-members countries.

Adjasi et al. (2008) studied the effect of exchange rate volatility on the Ghana Stock exchange. They used the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model on monthly data from 1995 to 2006 obtained from the IMF Trade Statistics Yearbooks, the Ghana Statistical Service and the Bank of Ghana quarterly bulletins. They concluded that there is a negative relationship between exchange rate volatility and stock market returns. Thus depreciation in the local currency leads to an increase in stock market returns in the long run. Where as in the short run it reduces stock market returns.

Phylakis and Ravazzolo (2005) investigated the stock prices and exchange rate dynamics. They found no long-run relationship between the real exchange and the local stock market in each of the pacific Basin countries except Hong Kong. Their research covered monthly data of 1980 to 1998 from six Pacific Basin Countries – Hong Kong, Indonesia, Malaysia, Singapore, Thailand and Philippines. They used cointegration and multivariate Granger causality tests in the analysis of the data. This was confirmed by Kurihara (2006) who studied the impact of macroeconomic variables on the stock prices in Japan and found that the US stock prices and exchange rates were the influential factors and not interest rates. The study covered the quantitative easing period of Japan, 2001 to 20005. But according to Abdelaziz et al. (2008) for oil-exporting countries, oil prices are the dominant determining factor of the relationship between exchange rates and stock prices. Egypt, Kuwait, Oman and Saudi Arabia were studied for the period 1994 to 2006.

Chi and Martin (2010) examined the effect of Exchange rates on the stock performance of Australian banks. Using the Capital Market approach, they analyzed quarterly data from 1997 to 2007 and found that there exist no significant relationship between Australian bank stock returns and foreign exchange rates. The banks studied included Australia and New Zewland Banking Group Limited, Commonwealth Bank of Australia, National Australia Bank and the Westpac Banking Corporation.

Similarly, Darfor and Agyapong (2009) examined the effects of macroeconomic factors on Ghana Commercial Bank (GCB) stock. The variables under consideration were exchange rate, rate of inflation, per capita income, unemployment rate and interest rate. They also found that inflation and exchange rates did not influence the stock prices of GCB significantly. They used the Autoregressive Distributed Lag model (ARDL) and the Vector Error Correction Model (VECM) in their study.

Bhasin (2004) used the Cointegration model, Vector Error Correction (VEC) model and the Vector Autoregressive (VAR) model to examine the dynamic interrelationships among domestic price level, nominal exchange rate, domestic credit and foreign exchange rate system in Ghana. From the findings, he recommended that in order to arrest the continuing depreciation of the local currency, the bank of Ghana could sell more foreign exchange in the foreign exchange market.

Chreif and Gazdar (2010) used panel data techniques to examine the influence of macroeconomic environment and institutional quality on stock market development. They used data from 14 Middle East and North African (MENA) countries over the period 1990 to 2007. They found that stock market development was influenced by income level, saving rate, stock market liquidity and interest rate.

Narth and Samanta (2002) used daily data from 1993 to 2002 to investigate the relationship between exchange rate and stock prices in India. They found the absence of causal link though there has been a strong causal influence from stock market return to forex market return. The method used for their analysis was the Granger causality test and cointegration model.

Beer and Hebein (2008) did an assessment on the Stock Market and Exchange rate dynamics in industrialized and emerging markets. The Exponential Generalized Autoregressive Conditional Heteroskedastic (EGARCH) framework was adopted for the study. Their results pointed to a significant positive price spillover for some of the countries studied – Canada, US and India.

Tabak (2006) studied the dynamic relationship between stock prices and exchange rates in the Brazilian economy for 1994 to 2002. It was found that there is no long-run relationship between stock prices and exchange rates. This is in line with Baharom et al. (2008) and Zia et al.(2011).

According to Frenkel et al. (2005) changes in the exchange rate is an important source of risks for non-financial corporations. They recommended more focus on economic foreign exchange rate exposure since risk management has become much more crucial for businesses in light of the globalization of business activities.

In a similar study, Kannagaraj and Sikarwar (2011) stated that countries which follow floating exchange rate regime are most vulnerable to exchange rate volatility which invariably affects their cash flows. They defined foreign exchange exposure as "sensitivity of firms' cashflows to fluctuations in exchange rate". They used the standard two factor model of regression ($R_{it} = \beta_{0i} + \beta_{mi} R_{mt} + \beta_{xi} R_{xt} + \varepsilon_{it}$) to examine the level of foreign exchange exposure for 361 non-financial Indian firms for the period April 2006 to March 2011. They found that only 16% of the firms studied are exposed at 10% level of significance.

Dominquez and Tesar (2001), found an exposure of a sample of eight non-US industrialized and emerging markets to exchange rate movements. They further found among other things, that the choice of exchange rate has an influence on the nature of the exchange rate exposure of the firms. They investigated exchange rate exposure for firms in Chile, France, Germany, Italy, Japan, the Netherlands, Thailand and the United Kingdom for the period 1980 to 1999. Nydahl (1999) confirmed this result in a study of Swedish firms. Choi and Prasad (1995) also obtained similar findings.

Connelly et al. (2009) studied the exposure of insurance firms to foreign exchange rate fluctuations in Asia-Pacific countries. They reported that stock returns and exchange rate exposure dynamics varies systematically across nations. Also, the size of the firm determines the extent of impact of exchange rate exposure to it (see Cheung and Ng , 1992). Considering firm size, maturity and a measure of natural-hedging as factors, Solakoglu (2004) studied exchange rate exposure for Turkey covering the period 2001 to 2003. He found that firm size and level of international activity are significant in lowering the exposure.

Mathieson and Moles (1998) corroborated the findings of Connelly et al (2009). They investigated Economic Currency Risk and Company Value of UK-listed importers and exporters for the period 1990 to 1997. Their results indicated that individual firms have different exposures to particular currencies. Additionally, they found a weak relationship between the share price of the firms studied and exchange rates exposure.

Erol et al. (2003) examined exchange rate exposure in emerging markets. They revealed measurable exposures which are not easily hedged. Also firms such as exporters and importers are exposed to exchange rate risk differently. In the view of Joliet (2011), financing cashflows of firms from emerging markets are more exposed to the US dollar, than unlevered cashflows. The study centered on the Dollar exposure of East Asian firms.

Chiang and Wen-Pang (2005), used GARCH (1, 1) and EGARCH models estimate exchange rate exposures of Taiwan's Stock Market. The results show that the exchange rate volatility is asymmetric. Randal et al (2008) in estimating short term exchange rate exposure for new Zealand firms allowed asymmetric response to changes in the exchange rates and found only few firms were significantly exposed. This is in line with the findings of Bartov & Bodnar (1994) and Koutmas & Martin (2003).

Palia and Thomas (1997) reported a strong relationship between stock returns and contemporaneous exchange rate changes. Their study focused on exchange rate exposure and firm valuation using daily stock returns of NYSE and AMEX. Subair and Salihu (2010) reported a negative impact of exchange rate volatility on the Nigerian Stock Market. They used the GARCH (1, 1) process on annual data of stock market capitalization, gross domestic product, inflation rate, interest rate and exchange rate volatility over the period 1981 to 2007. Several studies Huato et al (2009), Du, Ng & Zhao (2010), Chen & Ju (2011), Baum, Caglayan & Barkoulas (2001), Clark & Mefteh (2010), Tsuji (2012), and Chamberlain et al (1996) reported various levels of impact of exchange rate exposure on stock returns.

Hwang (2003) studied the effect of share prices on the demand for money. He used US and Canadian dollar rate for the period 1980 to 2000 to assess the dynamic forecasting of sticky-price monetary Exchange rate model. He found that the share price variable can improve the accuracy of forecasts of exchange rates at short-run horizons. This contrasts the notion that nominal exchange rate behavior is well described by the naïve random-walk model and that no systematic economic forces determine the exchange rate.

Berne et al. (2009) used the Generalized Autoregressive Conditional Heteroskedasticity in – Mean (GARCH-M) model to investigate the effect of interest rate and exchange rate risk on financial stock returns. The analysis was based on three financial sector indices, 90-day Treasury bill rates, 10-year government bond yields and US dollar bilateral exchange rates for 16 European economies including the US and Japan obtained from the IMF's International Financial Statistics and DataStream. They found that interest rate and exchange rate effects seem to be most prevalent in the banking and financial sectors, with a much more limited effect on the insurance sector. Exchange rates affects is however more easily interpretable in terms of the foreign net position of the financial institutions involved.

Jebuni (2006) holds that exchange rate is one of the most important economic adjustment instruments and also one of the most difficult economic policy tools because of its economic and political effects on a nation. According to Mussa (1984) factors that determine the exchange rates in an economy are largely dependent on the type of exchange rate regime (flexible or fixed) operated by the country**.** Pastor and Stambaugh (2009) investigated whether stock are really less volatile in the long run. They found that even with two centuries of data, stocks are substantially more volatile over long horizons from an investor's perspective. This is recognition of the fact that economic parameters are uncertain.

In the view of Budden et al. (2010) maintaining a robust stock market would help stimulate the economy. They examined stock performance, the exchange rate and the

Brazilian economy with data from the IMF's international Financial Statistics for the period 1996 to 2009 with a total of 53 observations.

Dimitrova (2005) showed that the stock market and the foreign exchange market are interconnected. In his view, a depreciation of the currency may depress the stock market and an upward trend in the stock market may also cause currency depreciation. Sim and Chang (2008) conducted an empirical analysis on whether the monetary model of exchange rate determination considers the stock market or not. The Auto regressive Distributed Lag (ARDL) model was implemented on monthly data for the period 1990 to 2007 from US and Korea. Their findings showed that the monetary model can be extended to contain equity and bond market.

According to Stockman (1978), the behavior of exchange rates in the flexible rate system has puzzled many economists. He offered an explanation for the behavior of exchange rates and how they are determined. In his view, foreign exchange can be considered as a derived demand because foreign exchange is demanded to purchase foreign goods and assets. He stated that the expected rate of change of the exchange rate should be related to anticipated changes in the terms of trade or factors associated with the terms of trade as well as to the anticipated inflation differential.

His findings were corroborated by Mumuni et al (2004). They implored the monetary approach to investigate the determinants of the Cedi/Dollar rate of exchange in Ghana. They observed that, both domestic and foreign money supply conditions matter in the Cedi/Dollar dynamics. They concluded that the Cedi/Dollar rate of exchange is determined by the economic fundamentals and speculations based on the immediate past history of the rate itself.

Lothian et al (2001) used monthly data from 1974 to 1993 to determine the behavior of the Canadian dollar over the long-run. Their result showed a strong support for the monetary model of exchange rates. This is consistent with Ian (2009) who found the validity of the monetary approach to the exchange rate determination in the long-term. Stockman (1978) hinted that the monetary models have not being very successful in explaining the short-run movement in exchange rates. This is in line with the findings of Lothian et al (2001).

2.2 REVIEW OF METHODS

The ARCH family of models: ARCH, GARCH, EGARCH, TARCH are widely used in measuring volatility. These models are used largely in modeling interest rates, exchange rates and stock index returns (Timo, 2006). From the literature, it is shown that the most popular GARCH model in applications is the GARCH (1, 1) model.

According to Ramasamy and Munisamy (2012), the GARCH models predict more volatile series well. They studied the predictive accuracy of GARCH, Glosten-Jagannathan-Runkle (GJR) and EGARCH models on select exchange rates. The results also showed that incorporating the leverage effect in the GJR and EGARCH models did not improve the results much. The GARCH class models also dominate linear models in predicting stock return volatility using the Root Mean Square Error (RMSE) criterion

(Rashid and Ahmed, 2008). Hansen and Lunde (2005), compared volatility models. They used daily exchange rate data and IBM Stock prices. Even though there was no winner among the models studied, but no model provided significantly better forecast than the GARCH (1, 1).

Guan and Ederington (2004) found the GARCH (1, 1) generally yields better forecasts than the exponentially weighted Moving Average Model even though between GARCH and EGARCH there is no clear favorite. they investigated Financial Volatility using four financial series: the S&P 500 index, the Yen/ Dollar exchange rate, the 3-month Euro/ dollar rate, the 10-year Treasury Bond rate, and five equities chosen from those in the Dow-Jones Index: Boeing, GM, International Paper, McDonald's and Merck. Tian and Guo (2007) corroborated this in a study titled "Intraday Data and Volatility Models: Evidence from Chinese stocks". They found that the GARCH (1, 1) model best describes the volatility of intraday returns.

In a study captioned "Econometric Analysis of realized Volatility: Evidence of Financial Crises", Neokosmidis (2009) asserts that financial data have some key features, volatility clustering and leverage effects which cannot be captured by models such as the ARMA model. He proposed the use of ARCH family of models to estimate financial time series. According to Giovanis (2008) the GARCH model is able to capture volatility clustering successfully making it an appropriate model for volatility forecasting.

