MODELING THE SUB-SAHARAN FINANCIAL MARKETS USING THE GARCH MODELS (VOLATILITY TRANSMISSION AND THE INFLUENCE OF EXCHANGE RATE)

A

Dissertation

Presented to the

Graduate Faculty of the

United States International College of Business

Alliant International University

In Partial Fulfillment

of the Requirements for the Degree of

Doctor of Business Administration

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by

Maina Gakure

San Diego, 2005

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Abstract of Dissertation

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Committee Chairperson: Hamid Rahman, Ph.D.

Several studies have concluded that market volatility, integration, and volatility transmission have recently increased. Most recent studies found equity markets to be interlinked. The cause for this increase is attributed to advanced communication system and information technology, globalization and increasing international trades, trade blocks, deregulation of international financial markets, and exchange rates volatility. Most available and current research has concentrated on North American, European, and Asian financial markets; this study expanded available literature by examining Sub-Saharan financial markets.

The purpose was to investigate the influence of exchange rate volatility on Sub-Saharan stock returns. The transmission of volatility and correlation between the countries were investigated. Also examined was the nature of transmission of stock return volatility from the United States and Great Britain into Sub-Saharan financial markets. The study concentrated on five Sub-Saharan African economies: Botswana, Kenya, Nigeria, South Africa, and Zimbabwe.

All data used were secondary. The daily data observation period was January 1998-April 2004. To investigate the relationship among the stock market returns of the five countries, the Pearson correlation test was used. The Generalized Autoregressive Conditional Heteroskedastic (GARCH) model was utilized to examine the relationship between the exchange rate volatility and each country's stock return. The Exponential Generalized Autoregressive Conditional Heteroskedastic (EGARCH) model was used to examine the transmission of volatility within studied markets. The Augmented Dickey-Fuller (ADF; unit root) was used to test for stationarity of stock exchange data. Other statistical techniques applied as a residual test (to test the accuracy of the GARCH model) were the Correlogram Squared Residuals, Histogram-Normality Test, and ARCH LM Test. A variance decomposition test was conducted to determine the relative importance of various markets in causing fluctuations in returns.

A relationship was demonstrated between foreign exchange volatility and stock market returns volatility in markets of Botswana, Kenya, Nigeria, and South Africa, but no such relationship in Zimbabwe stock market volatility. The study found no relationships among the five Sub-Saharan financial markets. Analysis of data revealed transmission of volatility among the five Sub-Saharan countries. It was concluded that there is transmission of volatility from financial markets in the United States and Great Britain to markets in five countries studied.

DEDICATION

To those who were with me.

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Without help, guidance, encouragement, and invaluable support, this dissertation would not have been finished. I would like to express my sincere gratitude to Dr. Hamid Rahman for his patience, invaluable support, advice, and guidance in the planning and implementation of this dissertation. I am also very thankful to my other committee members, Dr. Bijan Massrour and Dr. Meenakshi S. Krishnamoorthy for their encouragement and contributions to this research project. I further extend my thanks to Dr. Ayo Salami (U.K.) for his support in providing most data observations in this study.

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Chapter 1
INTRODUCTION

Several studies (e.g., Becker et al., 1990; Eun & Shim, 1989; Koch & Koch, 1991) have concluded that market volatility, integration, and volatility transmission have increased in recent years. Most recent studies have found a majority of the equity markets to be interlinked. The causes for this increase are attributed to advanced communication systems and information technology, globalization and increasing international trade, trade blocks, deregulation of international financial markets, and exchange rate volatility. Unfortunately, most of the available current research has concentrated on the North America, European, and Asian financial markets.

Africa has observed a period of economic and monetary integration as it reorganizes its internal trading basis, for example, the introduction of numerous trading blocks. In addition, significant progress has been made in strengthening and deepening African equity markets, for example, the formation of regional stock exchanges. In light of this, this dissertation expands the available literature by studying the volatility and volatility transmission of the Sub-Saharan financial markets. The importance of this topic arises because current studies have shown that the emerging and frontier equity markets of Asia and Eastern Europe have actually held their value more successfully than have developed markets (Kirativanich, 2000; Nijathaworn & Dejthamrong, 1994; Songcharoen, 1999). Unfortunately, only minimal study has been conducted on the Sub-Saharan markets, despite the fact that they have been recognized to have some of the best-performing stock exchanges. Previous research had not focused on the Sub-Saharan equity markets for a number of reasons, including restriction of access to data and corrupted data. It is important to study and

understand the regional and international transmission of volatility to the Sub-Saharan financial markets, especially after such crises as the 1987 stock market crash, 1997 Asian crisis, and 1994 Tequila effect.

According to Salami (2002), even though Africa has 7 of the 20 fastest-growing economies, investors are still shying away. The World Bank and the United Nations label the Sub-Saharan financial markets as very promising (United Nations Development Program, 2003). Apart from South Africa, Sub-Saharan financial markets are almost insignificant in global terms. During the past decade, the Sub-Saharan region has established new stock markets or expanded existing ones, formed financial alliances, and developed trading blocks as a way of obtaining equity. As the Sub-Saharan financial market continues to grow and be recognized in the international community, and as more investors diversify and exploit investment opportunities in the emerging market, the question of Sub-Saharan stock market volatility and its transmission of volatility should be examined. The findings of such a study may help to slow down or prevent the transmission of stock market volatility during a period of crisis, encourage international investment, help both government and private sectors to solve pressing economic problems, contribute to the development and expansion of businesses, and help countries to maintain or gain competitive advantages.

The past decade has shown an improvement in the Sub-Saharan policy changes that were implemented by internal political pressure and external forces (e.g., the Bretton Woods Foundation, the International Monetary Fund [IMF], and the World Bank) in order to attract foreign investors and minimize the risk that they face. However, unlike similar cases (e.g., Eastern Europe), where investors rushed in when similar positive policy changes were implemented, investors continue to avoid investing in Sub-Saharan economies.

Why has Sub-Saharan Africa been left out? One of the main reasons is that Africa has a long history of mismanaging foreign investments; therefore, investors consider the risk level to be high (Collier & Pattillo 2000). But others have countered this misconception; for example, Haque, Mark, and Mathieson (2000) stated that most of the international rating agencies tend to rate Africa as riskier than is warranted. Other notable causes are that African financial markets have few indigenous companies; most companies are small and/or family owned, with low liquidity level; and corrupt leadership had overrun the continent.

However, there have been many positive changes within the past decade. For example, a majority of the countries in Africa have stable and democratically elected governments that are implementing constructive economical changes. Elsewhere, the growth of the African financial market (especially within the Sub-Saharan region) is well demonstrated by an increase in the number of stock market exchanges that have emerged, an greater number of trading blocks and companies registered across international borders, improving gross domestic product, and improving infrastructure. It is no wonder that the Paris-based Federation of International Stock Exchanges annual report (FIBV, 1995) noted that, among the developing continents, Africa is attracting the greatest expectations and that an increasing number of fund managers that are currently realizing capital gains from mature emerging markets are starting to turn more and more to Africa.

There is widespread knowledge that Africa is in debt. According to Erb, Harvey, and Viskanta (2000), Africa owes about 15% of the total developing world debt, and Ng and Yeats (1997) wrote that the high debt level has resulted in African countries being marginalized in world trade. Unfortunately, most investors are not aware that these African countries are also making major economic adjustments, as

shown by the growth of their financial markets. This lack of information, due chiefly to a lack of research on the Sub-Saharan financial markets, deters investors who would be willing to diversify their portfolios into the Sub-Saharan region if positive information were made available to them.

Background of the Problem

The background of the problem of focus for this study is described in terms of markets correlation, modern portfolio theory, diversification theory, influence of foreign exchange volatility, and volatility transmission.

Markets Correlation

As the world's economies and financial markets have become more integrated, there has been an increase in correlation of national stock indexes. Shalen (2000) stated that this trend is widely acknowledged for the European and U.S. indexes, and it is suspected to have spread to other markets. According to Flavin, Hurley, and Rousseau (2002), attention should be paid to stock market correlation, especially after the aftermath of 1987 stock market crash. Bodart and Reding (1999) noted that correlation increases when the market becomes more volatile. Ripley (1973) and Roll (1992) stated that correlation among stock markets is affected by time zones; for example, the Sub-Saharan stock markets have a stronger correlation with Great Britain than with the United States. Kirativanich (2000) stated that, if cross-market linkages exist in closely related markets, events in one country's financial market can cause the same event to occur in the markets of other countries in the region. Sabri (2002) found that stock price movements are spreading to the developing nations. He wrote that the

emerging stock markets are becoming more correlated with the developed stock exchanges.

As the African markets continue to expand, and because they are all in the same region and within the same time zone, it is important to document the linkages and interdependence of these equity markets. This knowledge would be helpful because, if the African financial markets are found to be correlated, there is a chance that volatility can be transmitted easily among the countries, making these markets a poor choice for a diversified portfolio.

Modern Portfolio Theory

Harry Markowitz (1952), a 1990 Nobel Prize Winner, revolutionized portfolio management by pointing out that the best stock theory was contrary to portfolio diversification. He introduced the mean variance theory, which quantified the risk from different securities' expected return. In his theory he combined the securities that were having opposing market movement characteristics in order to reduce overall portfolio risk. By combining assets that were not correlated, he reduced the portfolio risk without sacrificing portfolio return.

Correlation is the statistical measure of relationship. When two series move in the same direction, as seen in the case of the S&P 500 and South Africa in Figure 1, they are positively correlated; if they move in opposite directions, as in the case of the S&P 500 and Ghana, they are negatively correlated.

According to Gitman (2000), the concept of correlation is important for portfolio diversification. To reduce risk, an investor should select assets that have low, negative, or zero correlation.

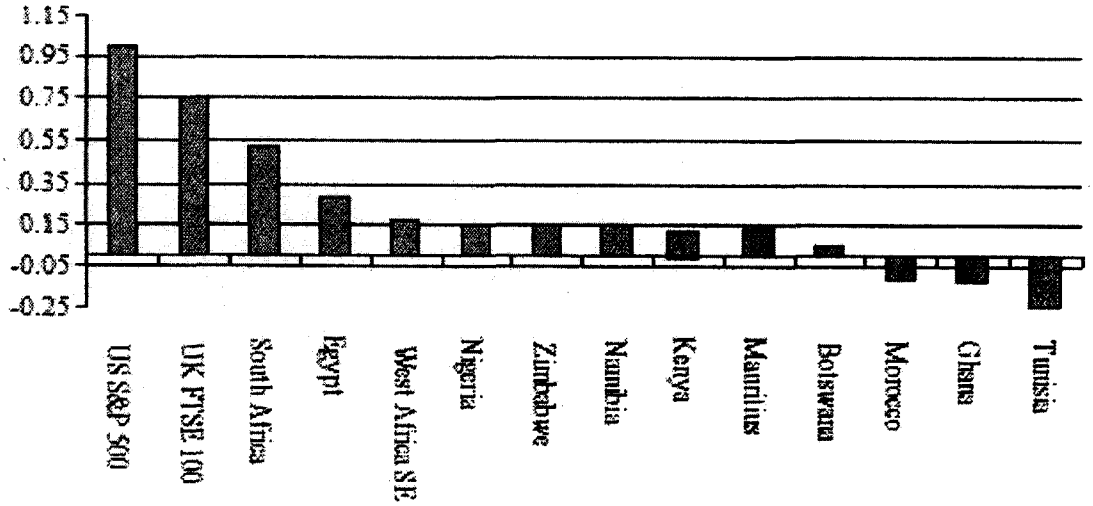

Figure 1. Correlation between African and international financial markets. Source: *Emerging Market Fact Book 2002*, by International Financial Corporation, Washington, DC: Author.

Figure 1 shows that the correlation of the African financial markets during the period 1996 to 2001 was low in relation to those of the United States and Great Britain. Such a low correlation is good for investors who are interested in reducing overall risk. As the figure shows, the Ghana and Tunisia financial markets have a negative correlation, which would make them an ideal place for investors, as they can reduce overall variability of returns. Figure 1 is also supported by Bekaert (1995) and Bekaert and Harvey (1997), who stated that the emerging stock markets lacked strong correlation with major markets.

Diversification Theory

Diversification can assist investors to reduce unsystematic risk. The Markowitz diversification strategy combines assets with returns that are less than

perfectly correlated. This reduces overall risk without sacrificing portfolio return. By diversifying, concentrations in single asset categories are avoided. Diversification is the best way to guarantee a positive return. But investors must consider the correlation level when investing in international financial markets because the bear market can spread to overseas markets that are correlated or integrated. Therefore, there is a need to identify the newer financial markets that have low, negative, or no correlation with the more established markets as a means of encouraging diversification.

Influence of Foreign Exchange Volatility (Asset Market Approach and Portfolio Balance Approach)

One of the theories that explain the relationship between stock price and exchange rate is the asset market approach. According to Dornbusch and Fischer (1980), changes in exchange rate affect firm competitiveness by impacting the level of earnings and therefore influencing a firm stock price. They explained that this is caused by the fact that many firms borrow in foreign currency. Another theory to explain the relationship between stock price and exchange rate is the portfolio balance approach (e.g., Frankel, 1983), which states that exchange rates are determined by market mechanism (i.e., when stock prices fall, investors sell stocks to avoid further losses, and convert their money into foreign currencies to move out of the country, and vice versa).

Several factors can influence the level of financial market volatility. Among them are macroeconomics variables, such as foreign exchange volatility (Shiller, (1981). The stock market crash of 1987 was blamed on various factors; the crash fueled studies and speculation of its causes. Among the suspected causes were macro-economic and microeconomic forces (Limmack & Ward, 1990; Malliaris & Urrutia,

1992; Roll, 1988). Their theories suggested that factors such as budget deficits, balance of payments, speculative activities, and exchange rate fluctuation were among the causes. Dornbusch (1976) wrote that foreign exchange has a great impact on the financial markets; for example, overvaluing of exchange rates has a negative impact on foreign investors.