On the contrary, Su (2010) indicated that the EGARCH model is more fitting than GARCH. He studied the financial volatility of daily returns in China using the GARCH and EGARCH. Similarly, Jean-Philippe (2001) stated that GJR-GARCH and APARCH give better forecasts than symmetric GARCH. The study was captioned "Estimating and forecasting volatility of stock indices using asymmetric GARCH models and (Skewed) Student-t densities". FTSE 100 and DAX 30 daily data over a 15-years period were used for the analysis.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This chapter contains the time series econometric methods and techniques employed to carry out an analysis on the 'effect of exchange rates volatility on stock prices'. Details of the specification of the Augmented Dickey-Fuller (ADF) test and the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model are covered in this chapter.

3.1 FEATURES OF TIME SERIES DATA AND STOCHASTIC PROCESSES

Statistical techniques are normally employed to capture various events and phenomena for analysis. Statisticians apply these techniques to study areas such are economics and finance. Economic data can be recorded in several forms and frequencies and are therefore categorized as cross-sectional data, Time Series data and Panel data for ease in their use. Times Series data involve the sequential observation of a phenomenon over time. They are often ordered chronologically and in different frequencies such as daily, monthly, quarterly and annually. Time series data are usually denoted with the subscript t. If stock prices are denoted by Y, then the time series for the period 2000 to 2013 will be stated as:

Y_t for $t = 1,2,\ldots\ldots\ldots T$

Where $t = 1$ represents the year 2000 and $t = T = 14$ represents the year 2013.

Also, past events have the tendency of influencing future events and economic trends, therefore time component is of great essence in time series data analysis. Usually a variable lagged one period is denoted by Y_{t-1} and Y_{t-q} denotes a variable lagged q periods.

3.2 HETEROSKEDASTICITY

For a meaningful analysis of a time series data, certain inherence features must be considered and handled appropriately. One of such features is homoskedasticity. Homoskedasticity means that all disturbance (error) terms have the same variances, so that from the classical linear regression model in equation (3.1), the variance is constant as in equation (3.b)

$$Y_t = \alpha + \beta x_t + u_t \tag{3.1}$$

$$Var(u_t) = \delta^2 = \text{ constant for all } t. \tag{3.2}$$

Where Y_t is the dependent variable, α and β are constants, Var is the variance, u_t is the error term, and δ^2 is the variance value.

For a model with a single explanatory variable, the variance of $\hat{\beta}$ is stated as

$$Var(\hat{\beta}) = \sum \left(\frac{x_t}{\sum x_t^2} \right)^2 \delta^2 = \frac{\sum x_t^2 \delta^2}{\left(\sum x_t^2\right)^2} = \delta^2 \frac{1}{\sum x_t^2} \tag{3.3}$$

The equation above represents the case where the error term are homoskedastic which gives a constant variance of the residuals.

However, in practice, time series more often than not shows evidence of heteroskedasticity. Heteroskedasticity means unequal variances of the disturbance term.

$$Var(u_t) = \delta_t^2 \quad (3.4)$$

This implies that the variance can take any value t from different observations in the series $t = 1,2,\ldots\ldots\ldots\ldots T$. Heteroskedasticity has far reaching consequences for the OLS estimators. Heteroskedastic error terms produce a variance of $\hat{\beta}$ such as

$$Var(\hat{\beta}) = \sum\left(\frac{x_t}{\sum x_t^2}\right)^2 \delta_t^2 = \frac{\sum x_t^2 \delta_t^2}{\left(\sum x_t^2\right)^2} \quad (3.5)$$

In this case the variance of the residuals is not constant thereby giving t-ratios that are falsely high, leading to incorrect conclusions on the impact of the explanatory variable. In this research, we will use the ARCH test (Engle, 1982) to investigate the presence of ARCH effect (heteroskedasticity).

3.3 AUTOCORRELATION

Another feature of time series data set that is highly critical is Autocorrelation. To get meaningful Ordinary Least Square (OLS) estimators, the covariance and correlation between difference disturbances must be zero. This requires that all disturbances are independently distributed or are not correlated with one another, so that

$$Cov(u_t u_s) = E\left[(u_t - Eu_t)(u_s - Eu_s)\right] = E(u_t, u_s) = 0 \quad (3.6)$$

For all $t \neq s$.

This expected feature is known as Serial independence.

However, time series data have high likelihood of having intercorrelations between observations especially if the time interval is shorter like daily or monthly frequencies. The implication of this is that $Cov(u_t, u_s) \neq 0$ for some $t \neq s$ such that an error at period t may be correlated with one at periods. Autocorrelation is often caused by either omitted variables or misspecification of the model. Serial correlation which is the presence of autocorrelation in the time series results in overestimated R^2 and high t-statistics (Asteriou and Hall, 2007).

3.4 STOCHASTIC PROCESSES

The variables or phenomena that Financial Analysts investigate are considered to be stochastic processes. "Stochastic processes are random variables ordered in time" (Engle et al., 2007). Stock returns, interest rates, Exchange rates and GDP are examples of economic variables which are stochastic processes.

According to Engle at el. (2007), "Since the groundbreaking work of Haavelmo (1944), economic time series are considered to be realizations of stochastic processes. That is, each point of an economic time series is considered to be an observation of a random variable. We can look at a stochastic process as a sequence of variables characterized by joint-probability distributions for every finite set of different time points".

Financial analysts have an overarching interest in investigating the behavior of these stochastic processes. For this reason analyst often require time series data on various financial variables for their study. For a successful analysis, the preliminary properties of the data must be ascertained. One such property of great concern to analysts is whether or not the data is stationary.

3.4.1 Stationary and Unit Root Test

According to Asteriou et al. (2007), a key concept underlying time series processes is that of stationarity. Salvatore and Reagle (2002) posited that a nonstationary series invalidates the standard statistical tests because its variance is not constant. Regressions with non-stationary series may have no meaning and are therefore called ‘spurious’.

A time series is stationary if its statistical properties do not depend on time. A a financial time series whose mean, variance and autocovariance are constant is considered to be stationary.

That is

1. $E(Y_t) = \mu$ (constant mean) (3.7)
2. $E(Y_t - \mu)^2 = \text{var}(Y_t) = \sigma_y^2$ (constant variance) (3.8)
3. $E[(Y_t - \mu)(Y_{t-k} - \mu)] = Cov(Y_t, Y_{t-k}) = Y_k$ (constant covariance) (3.9)

3.1.2 UNIT ROOT TEST

A time series that is nonstationary is said to exhibit unit root.
Let Y_t be an Autoregressive model order one: AR (1)

$$Y_t = \Phi Y_{t-1} + u_t \qquad (3.10)$$

$-1 \leq \Phi \leq 1$; Where u_t is a white noise error term.

Then, we estimate the model above, and conclude as appropriate if

1. $|\Phi| < 1$, then the series (Y_t) is stationary.
2. $|\Phi| > 1$, the series explodes
3. $|\Phi| = 1$, the series contains a unit root and is nonstationary. This also means that, the series will exhibit trend behavior.

Several methods for testing for unit root are presented in econometric theory. These include Dickey – Fuller (DF) and Augmented Dickey – Fuller test, Philip – Peron Test and NP test. We shall use the Augmented Dickey-Fuller (ADF) test to establish the stationarity or otherwise of the data.

Given that:

$Y_t = \Phi Y_{t-1} + u_t$ is an AR(1) model as in equation (3.10). We regress Y_t on its lagged value Y_{t-1} and find out if the estimated Φ is statistically equal to 1.

The unit root test is done based on the following model equations.

1. If Y_t is a random walk with drift - **intercept**

$$Y_t = \beta_0 + \rho Y_{t-1} + u_t \qquad (3.11)$$

2. If Y_t is a random walk with drift around a stochastic trend – **intercept and trend**

$$\Delta Y_t = \beta_0 + \beta_1 t + \rho Y_{t-1} + u_t \qquad (3.12)$$

3. If Y_t is a pure random walk - **none**

$$\Delta Y_t = \rho Y_{t-1} + u_t \qquad (3.13)$$

Where: *t* is time or trend value.

The ADF is conducted by adding the lagged values of the dependent variable ΔY_t.

$$\Delta Y_t = \beta_0 + \beta_1 t + \delta Y_{t-1} + \alpha_1 \Delta Y_{t-1} + u_t \qquad (3.14)$$

Decision Rule

If the DF value is smaller than the critical value, then we reject the null hypothesis of a unit root and conclude that Y_t is a stationary process.

Differencing

If the ADF shows the presence of a unit root, we will need to compute a first difference of the data to ensure stationarity. The ADF test is performed on the differenced series for its stationarity to be established. The differencing process follows by subtracting Y_{t-1} from both sides of equation (3.10)

$$Y_t - Y_{t-1} = \Phi Y_t - Y_{t-1} + u_t \tag{3.15}$$

$$\Delta Y_t = (\Phi - 1)Y_{t-1} + u_t \tag{3.16}$$

$$\Delta Y_t = \rho Y_{t-1} + u_t \tag{3.17}$$

Where $\rho = \Phi - 1$ and Δ is first difference operator

3.3 THE MODEL

The model used for this study is the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. The GARCH model comes from the ARCH family of models developed by Engle (1982). The model (ARCH) suggests that the residuals at time t depend on the squared error terms from past periods. Engle suggested that it is better to simultaneously model the mean and the variance of a series when we suspect that the conditional variance is not constant.

The GARCH model is useful in forecasting the volatility of asset returns and other financial time series. It is also able to explain volatility clustering or volatility pooling in financial markets. The model is normally employed in modeling data that are heteroskedastic. According to Brooks (2002), the GARCH is better than the ARCH model because the GARCH model is avoids overfitting.

3.3.1 ARCH (q) model

The conditional variance can depend not only on one lagged realization but more than one, with each case producing a different ARCH process. ARCH (1) model is specified as follows:

Given that Y_t is a time series of stock returns, then

$$Y_t = a + \beta' X_t + u_t \tag{3.18}$$

$$u_t \setminus \Omega_t \sim iidN(0, h_t);\ h_t \equiv \sigma^2 \tag{3.19}$$

$$h_t = y_0 + y_1 + u_{t-1}^2 \tag{3.20}$$

Where

u_t = error term

h_t = variance of residuals

Ω_t = information set.

Normally, it is assumed that u_t is independently distributed with zero mean and a constant variance σ^2

Therefore the ARCH (2) process will be:

$$h_t = y_0 + y_1 u_{t-1}^2 + y_2 u_{t-2}^2 \tag{3.21}$$

The ARCH (3) will be given by

$$h_t = y_0 + y_1 u_{t-1}^2 + y_2 u_{t-2}^2 + y_3 u_{t-3}^2 \tag{3.22}$$

Hence the ARCH (q) process will be given by:

$$h_t = y_0 + y_1 u_{t-1}^2 + y_2 u_{t-2}^2 + \ldots\ldots\ldots + y_q u_{t-q}^2 \tag{3.23}$$

$$h_t = y_0 + \sum_{j=1}^{q} y_j u_{t-j}^2 \tag{3.24}$$

3.3.2 THE GARCH (p,q) MODEL

To resolve this issue, Bollerslev (1986) came up with the idea of the Generalized ARCH (GARCH) model. The general GARCH (p,q) model has the following form:

$$y_t = a + \beta^{/} X_t + u_t \tag{3.25}$$

$$u_t / \Omega_t \sim iidN(0, h_t) \tag{3.26}$$

$$h_t = y_0 + \sum_{i=1}^{p} \delta_i h_{t-i} + \sum y_j u_{t-j}^2 \tag{3.27}$$

Where all variables are as defined above.

Therefore the GARCH (1,1) model has its variance equation been:

$$h_t = y_0 + \delta_1 h_{t-1} + y_1 u_{t-1}^2 \tag{3.28}$$

3.4 MODEL ILLUSTRATION

The GARCH (1, 1) model is widely used in forecasting financial asset prices. Table 3.1 below shows a sample data used to illustrate the estimation of the GARCH (1, 1) model which is to be employed for the analysis in this study. The first column of the table contains the sequence of time in months in which the data is categorized. Column 2 and column 3 contain the series of stock returns and Exchange rates respectively that are used for this demonstration. The ADF test was performed on the data sets and both were found to be stationary as is shown in **table 3.2**.