Before the crash of the Asian financial markets, Thailand's government had adjusted its foreign exchange rate in an effort to promote growth (Nijathaworn & Dejthamrong, 1994; Songcharoen, 1999). The Thai authority's priority was to liberate and maintain the foreign exchange market.

Dornbusch and Fischer (1980) and Gavin (1989) stated that changes in exchange rate affect international competitiveness and trade balances by impacting stock markets. Branson (1983) and Frankel (1983) explained that exchange rates equate the supply and demand for assets, such as stocks and bonds. Bahmani-Oskooee and Sohrabian (1992) demonstrated a linkage between stock prices of the S&P 500 index and exchange rates. Lee (2001) stated that there was short-term relationship between stock prices and exchange rates in the Asian markets.

Aron (1997) noted that in the 1970s exchange rates in Africa were held fixed, with infrequent adjustments. He stated that these rates were overvalued and that they experienced stringent rationing of foreign exchange. In 1980, the Bretton Woods institution promoted transitional systems toward unified, market-determined, and convertible exchange rates. Among the African countries that embraced these changes were Kenya, Mozambique, Nigeria, and Zimbabwe, who adopted the changes in the 1980s and 1990s. Since then, according to Salami (2002), some of these African currencies have depreciated by over 80%.

The Second Amendment to the Articles of Agreement of the IMF states that members of the IMF are free to choose the method by which their own exchange rate is determined. Table 1 shows that Botswana and Nigeria have their currencies pegged to other currencies, while Kenya, South Africa, and Zimbabwe have a free-flowing currency.

Table 1

Sub-Saharan Africa: Forms of Foreign Exchange Arrangements

Country	Form of exchange arrangement
Botswana	Pegged to a weighted currency composite
Kenya	Independently floating
Nigeria	Pegged to the USA dollars
South Africa	Independently floating
Zimbabwe	Independently floating

Source: *Currency Board Arrangements: Issues and Experiences* (IMF Occasional Paper 151), 1997, by T. Baliño, C. Enoch, A. Ize, V. Santiprabhob, P. Stella, Washington, DC: International Monetary Fund.

According to Aghevli, Khan, and Monteil (1991), there is no answer as to which is the best exchange rate policy for the developing countries. This is because the optimal management of exchange rate depends on the policy makers, economic objectives, the source of shocks to the economy, and the country's structure characteristic. They explained that the developing countries design their exchange rate policies to maintain external competitiveness at a level consistent with a sustainable balance of

payment option. A country's currency is crucial in a free market economy. Theories that explain currency behaviors includes, the purchasing power parity theory (PPP), monetary theory of currency determination, term of trade theorem of currency determination, the rational expectations theory, and the comprehensive portfolio balance model.

Volatility Transmission

Because of continuous expansion of the global market and increasing levels of communication technology, there has been an increase in the number of studies of transmission of volatility. Varian (1998) stated that this increasing interdependency is being created by advanced computer technology and an improved network process of news. King and Wadhwani (1990) and Hamao, Masulis, and Ng (1990) wrote that returns and volatility tend to spill over from the U.S. equity markets to Japan and the United Kingdom (UK) financial markets. According to Gemmill and Kamiyama (1997), spillovers of returns and volatility across markets have important implications for portfolio choice and risk management. Melvin and Melvin (2003) explained that new information might not have an immediate effect on the stock markets. In agreement with them, Müller, Dacorogna, Olsen, and Pietet (1997) emphasized that traders react differently to volatility news as they digest the effects of the information.

According to Sabri (2002), liberalization, integration, and increasing linkages are associated with transmission of high volatility of stock price movements. He explained that such activities could create global market instability.

The transmission of volatility is not limited to the developed nations, and the impact is not limited to regional areas. The impact of the 1997 Asian crisis had a global effect; it had an immediate impact on the Western financial markets. Since

then, there has been an increasing relationship between the Asian financial markets and the U.S. and Great Britain financial markets.

According to Ouattara (1999), the African economies are not fully integrated into the global economies, and therefore they have been able to avoid financial contagion. However, the African countries have started to reap the benefits of globalization, such as the chance to quicken the pace of investment, job creation, and growth.

The African stock exchanges have also been displaying similar characteristic as those shown by the Asian economies before the crash of 1997. This raises the question of the African market volatility level, and this level of volatility transmission should be examined.

Statement of the Problem

According to Alsalman (2002), extensive research on the volatility of stock returns and transmission of volatility has been conducted in developed countries but very limited research has been conducted in emerging countries. Salami (2002) explained that the African economies have begun to grow rapidly. As shown in Table 2, the long-term performance of the Sub-Saharan Africa index was very good, with Botswana having a return as high as 225%, Nigeria 96%, and Ghana 57%. The short-term returns have been mild but better than other global indices.

United Nations Development Programs (2003) and Clark (1998) wrote that the African market indexes have been recognized to have some of the best performers in the world. The United Nations Conference on Trade and Development (UNCTAD) in 1998 (UNCTAD, 1999) showed that the average rate of return to U.S. foreign direct investment (FDI) was 25% in Africa, 16% in Asia, 12% in South America, and 14% from all developing countries. Basu, Calamitsis, and Ghura (2000) stated that the

Table 2

Returns of the Sub-Saharan Markets (Percentages)

Stock market	1 Year	2 Years	3 Years	5 Years
Botswana	41.8	96.1	59.7	225.5
West Africa	27.4	58.0	N/A	27.0
Ghana	33.3	56.9	-60.0	-5.9
Kenya	7.7	3.9	-38.9	-34.2
Mauritius	30.8	22.5	-20.3	12.7
Nigeria	7.6	38.0	96.3	42.7
Zambia	9.9	-17.1	58.6	-26.1
Zimbabwe	-52.2	-59.9	-42.8	-78.15
South Africa	27.9	5.7	N/A	-0.4

Note: Source: *African Stock Markets Handbook*, by United Nations Development Program, 2003, New York: Author.

Sub-Saharan markets were showing significant progress. Bekaert and Harvey (2001) noted that, since 1980, there has been a desire to privatize state-owned enterprises in Sub-Saharan Africa. Other indicators of this continuing progress are the level of performance in terms of the global market; increasing establishment of reputable investment funds such as African Investment Fund, Alliance Capital, and Robert Fleming; and improvement in market capitalization.

Piesse and Hearn (2002b) discussed the Sub-Saharan African spillover effects, using weekly data. As the technology increases and information dissemination improves, the national stock markets news can be transmitted within hours. Therefore,

it would be wise to use high-frequency data, such as the daily index price, to examine spillover effects. This study uses the daily index data to investigate volatility and transmission of volatility within the five financial markets.

Purpose and Importance of the Study

Among other things, this study investigated the characteristic of Sub-Saharan financial volatility. Its primary contribution lies in providing informative literature that may assist in the allocation of resources. This will be achieved by providing feedback about Sub-Saharan historical performance and continuous growth. Another contribution comes from the fact that many of the African investors hold individual stocks and have not diversified (Cameron, 2004). The results of this study will discourage or encourage such behavior by showing the volatility level and the correlation of the studied markets. Because the studied financial markets are in their early stage of development and growth (they are all frontier markets), this study will add valuable literature on which future studies can be based.

In light of this, the objectives of this study may be described as follows:

1. To determine the level of interdependencies among Botswana, Kenya, Nigeria, South Africa, and Zimbabwe;

2. To investigate the influence of exchange rate volatility in the Sub-Saharan stock markets;

3. To determine whether volatility is transmitted among the five countries; and

4. To determine whether volatility is transmitted from the financial markets of the United States or Great Britain into those of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe.

Research Questions

The addressed research questions were as follows:

1. What is the relationship among the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

2. What is the relationship between the exchange rate volatility and the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

3. Is there any transmission of stock market volatility among the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

4. Is there any transmission of stock market volatility from the United States or Great Britain to the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

There is a need to study the level and behavior of Sub-Saharan financial market volatility, as its impact can be overwhelming to the African and global economies. For example, market volatility can influence investors, it acts as an indicator of the level of financial default, it influences the level of investors' confidence in a country's stock market, and it can affect the growth of the real sector in an economy. It is necessary to document the level of volatility spillover, if any. The overall benefit of such a study is that it can assist potential private or government investors to allocate funds wisely. It can also help policy makers to set regulations accordingly.

Scope of the Study

Some studies (e.g., Bekaert & Harvey, 1998; McKinnon & Ohno, 1997; Najand & Rahman, 1991) have suggested a positive relationship between stock market volatility and macroeconomics variables volatility. However, other studies (e.g., Baxter & Stockman, 1989; Belanger & Gutierrez, 1990; Duarte & Stockman, 2001;

Flood & Rose, 1995; Kirativanich, 2000; Obstfeld & Rogoff, 2000) have reported limited or no relationship between macroeconomic variables volatility and stock market volatility. This study expands on that research by investigating the volatility of the Sub-Saharan financial markets.

In addition, in order to study the transfer of volatility, the linkages and inter-dependencies of the stock markets were examined. Prior studies have addressed concerns over the growing linkages among stock markets, especially after the Asian crisis. The African markets have started to display characteristic similar to those of the Asia equity markets before the 1997 crash: currency fluctuation, rapid expansion, and high growth rates. This research will expand this knowledge by analyzing the markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe. These countries were selected because (a) They are all within the Sub-Saharan region, (b) they are the most volatile stock exchanges within the region, (c) they have well-documented stock index data, (d) they have similar economical patterns, such as regulatory structure and legal system, and (e) they have perfect-time synchronous trading data, as shown in Figure 2.

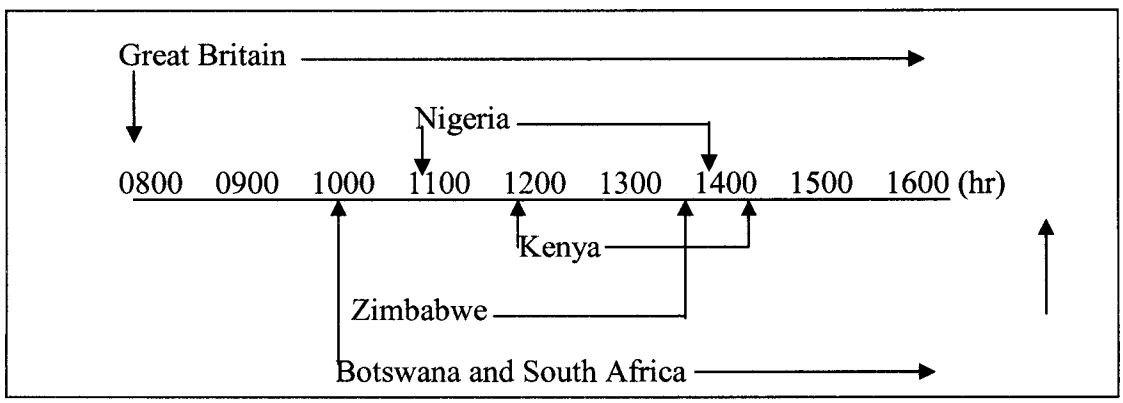

Figure 2. Sub-Saharan Africa trading hours. Noted in Greenwich Mean Time.

The study also investigated whether there was any transmission of volatility from the markets of the United States and Great Britain into the stock markets of the five Sub-Saharan markets. These international markets were selected because they are the most dominating and influential trading partners of the Sub-Saharan nations. Also, these African countries used to be colonized by Great Britain. According to Eun and Shim (1989) and Koch and Koch (1993), the U.S. financial markets are the most dominant and they affect almost all other stock exchanges.

This study is unique; there is no dissertation or published information in any reliable journal that has been undertaken such a study for all of the selected countries. The study also uses the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) and Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) models, using daily data from the Sub-Saharan Africa financial markets. For example, it uses high-frequency stock index data to analyze the level of transmission of volatility within the Sub-Saharan region. Also, there is no recent study to investigate the transmission of volatility of the Sub-Saharan markets from the United States or Great Britain.

The study focuses on the influence of exchange rate volatility among the five Sub-Saharan countries. The period of the study is January 1998 to April 2004. This time frame was chosen because it includes a sudden increase in the number of stock exchanges, the quality of the data, and data availability.

Definition of Terms

BSE Index (Botswana): A weighted-average index of the Botswana Stock Exchange. It is weighted according to the volume of shares in issue and the current bid price, including equities and Botswana Development Corporation (BDC) bond.

NSE Index (Kenya): A market capitalization weighted average index calculated from shares prices of 20 stocks listed in the stock exchange of Kenya.

NSE Index (Nigeria): A market capitalization weighted average index calculated from shares prices of all common stocks listed in the stock exchange of Nigeria.

JSE Index (South Africa): A price index formed as the total market capitalization divided by the market divisor. The divisor is defined as the base value capitalization; it is attached to all corporate actions on market.

ZSE (Zimbabwe): The industrial market capitalization weighted average index calculated on capital weighted basis with base period index at 100.

Standard & Poor's 500 (S&P 500): A basket of 500 U.S. stocks that are considered to be widely held. The index is weighted by market value, and its performance is thought to be representative of the U.S. stock market in general

FTSE 100 (Great Britain): This index is made up of the UK's 100 largest companies by market capitalization, representing approximately 80% of the UK market. It is recognized as the measure of the UK financial markets.

Stock return volatility: The daily stock index compounded return. It is calculated by taking the logarithm of the daily stock index multiplied by 100, that is,

$$(R_t = \ln(\frac{P}{P_{t-1}}) * 100$$

where R_t is the stock return volatility and P is the studied country daily stock index Akgiray, 1989).

Exchange rate volatility: The exchange rate is defined as the price of one currency expressed in terms of another currency. That is, it is the official value of the studied country's monetary unit at a given date or over a given period of time, as expressed in units of local currency in terms of the U.S. dollar and as determined by

international market forces. The exchange rate volatility is expressed by calculating the daily percentage change of each variable value (Kirativanich, 2000; Songcharoen, 1999 (i.e., $C_t = (\frac{X_t - X_{t-1}}{X_{t-1}}) * 100$, with C_t being the percentage exchange rate change and X_t the currency at day t.

Summary

The motivation for the study stems from the lack of information being transmitted from Sub-Saharan Africa to the global market. By analyzing the level of regional and international interdependence, the study will provide literature to show whether a failure of one or more markets can result in the crash of all African markets. This study pinpoints whether the Sub-Saharan markets are communicating with one another. In addition, through extensive literature review, the researcher found no reputable published document or dissertation that has explored the above mentioned areas. Therefore, the study would be helpful in providing contributions for further study in the field of emerging financial markets.

This study may help both government and private sectors to solve pressing economic problems, to develop and expand business, and to maintain or gain competitive advantages. The study investigates the relationships among the Sub-Saharan countries, explores the influence of exchange rate volatility into the Sub-Saharan Africa financial markets, and investigates the transmission of volatility among the selected African countries.

Chapter 1 presents the introduction, background information, scope of the study, and the motivation for the research. Chapter 2 reviews the Sub-Saharan financial markets, including the literature on financial market volatility, correlation,

and transmission of volatility. Chapter 3 presents the theoretical back ground. In this chapter the GARCH and EGARCH models are introduced. Other statistical models (e.g., the Pearson correlation model and the variance decomposition model) are also discussed. The data collection procedures and data sources are presented. The chapter discusses the limitations and assumptions related to this study.

Chapter 2

REVIEW OF LITERATURE

The first section of this chapter provides the necessary economic background of the Sub-Saharan Africa financial markets. The second section provides the theoretical framework of the studied Sub-Saharan countries and their stock markets. The section also provides background literature about the relationship between exchange rate volatility and stock market volatility. The third section reviews the literature on transmission of stock market volatility across borders.

The Sub-Saharan Economies and Financial Markets: An Overview

In 2003 Sub-Saharan Africa had a population of over 851 million (Demographic Trends, 2002). Within the past decade, new but aggressive financial markets have emerged; for example, nine new exchanges have been created, bringing the total number to 21 stock markets with over $140 billion in market capitalization. These stock markets have had a high rate of return. For example, in 1997 Botswana had a 96% rate of return and in 1996 Zimbabwe had a 35% rate of return. According to Nkontchou (Cox, 2004), the Ghana stock exchange posted a gain of 144%, Kenya had 112%, and Uganda had 140%, making them among the world's best performers.

> Many of the companies listed on these African exchanges—more than 2,200 in 2002—generate high returns for their shareholders. In 2002, for example, the JSE index showed an average return of 27.9 per cent (calculated in US dollars), while the Abidjan exchange reached 27.4 per cent, Ghana 33.3 per cent and Botswana 41.4 per cent. By contrast, that same year, the US's Standard and Poors 500 index registered a 22.4 per cent loss, while the combined index for all emerging markets fell by 7.5 per cent. (Harsch, 2003, p. 12)

The Sub-Saharan markets are starting to establish themselves as the future movers, and their presence is being recognized within the major financial traders. Okereke-Onyiuke (2003) stated that this profitable gain is because the Sub-Saharan financial markets are still in their growth stage and that they are new ventures with room for expansion. Some of the other positive indicators are that nine Sub-Saharan stock exchanges recorded a cumulative return of over 15% (United Nations Development Program, 2003). Within the past 4 years, the African equity markets have outperformed other emerging markets. According to Seaman (2003), the African companies listed on the New York Stock Exchange (NYSE) recorded trading volumes greater than those of other non-United States listed firms.

Unfortunately, some limitations are hindering these Sub-Saharan financial markets. For example, they have limited trading hours, the trading is dominating by a few active stocks, and the markets do not have an established positive track record.

The Johannesburg stock exchange is the largest stock market in Sub-Saharan Africa. It is ranked within the top 20 in the world in terms of market capitalization. The Nigeria stock exchange is the second largest in the Sub-Saharan region; its size in terms of capitalization is far behind the Johannesburg stock exchange. The Zimbabwe stock exchange is ranked third, followed by the Nairobi stock exchange and then the Botswana stock exchange.

Table 3 shows the characteristics of the African financial markets. As shown in the table, the five studied countries have a total of 875 listed companies that are not integrated. The countries have different trading times but are within a 3-hour trading time frame (i.e., Ivory Coast is in the Greenwich meridian at West Africa, while Kenya is at Greenwich meridian plus 3 hours in East Africa). The number of listed companies ranges from 3 in Algeria to over 473 in South Africa.

Table 3

Characteristics of Sub-Saharan Africa Stock Markets

Country	Index	Number of listed companies	Value traded (mill USD)	Trading hours
Algeria	LA	3	< 0.5	9:30-11:30 am (M)
Botswana	BSE	19	62	9-4 pm (M-Th), 9-12 pm (F)
Ghana	GSE	24	11	9-12 pm (M, W, F)
Ivory Coast	BVRM	38	16	8:30-12:30 pm (M, W, F)
Kenya	NSE	50	36	10-12 pm (M-F)
Malawi	MSE	8	3	9-12 pm (M-F)
Mauritius	SEMDEX	40	59	9-11:30 am (M-F)
Namibia	NSX	13	192	9-5 pm (M-F)
Nigeria	NSE	195	468	11-2 pm (M-F)
Swaziland	SSX	5	< 0.5	10-12 pm (M-F)
South Africa	JSE	472	76792	9-4 pm (M-F)
Zambia	LuSE	11	2	10-1 pm (M-F)
Zimbabwe	ZSE	77	131	9-12:15 pm (M-F)

Note. Source: *African Stock Markets Handbook*, by United Nations Development Program, 2003, New York: Author.

Table 4 demonstrates the growth of Sub-Saharan Africa in terms of the gross domestic product (GDP). As shown, the average GDP growth declined over the period. This can be attributed to factors such as global and regional political strife, bad weather (effect on agriculture subsidies), low literacy rates, low saving rate, high

Table 4

Real Growth of Gross Domestic Product From 1998 to 2003

	1998	1999	2000	2001	2002
Botswana	6.02	5.39	7.55	5.27	3.08
Ghana	4.70	4.41	3.70	4.20	4.50
Ivory Coast	4.74	1.59	-2.47	0.35	-1.79
Kenya	1.62	1.29	-0.16	1.13	1.03
Nigeria	1.88	1.10	4.2	2.90	-0.90
South Africa	0.75	2.03	3.5	2.83	2.98
Zimbabwe	2.89	-0.7	-4.88	-8.42	-5.58

Note. Source: *The World Fact Book*, by U.S. Central Intelligence Agency, 2004, retrieved February 20, 2004, from http://www.cia.gov/cia/publications/factbook/index.html

debt (Krugman, 1997), and declining world trade. When compared to the world GDP growth rate, the Sub-Saharan Africa average growth rate was lower than that of Asian countries, which had witnessed a GDP growth of over 5%, and Latin America (4%). However, according to the United Nations, the growth rate for the African region is projected to be 5-7% within the next few years.

The Growth of the African Stock Market

Africa has 53 countries and 21 stock exchanges. It is the home of the Johannesburg stock exchange, which had a market capitalization of over 208.5 billion USD and a liquidity of 32.2% in 2002. According to figures from the Johannesburg stock exchange Web site, in 2002 the Namibia stock exchange had 13 listed

companies with a market capitalization of $231 million. The Ghana stock exchange had 24 listed companies with a market capitalization of $384 million. The Zambian stock exchange had 11 listed companies with a market capitalization of $231 million. The Zimbabwe stock exchange had 77 listed companies with a market capitalization of $11,689 million.

Within the past decade, there have been favorable political scenes that have resulted in a boost of the Africa stock markets and an increasing activity in their capital markets as a means of raising funds. This is a turn of events.

> Much of the development history of Africa has emphasised the banking sector as the primary source of funds, in part due to the inherited legacy of commercial banks set up to support colonial trade. As a consequence of this, many countries have been reluctant to introduce securities markets at all. (Piesse & Hearn, 2002a, p. 2)

The switch from a bank-oriented economy to a stock market-oriented economy started in the 1980s because Sub-Saharan Africa financial development was witnessing a very slow growth. In the 1990s the countries undertook financial structure adjustments and sound economic reforms, mainly because of external pressure from such forces as the Bretton Woods institution, the World Bank, and other donor markets. Benefits from these restructurings include a surge in registered African equities in the developed nations financial markets (Seaman, 2003). Although they are smaller, the Sub-Saharan markets have beaten the odds and are increasing their share values worldwide as investors recognize the low correlation between the African equities and more prominent international equities.

Sub-Saharan Africa Correlation Level

According to Harvey (1995), African equities have low or negative correlation with more-developed financial markets. The Sub-Saharan region has the fewest stock

markets in the world, and most of them are just starting to establish themselves. As in other frontier markets, the Sub-Saharan stocks rise and fall for reasons that are different from those of the developed markets. Examples include power outages, hyperinflation, political unrest, floods, drought, or even rumors. For example, La Lupa (2000) explained that inflation causes people to sell their stocks in the U.S. stock market, but in the Latin American markets investors are known to buy more shares during inflation. Because the Sub-Saharan stock markets have low correlation with the developed or efficient stock markets, as shown in Table 5, they are an ideal place to diversify.

According to Salami (2002), an Africa All-Share index was developed in 1999 to track the development of African stock markets. This index omits the South African market because of its size and close relationship to other dominating international stock markets (Collins & Biekpe, 2001). The Africa All-Share index covers 500 of the largest companies listed on African stock exchanges. It is a composite measure of the performance of the African stock exchanges. The correlation of this index to the other world markets is shown in Table 5.

Sub-Saharan Africa is known to have an economic disadvantage: Although the continent is blessed with abundant minerals, including oil, gold, and diamonds, the region is also the home of some of the worst corruption and economic violence in the world. According to United Nations economic data there have been some changes within the past decade and a growing number of countries in Sub-Saharan Africa are showing signs of economic and political improvement. For example, there has been a sudden decrease in bloody coups, and fair elections are being conducted, as in the case of Kenya during the 2002 elections. These achievements are demonstrated by a gain in market capitalization, as shown in Table 6.

Table 5

Correlation Matrix: International and Africa All-Share Financial Markets, Based on Daily Returns January 1, 1999, Through May 31, 2002

	African All-Share	JSE	FTSE	Nikkei 225	S&P 500	MSCI World
Africa All-Share	1.00					
JSE All-Share	0.03	1.00				
FTSE All-Share	-0.04	0.46	1.00			
NIKKIE – 225	0.04	0.30	0.21	1.00		
S&P 500	-0.05	0.24	0.41	0.12	1.00	
MSCI World	-0.01	0.41	0.66	0.34	0.89	1.00

Note. JSE = Johannesburg stock exchange, FTSE = Financial Times Actuaries All Share Index, S&P = Standard and Poor's, MSCI = Morgan Stanley Capital International. Sources: African financial markets.

African Trading Blocks

As the Sub-Saharan African nations try to turn around their economies, they have started to realize that the stock market is especially a good way to encourage individual savings. However, some of the Sub-Saharan stock markets are under-developed and undercapitalized; for example, some of them have less than 10 registered companies. In order to encourage the growth of the Sub-Saharan region as a block, there is a growing movement to merge the African stock markets and to cross-list on multiple exchanges (McCulloch & McPherson, 2001).

The African Stock Exchange (ASE) was formed in 1993. Its primary work is to promote the development and integration of the African stock markets; its other objective is to remove restrictions to the free movement of people, goods, services,

Table 6

Africa Market Capitalization (in Millions of Dollars), 1998-2002

	1998	1999	2000	2001	2002
Algeria	-	306	303	199	145
Botswana	724	1,052	978	1,269	1,717
Ivory Coast	1,818	1,514	1,185	1,165	1,329
Egypt	24,381	32,838	28,741	24,335	26,245
Ghana	1,384	916	502	528	382
Kenya	2,024	1,409	1,283	1,050	1,676
Malawi	148	161	212	152	107
Mauritius	1,849	1,643	1,335	1,061	1,324
Morocco	15,676	13,695	10,899	9,087	8,319
Namibia	429	691	311	151	201
Nigeria	2,887	2,940	4,237	5,404	5,989
South Africa	170,252	262,478	204,952	139,750	182,616
Swaziland	85	95	73	127	146
Tanzania	236	181	233	398	695
Tunisia	2,268	2,706	2,828	2,303	1,810
Uganda	-	-	37	34	52
Zambia	301	280	236	217	231
Zimbabwe	1,310	2,514	2,432	7,972	11,689

Note. Source: *African Stock Markets Handbook*, by United Nations Development Program, 2003, New York: Author.

and capital. Some of the achievements of the ASE are the development of alliances and trading blocks as a way of increasing liquidity level. The plan is to create four major African trading region: (a) in East Africa, the exchanges of Kenya, Tanzania, and Uganda will be joined together; (b) in South Africa, the Johannesburg stock exchange will be joined to the surrounding smaller markets; (c) in North Africa, the Cairo and Alexandria stock exchanges will lead the region; and (d) in West Africa, the Nigeria and Ghana exchanges and the Bourse Régionale des Valeurs Mobilières (the Francophone regional exchange) will be in the same group.

The growth of the regional stock market is not the only thing that is being promoted. Also, numerous trading blocks have emerged or expanded within the Sub-Saharan region (Bhagwati & Panagariya, 1996; Fernandez, 1997; Gibb, 1998; Radelet, 2001). Some of these trading blocks are as follows:

1. Common Market for Eastern and Southern Africa (COMESA). The current members are Angola, Burundi, Comoros, Democratic Republic of Congo, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Namibia, Rwanda, Seychelles, Sudan, Swaziland, Uganda, Zambia, and Zimbabwe. Its main purpose is to eliminate or reduce tariffs and nontariff trading barriers.

2. East African Community (EAC). The EAC is composed of Kenya, Tanzania, and Uganda. The objectives of EAC include harmonizing tariffs and customs regimes, free movement of people, and improving regional infrastructure.

3. Economic Community of West African States (ECOWAS). Current members are Benin, Burkina Faso, Cote d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo. It is an economic and trade agreement.