Table 3.1: Data set for GARCH (1,1) demonstration

Month	Stock return (Y)	Exchange Rate(X)
Jan-73	-0.02672	1.14
Feb-73	-0.04409	7.13
Mar-73	-0.00671	4.49
Apr-73	-0.04759	1.13
May-73	-0.0234	4.68
Jun-73	-0.01021	4.57
Jul-73	0.050618	-3.87
Aug-73	-0.03499	-6.18
Sep-73	0.051389	-5.74
Oct-73	-0.00322	1.09
Nov-73	-0.12124	-4.22
Dec-73	0.013259	-6.96
Jan-74	-0.00228	-9.34
Feb-74	-0.00195	5.09
Mar-74	-0.02605	6.57
Apr-74	-0.04511	4.8
May-74	-0.0407	2.51
Jun-74	-0.02132	-2.35
Jul-74	-0.0746	-0.06
Aug-74	-0.09256	-4.4
Sep-74	-0.11277	-2.91
Oct-74	0.164827	1.64
Nov-74	-0.04766	-0.77
Dec-74	-0.02667	0.42
Jan-75	0.132819	3.29
Feb-75	0.053124	3.35
...	…	…
…	…	…
…	…	…
Jan-95	0.021738	1.59
Feb-95	0.034535	-0.26
Mar-95	0.024225	2.82
Apr-95	0.022067	0.71
May-95	0.032549	-1.99
Jun-95	0.019783	0.74
Jul-95	0.031769	0.04
Aug-95	0.003925	-2.84
Sep-95	0.037653	-0.78
Oct-95	-0.0128	1.89
Nov-95	0.044593	-1.54
Dec-95	0.017534	-2.2

Source: Sampled from http://www.wiley.com/go/koopafd

Table 3.2 contains the results of the ADF unit root test performed on the data in **table 3.1**. The variables for the test Y_t and X_t are in the first cells of rows 3 and 4 respectively. The outputs of the test statistic for the variables follows in columns 2, 3 and 4 for cases of intercept (equation 3.11), Trend & Intercept (equation 3.12) and None (equation 3.13) respectively. The last three rows of the table houses the critical values by which the t-statistics must be compared for inference to be made.

Table 3.2: Summary of Stock returns and exchange rates stationary test results

Variables	**Intercept**	**Trend & Intercept**	**None**
	t-statistic	**t-statistic**	**t-statistic**
Y_t	-16.30112	-16.37499	-15.973398
X_t	-10.91664	-10.91986	-10.92136
Critical values			
1%	-3.453997	-3.991780	-2.573398
5%	-2.871845	-3.426251	-1.941982
10%	-2.572334	-3.136336	-1.615929

The result of the ADF test shown in **table 3.2** reveals that both the stock returns and exchange rates are stationary at levels (1%, 5% and 10%). The absolute values of the stock returns (-16.30112, -16.37499 and -15.973398) are all greater than the critical values. Also, the absolute values of the exchange rates (-10.91664, -10.91986 and -10.92136) are greater than the critical values. This implies that neither the stock returns data nor the exchange rate data has a unit root. It implies that the GARCH (1, 1) model estimation on this data will produce relevant results.

3.4.1 MODEL ESTIMATION

From equations (3.25 & 3.27), the model to be estimated can be written as:

$$Y_t = C_1 + C_2 X_t + u_t \quad (3.29)$$

$$H_t = C_3 + C_4 * H_{t-1} + C_5 * u_{t-1}^2 \quad (3.30)$$

Where

Y_t = stock returns;

X_t = is exchange rates

u_t = residuals or error term

H_t = variance of residuals

H_{t-1} = one lagged period of variance of residuals

u_{t-1}^2 = one lagged period of squared residuals

C_1, C_2, C_3, C_4, and C_5 are regression parameters to be obtained.

According to Engle, "the estimation of α and β can be considered separately without loss of asymptotic efficiency. The procedure recommended here is to initially estimate β by ordinary least squares, obtain the residuals. From these residuals, an efficient estimate of α can be constructed" (Engle, 1982, pp 996-997). We will use the ordinary least Square technique developed by (Zhang, n.d) to obtain the values for the constants C_1, C_2, C_3, C_4, and C_5 in equations (3.29) and (3.30) of the GARCH (1, 1) model above.

From equation (3.29) the error term is given as:

$$\hat{u}_t = (Y_t - \hat{Y}_t) = (Y_t - C_1 - C_2 X_t) \quad (3.31)$$

For a sample of n observations, the mean error is:

$$\bar{u}_t = \frac{1}{n}\sum_{t=1}^{n} u_t = \frac{1}{n}\sum_{t=1}^{n} (Y_t - C_1 - C_2 X_t) \quad (3.32)$$

$$\bar{u}_t = \bar{Y} - C_1 - C_2\bar{X} \tag{3.33}$$

Setting the mean error to be zero, we obtain

$$C_1 = \bar{Y} - C_2\bar{X} \tag{3.34}$$

Substituting C_1 into the error expression, we get

$$u_t = Y_t - \bar{Y} + C_2\bar{X} - C_2X_t = (Y_t - \bar{Y}) - C_2(X_t - \bar{X}) \tag{3.35}$$

The sum of squared errors RSS is:

$$RSS = \sum_{t=1}^{n} u_t^2 \tag{3.36}$$

$$RSS = \sum_{t=1}^{n} \left[(Y_t - \bar{Y})^2 - 2C_2(Y_t - \bar{Y})(X_t - \bar{X}) + C_2^2(X_t - \bar{X})^2\right] \tag{3.37}$$

$$\frac{RSS}{n-1} = \frac{1}{n-1}\sum_{t-1}^{n}(Y_t - \bar{Y})^2 - 2C_2\frac{1}{n-1}\sum_{t-1}^{n}(Y_t - \bar{Y})(X_t - \bar{X}) + C_2^2\frac{1}{n-1}\sum_{t-1}^{n}(X_t - \bar{X})^2 \tag{3.38}$$

$$\frac{RSS}{n-1} = S_Y^2 - 2C_2S_{XY}^2 + S_X^2 \tag{3.39}$$

Differentiating this equation with respect to C_2 and equating the result to zero, we obtain:

$$\frac{d(RSS)}{dC_2} = -2S_{XY}^2 + 2C_2S_X^2 = 0 \tag{3.40}$$

That is ,

$$C_2 = \frac{S_{XY}^2}{S_X^2} = \frac{\sum_{t=1}^{n} XY - n\bar{X}\bar{Y}}{\sum_{t-1}^{n} X^2 - n(\bar{X})^2} \tag{3.41}$$

Where $\bar{Y}$ is the sample mean of the stock returns and $\bar{X}$ is the sample mean of the exchange rates series.

From the data in **table 3.1**

$n = 276$

$\sum XY = 0.987702$

$\sum X^2 = 6238.281$

$\bar{Y} = 0.006841$

$\overline{X} = -0.19779$

Therefore

$$C_2 = \frac{0.987702 - 276(-0.19779)*0.006841}{6238.281 - 276(-0.19779)^2} = \frac{1.361152464}{6227.483636} = 0.00022$$

Therefore

$$C_1 = 0.006841 - 0.00022(-0.19779) = 0.0068845$$

To obtain the values of C3, C4 and C5, from equation 3.30, let $H_t = Y_t'$; $h_{t-1} = X_{1t}$ and $u_{t-1}^2 = X_{2t}$; and assuming the variance equation as multiple regression equation,

Hence, equation 3.30 becomes:

$$Y_t' = C_3 + C_4 X_{1t} + C_5 X_{2t} \qquad (3.42)$$

The error term is stated as:

$$u_t = Y_t' - C_3 - C_4 X_{1t} - C_5 X_{2t} \qquad (3.43)$$

$$E(u_t) = 0; \qquad u_t \approx N(0, \delta^2) \qquad (3.44)$$

Errors squares function $S(C_3, C_4, C_5)$ is given as:

$$S = \sum_{t-1}^{n} u_t^2 = \sum_{t=1}^{n} (Y_t' - C_3 - C_4 X_{1t} - C_5 X_{2t})^2 \qquad (3.45)$$

To obtain the values of C_3, C_4, and C_5 that will minimize the sum of squared errors, we will proceed as follows:

$$\frac{\partial S}{\partial C_3} = 2\sum_{t-1}^{n} (Y_t' - C_3 - C_4 X_{1t} - C_5 X_{2t})(-1) = 0 \qquad (3.46)$$

$$\frac{\partial S}{\partial C_4} = 2\sum_{t=1}^{n} (Y_t' - C_3 - C_4 X_{1t} - C_5 X_{2t})(-X_{1t}) = 0 \qquad (3.47)$$

$$\frac{\partial S}{\partial C_5} = 2\sum_{t=1}^{n} (Y_t' - C_3 - C_4 X_{1t} - C_5 X_{2t})(-X_{2t}) = 0 \qquad (3.48)$$

Therefore the normal equations are

$$\sum_{t=1}^{n} Y_t' = NC_3 + C_4 \sum_{t=1}^{n} X_{1t} + C_5 \sum_{t=1}^{n} X_{2t} \qquad (3.49)$$

$$\sum_{t=1}^{n} X_{1t}Y_t' = C_3\sum_{t=1}^{n} X_{1t} + C_4\sum_{t=1}^{n} X_{1t}^2 + C_5\sum_{t=1}^{n} X_{1t}X_{2t} \tag{3.50}$$

$$\sum_{t=1}^{n} X_{2t}Y_t' = C_3\sum_{t=1}^{n} X_{2t} + C_4\sum_{t=1}^{n} X_{1t}X_{2t} + C_5\sum_{t=1}^{n} X_{2t}^2 \tag{3.51}$$

We solve this system above by deviation form.

That is:

$$\sum X_{1t} = \sum \left(X_{1t} - \bar{X}_1\right) = 0;\ \sum X_{2t} = \sum \left(X_{2t} - \bar{X}_2\right) = 0;\ \sum Y_t' = \sum \left(Y_t' - \bar{Y}\right) = 0 \tag{3.52}$$

Therefore

$$\sum_{t=1}^{n} X_{1t}Y_t' = C_4\sum_{t=1}^{n} X_{1t}^2 + C_5\sum_{t=1}^{n} X_{1t}X_{2t} \tag{3.53}$$

$$\sum_{t=1}^{n} X_{2t}Y_t' = C_4\sum_{t=1}^{n} X_{1t}X_{2t} + C_5\sum_{t=1}^{n} X_{2t}^2 \tag{3.54}$$

In order to get the value of C_5, eliminate C_4 by multiplying equation (3.53) by $\sum X_{1t}X_{2t}$

and equation (3.54) by $\sum X_{1t}^2$

$$C_5 = \frac{\sum_{t=1}^{n} X_{1t}X_{2t}\sum_{t=1}^{n} X_{1t}Y_t' - \sum_{t=1}^{n} X_{2t}Y_t'\sum_{t=1}^{n} X_{1t}^2}{\left(\sum_{t=1}^{n} X_{1t}X_{2t}\right)^2 - \sum_{t=1}^{n} X_{2t}^2\sum_{t=1}^{n} X_{1t}^2} \tag{3.55}$$

Use the value of C_5 in equation (3.53) to get the value of C_4. Equation (3.53) can be rewritten as:

$$\frac{\sum_{t=1}^{n} X_{1t}Y_t'}{\sum_{t=1}^{n} X_{1t}^2} = C_4 + C_5\frac{\sum_{t=1}^{n} X_{1t}X_{2t}}{\sum_{t=1}^{n} X_{1t}^2} \tag{3.56}$$

Therefore, substituting the value C_5 in, we obtain

$$C_4 = \frac{\sum X_{1t}}{\sum X_{1t}^2} - \left[\frac{\sum X_{1t}X_{2t} \sum X_{1t}Y_t' - \sum X_{2t}Y_t' \sum X_{1t}^2}{\left(\sum X_{1t}X_{2t}\right)^2 - \sum X_{2t}^2 \sum X_{1t}^2} \right] \frac{\sum X_{1t}X_{2t}}{\sum X_{1t}^2} \qquad (3.57)$$

Hence

$$C_4 = \frac{\sum_{t=1}^{n} X_{1t}X_{2t} \sum_{t=1}^{n} X_{2t}Y_t' - \sum_{t=1}^{n} X_{1t}Y_t' \sum_{t=1}^{n} X_{2t}^2}{\left(\sum_{t=1}^{n} X_{1t}X_{2t}\right)^2 - \sum_{t=1}^{n} X_{2t}^2 \sum_{t=1}^{n} X_{1t}^2} \qquad (3.58)$$

The values of C_5 and C_4 can be used to find the value of C_3:

$$C_3 = \bar{Y}' - C_4\bar{X}_1 - C_5\bar{X}_2 \qquad (3.59)$$

From analysis the data in **table 3.1** shown in the appendix D:

$\sum X_{1t}X_{2t} = 0.009253$

$\sum X_{1t}Y_t' = 0.00464$

$\sum X_{2t}Y_t' = 0.004632$

$\sum X_{1t}^2 = 0.009282$

$\sum X_{2t}^2 = 0.009227993$

$\bar{X}_1 = -3.6801E-6$

$\bar{X}_2 = -3.71493E-6$

$\bar{Y}' = 0.001998031$

Therefore

$$C_5 = \frac{(0.009253 * 0.00464) - (0.004632 * 0.009282)}{(0.009253)^2 - (0.009227993 * 0.009282)} = 1.6648$$

$$C_4 = \frac{(0.009253 * 0.004632) - (0.00464 * 0.009227993)}{(0.009253)^2 - (0.00927993 * 0.009282)} = -1.15975$$

$$C_3 = 0.001998031 - (-1.15975 * -3.6801E-6) - (1.6648 * -3.71493E-6) = 1.987E-03$$

Hence, the fitted GARCH (1, 1) model is as:

$$Y_t = 0.0068845 + 0.000206\, X_t + u_t \qquad (3.60)$$

$$H_t = (1.987E-03) - 1.15975\, h_{t-1} + 1.6648\, u_{t-1}^2 \qquad (3.61)$$

CHAPTER 4

DATA ANALYSIS AND RESULTS

4.0 INTRODUCTION

This chapter presents the results of the estimation of the GARCH (1, 1) model presented in equations (3.29) and (3.30). The analysis is carried out using monthly data of the Ghana Stock Exchange-All Share Index (GSE-ASI) and the Ghana Cedi/ US dollar exchange rates for the period January, 2000 to March, 2013. This chapter also contains the results of the Augmented Dickey- Fuller (ADF) stationary (Unit root) test results for the variables used in this study.