4. Southern African Development Community (SADC). Current members are Angola, Botswana, the Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, and Swaziland.

5. Communauté Economique de l'Afrique de l'Ouest (CEAO). This subset of ECOWAS was founded in 1973, following Union Douaniéré et Economique de l'Afrique (UDAO) and Union Douaniéré et Economique de l'Afrique de l'Ouest (UDEAO), which were founded in 1959 and 1966, respectively. Members of CEAO are Benin, Burkina Faso, Côte d'Ivoire, Guinea (observer), Mali, Mauritania, Niger, Senegal, and Togo. It is a trade and custom union.

6. Union Economique et Monétaire Ouest Africaine (UEMOA) was formed in 1994. It is also referred to as the Franc Zone. Its members are Cameroon, Central African Republic, Chad, Comoros, Congo, Equatorial Guinea, Gabon, Guinea Bissau, Guiana, Guadeloupe, Martinique, Reunion, Mayotte, Saint Pierre, Miquelon, French Polynesia, New Caledonia, Wallis, and Futuna. It is a monetary union.

Stock Exchanges

This section provides background information about the five Sub-Saharan financial markets: the Botswana stock exchange, the Nairobi stock exchange (Kenya), the Nigeria stock exchange, the Johannesburg stock exchange, and the Zimbabwe stock exchange.

The Botswana Stock Exchange

The Botswana stock exchange was started in 1989; in 2003 it had a market capitalization of $31,668 million and a GDP of $8,800 million (U.S., 2004). Botswana is considered to have a good credit risk, compared to other African

countries. It has been experiencing a good per capita growth rate, with its main revenue generated from the sale of diamonds and tourism. Like the other African exchanges, the Botswana stock exchange growth is limited by such factors as too few indigenous companies and low liquidity levels.

The Botswana stock exchange has 19 listed companies but not all of them are actively trading. It is one of the few Sub-Saharan countries that do not have restriction on foreign ownership. The Botswana stock market index is weighted according to the volume of shares in issue and the current bid price including equities, and BDC bond; the Ministry of Finance is the overall licensing authority. The trading days are from Monday through Thursday at 9:00 a.m. to 4:00 p.m. and Friday from 9:00 a.m. to 12:00 noon. The trading method is the Outcry system, and the settlement of this stock exchange is T+5.

The Botswana stock exchange has the responsibility to operate and monitor the equity and the security market of Botswana. It contributes to the general growth of the economy by assisting in raising debt and playing host to local and international companies that conduct business in Botswana. As shown in Figure 3, this stock market has continued to grow at a steady rate.

The study tests the following hypothesis for research question 2:

1. There is a relationship between the exchange rate and Botswana stock exchange volatility.

The study tests the following hypotheses for research question 3:

1. There is transmission of stock market volatility between Botswana and Kenya.

2. There is transmission of stock market volatility between Botswana and Nigeria.

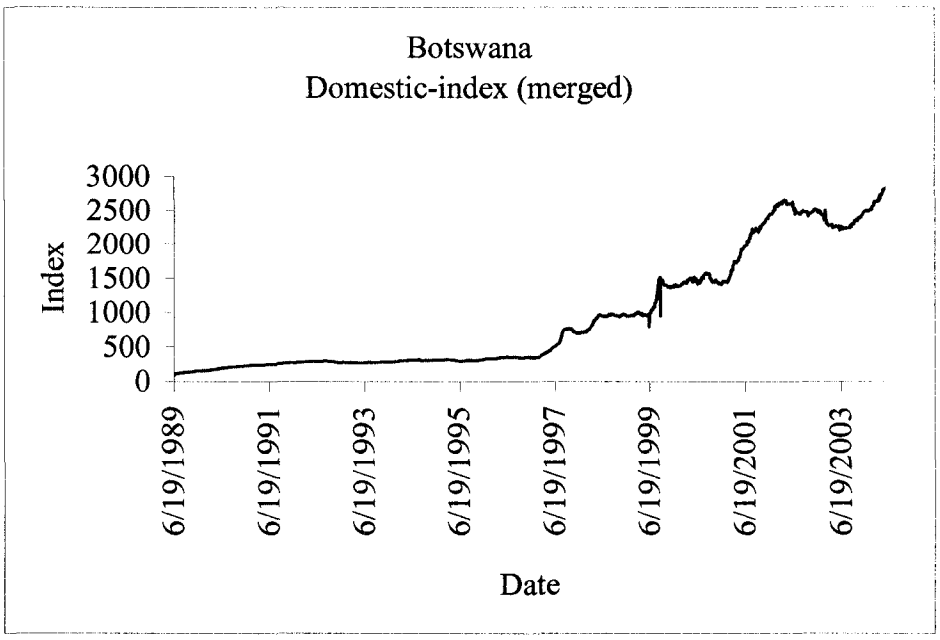

Figure 3. Performance index of the Botswana stock exchange, 1989-2003.

3. There is transmission of stock market volatility between Botswana and South Africa.

4. There is transmission of stock market volatility between Botswana and Zimbabwe.

The study tests the following hypothesis for research question 4:

1. There is transmission of stock market volatility from the United States or Great Britain into Botswana.

Nairobi Stock Exchange (Kenya)

Within the past 5 years the market capitalization of the Nairobi stock exchange has improved dramatically. The Nairobi stock exchange is the fourth-largest in the Sub-Saharan region. It was established in 1954 as a voluntary association of stock

brokers. As of 2003, it had 57 listed companies. According to Ogum and Beer (2002), it is one of the vibrant capital markets in Africa. It is a model for the emerging markets in Africa in view of its high returns on investment and well-developed market structure.

Some of the main roles of this exchange are mobilizing capital for development, promoting a culture of thrift, saving, transfer of savings to investment, promoting higher standards of accounting, resource management and transparency in the management of business, educational role, developing the creative and supportive role of investment, and acting as a catalyst in development rather than as a traditional regulator.

The Nairobi stock exchange has experienced a positive growth within the past decade. Among the factors that have created this positive change are low interest rates, positive political expectations, and the entry of fund management institution. Other factors that have had a great impact on the Nairobi stock exchange are that (a) in 1994 the Kenyan exchange controls were abolished, which resulted in Kenya shilling floatation within the international markets; (b) the government started the privatization of parastatals; (c) foreign investors were allowed to buy the majority of the privatized industries; and (d) in 1995 the government eased restrictions on foreign portfolio investment in the domestic market. Figure 4 shows the growth rate of the Nairobi stock exchange. As the graph demonstrates, there was a period of volatility, especially during 1994, when the government started to allow foreign investors into the market.

The study tests the following hypothesis for research question 2:

1. There is a relationship between the exchange rate and Kenya stock exchange volatility.

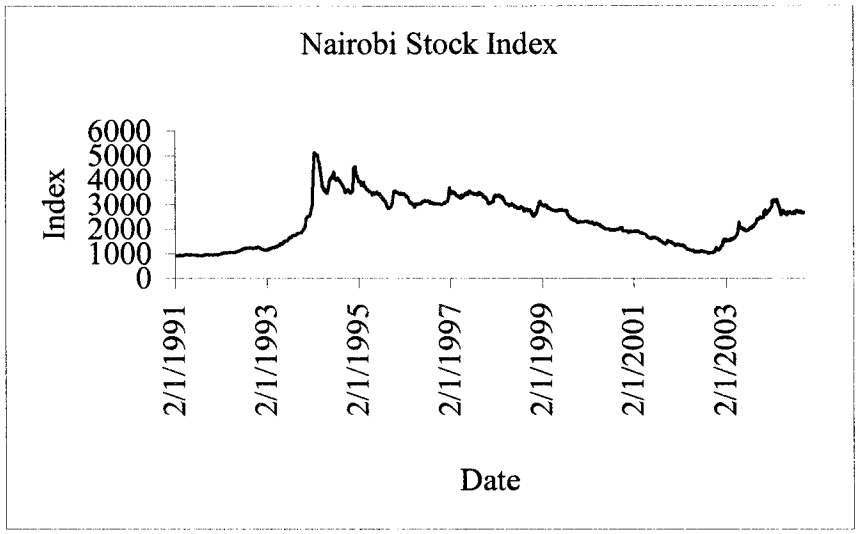

Figure 4. Performance index of the Nairobi, Kenya stock exchange, 1991-2003.

The study tests the following hypotheses for research question 3:

1. There is transmission of stock market volatility between Kenya and Nigeria.

2. There is transmission of stock market volatility between Kenya and South Africa.

3. There is transmission of stock market volatility between Kenya and Zimbabwe.

The study tests the following hypothesis for research question 4:

1. There is transmission of stock market volatility from the United States or Great Britain into Kenya.

Nigeria Stock Exchange

The Nigeria stock exchange was established in 1960 as the Lagos stock exchange; it was renamed the Nigerian Stock Exchange in December 1977. A regulatory body known as the Securities and Exchange Commission (SEC) was established

in 1978, with the role of supervising the operation of the exchange, investigating allegations of impropriety, administering prices in the primary market, and regulating the operation of the stock market, as well as the registration of securities. It is the second largest of the Sub-Saharan stock markets. In 2002 it had a total of 195 listed companies and a market capitalization of $5,989 million. This stock exchange is highly regulated.

The Nigerian stock exchange operates a Call-Over system. For example, once trading starts, the securities are called out by an officer of the exchange, for the dealing members to indicate interest by either bidding for or offering the mentioned security at an asking price. As shown in Figure 5, the exchange experienced a period of high volatility during the 1997 because of political unrest.

The study tests the following hypothesis for research question 2:

1. There is a relationship between the exchange rate and Nigerian stock exchange volatility.

The study tests the following hypotheses for research question 3:

1. There is transmission of stock market volatility between Kenya and South Africa.

2. There is transmission of stock market volatility between Nigeria and Zimbabwe.

3. There is transmission of stock market volatility between Kenya and Zimbabwe.

The study tests the following hypothesis for research question 4:

1. There is transmission of stock market volatility from the United States or Great Britain into Nigeria.

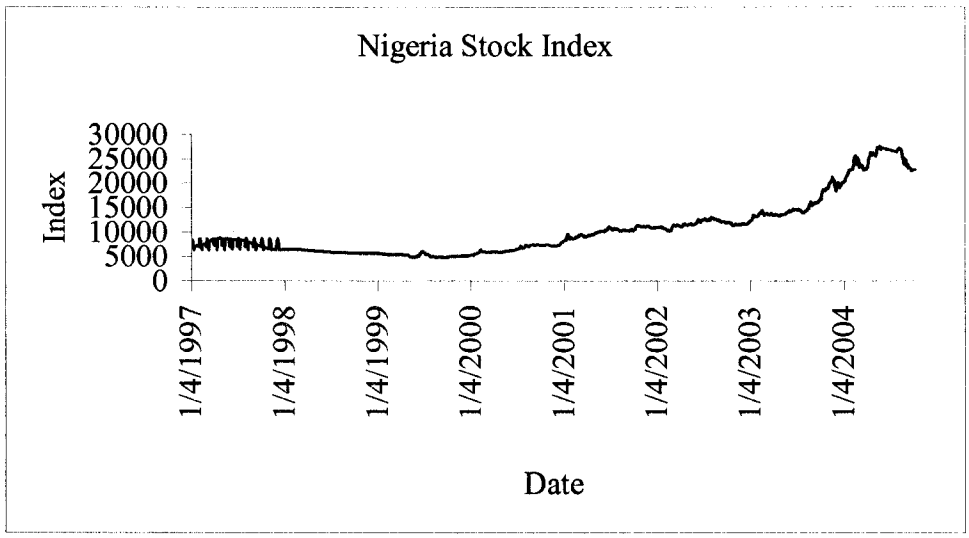

Figure 5. Performance index of the Nigerian stock exchange, 1997-2004.

Johannesburg Stock Exchange

The South Africa stock exchange was established in 1887; it is the oldest in Africa. In 2002 it had 472 listed companies with a market capitalization of $200 billion. It is the 18th-largest exchange in the world; it is the largest in Africa in terms of size and capitalization. It is well recognized in global terms as a major player and therefore, unlike its Sub-Saharan counterparts, it benefits from inflow of foreign investment. It is regulated by the Stock Exchanges Control Act of 1947 (as amended occasionally) and supervised through a body of rules and regulations enforced by the Johannesburg Stock Exchange Committee. The Johannesburg stock exchange opens daily Monday to Friday from 9:30 a.m. to 1:00 p.m. 2:00 p.m. to 4:00 p.m.

Figure 6 shows that this stock exchange experience considerable volatility. Because of its size and integration with the international market, the Johannesburg stock exchange is bound to be affected by international events more than local ones.

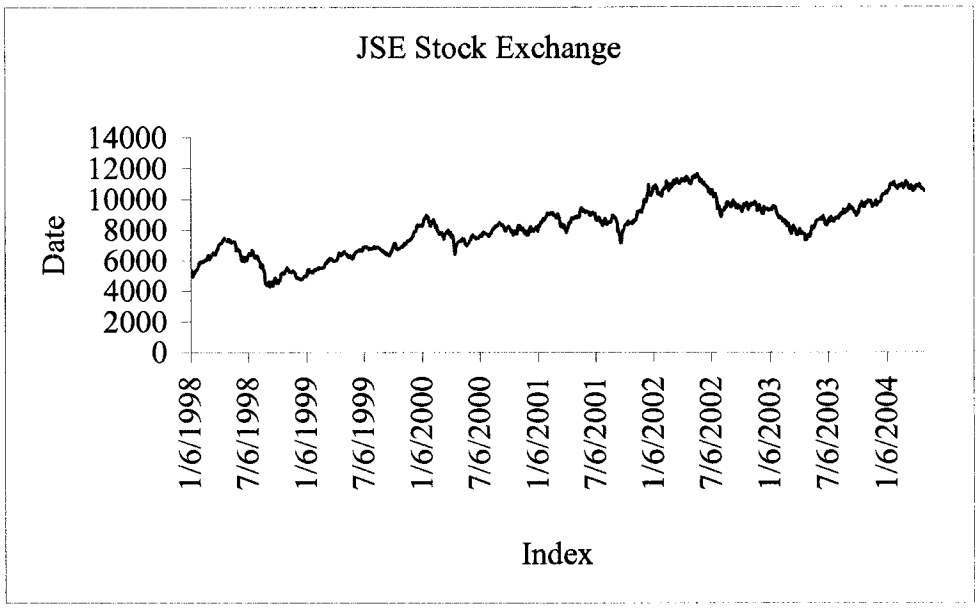

Figure 6. Performance index of the South Africa stock exchange, 1998-2004.

The study tests the following hypothesis for research question 2:

1. There is a relationship between the exchange rate and Johannesburg stock exchange volatility.

The study tests the following hypothesis for research question 3:

1. There is transmission of stock market volatility between South Africa and Zimbabwe.

The study tests the following hypothesis for research question 4:

1. There is transmission of stock market volatility from the United States or Great Britain into South Africa.

Zimbabwe Stock Exchange

The Zimbabwe stock exchange was established in 1894. It has 75 listed companies, making it the third-largest in Sub-Saharan Africa. This stock exchange

has two indices: the Zimbabwe Industrial Index and the Zimbabwe Mining Index. Its main function is to raise capital for the government through issuing equities, debentures, and depository receipts. Other functions of this stock exchange are assisting new and old companies to be competitive and providing a buyer-and-seller meeting place. This stock market is regulated by the Zimbabwe Stock Exchange Act Chapter 24:18 of 1996. It uses the call-over system on the floors of the exchange and the settlement is T+7 against physical delivery of script. Foreign investment regulations on the Zimbabwe stock exchange are limited to 10% per individual and 40% to the total company.

The government regulates transaction fees but the prices of new issues are market determined. The trading floor is open Monday through Friday from 8:00 a.m. to 12:00 noon, and the business office of the exchange remains open until 4:30 p.m. However, the operating time of the Zimbabwe stock exchange is 9:00 a.m. to 12:00 noon Monday through Friday. As Figure 7 shows, this exchange experiences strong volatility, caused by such factors as political unrest and international sanctions.

The study tests the following hypothesis for research question 2:

1. There is a relationship between the exchange rate and Zimbabwe stock exchange volatility.

The study tests the following hypothesis for research question 4:

1. There is transmission of stock market volatility from the United States or Great Britain into Zimbabwe.

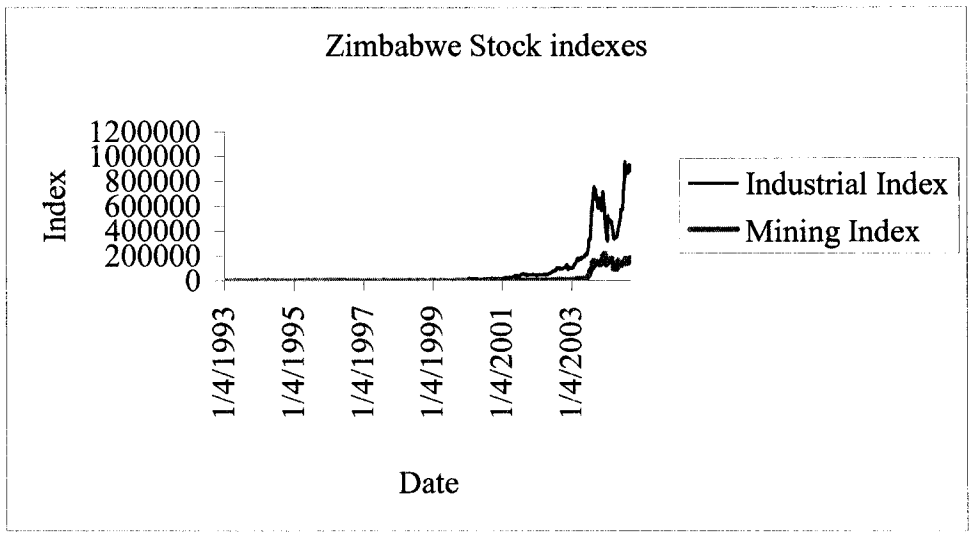

Figure 7. Performance index of the Zimbabwe stock exchange, 1993-2003.

Theoretical Review

This section reviews theoretical literature related to the study. It includes the volatility of stock exchange and its impact of stock returns, spillover effects, and transmission of volatility.

Correlation, Portfolio Selection, and Diversification Theory

Harry Markowitz (1952) promoted the idea of market correlation with regard to investing. According to Markowitz, a portfolio should be composed of low- or negatively correlated stocks to reduce unsystematic risk. When diversifying in the international community, it would be advisable to select countries with low, no, or negative financial market correlation

William Sharpe (1963), 1990 Nobel Prize winner, suggested that a portfolio diversification be based on the beta value. In his study, Sharpe published the Capital

Asset Pricing Model (CAPM), which decomposes a portfolio's risk into systematic and specific risk. Systematic risk is the risk of holding the market portfolio. As the market moves, each individual asset is more or less affected. To the extent that any asset participates in such general market moves, that asset entails systematic risk. Specific risk is considered to be the risk that is unique to an individual asset. It represents the component of an asset's return that is uncorrelated with general market moves. Sharpe suggested that the correlation of the selected stocks be measured against the S&P 500 (with the S&P 500 being considered as a neutral risk).

According to CAPM, the market place compensates investors for taking systematic risk but not for taking specific risk. This is because specific risk can be diversified away. When an investor holds the market portfolio, each individual asset in that portfolio entails specific risk; however, through diversification, the investor's net exposure is just the systematic risk of the market portfolio.

By analyzing the correlation of various portfolios, an investor is able to make a sound judgment. In order to reduce the level unsystematic risk, it is advisable to diversify into the international markets with low, no, or negative correlation.

Bessler and Yang (2003) studied nine major stock markets to investigate their interdependence. They used the error correction model and directed acyclic graphs. In their study they found that those of Great Britain, Switzerland, Hong Kong, France, and Germany were influenced by the U.S. financial markets. They also concluded that the U.S. market had a strong impact on price movements in the other major stock markets. They described the Japanese financial market as highly exogenous.

Ng (2000) studied the volatility spillover from Japan and the United States to six Pacific Basin equity markets. He found that regional and world markets contributed to the market volatility in the Pacific Basin region. Rahman and Yung (1994)

reported an increase in correlation between the Atlantic and Pacific financial markets. They attributed this to a growing level of integration of international economies. They also stated that this had increased the level of systematic risk. Johnson and Soenen (2002) investigated the volatility and integration of the Asian and Japan financial markets. They found that the financial markets of Australia, China, Hong Kong, Malaysia, New Zealand, and Singapore were integrated with the stock market in Japan.

Eun and Shim (1989) studied the daily stock market returns of nine major markets. They found existence of substantial interdependence among the national stock markets. They also concluded that the U.S. financial markets were the most dominant. Such findings were confirmed by Hamao et al. (1990), who reported a significant one-way spillover effect from the U.S. and UK stock markets to the Japanese market. Also, Park and Fatemi (1993) and Janakiramanan and Lamba (1998) stated that the U.S. market was most influential to the Pacific Basin countries.

Bergstrand (1985) showed that geographical factors have little effect on the correlation rate. He noted that variables associated with physical geography (e.g., great circular distances and market size) and psychological geography (e.g., neighboring countries, having past colonial links, common language) may not be key contributors to correlation and market linkages.

Exchange Rate Volatility

One of the theories that support the existence of a relationship between exchange rates and stock prices is the portfolio balance model. This model indicates that stock price influences exchange rate. The model explains that continuous increases in stock price can increase the demand for money and, in turn, increase

interest rates. Higher interest rates attract foreign investors, which can result in domestic currency volatility.

Another theory suggests that volatility moves from exchange rate to the stock market. This happens when currency depreciation increases sales volumes and profits of a company. The increasing demand forces the price of the company stock to increase.

The third theory is the asset market approach, which suggests that there are no relationships between exchange rate and stock price. According to Muhammad and Rasheed (2003), this theory treats the exchange rate as an essential part of the price of an asset in terms of foreign currency.

Alsalman (2002) described volatility as anything that is changeable. He explained that high volatility could be an indication of market disruption, unfairness, and infunctionability. The causes of foreign exchange volatility were explained by McCulloch and McPherson (2001), who stated that the total amount of aid flows combined with debt relief could promote real appreciation or reduce downward pressure via market forces. Thomas and Nash (1991) stated that among the export-enhancing policies that were successful in curbing volatility in East Asia included keeping the real exchange rate at a level consistent with profitable exporting and allowing exporters free access to imported inputs at world prices without administrative delays. According to the World Bank (2000), the reforms of the early 1990s helped Sub-Saharan Africa to implement measures that helped to stabilize their currencies.

According to Jefferis (1995), investors are fearful of uncertainty of exchange rate because governments normally curb an unstable exchange rate by using a devaluation policy. It is important that there be an understanding of the impact of flow of

foreign exchange rate volatility because it acts a signaler to any potential international investor; also, exchange rate volatility plays a crucial role in portfolio decisions and economic development.

Within the past decade there has been an increase in exchange rate volatility. The main cause of this volatility is the growth of international trade and the expansion of a freely floating exchange rate. Also, foreign exchange volatility can be caused by an overvalued official exchange rate. There is adequate research on the influence of exchange rate into the developed nations and Asian financial markets (e.g., Aggarwal, 1981; Branson, 1983; Caprio & Demirguc-Kunt, 1998; Chiang, Yang, & Wang, 2000; Coulson & Robins, 1985; Dornbusch & Fischer, 1980; Frankel, 1983; Gavin, 1989; Greenwood & Smith, 1997; Nieh & Lee, 2001; Songcharoen, 1999).

Aggarwal (1981) noted that stock prices and exchange rate have a positive correlation, but Ma and Kao (1990) noted that they have a low or negative correlation. These studies, together with Bahmani-Oskooee and Sohrabian (1992) and Ajayi and Mougoue (1996), concentrated on the industrial economies. Only a limited body of research has attempted to analyze the influence of exchange rate on the Sub-Saharan Africa financial markets. An interesting finding was noted by Bekaert and Harvey (1997) and Susmel (1998), who stated that major world events have little impact on markets such as the Sub-Saharan African financial market.

Several theoretical studies (e.g., Cushman, 1983; Ethier, 1973; Gagnon, 1993) have shown that an increase in exchange rate volatility has adverse effects on a country's financial market. McKinnon and Ohno (1997) explained that the volatility of foreign exchange can cause several problems in the economy; for example, it can result in a decrease in investor confidence in the stock market, cause financial default, or create a market inefficiency. On the other hand, Belanger and Gutierrez (1990)

argued that there is no significant influence of exchange rate volatility on the financial markets, citing that other factors, such as the local currency pricing, have larger influences on the markets. Macroeconomic policies can affect the growth performance through their impact on certain economic variables. For example, a high rate of exchange raises the cost of borrowing, which lowers the rate of capital investment.

Most of the available foreign exchange literature indicated that the volatility of the exchange rate has significant influence on stock market volatility (e.g., Bodart & Reding, 1999; Griffin & Stulz, 2001; Kearney, 1998; Phylaktis & Ravazzolo, 2000). Kearney found that exchange rate volatility was a more significant determinant of volatility of stock market than interest rate volatility. Griffin and Stulz found that exchange rate shocks are important for the stock returns of industries that produce international goods.

Hopper (1997) wrote that some of the reasons that volatility of exchange rates transmits is that the fundamentals of exchange rates, especially trade and investment, are related. Therefore, any new information about fundamentals might affect the volatility of corresponding countries at the same time. Hopper also stated that market psychology can create volatility in exchange rates.

King and Wadhwani (1990) stated that, during financial market crises, foreign exchange traders are unable to identify the source of shocks, especially between global shocks and local shocks. Attempts to identify the source of shocks from observing exchange rates could lead to correlation between exchange rate volatility and transmission of idiosyncratic errors to the other exchange rates. Eichengreen, Rose, and Wyplosz (1996) stated that external currency crises can increase the probability of attacks on domestic currency, even after taking ground rules into consideration.

Choudhry (2001) stated that extreme variations in exchange rates could have significant effects on stock price indices because of the changes that are occurring in the Sub-Saharan financial markets. Despite several studies that have been undertaken to investigate the influence of macroeconomic volatility into the stock markets, none has explored the area of Sub-Saharan Africa extensively. Therefore, it is important to document the influence of macroeconomic activities such as the exchange rate on the Sub-Saharan financial markets.

The Transmission of Volatility

Hamao et al. (1990) were among the first to propose the idea of volatility spillover (see also, Bae & Karolyi, 1994; Booth, Martikainen, & Yiuman, 1997; Chelley-Steekey & Steely, 1996; Kim & Rogers, 1995). However, these studies have concentrated on developed economies and Asian markets; unfortunately, there is limited research on the Sub-Saharan financial markets. Among the few studies that have covered the African financial markets volatility transfer are Piesse and Hearn (2002a, 2002b) and Appiah-Kusi and Pescetto (1998).

Globalization, integration of financial markets, and expanding information technology have fueled the transmission of volatility. This subject has been deeply researched by Hamao et al. (1990), Koutmos and Booth (1995), Chiang and Yang (2003), and Laopodis (1998).

The crash of stock markets in 1987 was a major economic event. Roll (1988) stated that most of the major stock markets lost more than 20% of their value, and Aderhold, Cumming, and Harwood (1988) noted that the loss was equivalent to $1.2 trillion. Speculation about the motivations associated with the crash were numerous. Among the suspected causes of the 1987 crash were macroeconomic and microeco-

nomic forces (Limmack & Ward, 1990; Malliaris & Urrutia, 1992; Roll, 1988). Their theories suggested that factors such as budget deficits, balance of payments, speculative activities, and stock market overvaluation were among the causes of the 1987 financial market crash.