4.1 DATA COLLECTION

The data used for this study are the monthly average interbank exchange rates of the Ghana Cedi (GH¢) and US dollar ($) obtained from the Ghana Statistical Service and the Bank of Ghana. Also Data on Stock indices were obtained from the Ghana Stock Exchange (GSE). The data used for the estimation of the GARCH (1, 1) model of this study is shown in **Table 4.1**. The first two columns of the table contain the Years and Months of the series from January 2000 to March 2013. Column 3 houses the stock index and it is named **GSE-ASI** which stands for **G**hana **S**tock **E**xchange-**A**ll **S**hare **I**ndex. The exchange rates data is shown in column 4 of the table and it is captioned **AVMONEXR** which stands for **AV**erage MONthly **EX**change Rates because the data are computed from the average of the daily inter-bank exchange rates for the respective months. The entire data sets used and the analysis are shown in **table A.1** in appendix A

Table 3 Table 4.1: Stock Prices and Exchange Rates

Year	Month	GSE-ASI	AVMONEXR
2000	Jan	741.7	0.3605
2000	Feb	739.7	0.375
2000	Mar	763.1	0.4095
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
2012	Nov	1145.97	1.8769
2012	Dec	1165.43	1.8785
2013	Jan	1232.52	1.8824
2013	Feb	1382.72	1.8848
2013	Mar	1639.73	1.8928

Source: Ghana Stock Exchange and Bank of Ghana

4.2 DATA PROCESSING

The data in table 4.1 was subjected to some preliminary analysis to obtain appropriate data forms for reliable estimation of the model. The ADF test and the GARCH (1, 1) construction were done with the aid of Eviews 6 software installed on a Dell Inspiron N4010 laptop with RAM of 3.00GB, 64-bit Windows 7 Ultimate operating system and 4GHz processing speed. Growth rates of each set of data were undertaken by using the formula:

$$R_t = \frac{Y_t - Y_{t-1}}{Y_{t-1}} \qquad (4.1)$$

Where R_t = rate of return at time t, Y_t = present month's stock price or exchange rate and Y_{t-1} = previous month's stock price or exchange rate. The details of the analysis is shown in **table A.1** in Appendix A

4.2.1 STATIONARY (UNIT ROOT) TEST

The Augmented Dickey-Fuller (ADF) test was applied to the data to establish their integration factors. Preliminary examination of the graphs of each data set was undertaken to obtain basic information of the nature of the data before the stationary test was performed.

Figure 4.1 shows the graph of the stock index from January 2000 to March 2013. The vertical axis shows the stock returns whereas the horizontal axis shows the time intervals in years.

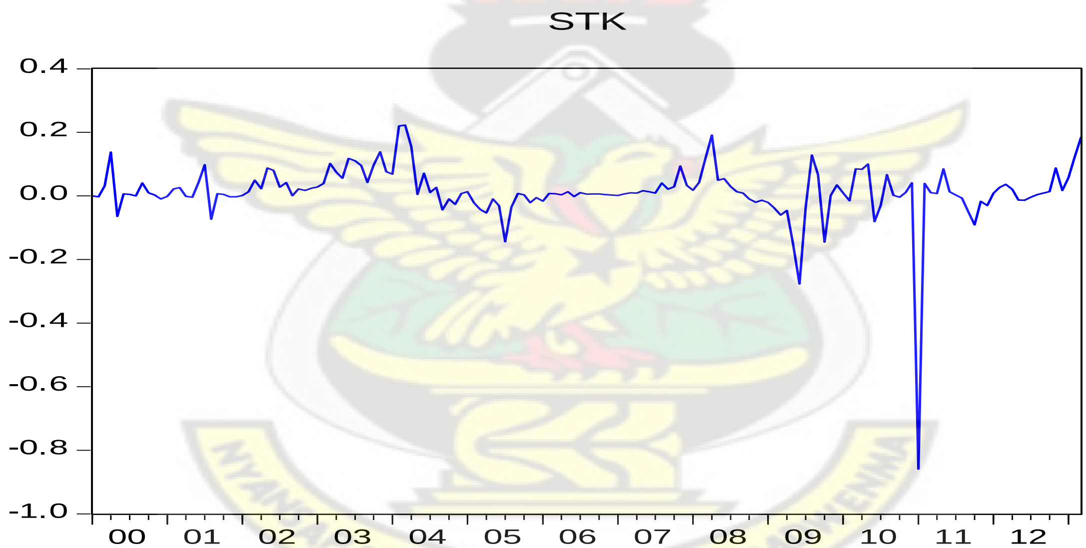

Figure 1 Figure 4.1: Graph of stock prices

The figure above shows the presence of volatility clustering in the stock index. Incidences of high volatility are followed immediately by high volatilities as seen between late 2002 and 2004 in the graph. Also the occurrences of low volatility are followed by low volatilities as is depicted between 2009 and 2011 of the graph.

Figure 4.2 shows the graph of the exchange rates from January 2000 to March 2013. The vertical axis shows the exchange rate data points whereas the horizontal axis shows the time intervals in years.

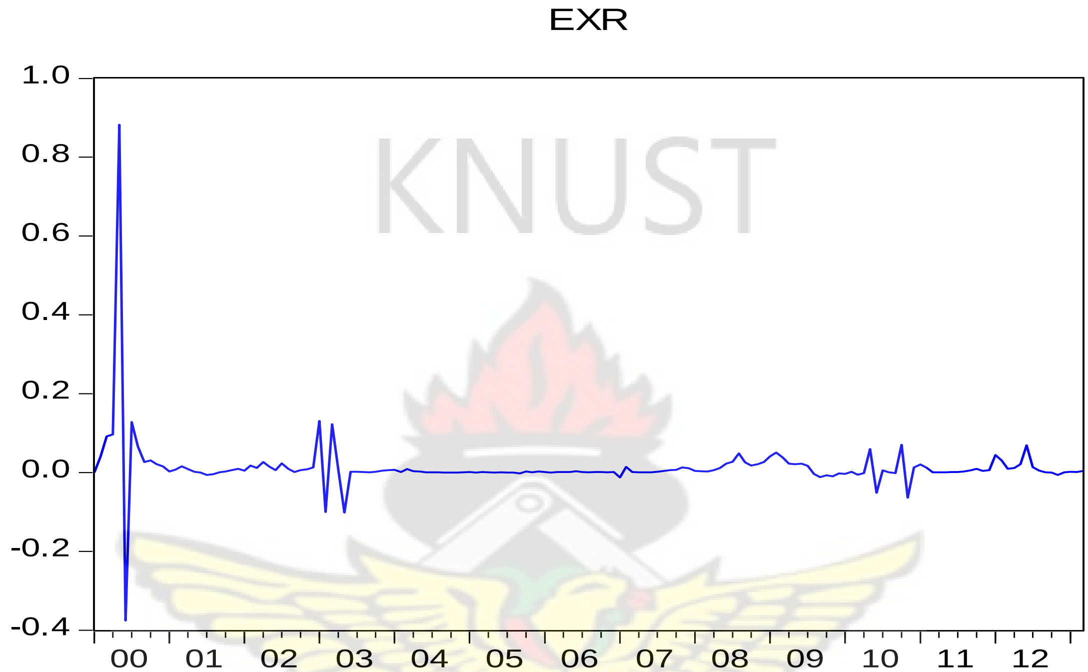

Figure 4.2: Graph of interbank exchange rates

A cursory look at the graph in **figure 4.2** displayed above indicates the data set for both the exchange rates are stationary. The graph further reveal periods of volatility clustering such that a period of high volatility is followed by a period of high volatility as can be seen for late 2002 and early 2003 and periods of low volatility are also followed by period of low volatility as seen in 2000 to 2002.

Even though the graphs in **figure 4.1** and **4.2** suggest that the data may be stationary, we need to perform the Augmented Dickey-Fuller statistical test for unit roots to investigate the stationary status of our data sets.

The ADF test was executed on the data for stock returns and exchange rates and the result is shown in **table (4.2)** below. The first column in **table 4.2** contains the variables under consideration: stock returns (Y_t) and exchange rates (X_t). The critical values shown in the last three rows of the table are the t-statistics computed by Dickey and Fuller that we have to compare our ADF values with in order to make a decision whether or not the respective variables have unit roots. The columns for intercept, trend & intercept and none contains results of the ADF test computation as indicated in equation (3.11), (3.12) and (3.13) respectively.

Table 4.2: Summary of ADF test results

Variables	**Intercept**	**Trend & Intercept**	**None**
Y_t	-10.06974	-10.18083	-9.90680
X_t	-6.620513	-6.777534	-6.235385
Critical values			
1%	-3.471987	-4.017185	-2.579680
5%	-2.879727	-3.438515	-1.942856
10%	-2.576546	-3.143558	-1.615368

The result of the ADF test shown above reveals that both the stock returns and exchange rates are stationary at levels (1%, 5% and 10%). The absolute values of the stock returns (-10.06974, -10.18083 and -9.90680) are all greater than the critical values. The absolute values of the exchange rates (-6.620513, -6.777534 and -6.235385) are also greater than the critical values. This implies that neither the stock returns data nor the exchange rate data has a unit root. It means that the GARCH (1, 1) model estimation of this data will produce relevant results.

4.3 GARCH ORDER SELECTION

To be able to select an appropriate order (*p and q*) of the GARCH (p, q) model for the data used in this research, a simple selection procedure was undertaken. A summary of the results from this order selection process is presented in **Table 4.3**. The table contains the variables and their probability values from different estimates of the GARCH model. The first column houses all the variables whose probability values are shown in the rest of the table for GARCH (1, 1), GARCH (1, 5), GARCH (5, 1) and GARCH (5, 5) for comparison purpose. The detail results for each of the model estimates placed in **appendix C** of this work.

Table 4.3: Summary of GARCH order selection results

VARIABLES	**PROBABILITY VALUES**			
	GARCH(1,1)	**GARCH(1,5)**	**GARCH(5,1)**	**GARCH(5,5)**
C	0.0031	0.2115	0.3614	0.2981
X_t	0.2869	0.8403	0.8781	0.8692
VARIANCE EQUATION				
C	0.1146	0.5684	0.4622	0.7206
RESID(-1)^2	0.0000	0.6801	0.5693	0.6269
RESID(-2)^2			0.5240	0.8756
RESID(-3)^2			0.4688	0.9656
RESID(-4)^2			0.6161	0.9836
RESID(-5)^2			0.3098	0.9788
GARCH(-1)	0.0000	0.8047	0.6452	0.9468
GARCH(-2)		0.9894		0.9969
GARCH(-3)		0.9933		0.9972
GARCH(-4)		0.9928		0.9958
GARCH(-5)		0.9853		0.9688

The data presented in **table 4.3** has overwhelmingly demonstrated that the GARCH (1, 1) is the appropriate model for this research. The probability values of the variance equation of all the models estimated are statistically insignificant, except the probability values of the variance equation of the GARCH (1, 1). The probability values for GARCH (1, 5), GARCH (5, 1), and GARCH (5, 5) shown in columns 3, 4 and 5 respectively are all above 5%, thus making them statistically insignificant and inappropriate.

4.4 RESULTS FROM GARCH (1, 1) ESTIMATION

The table below **(Table 4.4)** shows the results of the GARCH (1, 1) estimation. The first two rows of the table houses the results of the fitted mean equation (3.29) of the model. The second part of the table contains the results of the variance equation (3.30) of the model estimated. The values for all the parameters in the model C_1, C_2, C_3, C_4 and C_5 are shown in the second column labeled **Coefficient.** The last column of the first part of the table labeled **Prob.,** contains probability values of the various parameters estimated. The probability values are used to determine whether the impact of those parameters is significant in the relationship between the variables of concern.