The arbitrage pricing theory was pinpointed as a cause of the stock market crash by Thorbecke (1994) and Limmack and Ward (1990). This theory suggested that trade deficits created a methodical risk that prompted the decline of stock prices. Limmack and Ward analyzed 270 companies in Europe.

Sabri (2002) stated that the increasing level of cross listing was creating linkages among stock exchanges. He stated that, when firms cross list across borders, they tend to increase the movement of stock market prices. Other studies that have reported a similar view are Hargis (2000) and Domowitz, Jack, and Madhavan (1998).

The 1987 stock market crash was suggested to have started in the United States USA (Goodhart, 1988); Rahman & Yung, 1994), but this suggestion was contradicted by Roll (1988). However, Malliaris and Urrutia (1992) and Najand (1996) stated that the cause of this phenomenon was a global simultaneous reaction. Regardless of the cause or the origin of the 1987 stock market crash, the transmission of stock market volatility occurred. Malliaris and Urrutia, Najand, Lee and Kim (1993), Bennett and Kelleher (1988), Jeon and Furstenberg (1990), and Koutmos and Booth (1995) researched the transmission of stock market volatility during this period and concluded that there was little evidence of spillover effect.

Since the crash of 1987, there has been extensive research on the topic of transmission of volatility. Some (e.g., Hamao et al., 1990; King & Wadhwani, 1990; Kofman & Martens, 1997; Koutmos, 1996) concluded that negative news creates a higher volatility transfer than positive news. Eun and Shim (1989) found that the U.S.

financial market was the most influential source of volatility transfer. This study continues the research reported in the above literature by analyzing the transfer of volatility among the newer markets of Sub-Saharan Africa. It also seeks to determine whether the U.S. financial market has any spillover effect on the studied African countries.

Piesse and Hearn (2002b) studied the transmission of volatility of some financial markets of the Latin America and the Caribbean region. They noted that the markets were highly illiquid, had few listed companies, and were vulnerable to financial instability and financial crises elsewhere that had spread because of inter-market contagion. Their results showed that four countries acted as hubs of activity, with each acting as a focus of activity for its neighbors: Peru, Mexico, Argentina, and Jamaica. They also found evidence of volatility transmission or spillovers between countries. They reported a strong bidirectional effect between Jamaica and Chile, Jamaica and Mexico (both transmit volatility to New York), and Jamaica (volatility spills over to Colombia).

Jefferis, Okeahalam, and Matome (2001) suggested that some of the causes of volatility transfer are removal of control on capital movement, reduced government intervention, technology advances, and increasing international trade. They studied the South African market for volatility transfer among the countries of South Africa, Zimbabwe, and Botswana. They concluded that there were linkages between the South Africa and Botswana but no linkages between Zimbabwe and the other countries. They concluded that the strong economic ties and open relationships resulted in a high level of volatility transfer between Botswana and South Africa. Other findings in this study were that, with time, there was an increasing level of

linkages between markets (i.e., increased in the 1989-1993 period to the 1989-1996 period and got higher for the 1994-1996 period).

Piesse and Hearn (2002a) used weekly data for the period 1993 to 2000 to study the volatility of 10 African financial markets. They found evidence of volatility transmission. They concluded that the transmission was strong where the countries had associations. They found that the South African economy, even though robust, was experiencing bidirectional volatility links with other countries. Also, they found that the Ghana financial market influenced the South African market but not vice versa. Booth et al. (1997) found that the Nairobi stock exchange had international integration, based on data from 1990 to 1998.

Appiah-Kusi and Pescetto (1998) used the EGARCH model to study the market spillover of African financial markets from 1990 through 1995. They found evidence of high volatility and spillover in some regions.

The present study uses the more current daily data of 1998 to 2004 to research the subject area. The study concentrates on five countries in Sub-Saharan Africa because they can provide the most reliable data. Also, the study uses the Great Britain and United States financial markets to represent international financial markets.

Chapter 3

RESEARCH DESIGN AND METHODOLOGY

This study was designed to investigate the relationships among Sub-Saharan Africa financial markets and the influence of exchange rate volatility on those markets. The study examines the nature of transmission of stock return volatility among five Sub-Saharan countries: Botswana, Kenya, Nigeria, South Africa, and Zimbabwe. It investigates the transmission of volatility from the United States or Great Britain to the Sub-Saharan financial markets.

This chapter presents the research questions, identifies the data sources, and explains the method of data collection. The statistical tests and models used to analyze the data are explained.

Research Questions

1. What is the relationship among the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

2. What is the relationship between the exchange rate volatility and the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

3. Is there any transmission of stock market volatility among the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

4. Is there any transmission of stock market volatility from the United States or Great Britain to the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

Analysis of Data

To answer research question 1, the Pearson correlation model was used. This correlation test is used to measure the strength of the linear relationship between two variables (Mason & Lind, 1992). It is the most widely used measure of correlation or predictability. This statistic method was used to investigate the relationships among the five countries (Botswana, Kenya, Nigeria, South Africa, Zimbabwe). The equation form of the Pearson correlation model is as following:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n(\sum x^2) - (\sum x)^2][n(\sum y^2) - (\sum y)^2]}} \quad (1)$$

where x and y are the studied variables and n is the number of paired observations; r ranges from -1.0 to + 1.0, the signs indicating whether the relationship is direct (+) or inverse (-). The absolute value of the coefficient indicates its strength.

To answer research question 2, the GARCH model was used. Engle (1982) introduced the Autoregressive Conditional Heteroskedasticity (ARCH) model, which was later modified by Bollerslev (1986) as the GARCH model. The GARCH model is highly recommended and widely used as a tool for measuring the influence of macroeconomic volatility on a stock exchange (e.g., Choudhry, 2001; Najand & Rahman, 1991; Ogum & Beer, 2002; Piesse & Hearn, 2002b). Other studies have applied the GARCH model as a tool to investigate the time series behavior of stock prices volatility (Akgiray, 1989; Baillie & DeGennaro, 1990; Campbell & Hentschel, 1992; French, Schwert, & Stambaugh, 1987; Glosten, Jagannathan, & Runkle, 1993; Hamao et al., 1990; Nelson, 1991).

Hall, Lilien, and Johnston (1995) explained that the GARCH (1,1) model refers to one GARCH term and one ARCH term, meaning that the specific of the error term depends upon only the past values of the dependent variable. This model is explained as:

$$Y_t = \phi Y_{t-1} + \varepsilon_t$$
$$\varepsilon_{t\,t-1} \mid \Phi_{t-1} \sim N(0, h_t)$$
$$h_t = \varpi + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} + \delta z_t \qquad (2)$$

where Y_t is the daily stock index, ε_t random error term, Φ_{t-1} is the given information and news through time, $\sim N$ is the normal distribution h_t is the variance of the error term, ϖ is the constant variance, Φ is the parameter of Y_{t-1}, α is the parameter of error, β is the parameter of variance, δ is the parameter of a predetermined exogenous variable, and z_t is the predetermined exogenous variable.

Equation 2 summarizes that variance today depends today upon a constant, while variance yesterday depends on news or information about the stock market. The equation shows that the dependent variable is dependent upon a previous value. This value is taken to be the square residual from yesterday (ARCH) and yesterday's forecast variance (GARCH), plus a determined regressor.

Although the GARCH models successfully capture thick-tailed returns and volatility clustering, they do not effectively capture the leverage effect. This is because the conditional variance is a function only of the magnitudes of the lagged residuals and not their signs. Also, in the GARCH model, constraints must be put on the coefficient to ensure nonnegativity.

Therefore, to examine the transmission of volatility among the Sub-Saharan Africa financial markets, the EGARCH model was applied. This was because this

model allows a more flexible dynamic lag structure and does not require symmetry. Another reason for using the EGARCH model is that it is able to capture the influence of both the bad (market retreats) and good (market advances) news.

To answer research questions 3 and 4, the EGARCH model was applied. The EGARCH model was presented by Nelson (1991). It loosens the positivity constraints from the standard GARCH but keeps the nonnegative constraint on the volatility for the conditional variance. The EGARCH model also benefits by the fact that there are no parameter restrictions; thus, the possible instabilities of optimization routines are reduced.

Using a method similar to that used by Piesse and Hearn (2002a) and Ogum and Beer (2002), the EGARCH model is stated as ARCH(1) form as follows:

$$\sigma_t^2 \equiv \mathrm{E}\{\varepsilon^2{}_t \left| \Omega_{t-1} \right.\} = \varpi + \alpha \varepsilon^2{}_{t-1}, \varpi, \alpha \geq 0 \tag{3}$$

where Ω_{t-1} is the information set. It includes ε_{t-1} and its history.

The ARCH(p) is rewritten as (by varying the lag length):

$$\sigma_t^2 = \varpi + \alpha_1 \varepsilon^2{}_{t-1} + \alpha_2 \varepsilon^2{}_{t-2....,} \alpha_p \varepsilon^2{}_{t-p,} \omega, \alpha_i, \geq 0 \tag{4}$$

The GARCH (1,1) where $\omega, \alpha, and \beta$ are the estimated parameters is as follows:

$$\sigma_t^2 = \varpi + \alpha_1 \varepsilon^2{}_{t-1} + \beta \sigma^2{}_{t-1}, \alpha, \beta \geq 0 \tag{5}$$

In order to allow for the asymmetry, the EGARCH model is written as follows:

$$\log \sigma_t^2 = \omega + \beta \log \sigma_{t-1}^2 + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}}, \gamma \neq 0 \tag{6}$$

In this case the $\varpi, \beta, \alpha, and \gamma$ are the perimeters to estimates. Since the level $\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$ is included, the model is asymmetric while $\gamma \neq 0$. When $\gamma < 0$, the positive shocks generate less volatility than negative shocks. The model is written as a logarithm to ensure that the variance never becomes negative.

The final model is written as follows:

$$\log\sigma^2{}_{i,t} = \omega + \beta \log\sigma^2_{i,t-1} + \alpha_i \left| \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} \right| + \gamma \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \theta\sigma^2{}_{j,t-1} \quad \gamma \neq 0 \tag{7}$$

where i is the dependent country stock index and j is the independent country stock index. The estimated parameter θ displays the volatility spillover between the markets.

$$\log\sigma^2{}_{i,t} = \omega + \beta \log\sigma^2_{i,t-1} + \alpha_i \left| \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} \right| + \gamma \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \theta\sigma^2{}_{j,t-1} \tag{8}$$

Variance Decomposition

After estimating the EGARCH models, it is possible to obtain the variance decompositions. The purpose of the variance decomposition test is to determine the importance of the various markets in causing fluctuations in returns of those markets. This study applied the Choleski method; Sims (1986) and others have noted that, when there is contemporaneous correlation among variables, the choice of an ordering in the Choleski decomposition may make a significant difference in interpretation of impulse responses and forecast error variance decompositions. While Chowdry (1994) and Girard, Rahman, and Zaher (2001) selected the Choleski ordering according to the longitudinal distance of the market from the international dateline, this study used the Cholesky ordering according to the level of market integration, information technology

capabilities, and size in terms of capitalization. As the review of literature demonstrated and as Eun and Jeong (1999) indicated, the U.S. stock markets are the main source of transmission. Therefore, the study first considers the effect of a shock that originates in the United States and then moves to Great Britain, South Africa, Nigeria, Zimbabwe, Kenya, and Botswana.

Descriptive Statistics

Descriptive statistics are also required for the GARCH models. These statistics were used to compute the means, medians, variances, standard deviations, skewness, and kurtosis for the data collected. These data are necessary when conducting the GARCH models.

According to Hall et al. (1995), the stationarity of data observation is required for the GARCH model. The *unit root* test was applied to determine the stationarity of the time series. This study used the Augmented Dickey-Fuller (ADF) test. The null hypothesis of testing the unit root was that unit root exists and the time series is nonstationary.

Residual tests/correlogram squared residual displays the correlogram (autocorrelations and partial autocorrelations) of the standardized residuals. This statistical test view can be used to investigate for any remaining ARCH in the variance equation and to check the specification of the variance equation. If the variance equation is correctly specified, all Q-statistics should not be significant.

The *residual tests/histogram—normality test* displays descriptive statistics and a histogram of the standardized residuals. The Jarque-Bera statistic is used to test whether the standardized residuals are normally distributed. If the standardized residuals are normally distributed, the Jarque-Bera statistic should not be significant.

Residual test/ARCH LM test carries out the Lagrange multiplier tests to test whether the standardized residuals exhibit additional ARCH. If the variance equation is correctly specified, there should be no ARCH left in the standardized residuals.

The *daily stock return series* were calculated in continuously compounded returns. This compound return was calculated by taking the logarithm of the daily stock index price multiplied by 100. The stock return was defined as follows:

$$R_t = Ln(\frac{P_t}{P_{t-1}}) * 100 \qquad (9)$$

where R_t is the daily stock return, P_t is the last daily stock index in day t, and P_{t-i} is the last stock index price in day t-1. According to Akgiray (1989), such a return series is regarded as a white noise process.

Data Collection

The data consist of a comprehensive set of indices of closing stock market prices for all five countries: Botswana, Kenya, Nigeria, South Africa, and Zimbabwe. The data were obtained from the individual national stock exchanges and other published sources. All data are daily data for the same trading day and date (except for the United States). Some data were eliminated, depending on such factors as individual country holidays or other nontrading days.

Booth et al. (1997), Eun and Shim (1989), Koch and Koch (1991), and Arshanapalli and Doukas (1993) noted that near-perfect-time nonsynchronous and perfect-time synchronous spillover effects are factors that should be considered in using daily data. *Near-perfect-time nonsynchronous* is defined as the time difference

between the considered countries. For example, the time difference between the New York and Johannesburg stock exchanges does not overlap, and a day's difference should be considered when using the daily data. In perfect-time synchronous data the countries' trading days should overlap or be within a considerable time frame. In the case of this study the five countries are within 2 hours trading difference and there is continuously trading at the same time; therefore, the Sub-Saharan markets were considered to be in a perfect-time synchronous situation. Also, the Sub-Saharan stock exchanges are not highly computerized or integrated, as they are within the developed nations, and this reduces the level of constant information transmission. Others who applied a perfect-time synchronous application method within the Sub-Saharan market include Appiah-Kusi and Pescetto (1998), Karolyi (1995), and Piesse and Hearn (2002a).

All data were readily available for all studied countries; therefore, no primary data were collected. The stock market data were obtained from each country's online Web site, the United Nations economic data Web site, and the African financial market database. These data were necessary for testing the Pearson correlation and the GARCH and EGARCH models. The foreign exchange data were available from numerous published records. The level of measurement used was the ratio scale.

The data sources were as follows:

1. Botswana Composite Index, published in http://www.bse.bw
2. Nairobi Composite Index, published in http://www.nse.co.ke
3. Nigeria Composite Index, published in http://www.nse.com.ng
4. South Africa Composite Index, published in http://www.jse.co.za
5. Zimbabwe Composite Index, published in http://www.zse.co.zw

All daily stock index data were published at http://www.africanfinancialmarkets.com. Stock index data were available from United Nations Development Programs Web site. Foreign exchange data were available from numerous sources.

Research Models

The research models used to answer the research questions are described below. Formulas are applied for the calculations for the GARCH and EGARCH models and for the models to measure transmission of volatility.

GARCH Models

Research question 2 was, *What is the relationship between the exchange rate volatility and the Sub-Saharan financial markets return of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe*? To answer this question, the GARCH (1,1) model was used.

Research Model 1(a)

Research model 1(a) was developed to examine the relationship between foreign exchange rate volatility and Botswana's daily stock index, as follows:

$$Fx_t = \phi Fx_{t-1} + \varepsilon_t$$
$$\varepsilon_{t\,t\text{-}1} \mid \Phi_{t\text{-}1} \sim N(0, h_t)$$
$$h_t = \varpi + \alpha \varepsilon^{2}_{t-1} + \beta h_{t-1} + \delta VBw_t \qquad (10a)$$

$$Bw_t = \phi Bw_{t-1} + \varepsilon_t$$
$$\varepsilon_{t\,t\text{-}1} \mid \Phi_{t\text{-}1} \sim N(0, h_t)$$
$$h_t = \varpi + \alpha \varepsilon^{2}_{t-1} + \beta h_{t-1} + \delta VFx_t \qquad (10\,b)$$

where Bw_t is the Botswana daily stock index and $VBwFx_t$ is the volatility of Botswana foreign exchange rate. The other symbols remain the same.

Research model 1(b)

Research model 1(b) was developed to examine the relationship between the foreign exchange rate volatility and Kenya's daily stock index as follows:

$$\begin{aligned} Fx_t &= \phi Fx_{t-1} + \varepsilon_t \\ \varepsilon_{t\,t-1} \Big| \Phi_{t-1} &\sim N(0, h_t) \\ h_t &= \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VKe_t \end{aligned} \tag{11a}$$

$$\begin{aligned} Ke_t &= \phi Ke_{t-1} + \varepsilon_t \\ \varepsilon_{t\,t-1} \Big| \Phi_{t-1} &\sim N(0, h_t) \\ h_t &= \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VFx_t \end{aligned} \tag{11b}$$

where Ke_t is the Kenya daily stock index and $VKeFx_t$ is the volatility of Kenya foreign exchange rate. The other symbols remain the same.

Research Model 1(c)

Research model 1(c) was developed to examine the relationship between the foreign exchange rate volatility and Nigeria's daily stock index, as follows:

$$\begin{aligned} Fx_t &= \phi Fx_{t-1} + \varepsilon_t \\ \varepsilon_{t\,t-1} \Big| \Phi_{t-1} &\sim N(0, h_t) \\ h_t &= \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VNg_t \end{aligned} \tag{12a}$$

$$\begin{aligned} Ng_t &= \phi Ng_{t-1} + \varepsilon_t \\ \varepsilon_{t\,t-1} \Big| \Phi_{t-1} &\sim N(0, h_t) \\ h_t &= \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VFx_t \end{aligned} \tag{12b}$$

where Ng_t is the Nigeria daily stock index and $VNgFx_t$ is the volatility of Nigeria foreign exchange rate. The other symbols remain the same.

Research Model 1(d)

Research model 1(d) was developed to examine the relationship between the foreign exchange rate volatility and South Africa's daily stock index as follows:

$$Fx_t = \phi Fx_{t-1} + \varepsilon_t$$
$$\varepsilon_{t\,t\text{-}1} \mid \Phi_{t\text{-}1} \sim N(0, h_t)$$
$$h_t = \varpi + \alpha\varepsilon^2_{t-1} + \beta h_{t-1} + \delta VZa_t \qquad (13a)$$

$$Za_t = \phi Za_{t-1} + \varepsilon_t$$
$$\varepsilon_{t\,t\text{-}1} \mid \Phi_{t\text{-}1} \sim N(0, h_t)$$
$$h_t = \varpi + \alpha\varepsilon^2_{t-1} + \beta h_{t-1} + \delta VFx_t \qquad (13b)$$

where Za_t is the South Africa daily stock index and $VZaFx_t$ is the volatility of South Africa's foreign exchange rate. The other symbols remain the same.

Research Model 1(e)

Research model 1(e) was developed to examine the relationship between the foreign exchange rate volatility and Zimbabwe's daily stock index as follows:

$$Fx_t = \phi Fx_{t-1} + \varepsilon_t$$
$$\varepsilon_{t\,t\text{-}1} \mid \Phi_{t\text{-}1} \sim N(0, h_t)$$
$$h_t = \varpi + \alpha\varepsilon^2_{t-1} + \beta h_{t-1} + \delta VZw_t \qquad (14a)$$

$$Zw_t = \phi Zw_{t-1} + \varepsilon_t$$
$$\varepsilon_{t\,t-1} \mid \Phi_{t-1} \sim N(0, h_t)$$
$$h_t = \varpi + \alpha\varepsilon^{2}_{t-1} + \beta h_{t-1} + \delta VFx_t \quad (14b)$$

where Zw_t is the Zimbabwe daily stock index and $VZwFx_t$ is the volatility of Zimbabwe's foreign exchange rate. The other symbols remain the same.

EGARCH Models

The EGARCH model was used to answer the research question 3: *Is there any transmission of stock market volatility between the Sub-Saharan financial markets return of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?*

Research Model 2(a)

Research model 2(a) was developed to examine the transmission of the stock market volatility from Kenya, Nigeria, South Africa, and Zimbabwe's stock exchanges to the Botswana stock exchange. The equation for this model is as follows:

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Ke,t-1)} \quad (15a)$$

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Ng,t-1)} \quad (15b)$$

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Za,t-1)} \quad (15c)$$

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Zw,t-1)} \quad (15d)$$

where (Bw) is the Botswana's daily stock index, (Ke) is the Kenya's daily stock index, (Ng) is the Nigeria's daily stock index, (Za) is the South Africa's daily stock index, and (Zw) is the Zimbabwe's daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Model 2(b)

Research model 2(b) was developed to examine the transmission of the stock market volatility from Botswana, Nigeria, South Africa, and Zimbabwe's stock exchanges to the Kenyan stock exchange. The equation form for this model is as follows:

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Ke,t-1} + \alpha_{Ke}\left|\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}}\right| + \gamma\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}} + \theta\sigma^2{}_{(Bw,t-1)} \quad (16a)$$

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Ke,t-1} + \alpha_{Ke}\left|\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}}\right| + \gamma\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}} + \theta\sigma^2{}_{(Ng,t-1)} \quad (16b)$$

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Ke,t-1} + \alpha_{Ke}\left|\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}}\right| + \gamma\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}} + \theta\sigma^2{}_{(Za,t-1)} \quad (16c)$$

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Ke,t-1} + \alpha_{Ke}\left|\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}}\right| + \gamma\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}} + \theta\sigma^2{}_{(Zw,t-1)} \quad (16d)$$

where (Ke) is the Kenya's daily stock index, (Bw) is the Botswana's daily stock index, (Ng) is the Nigeria's daily stock index, (Za) is the South Africa's daily stock index, and (Zw) is the Zimbabwe's daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Model 2(c)

Research model 2(c) was developed to examine the transmission of the stock market volatility from Botswana, Kenya, South Africa, and Zimbabwe's stock exchanges to the Nigerian stock exchange. The equation form for this model is as follows:

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Bw,t-1)} \tag{17a}$$

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Ke,t-1)} \tag{17b}$$

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Za,t-1)} \tag{17c}$$

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Zw,t-1)} \tag{17d}$$

where (Ng) is the Nigeria's daily stock index, (Bw) is the Botswana's daily stock index, (Ke) is the Kenya's daily stock index, (Za) is the South Africa's daily stock index, and (Zw) is the Zimbabwe's daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Model 2(d)

Research model 2(d) was developed to examine the transmission of the stock market volatility from Botswana, Kenya, Nigerian, and Zimbabwe's stock exchanges to the South Africa stock exchange. The equation form for this model is as follows:

$$\log\sigma^2_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2_{(Bw,t-1)} \quad (18a)$$

$$\log\sigma^2_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2_{(Ke,t-1)} \quad (18b)$$

$$\log\sigma^2_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2_{(Ng,t-1)} \quad (18c)$$

$$\log\sigma^2_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2_{(Zw,t-1)} \quad (18d)$$

where (Za) is the South Africa's daily stock index, (Bw) is the Botswana's daily stock index, (Ke) is the Kenya's daily stock index, (Ng) is the Nigeria's daily stock index, and (Zw) is the Zimbabwe's daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Model 2(e)

Research model 2 (e) was developed to examine the transmission of the stock market volatility from Botswana, Kenya, Nigerian, and South African stock exchanges to the Zimbabwe's stock exchange. The equation form for this model is as follows:

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Bw,t-1)} \quad (19a)$$

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Ke,t-1)} \quad (19b)$$

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Ng,t-1)} \quad (19c)$$

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Za,t-1)} \quad (19d)$$

where (Zw) is the Zimbabwe's daily stock index, (Bw) is the Botswana's daily stock index, (Ke) is the Kenya's daily stock index, (Ng) is the Nigeria's daily stock index, and (Za) is the South African daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

International Transmission of Volatility

Research question 4 asked, *Is there any transmission of stock market volatility from the USA or Great Britain into the Sub-Saharan financial Markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe*? The following models were used to answer research question 4:

Research Model 3(a)

Research model 3(a) was developed to examine the transmission of the stock market volatility from the United States and Great Britain to the Botswana stock market. The equation form for this model is as follows:

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Us,t-1)} \quad (20a)$$

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Gb,t-1)} \quad (20b)$$

where (Bw) is the Botswana's daily stock index, (Us) is the USA (S&P 500) daily stock index and (Gb) is the Great Britain (FTSE 100) daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Model 3(b)

Research model 3(b) was developed to examine the transmission of the stock market volatility from the USA and Great Britain into the Kenya stock market. The equation form for this model is as follows:

$$\log\sigma^2{}_{ke,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Us,t-1)} \quad (21a)$$

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Gb,t-1)} \quad (21b)$$

where (Ke) is the Kenya's daily stock index, (Us) is the USA (S&P 500) daily stock index and (Gb) is the Great Britain (FTSE 100) daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Model 3(c)

Research model 3(c) was developed to examine the transmission of the stock market volatility from the USA and Great Britain into the Nigeria stock market. The equation form for this model is as follows:

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Us,t-1)} \quad (22a)$$

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Gb,t-1)} \quad (22b)$$

where (Ng) is the Nigeria's daily stock index, (Us) is the USA (S&P 500) daily stock index and (Gb) is the Great Britain (FTSE 100) daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Model 3(d)

Research model 3(d) was developed to examine the transmission of the stock market volatility from the USA and Great Britain into the South Africa stock market. The equation form for this model is as follows:

$$\log\sigma^2{}_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2{}_{(Us,t-1)} \quad (23a)$$

$$\log\sigma^2{}_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2{}_{(Gb,t-1)} \quad (23b)$$

where (Za) is the South Africa's daily stock index, (Us) is the USA (S&P 500) daily stock index and (Gb) is the Great Britain (FTSE 100) daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Model 3(e)

Research model 3(e) was developed to examine the transmission of the stock market volatility from the USA and Great Britain into the Zimbabwe stock market. The equation form for this model is as follows:

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Us,t-1)} \quad (24a)$$

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Gb,t-1)} \quad (24b)$$

where (Zw) is the Zimbabwe's daily stock index, (Us) is the USA (S&P 500) daily stock index and (Gb) is the Great Britain (FTSE 100) daily stock index. The other symbols remain the same, as explained in equations 3, 4, 5, 6, and 7.

Research Assumptions

The following assumptions were made for this study:

1. The data were valid and suitable for this study.
2. Research methods and procedures were appropriate.
3. The models were assumed to be uninfluenced by the other country's spillovers.

Research Delimitations

The factors used in this study were only those that the researcher considered to be the primary ones of interest.

1. The study was delimited to the selected Sub-Saharan stock exchanges.

2. The study was delimited to the United States and Great Britain as the international markets.

3. The study period was from 1998 to 2004, and not all daily index data were available or used.

Chapter 4
FINDINGS

Chapter 4 presents the results of the study in reference to the research questions. The first section applies the Pearson correlation test to determine the extent, if any, to which five Sub-Saharan stock markets are interrelated. The second section displays the results of the descriptive statistical analysis and the results of stationarity analysis using the Augmented Dickey-Fuller Test (Unit root test for the stock exchange returns). The third section presents results of the GARCH model analysis, investigating the relationship between exchange rate volatility and the Sub-Saharan Africa financial markets. The fourth section presents results of the EGARCH model analysis testing whether there is transmission of stock market volatility among the studied five countries. The fifth section presents the final findings of the EGARCH model testing whether there is transmission of volatility from the United States or Great Britain into the Sub-Saharan financial markets. The sixth section presents the results of the analysis using the variance decomposition model. The seventh section presents results of the model fit test. The final two tests were used to measure the accuracy of the GARCH and EGARCH models. Conclusions are presented to close the chapter.