Table 4.4: Results of GARCH (1, 1) estimation

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C (C_1)	0.017798	0.006009	2.961978	0.0031
X_t (C_2)	-0.060337	0.056659	-1.064909	0.2869
Variance Equation				
C (C_3)	-4.97E-05	3.15E-05	-1.577770	0.1146
u_{t-1}^2 (C_5)	-0.039781	0.003680	-10.81063	0.0000
h_{t-1} (C_4)	1.066389	0.013988	76.23848	0.0000

R-squared	0.002409	Mean dependent var	0.013975
Adjusted R-squared	-0.023502	**S.D. dependent var**	0.093397
S.E. of regression	0.094488	Akaike info criterion	-2.616964
Sum squared resid	1.374924	Schwarz criterion	-2.520458
Log likelihood	213.0486	Hannan-Quinn criter.	-2.577774
F-statistic	0.092982	Durbin-Watson stat	1.575834
Prob(F-statistic)	0.984559		

From the table above, values of the parameters are given as:

C_1 = 0.017798

C_2 = -0.060337

C_3 = -4.97E-05

C_4 = 1.066389

C_5 = - 0.039781

Fitted GARCH (1, 1) model

The main focus of this research is to determine the relationship between exchange rates and stock prices. From the results depicted in **table 4.4**, the fitted GARCH (1, 1) can be stated as follows:

$$Y_t = 0.01778 - 0.060337 \ X_t \tag{4.2}$$

$$H_t = -0.0000497 + 1.06639 \ h_{t-1} - 0.03978 \ u_{t-1}^2 \tag{4.3}$$

This result shows a negative relationship between exchange rates volatility and stock returns. The probability value of the coefficient of exchange rates in the model is 0.2869, which means that the effect of exchange rate volatility on stock returns in the Ghana stock exchange is insignificant. The probability values for the u_{t-1}^2 and h_{t-1} are 0.0000 and 0.0000 each. This shows a high level of significant internal shocks in the stock market.

4.5 MODEL CHECKING

To test the appropriateness of the model estimated and the validity of its forecasts, a residual diagnostic check was conducted. This section presents the results of the Correlogram squared residuals, normality test and ARCH test on the residuals of the GARCH (1, 1) model.

The correlogram squared residual test is engaged to find out whether or not the residuals of the estimated model are serially correlated. If the results are serially correlated, it means there is autocorrelation in the data set thereby violating the assumption upon which the model is built. **Table 4.5** shows the results from the Correlogram where column one is the lags from 1 to 36. Column two and three contain the Autocorrelation (AC) and Partial Autocorrelation (PAC) results respectively. The Last Column is where the probability values of correlogram are placed.

Table 4.5: Results of Correlogram Squared Residuals.

Lags	AC	PAC	Q-Stat	Prob
1	0.123	0.123	2.4634	0.117
2	-0.009	-0.024	2.4758	0.290
3	-0.031	-0.027	2.6306	0.452
4	0.039	0.047	2.8811	0.578
5	-0.029	-0.041	3.0166	0.697
6	-0.058	-0.050	3.5746	0.734
7	-0.030	-0.014	3.7221	0.811
8	0.012	0.012	3.7456	0.879
9	0.060	0.057	4.3595	0.886
10	-0.033	-0.046	4.5420	0.920
11	-0.036	-0.026	4.7664	0.942
12	-0.046	-0.042	5.1405	0.953
13	-0.037	-0.037	5.3759	0.966
14	-0.045	-0.032	5.7393	0.973
15	0.047	0.062	6.1387	0.977
16	0.050	0.035	6.5871	0.980
17	0.045	0.029	6.9497	0.984
18	-0.050	-0.065	7.4011	0.986
19	0.075	0.087	8.4244	0.982
20	-0.002	-0.026	8.4252	0.989
21	-0.040	-0.034	8.7276	0.991
22	-0.010	0.020	8.7470	0.995
23	-0.045	-0.055	9.1237	0.996
24	-0.047	-0.051	9.5340	0.996
25	0.006	0.020	9.5406	0.998
26	0.103	0.099	11.564	0.993
27	-0.046	-0.064	11.971	0.994
28	-0.019	-0.011	12.044	0.996
29	-0.062	-0.050	12.805	0.996
30	-0.049	-0.051	13.291	0.996
31	-0.024	-0.008	13.409	0.997
32	-0.018	-0.009	13.473	0.998
33	0.060	0.080	14.209	0.998
34	-0.035	-0.081	14.464	0.999
35	-0.057	-0.079	15.145	0.999
36	-0.071	-0.059	16.181	0.998

The decision of whether or not there is serial correlation in the squared residual is based on the probability values. From **Table 4.5**, it is shown that all the 36 lags of the correlogram squared residual test have probability values higher that 5% which is statistically insignificant. Therefore there is no serial correlation in the residuals.

A Histogram – normality test was also performed on the residuals of the estimated model. In **figure 4.3**, the box at the right hand side contains the statistics of the normality test. A diagrammatic form of the statistics is shown in the histogram at the left hand side.

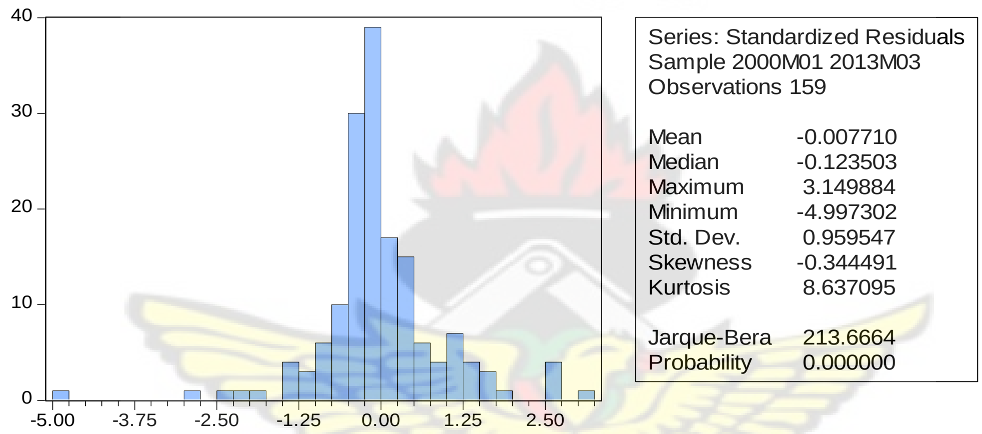

Figure 4. 3: A histogram – test of the residuals

The result is shown in **figure 4.3** indicates that the residuals are not normally distributed. This can be seen in the p-value which is 0% and skewness which is -0.3445 indicating that the graph is skewed to the left. This results not withstanding this result, the GARCH (1, 1) model usually gives valid forecast. Therefore we can conclude that the model was well estimated since there is neither serial correlation in the residuals.

4.6 FORECASTING STOCK RETURNS VOLATILITY

This section offers the forecast and VaR analysis of the study. The first portion is on the stock volatility and the next portion is on the Value at Risk.

4.6.1 STOCK RETURNS VOLATILITY

A forecast of the volatility and VaR was undertaken for the stock returns used in this study. Based on the GARCH (1, 1) estimated, the volatility of the Ghana Stock Market is 0.093397 (0.9%).

Table 4.7 shows results of the stock returns forecast. Column one contains the parameters captured under the forecast and column two presents the values for each computed parameter.

Table 4.7: Stock returns forecast results

VARIANCE	VALUES
Mean	0.01702
Median	0.017631
Maximum	0.040456
Minimum	-0.035444
Standard Deviation	0.004873
Skewness	-7.244079
Kurtosis	89.11197
Jarque-Bera	50516.81
Probability	0.000000
Sum	2.704893
Sum Sq. Dev.	0.003751
Observations	159

From the forecast table, the volatility (Standard deviation) is 0.004873 (0.05%) which is a decline from the actual volatility (0.9%) of the data estimated.

Also, figure 4.4 reveals the behavior of the stock returns over the period under study. The graph labeled **forecast of variance** shown in the bottom of the figure displays the variance of stock returns for 2000 to 2013. The vertical axis is the returns series while the horizontal axis is the time intervals. The box displayed at the top-right of the figure is the statistics for the forecast.

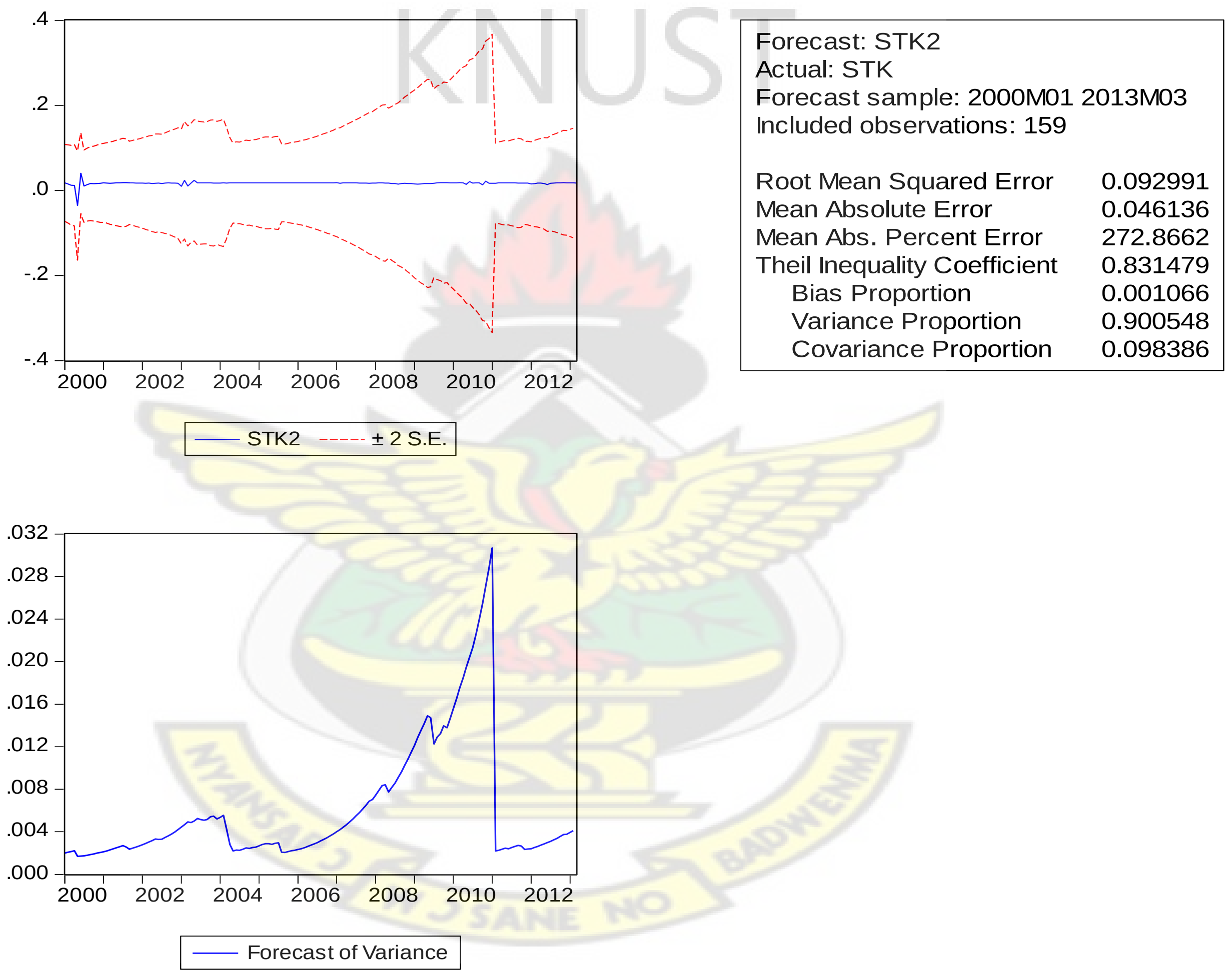

Figure 4.4: Graph of forecast of stock returns

The graph in figure 4.4 labeled Forecast of Variance shows that the variance of the stock returns for the period 2000 to March, 2013, reached its peak in 2010. It then declined to

0.0002 in 2011. The graph further shows that the variance took an upward trend from 2011.

The bias proportion is given in the box at the top-right of figure 4.4. The Bias proportion is an indication of systematic error. The desirable value is normally zero. The value of bias proportion from figure 4.4 is 0.001066 which is close to zero showing a lack of over or under prediction. This implies that the model was appropriately fitted and the prediction is free from systematic errors.

4.6.2 VaR

The question that begs for an answer is, how much of the market value is affected by this apparent movement (volatility) of stock returns in the Ghana stock exchange? To answer this question, the researcher used the VaR method. The Value at Risk (VaR) is a measure of the possible loss of a financial portfolio within a certain period of time for a given probability.

The equation for VaR is:

$$VaR = Z_{1-p}\delta_t \tag{4.4}$$

Where Z_{t-p} is the 100 (1-p)th quantile of the standard normal distribution.

For $p = 0.05$, $Z_{1-0.05} = 1.65$

$\delta_{159} = 0.004873$ (from the forecast)

Therefore

$VaR = 1.65 * 0.004873 = 0.00804045$

The market capitalization of the Ghana Stock Exchange as at 28th March, 2013 was GH¢57740.56 (in million). Therefore the VaR in monetary terms is:

$VaR = GHC57740.56 * 0.00804045 = GHC464.26$ (in million).

This means that 0.8% of the Market value of the Ghana Stock exchange is at risk for the next one month. It implies that an investment in the Ghana Stock Exchange is subject to a loss of 0.8% in value.

4.7 DISCUSSION OF RESULTS

From **Table 4.4** and **equation (4.2)**, it is shown that the coefficient of exchange rate volatility is -0.060337 which indicate a negative relationship between exchange rate volatility and stock returns. This implies that an increase in exchange rate volatility will lead to a decrease in stock returns volatility. When exchange rates volatility increases by one (1) unit, stock returns volatility will decrease by -0.04254. Conversely, a decrease in exchange rate volatility will lead to an increase in stock price volatility. The findings suggest that the foreign exchange market has a spillover effect (though insignificant) on the economy in general since the stock market represent the cream of the major businesses in the economy of Ghana. There is also the presence of strong volatility shocks in the stock returns since the p-values of the GARCH and squared residual terms in the variance equation are below 5% and hence are very significant.

However, the high value of 0.2867 (28%) of the exchange rate probability value shows that the effect of exchange rate volatility is not significant in determining stock returns volatility. This is confirmed by the 0.241% value of the squared residual. It shows that the independent variable, X_t, explains only 0.2% of the volatility in the stock market. It implies many other financial variables, including the stock returns themselves, determine movements in the stock market of Ghana.

The results of the forecast of stock volatility shown in Table 4.7, reveals very low volatility in the Ghanaian stock market. A volatility of 0.004873 was forecasted, which reveals that investment returns in the market is stable and can be predicted with high levels of accuracy. This was confirmed by the results of the VaR analysis. The VaR showed that only 0.8% of the market value is exposed to risk. Therefore, investors can confidently put their financial resources into the Ghanaian stock market and expect good returns since the market is stable. Also, the stock volatility analysis based on the GSE-ASI can be a reliable risk management tool for risk managers. The findings will help investors to know the trends of the GSE and therefore confidently formulate appropriate investment strategies.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSION

The aim of this study was to assess the effect of exchange rate volatility on stock prices. The GARCH (1, 1) model was used to carry out an analysis on the exchange rate and stock returns time series data sets. The analysis of the data gave a fitted GARCH (1, 1) model as:

$$Y_t = 0.01778 - 0.060337\ X_t \quad (4.5)$$

$$H_t = -0.0000497 + 1.06639\ h_{t-1} - 0.03978\ u_{t-1}^2 \quad (4.7)$$

This shows that there is a negative relationship between stock prices and exchange rates volatility in the Ghanaian economy. The results in this study confirms the findings of Adjasi et al (2008), Palia & Thomas (1997), and Subair & Salihu (2010) who reported a negative impact of exchange rate exchange volatility on stock market volatility. On the other hand, the result of this study is contrary to the findings of Phylakis & Ravazzolo (2005), Chi and Martin (2010) and Darfor & Agyapong (2009).

The results also showed that the impact is not strong and is very insignificant. The analysis further reveals that there exist volatility shocks in the Ghanaian stock market. This shows that volatility in the Ghanaian stock market is impacted by trends in its index. Increase in the volatility of exchange rate leads to a reduction in the volatility of the stock market. The presence of internal shocks (shocks from the stock returns themselves) implies that investors can successfully predict returns based on the stock markets indices.

The actual volatility of the stock returns was found to be 0.0933, whereas the forecasted volatility is 0.004873. This shows a decline in volatility for the next month in the market.

5.2 RECOMMENDATIONS

This study has established that the effect of exchange rate volatility on stock prices is negative and insignificant. Monetary authorities in Ghana and Investors interested in doing business in Ghana should consider the volatility of other macroeconomic variables in making policy and investment decisions respectively.

Based on the findings, it is recommended that the Ghanaian government should be very cautious in implementing exchange rate policies. The result of this research shows that volatility in exchange rates does not have significant impact on businesses. This can be viewed in the light of fact that the Ghanaian economy is primarily an import based economy. This implies that policy makers should focus more on controlling other macroeconomic variables such as inflation, interest rates and trade deficit.

As shown by Aydemir and Demirhan (2009), exchanges rate volatility affects various sectors of the economy in different ways. A study on the various business sectors represented at the Ghana Stock Exchange should be undertaken to throw more light on the impact of exchange rate volatility on the Ghanaian economy. A research on the financial sector, services sector and commodities sector is imperative.

To assess the impact of the 2007, redenomination of the cedi on the country's economy, the research should be extended to indicators of economic growth such as GDP since exchange rates volatility is found not to have much impact on the businesses in Ghana.

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APPENDIX A

Table A.1: Data sets of Stock index and exchange rates with analyzed forms.

Year	Month	GSE-ASI	Yt	EXRMONAVR	Xt	Fitted	Residual
2000	Jan	741.7	0.00000	0.3605	0.00000	0.01780	-0.01780
2000	Feb	739.7	-0.00270	0.375	0.04022	0.01537	-0.01807
2000	Mar	763.1	0.03163	0.4095	0.09200	0.01225	0.01939
2000	Apr	868.2	0.13773	0.449	0.09646	0.01198	0.12575
2000	May	812.6	-0.06404	0.8452	0.88241	-0.03544	-0.02860
2000	Jun	817.8	0.00640	0.5278	-0.37553	0.04046	-0.03406
2000	Jul	821.9	0.00501	0.5955	0.12827	0.01006	-0.00504
2000	Aug	822	0.00012	0.6351	0.06650	0.01379	-0.01366
2000	Sep	855.5	0.04075	0.6522	0.02692	0.01617	0.02458
2000	Oct	863.8	0.00970	0.6722	0.03067	0.01595	-0.00625
2000	Nov	866.3	0.00289	0.6865	0.02127	0.01651	-0.01362
2000	Dec	858	-0.00958	0.6974	0.01588	0.01684	-0.02642
2001	Jan	857.2	-0.00093	0.6992	0.00258	0.01764	-0.01857
2001	Feb	876.2	0.02217	0.7042	0.00715	0.01737	0.00480
2001	Mar	899.3	0.02636	0.7152	0.01562	0.01686	0.00951
2001	Apr	897.9	-0.00156	0.7217	0.00909	0.01725	-0.01881
2001	May	894.5	-0.00379	0.7231	0.00194	0.01768	-0.02147
2001	Jun	932.5	0.04248	0.7232	0.00014	0.01779	0.02469
2001	Jul	1024.3	0.09845	0.7188	-0.00608	0.01816	0.08028
2001	Aug	949.6	-0.07293	0.7155	-0.00459	0.01807	-0.09100
2001	Sep	956	0.00674	0.7159	0.00056	0.01776	-0.01102
2001	Oct	961	0.00523	0.7176	0.00237	0.01765	-0.01242
2001	Nov	958.5	-0.00260	0.7217	0.00571	0.01745	-0.02005
2001	Dec	955.9	-0.00271	0.7287	0.00970	0.01721	-0.01992
2002	Jan	957.3	0.00146	0.7322	0.00480	0.01751	-0.01604
2002	Feb	969.9	0.01316	0.7452	0.01775	0.01673	-0.00356
2002	Mar	1018	0.04959	0.7537	0.01141	0.01711	0.03248
2002	Apr	1041	0.02259	0.7739	0.02680	0.01618	0.00641
2002	May	1132.7	0.08809	0.7852	0.01460	0.01692	0.07117
2002	Jun	1223.7	0.08034	0.79	0.00611	0.01743	0.06291
2002	Jul	1257.1	0.02729	0.8084	0.02329	0.01639	0.01090
2002	Aug	1309.7	0.04184	0.8158	0.00915	0.01725	0.02460
2002	Sep	1310.7	0.00076	0.817	0.00147	0.01771	-0.01695
2002	Oct	1339.8	0.02220	0.8222	0.00636	0.01741	0.00479
2002	Nov	1362.7	0.01709	0.8287	0.00791	0.01732	-0.00023
2002	Dec	1395.3	0.02392	0.8393	0.01279	0.01703	0.00690
2003	Jan	1434.7	0.02824	0.9492	0.13094	0.00990	0.01834
2003	Feb	1491	0.03924	0.8541	-0.10019	0.02384	0.01540
2003	Mar	1643.7	0.10241	0.9588	0.12259	0.01040	0.09201

2003	Apr	1766.4	0.07465	0.9658	0.00730	0.01736	0.05729
2003	May	1865	0.05582	0.8674	-0.10188	0.02394	0.03187
2003	Jun	2084.7	0.11780	0.8691	0.00196	0.01768	0.10012
2003	Jul	2315.3	0.11062	0.8708	0.00196	0.01768	0.09294
2003	Aug	2535.6	0.09515	0.8718	0.00115	0.01773	0.07742
2003	Sep	2643.3	0.04248	0.8722	0.00046	0.01777	0.02471
2003	Oct	2899	0.09674	0.8737	0.00172	0.01769	0.07904
2003	Nov	3300.8	0.13860	0.8777	0.00458	0.01752	0.12108
2003	Dec	3553.4	0.07653	0.8832	0.00627	0.01742	0.05911
2004	Jan	3798.1	0.06886	0.889	0.00657	0.01740	0.05146
2004	Feb	4633.1	0.21985	0.8899	0.00101	0.01774	0.20211
2004	Mar	5665	0.22272	0.8977	0.00877	0.01727	0.20545
2004	Apr	6544	0.15516	0.9007	0.00334	0.01760	0.13757
2004	May	6575.9	0.00487	0.9028	0.00233	0.01766	-0.01278
2004	Jun	7045.4	0.07140	0.9034	0.00066	0.01776	0.05364
2004	Jul	7125	0.01130	0.9036	0.00022	0.01778	-0.00649
2004	Aug	7316.3	0.02685	0.9042	0.00066	0.01776	0.00909
2004	Sep	6997.8	-0.04353	0.9042	0.00000	0.01780	-0.06133
2004	Oct	6932.9	-0.00927	0.9042	0.00000	0.01780	-0.02707
2004	Nov	6747.4	-0.02676	0.9043	0.00011	0.01779	-0.04455
2004	Dec	6798.5	0.00757	0.9045	0.00022	0.01778	-0.01021
2005	Jan	6889.4	0.01337	0.9055	0.00111	0.01773	-0.00436
2005	Feb	6737.2	-0.02209	0.9056	0.00011	0.01779	-0.03988
2005	Mar	6453.8	-0.04206	0.9068	0.00133	0.01772	-0.05978
2005	Apr	6108.2	-0.05355	0.9073	0.00055	0.01776	-0.07131
2005	May	6050	-0.00953	0.9072	-0.00011	0.01780	-0.02733
2005	Jun	5862.7	-0.03096	0.9076	0.00044	0.01777	-0.04873
2005	Jul	5019.7	-0.14379	0.9075	-0.00011	0.01780	-0.16159
2005	Aug	4842.3	-0.03534	0.9073	-0.00022	0.01781	-0.05315
2005	Sep	4878.3	0.00743	0.9053	-0.00220	0.01793	-0.01050
2005	Oct	4894.7	0.00336	0.9078	0.00276	0.01763	-0.01427
2005	Nov	4793.1	-0.02076	0.9085	0.00077	0.01775	-0.03851
2005	Dec	4769	-0.00503	0.911	0.00275	0.01763	-0.02266
2006	Jan	4692.8	-0.01598	0.912	0.00110	0.01773	-0.03371
2006	Feb	4730.2	0.00797	0.9119	-0.00011	0.01780	-0.00983
2006	Mar	4764.1	0.00717	0.913	0.00121	0.01772	-0.01056
2006	Apr	4780.2	0.00338	0.9139	0.00099	0.01774	-0.01436
2006	May	4843.8	0.01330	0.9148	0.00098	0.01774	-0.00443
2006	Jun	4833.3	-0.00217	0.9176	0.00306	0.01761	-0.01978
2006	Jul	4885.3	0.01076	0.919	0.00153	0.01771	-0.00695
2006	Aug	4913.3	0.00573	0.9196	0.00065	0.01776	-0.01203
2006	Sep	4943.5	0.00615	0.9207	0.00120	0.01773	-0.01158
2006	Oct	4973.3	0.00603	0.9219	0.00130	0.01772	-0.01169
2006	Nov	4992.9	0.00394	0.9225	0.00065	0.01776	-0.01382
2006	Dec	5006	0.00262	0.9234	0.00098	0.01774	-0.01511

2007	Jan	5012.2	0.00124	0.912	-0.01235	0.01854	-0.01730
2007	Feb	5044.9	0.00652	0.9247	0.01393	0.01696	-0.01043
2007	Mar	5092.3	0.00940	0.926	0.00141	0.01771	-0.00832
2007	Apr	5139.7	0.00931	0.9267	0.00076	0.01775	-0.00844
2007	May	5224.5	0.01650	0.9274	0.00076	0.01775	-0.00125
2007	Jun	5294.6	0.01342	0.9277	0.00032	0.01778	-0.00436
2007	Jul	5341.8	0.00891	0.9295	0.00194	0.01768	-0.00877
2007	Aug	5557.4	0.04036	0.9332	0.00398	0.01756	0.02280
2007	Sep	5676.8	0.02148	0.939	0.00622	0.01742	0.00406
2007	Oct	5839.6	0.02868	0.9455	0.00692	0.01738	0.01130
2007	Nov	6387.2	0.09377	0.9576	0.01280	0.01703	0.07675
2007	Dec	6599.8	0.03329	0.968	0.01086	0.01714	0.01614
2008	Jan	6718.9	0.01805	0.972	0.00413	0.01755	0.00050
2008	Feb	7005.3	0.04263	0.975	0.00309	0.01761	0.02501
2008	Mar	7848.1	0.12031	0.9773	0.00236	0.01766	0.10265
2008	Apr	9349.6	0.19132	0.9831	0.00593	0.01744	0.17388
2008	May	9815.2	0.04980	0.9943	0.01139	0.01711	0.03269
2008	Jun	10346.3	0.05411	1.0166	0.02243	0.01644	0.03767
2008	Jul	10650.7	0.02942	1.0446	0.02754	0.01614	0.01329
2008	Aug	10791	0.01317	1.0956	0.04882	0.01485	-0.00168
2008	Sep	10890.8	0.00925	1.1243	0.02620	0.01622	-0.00697
2008	Oct	10788.3	-0.00941	1.1442	0.01770	0.01673	-0.02614
2008	Nov	10573.4	-0.01992	1.168	0.02080	0.01654	-0.03646
2008	Dec	10431.6	-0.01341	1.1993	0.02680	0.01618	-0.02959
2009	Jan	10221	-0.02019	1.2487	0.04119	0.01531	-0.03550
2009	Feb	9836.8	-0.03759	1.3116	0.05037	0.01476	-0.05235
2009	Mar	9247.2	-0.05994	1.3621	0.03850	0.01547	-0.07541
2009	Apr	8822.9	-0.04588	1.3927	0.02247	0.01644	-0.06233
2009	May	7496	-0.15039	1.4218	0.02089	0.01654	-0.16693
2009	Jun	5424	-0.27641	1.4539	0.02258	0.01644	-0.29285
2009	Jul	5230.5	-0.03567	1.4783	0.01678	0.01678	-0.05246
2009	Aug	5900.4	0.12808	1.473	-0.00359	0.01801	0.11006
2009	Sep	6292.1	0.06639	1.4561	-0.01147	0.01849	0.04790
2009	Oct	5378.7	-0.14517	1.4463	-0.00673	0.01820	-0.16337
2009	Nov	5386.5	0.00145	1.4323	-0.00968	0.01838	-0.01693
2009	Dec	5572.3	0.03449	1.4295	-0.00195	0.01792	0.01658
2010	Jan	5625.4	0.00953	1.4242	-0.00371	0.01802	-0.00849
2010	Feb	5541.2	-0.01497	1.427	0.00197	0.01768	-0.03265
2010	Mar	6014.3	0.08538	1.419	-0.00561	0.01814	0.06724
2010	Apr	6518.9	0.08390	1.4173	-0.00120	0.01787	0.06603
2010	May	7172.1	0.10020	1.5014	0.05934	0.01422	0.08598
2010	Jun	6591.1	-0.08101	1.4239	-0.05162	0.02091	-0.10192
2010	Jul	6394	-0.02990	1.4312	0.00513	0.01749	-0.04739
2010	Aug	6821.8	0.06691	1.4319	0.00049	0.01777	0.04914
2010	Sep	6835.7	0.00204	1.4299	-0.00140	0.01788	-0.01584

2010	Oct	6,809.34	-0.00386	1.5306	0.07042	0.01355	-0.01741
2010	Nov	6,882.74	0.01078	1.4331	-0.06370	0.02164	-0.01086
2010	Dec	7,165.17	0.04103	1.4517	0.01298	0.01701	0.02402
2011	Jan	1,011.38	-0.85885	1.481	0.02018	0.01658	-0.87543
2011	Feb	1,050.88	0.03905	1.4995	0.01249	0.01704	0.02201
2011	Mar	1,061.82	0.01041	1.5003	0.00053	0.01777	-0.00735
2011	Apr	1,070.34	0.00802	1.5008	0.00033	0.01778	-0.00975
2011	May	1,161.08	0.08478	1.5014	0.00040	0.01777	0.06701
2011	Jun	1,176.55	0.01332	1.5031	0.00113	0.01773	-0.00441
2011	Jul	1,180.14	0.00305	1.5048	0.00113	0.01773	-0.01468
2011	Aug	1,172.40	-0.00656	1.5085	0.00246	0.01765	-0.02421
2011	Sep	1,112.94	-0.05071	1.5166	0.00537	0.01747	-0.06819
2011	Oct	1,011.90	-0.09078	1.5306	0.00923	0.01724	-0.10802
2011	Nov	994.53	-0.01717	1.537	0.00418	0.01755	-0.03472
2011	Dec	964.84	-0.02985	1.546	0.00586	0.01744	-0.04729
2012	Jan	973.031	0.00849	1.6144	0.04424	0.01513	-0.00664
2012	Feb	999.123	0.02682	1.6635	0.03041	0.01596	0.01085
2012	Mar	1035.44	0.03634	1.6791	0.00938	0.01723	0.01911
2012	Apr	1057.02	0.02085	1.6989	0.01179	0.01709	0.00376
2012	May	1043.43	-0.01285	1.7348	0.02113	0.01652	-0.02938
2012	Jun	1029.41	-0.01344	1.8552	0.06940	0.01361	-0.02705
2012	Jul	1025.06	-0.00423	1.8804	0.01358	0.01698	-0.02121
2012	Aug	1029.77	0.00459	1.8892	0.00468	0.01752	-0.01292
2012	Sep	1038.93	0.00890	1.89	0.00042	0.01777	-0.00887
2012	Oct	1053.31	0.01384	1.8891	-0.00048	0.01783	-0.00399
2012	Nov	1145.97	0.08797	1.8769	-0.00646	0.01819	0.06978
2012	Dec	1165.43	0.01699	1.8785	0.00085	0.01775	-0.00076
2013	Jan	1232.52	0.05757	1.8824	0.00208	0.01767	0.03989
2013	Feb	1382.72	0.12186	1.8848	0.00127	0.01772	0.10414
2013	Mar	1639.73	0.18587	1.8928	0.00424	0.01754	0.16833

Table A.1.1: Stock price unit root test with intercept

Null Hypothesis: STK has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.06974	0.0000
Test critical values:	1% level	-3.471987	
	5% level	-2.879727	
	10% level	-2.576546	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(STK)
Method: Least Squares
Date: 09/14/13 Time: 18:53
Sample (adjusted): 2000M02 2013M03
Included observations: 158 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
STK(-1)	-0.798682	0.079315	-10.06974	0.0000
C	0.011469	0.007398	1.550253	0.1231

R-squared	0.393939	Mean dependent var	0.001176
Adjusted R-squared	0.390054	S.D. dependent var	0.117933
S.E. of regression	0.092105	Akaike info criterion	-1.919202
Sum squared resid	1.323394	Schwarz criterion	-1.880435
Log likelihood	153.6169	Hannan-Quinn criter.	-1.903458
F-statistic	101.3997	Durbin-Watson stat	2.012663
Prob(F-statistic)	0.000000		

A.1.2: Stock return unit root test with trend and intercept

Null Hypothesis: STK has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.18033	0.0000
Test critical values:	1% level	-4.017185	
	5% level	-3.438515	
	10% level	-3.143558	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(STK)
Method: Least Squares
Date: 09/14/13 Time: 18:57
Sample (adjusted): 2000M02 2013M03
Included observations: 158 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
STK(-1)	-0.815202	0.080076	-10.18033	0.0000
C	0.028913	0.014996	1.928088	0.0557
@TREND(2000M01)	-0.000217	0.000162	-1.336257	0.1834

R-squared	0.400841	Mean dependent var	0.001176
Adjusted R-squared	0.393110	S.D. dependent var	0.117933
S.E. of regression	0.091874	Akaike info criterion	-1.917998
Sum squared resid	1.308322	Schwarz criterion	-1.859847
Log likelihood	154.5218	Hannan-Quinn criter.	-1.894382
F-statistic	51.84798	Durbin-Watson stat	2.000733
Prob(F-statistic)	0.000000		

A.1.3: Stock return unit root test with no trend nor intercept (none)

Null Hypothesis: STK has a unit root

Exogenous: None

Lag Length: 0 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.906816	0.0000
Test critical values:	1% level	-2.579680	
	5% level	-1.942856	
	10% level	-1.615368	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(STK)

Method: Least Squares

Date: 09/14/13 Time: 18:58

Sample (adjusted): 2000M02 2013M03

Included observations: 158 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
STK(-1)	-0.781694	0.078905	-9.906816	0.0000

R-squared	0.384602	Mean dependent var	0.001176
Adjusted R-squared	0.384602	S.D. dependent var	0.117933
S.E. of regression	0.092516	Akaike info criterion	-1.916572
Sum squared resid	1.343782	Schwarz criterion	-1.897188
Log likelihood	152.4092	Hannan-Quinn criter.	-1.908700
Durbin-Watson stat	2.018268		

A.2.1: Exchange rate unit root test with intercept

Null Hypothesis: EXR has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.620513	0.0000
Test critical values:	1% level	-3.472534	
	5% level	-2.879966	
	10% level	-2.576674	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EXR)
Method: Least Squares
Date: 09/14/13 Time: 18:59
Sample (adjusted): 2000M04 2013M03
Included observations: 156 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXR(-1)	-1.077832	0.162802	-6.620513	0.0000
D(EXR(-1))	-0.216439	0.130397	-1.659852	0.0990
D(EXR(-2))	-0.132581	0.080048	-1.656269	0.0997
C	0.013381	0.006558	2.040541	0.0430

R-squared	0.659412	Mean dependent var	-0.000563
Adjusted R-squared	0.652690	S.D. dependent var	0.131360
S.E. of regression	0.077414	Akaike info criterion	-2.253985
Sum squared resid	0.910931	Schwarz criterion	-2.175784
Log likelihood	179.8109	Hannan-Quinn criter.	-2.222223
F-statistic	98.09563	Durbin-Watson stat	2.020853
Prob(F-statistic)	0.000000		

Table A.2.2: Exchange rate unit root test with trend and intercept

Null Hypothesis: EXR has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.777534	0.0000
Test critical values:	1% level	-4.017956	
	5% level	-3.438886	
	10% level	-3.143776	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EXR)
Method: Least Squares
Date: 09/14/13 Time: 19:00
Sample (adjusted): 2000M04 2013M03
Included observations: 156 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXR(-1)	-1.128163	0.166456	-6.777534	0.0000
D(EXR(-1))	-0.181226	0.132549	-1.367233	0.1736
D(EXR(-2))	-0.117616	0.080566	-1.459878	0.1464
C	0.029538	0.013502	2.187695	0.0302
@TREND(2000M01)	-0.000192	0.000141	-1.367717	0.1734

R-squared	0.663580	Mean dependent var	-0.000563
Adjusted R-squared	0.654668	S.D. dependent var	0.131360
S.E. of regression	0.077193	Akaike info criterion	-2.253477
Sum squared resid	0.899784	Schwarz criterion	-2.155725
Log likelihood	180.7712	Hannan-Quinn criter.	-2.213775
F-statistic	74.46080	Durbin-Watson stat	2.013862
Prob(F-statistic)	0.000000		

Table A.2.3: Exchange rate unit root test with none

Null Hypothesis: EXR has a unit root
Exogenous: None
Lag Length: 2 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.235385	0.0000
Test critical values:	1% level	-2.579870	
	5% level	-1.942883	
	10% level	-1.615351	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EXR)
Method: Least Squares
Date: 09/14/13 Time: 19:02
Sample (adjusted): 2000M04 2013M03
Included observations: 156 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXR(-1)	-0.969330	0.155456	-6.235385	0.0000
D(EXR(-1))	-0.292675	0.126215	-2.318860	0.0217
D(EXR(-2))	-0.165341	0.079228	-2.086897	0.0386

R-squared	0.650082	Mean dependent var	-0.000563
Adjusted R-squared	0.645508	S.D. dependent var	0.131360
S.E. of regression	0.078211	Akaike info criterion	-2.239781
Sum squared resid	0.935884	Schwarz criterion	-2.181130
Log likelihood	177.7029	Hannan-Quinn criter.	-2.215959
Durbin-Watson stat	2.035338		

Table A.3: Result of GARCH estimation of stock returns and exchange rates

Dependent Variable: STK

Method: ML - ARCH (Marquardt) - Normal distribution

Date: 09/14/13 Time: 19:56

Sample: 2000M01 2013M03

Included observations: 159

Convergence achieved after 186 iterations

Presample variance: backcast (parameter = 0.7)

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.017798	0.006009	2.961978	0.0031
EXR	-0.060337	0.056659	-1.064909	0.2869
		Variance Equation		
C	-4.97E-05	3.15E-05	-1.577770	0.1146
RESID(-1)^2	-0.039781	0.003680	-10.81063	0.0000
GARCH(-1)	1.066389	0.013988	76.23848	0.0000

R-squared	0.002409	Mean dependent var	0.013975
Adjusted R-squared	-0.023502	S.D. dependent var	0.093397
S.E. of regression	0.094488	Akaike info criterion	-2.616964
Sum squared resid	1.374924	Schwarz criterion	-2.520458
Log likelihood	213.0486	Hannan-Quinn criter.	-2.577774
F-statistic	0.092982	Durbin-Watson stat	1.575834
Prob(F-statistic)	0.984559		

APPENDIX B

EVIEWS ANALYSIS OF DATA FOR THE MODEL ILLUSTRATION

TABEL B.1: UNIT ROOT TEST WITH INTERCEPT AT LEVELS STOCK RETURNS- STATIONARY

Null Hypothesis: Y has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.30112	0.0000
Test critical values:	1% level	-3.453997	
	5% level	-2.871845	
	10% level	-2.572334	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(Y)
Method: Least Squares
Date: 09/13/13 Time: 20:45
Sample (adjusted): 1973M02 1995M12
Included observations: 275 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y(-1)	-0.985577	0.060461	-16.30112	0.0000
C	0.006865	0.002738	2.507170	0.0128

R-squared	0.493249	Mean dependent var	0.000161
Adjusted R-squared	0.491393	S.D. dependent var	0.062950
S.E. of regression	0.044894	Akaike info criterion	-3.361801
Sum squared resid	0.550212	Schwarz criterion	-3.335497
Log likelihood	464.2476	Hannan-Quinn criter.	-3.351245
F-statistic	265.7266	Durbin-Watson stat	2.000147
Prob(F-statistic)	0.000000		

Table B.2: unit root test with Trend and intercept at levels stock returns- stationary

Null Hypothesis: Y has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.37499	0.0000
Test critical values:	1% level	-3.991780	
	5% level	-3.426251	
	10% level	-3.136336	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(Y)
Method: Least Squares
Date: 09/13/13 Time: 20:53
Sample (adjusted): 1973M02 1995M12
Included observations: 275 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y(-1)	-0.992192	0.060592	-16.37499	0.0000
C	0.000729	0.005422	0.134419	0.8932
@TREND(1973M01)	4.48E-05	3.42E-05	1.310656	0.1911

R-squared	0.496430	Mean dependent var	0.000161
Adjusted R-squared	0.492727	S.D. dependent var	0.062950
S.E. of regression	0.044835	Akaike info criterion	-3.360824
Sum squared resid	0.546758	Schwarz criterion	-3.321368
Log likelihood	465.1133	Hannan-Quinn criter.	-3.344989
F-statistic	134.0715	Durbin-Watson stat	2.000056
Prob(F-statistic)	0.000000		

Table B.3: unit root test with no Trend nor intercept (none) at levels stock returns-stationary

Null Hypothesis: Y has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.95412	0.0000
Test critical values:	1% level	-2.573398	
	5% level	-1.941982	
	10% level	-1.615929	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(Y)
Method: Least Squares
Date: 09/13/13 Time: 20:56
Sample (adjusted): 1973M02 1995M12
Included observations: 275 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y(-1)	-0.962809	0.060349	-15.95412	0.0000

R-squared	0.481581	Mean dependent var	0.000161
Adjusted R-squared	0.481581	S.D. dependent var	0.062950
S.E. of regression	0.045324	Akaike info criterion	-3.346310
Sum squared resid	0.562880	Schwarz criterion	-3.333158
Log likelihood	461.1176	Hannan-Quinn criter.	-3.341031
Durbin-Watson stat	1.998924		

Table B.4: unit root test with intercept at levels of exchange rates- stationary

Null Hypothesis: X has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.91664	0.0000
Test critical values:	1% level	-3.453997	
	5% level	-2.871845	
	10% level	-2.572334	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(X)
Method: Least Squares
Date: 09/13/13 Time: 21:02
Sample (adjusted): 1973M02 1995M12
Included observations: 275 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X(-1)	-0.607936	0.055689	-10.91664	0.0000
C	-0.127963	0.265135	-0.482633	0.6297

R-squared	0.303879	Mean dependent var	-0.012145
Adjusted R-squared	0.301329	S.D. dependent var	5.255919
S.E. of regression	4.393241	Akaike info criterion	5.805258
Sum squared resid	5269.056	Schwarz criterion	5.831562
Log likelihood	-796.2230	Hannan-Quinn criter.	5.815814
F-statistic	119.1731	Durbin-Watson stat	1.891609
Prob(F-statistic)	0.000000		

Tabel B.5: unit root test with Trend and intercept at levels of exchange rates-stationary

Null Hypothesis: X has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.91986	0.0000
Test critical values:	1% level	-3.991780	
	5% level	-3.426251	
	10% level	-3.136336	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(X)
Method: Least Squares
Date: 09/13/13 Time: 21:05
Sample (adjusted): 1973M02 1995M12
Included observations: 275 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X(-1)	-0.609789	0.055842	-10.91986	0.0000
C	-0.402672	0.533170	-0.755242	0.4508
@TREND(1973M01)	0.001988	0.003346	0.594105	0.5529

R-squared	0.304781	Mean dependent var	-0.012145
Adjusted R-squared	0.299669	S.D. dependent var	5.255919
S.E. of regression	4.398457	Akaike info criterion	5.811234
Sum squared resid	5262.227	Schwarz criterion	5.850689
Log likelihood	-796.0446	Hannan-Quinn criter.	5.827068
F-statistic	59.62179	Durbin-Watson stat	1.890845
Prob(F-statistic)	0.000000		

Tabel B.6: unit root test with no Trend nor intercept (none) at levels of exchange rates- stationary

Null Hypothesis: X has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.92136	0.0000
Test critical values:	1% level	-2.573398	
	5% level	-1.941982	
	10% level	-1.615929	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(X)
Method: Least Squares
Date: 09/13/13 Time: 21:06
Sample (adjusted): 1973M02 1995M12
Included observations: 275 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X(-1)	-0.606861	0.055566	-10.92136	0.0000

R-squared	0.303285	Mean dependent var	-0.012145
Adjusted R-squared	0.303285	S.D. dependent var	5.255919
S.E. of regression	4.387088	Akaike info criterion	5.798838
Sum squared resid	5273.551	Schwarz criterion	5.811990
Log likelihood	-796.3402	Hannan-Quinn criter.	5.804116
Durbin-Watson stat	1.891869		

APPENDIX C

Model order selection results

C.1: GARCH (1, 1) results

Dependent Variable: STK
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 09/15/13 Time: 11:08
Sample: 2000M01 2013M03
Included observations: 159
Convergence achieved after 186 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.017798	0.006009	2.961978	0.0031
EXR	-0.060337	0.056659	-1.064909	0.2869
		Variance Equation		
C	-4.97E-05	3.15E-05	-1.577770	0.1146
RESID(-1)^2	-0.039781	0.003680	-10.81063	0.0000
GARCH(-1)	1.066389	0.013988	76.23848	0.0000

R-squared	0.002409	Mean dependent var	0.013975
Adjusted R-squared	-0.023502	S.D. dependent var	0.093397
S.E. of regression	0.094488	Akaike info criterion	-2.616964
Sum squared resid	1.374924	Schwarz criterion	-2.520458
Log likelihood	213.0486	Hannan-Quinn criter.	-2.577774
F-statistic	0.092982	Durbin-Watson stat	1.575834
Prob(F-statistic)	0.984559		

C.2: GARCH (1, 5) results

Dependent Variable: STK
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 09/15/13 Time: 11:11
Sample: 2000M01 2013M03
Included observations: 159
Failure to improve Likelihood after 42 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*GARCH(-2) +
C(7)*GARCH(-3) + C(8)*GARCH(-4) + C(9)*GARCH(-5)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.016471	0.013182	1.249502	0.2115
EXR	-0.071426	0.354527	-0.201470	0.8403
		Variance Equation		
C	0.005307	0.009303	0.570465	0.5684
RESID(-1)^2	-0.013227	0.032076	-0.412360	0.6801
GARCH(-1)	0.392422	1.586723	0.247316	0.8047
GARCH(-2)	0.026427	1.998316	0.013225	0.9894
GARCH(-3)	0.027091	3.233205	0.008379	0.9933
GARCH(-4)	0.028281	3.128791	0.009039	0.9928
GARCH(-5)	0.029677	1.610090	0.018432	0.9853

R-squared	0.003236	Mean dependent var	0.013975
Adjusted R-squared	-0.049924	S.D. dependent var	0.093397
S.E. of regression	0.095700	Akaike info criterion	-1.805518
Sum squared resid	1.373784	Schwarz criterion	-1.631807
Log likelihood	152.5387	Hannan-Quinn criter.	-1.734976
F-statistic	0.060878	Durbin-Watson stat	1.576390
Prob(F-statistic)	0.999871		

C.3: GARCH (5, 1) results

Dependent Variable: STK
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 09/15/13 Time: 11:13
Sample: 2000M01 2013M03
Included observations: 159
Convergence achieved after 25 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-2)^2 + C(6)*RESID(-3)^2
+ C(7)*RESID(-4)^2 + C(8)*RESID(-5)^2 + C(9)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.012953	0.014193	0.912635	0.3614
EXR	-0.043567	0.284029	-0.153391	0.8781
Variance Equation				
C	0.006551	0.008911	0.735195	0.4622
RESID(-1)^2	0.048723	0.085625	0.569028	0.5693
RESID(-2)^2	-0.033046	0.051856	-0.637260	0.5240
RESID(-3)^2	-0.008513	0.011750	-0.724508	0.4688
RESID(-4)^2	-0.006049	0.012065	-0.501388	0.6161
RESID(-5)^2	-0.009976	0.009823	-1.015588	0.3098
GARCH(-1)	0.388758	0.844209	0.460500	0.6452

R-squared	0.002763	Mean dependent var	0.013975
Adjusted R-squared	-0.050423	S.D. dependent var	0.093397
S.E. of regression	0.095723	Akaike info criterion	-1.912972
Sum squared resid	1.374437	Schwarz criterion	-1.739260
Log likelihood	161.0812	Hannan-Quinn criter.	-1.842429
F-statistic	0.051941	Durbin-Watson stat	1.578439
Prob(F-statistic)	0.999929		

C.4: GARCH (5, 5) results

Dependent Variable: STK
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 09/15/13 Time: 11:15
Sample: 2000M01 2013M03
Included observations: 159
Failure to improve Likelihood after 23 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-2)^2 + C(6)*RESID(-3)^2
+ C(7)*RESID(-4)^2 + C(8)*RESID(-5)^2 + C(9)*GARCH(-1) + C(10)
*GARCH(-2) + C(11)*GARCH(-3) + C(12)*GARCH(-4) + C(13)*GARCH(
-5)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.013929	0.013386	1.040581	0.2981
EXR	-0.055805	0.338781	-0.164724	0.8692
		Variance Equation		
C	0.006236	0.017434	0.357659	0.7206
RESID(-1)^2	0.032642	0.067146	0.486136	0.6269
RESID(-2)^2	-0.023057	0.147285	-0.156546	0.8756
RESID(-3)^2	-0.009807	0.227522	-0.043105	0.9656
RESID(-4)^2	-0.005303	0.257576	-0.020589	0.9836
RESID(-5)^2	-0.005260	0.197698	-0.026605	0.9788
GARCH(-1)	0.297303	4.459734	0.066664	0.9468
GARCH(-2)	0.021958	5.624597	0.003904	0.9969
GARCH(-3)	0.022744	6.485655	0.003507	0.9972
GARCH(-4)	0.022485	4.232380	0.005313	0.9958
GARCH(-5)	0.022471	0.573633	0.039173	0.9688

R-squared	0.003332	Mean dependent var	0.013975
Adjusted R-squared	-0.078586	S.D. dependent var	0.093397
S.E. of regression	0.096998	Akaike info criterion	-1.810712
Sum squared resid	1.373652	Schwarz criterion	-1.559796
Log likelihood	156.9516	Hannan-Quinn criter.	-1.708818
F-statistic	0.040678	Durbin-Watson stat	1.577739
Prob(F-statistic)	1.000000		