Pearson's Correlation Test

The results of the Pearson correlation test for research question 1 (*What is the correlation relationship among the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?*) are displayed in Table 7. The table shows that the studied Africa markets were less correlated among themselves and with

Table 7

Pearson Correlation Matrix of Relationships Among the Sub-Saharan Financial Markets and Great Britain and the United States

	Bw	Ke	Ng	Za	Zw
Bw	1.00				
Ke	-.022	1.00			
Ng	-.022	.009	1.00		
Za	-.008	-.043	.036	1.00	
Zw	.004	.078	-.004	-.006	1.00
US	.009	.002	.017	.333	.023
GB	.021	-.032	-.010	.475	.002

Note. Bw = Botswana stock exchange, Ke = Kenya stock exchange, Ng = Nigeria stock exchange, Za = South Africa stock exchange, Zw = Zimbabwe stock exchange, US = United States (S&P 500), GB = Great Britain (FTSE 100).

those of the United States and Great Britain. The highest coefficient of correlation between the emerging and the developed markets was between South Africa and the Great Britain (FTSE 100), $r = .475$, and between South Africa and the United States (S&P 500), $r = .333$.

Descriptive Statistics and Stationarity Analysis of Dependent Data Observations

This section is divided into two reports of results. First, the results of descriptive statistical analysis are presented. Second, the results of the stationarity analysis (Augmented Dickey-Fuller Test) are presented.

Descriptive Statistics

As shown in Table 8, the standard deviations were higher than the means. South Africa and Botswana had a negative skewness. Botswana had the longest tail. The kurtosis of the studied market was extremely large (with 3 being the normal distribution). Botswana had the largest kurtosis, over 401. Based on this information, the studied markets were exhibiting nonnormality.

Table 8

Descriptive Statistics of the Five Sub-Saharan Markets Based on 1,424 Observations

	Bw	Ke	Ng	Za	Zw
Mean	0.09	-0.01	0.10	0.03	0.27
Median	0.00	-0.02	0.02	0.00	0.19
SD	1.95	0.84	0.84	1.35	2.13
Skewness	-2.24	0.89	0.39	-0.21	0.77
Kurtosis	401.65	16.17	7.70	6.44	20.89

Note. Bw = Botswana stock exchange, Ke = Kenya stock exchange, Ng = Nigeria stock exchange, Za = South Africa stock exchange, Zw = Zimbabwe stock exchange.

Results of Stationarity Analysis

To test whether the data series was stationary, the ADF method was used. As discussed in chapter 3, the null hypothesis for this test was that unit root exists and the time series is nonstationary. According to Hall et al. (1995), if the *t* statistic is less than critical, the null hypothesis of a unit root should be rejected and the data are deemed stationary.

Figure 8 shows that the ADF test of the Botswana Stock exchange test level was at -58.88376. Since the ADF test was less than the critical value, the null hypothesis for a unit root was rejected. Therefore, the Botswana stock exchange returns were deemed to be stationary.

Augmented Dickey-Fuller Test Equation		
Dependent Variable: (Bw)		
Method: Least Squares		
Date: 03/12/05 Time: 19:38		
Sample (adjusted): 60 1482		
Included observations: 1,423 after adjusting endpoints		
Level		
ADF Test Statistic -58.88376	1% Critical Value*	-3.4378
	5% Critical Value	-2.8640
	10% Critical Value	-2.5681

Figure 8. Augmented Dickey-Fuller Test on Botswana stock returns. *MacKinnon critical values for rejection of hypothesis of a unit root.

Figure 9 shows that the ADF test of the Nairobi Stock exchange test level was at -19.62584. Since the ADF test was less than the critical value, the null hypothesis for a unit root was rejected. Therefore, the Nairobi stock exchange returns were deemed to be stationary.

Figure 10 shows that the ADF test of the Nigeria Stock exchange test level was at -16.77142. Since the ADF test was less than the critical value, the null hypothesis

Augmented Dickey-Fuller Test Equation

Dependent Variable: (Ke)

Method: Least Squares

Date: 03/12/05 Time: 19:02

Sample (adjusted): 3 1482

Included observations: 1480 after adjusting endpoints

Level

ADF Test Statistic	-19.62584	1% Critical Value*	-3.4377
		5% Critical Value	-2.8640
		10% Critical Value	-2.5681

Figure 9. Augmented Dickey-Fuller Test on Nairobi stock returns. *MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: (Ng)

Method: Least Squares

Date: 03/12/05 Time: 20:53

Sample (adjusted): 6 1482

Included observations: 1477 after adjusting endpoints

Level

ADF Test Statistic	-16.77142	1% Critical Value*	-3.4377
		5% Critical Value	-2.8640
		10% Critical Value	-2.5681

Figure 10. Augmented Dickey-Fuller Test on Nigeria stock returns. *MacKinnon critical values for rejection of hypothesis of a unit root.

for a unit root was rejected. Therefore, the Nigeria stock exchange returns were deemed to be stationary.

Figure 11 shows that the ADF test of the Johannesburg Stock exchange test level was at -16.88243. Since the ADF test was less than the critical value, the null hypothesis for a unit root was rejected. Therefore, the Johannesburg stock exchange returns were deemed to be stationary.

Augmented Dickey-Fuller Test Equation		
Dependent Variable: (Za)		
Method: Least Squares		
Date: 03/12/05 Time: 21:03		
Sample (adjusted): 6 1482		
Included observations: 1477 after adjusting endpoints		
Level		
ADF Test Statistic -16.88243	1% Critical Value*	-3.4377
	5% Critical Value	-2.8640
	10% Critical Value	-2.5681

Figure 11. Augmented Dickey-Fuller Test on South Africa stock returns.
*MacKinnon critical values for rejection of hypothesis of a unit root.

Figure 12 shows that the ADF test of the Zimbabwe Stock exchange test level was at -14.49541. Since the ADF test was less than the critical value, the null hypothesis for a unit root was rejected. Therefore, the Zimbabwe stock exchange returns were deemed to be stationary.

Augmented Dickey-Fuller Test Equation		
Dependent Variable: (Zw)		
Method: Least Squares		
Date: 03/12/05 Time: 21:09		
Sample (adjusted): 6 1482		
Included observations: 1477 after adjusting endpoints		
Level		
ADF Test Statistic -14.49541	1% Critical Value*	-3.4377
	5% Critical Value	-2.8640
	10% Critical Value	-2.5681

Figure 12. Augmented Dickey-Fuller Test on Zimbabwe stock returns. *MacKinnon critical values for rejection of hypothesis of a unit root.

The ADF of all five studied markets led to rejection of the hypothesis of a unit root. Therefore, it was concluded that the five studied Sub-Saharan financial markets stock returns were stationary.

GARCH Model Analyses

The results of GARCH model analyses for research question 2 (*What is the relationship between the exchange rate and the African stock market in terms of volatility?*) are described in this section. Each GARCH research model is described and the results are presented.

Research Model 1(a): Botswana

The following model was developed to examine the relationship between foreign exchange rate volatility and Botswana's daily stock index.

$$Fx_t = \phi Fx_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t\text{-}1} \Big| \Phi_{t\text{-}1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VBw_t$$

$$Bw_t = \phi Bw_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t\text{-}1} \Big| \Phi_{t\text{-}1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VFx_t$$

As Table 9 shows, the GARCH and ARCH effects were very strong. The coefficient of the GARCH, ARCH, stock exchange rate, and foreign exchange rate volatility were statistically significant at $p < .01$. The estimate of the variance equation indicates that the coefficients of the stock and foreign exchange volatility rate were negative.

Table 9

GARCH (1,1) Estimates for Model 1(a): Botswana

Factor	ϖ	α	β	$\alpha+\beta$	δ
Bw	0.01***	0.01***	0.97***	0.98	-0.01***
Fx	3.49***	0.18***	0.57***	0.75	-0.76***

Note. Bw = Botswana stock exchange volatility, Fx = Botswana foreign exchange rate volatility.

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 1(b): Kenya

The following model was developed to examine the relationship between foreign exchange rate volatility and Kenya's daily stock index.

$$Fx_t = \phi Fx_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t\text{-}1} \mid \Phi_{t\text{-}1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VKe_t$$

$$Ke_t = \phi Ke_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t\text{-}1} \mid \Phi_{t\text{-}1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VFx_t$$

As Table 10 shows, the GARCH and ARCH effects were very strong. The coefficient of the GARCH, ARCH, stock exchange rate, and foreign exchange rate volatility were statistically significant at $p < .01$. The estimate of the variance equation indicates that the coefficient of the foreign exchange rate was negative.

Table 10

GARCH (1,1) Estimates for Model 1(b): Kenya

Factor	ϖ	α	β	$\alpha+\beta$	δ
Ke	0.19***	0.11***	0.59***	0.70	0.10***
Fx	0.55***	0.10***	0.51***	0.61	-0.22***

Note. Ke = Kenya stock exchange volatility, Fx = Kenya foreign exchange rate volatility.

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 1(c): Nigeria

The following model was developed to examine the relationship between foreign exchange rate volatility and Nigeria's daily stock index.

$$Fx_t = \phi Fx_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t-1} \Big| \Phi_{t-1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VNg_t$$

$$Ng_t = \phi Ng_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t-1} \Big| \Phi_{t-1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VFx_t$$

As Table 11 shows, the GARCH and ARCH were very strong. Coefficients of the GARCH, ARCH, stock exchange rate, and foreign exchange rate volatility were statistically significant at $p < .01$. The estimate of variance equation indicates that the coefficient of the stock and foreign exchange rate was positive.

Table 11

GARCH (1,1) Estimates for Model 1(c): Nigeria

Factor	ϖ	α	β	$\alpha+\beta$	δ
Ng	0.01***	0.01***	0.97***	0.98	0.02***
Fx	0.01***	0.28***	0.77***	1.05	0.01***

Note. Ng = Nigeria stock exchange volatility, Fx = Nigeria foreign exchange rate volatility.

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 1(d): South Africa

The following model was developed to examine the relationship between foreign exchange rate volatility and South Africa's daily stock index.

$$Fx_t = \phi Fx_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t-1} \Big| \Phi_{t-1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VZa_t$$

$$Za_t = \phi Za_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t-1} \Big| \Phi_{t-1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VFx_t$$

As Table 12 shows, the GARCH and ARCH effects were very strong. The coefficient of the GARCH, ARCH, and stock exchange was statistically significant at $p < .01$. The estimate of the variance equation indicates that the coefficient of the foreign exchange rate volatility was not significant but the coefficient of the stock exchange volatility was significant at $p < .01$.

Table 12

GARCH (1,1) Estimates for Model 1(d): South Africa

Factor	ϖ	α	β	$\alpha+\beta$	δ
Za	0.01***	0.11***	0.90***	1.00	-0.01***
Fx	0.06***	0.08***	0.88***	0.96	0.49

Note. Za = South African stock exchange volatility, Fx = South African foreign exchange rate volatility.

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 1(e): Zimbabwe

The following model was developed to examine the relationship between foreign exchange rate volatility and Zimbabwe's daily stock index.

$$Fx_t = \phi Fx_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t-1} \Big| \Phi_{t-1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VZw_t$$

$$Zw_t = \phi Zw_{t-1} + \varepsilon_t$$

$$\varepsilon_{t\,t-1} \Big| \Phi_{t-1} \sim N(0, h_t)$$

$$h_t = \varpi + \alpha \varepsilon^2_{t-1} + \beta h_{t-1} + \delta VFx_t$$

As Table 13 shows, the GARCH and ARCH effects for exchange rate were very strong and the coefficients of the GARCH and ARCH were statistically significant at $p < .01$. The results show that the coefficient of the exchange rate volatility and stock exchange rate volatility was not significant

Table 13

GARCH (1,1) Estimates for Model 1(e): Zimbabwe

Factor	ϖ	α	β	$\alpha+\beta$	δ
Zw	1,848.00	0.00	0.59	0.59	-0.56
Fx	0.52***	0.55***	0.44***	0.99	0.00

Note. Zw = Zimbabwe stock exchange volatility, Fx = Zimbabwe foreign exchange rate volatility.

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 2(a): Botswana

This model was developed to examine the transmission of the stock market volatility from the Kenya, Nigeria, South Africa, and Zimbabwe stock exchanges to the Botswana stock exchange volatility.

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Ke,t-1)}$$

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Ng,t-1)}$$

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Za,t-1)}$$

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Zw,t-1)}$$

As Table 14 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, was positive and statistically significant at $p < .01$ for Nigeria, and was negatively and statistically significant at $p < .01$ for Kenya, South Africa, and Zimbabwe. This indicates evidence of the leverage effect. It also indicates that a negative return shock from the Nigeria stock exchange to the Botswana stock exchange produces lower volatility than a positive return shock and a positive return shock from Kenya, South Africa, or Zimbabwe stock exchange to the Botswana stock exchange produces lower volatility than a negative return shock. The volatility for the Botswana stock exchange was asymmetric. The table shows that the coefficients of the Kenya, Nigeria, South Africa, and Zimbabwe markets' volatility were statistically significant at $p < .01$ and that Kenya and Zimbabwe had an inverse relationship with Botswana, while Nigeria and South Africa had a positive relationship with Botswana.

Table 14

EGARCH (1,1) Estimates for Model 2(a): Botswana

Market	ϖ	β	α	γ	θ
Ke	-0.10***	1.00***	0.21***	-0.07***	-0.03***
Ng	-0.21***	0.98***	0.40***	0.17***	0.20***
Za	-0.11***	1.07***	0.24***	-0.07***	0.03***
Zw	1.21***	-0.65***	-0.06***	-0.23***	-0.18***

Note. Bw = Botswana, Ke = Kenya, Ng = Nigeria, Za = South Africa, Zw = Zimbabwe.

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 2(b): Kenya

This model was developed to examine the transmission of the stock market volatility from the Botswana, Nigeria, South Africa, and Zimbabwe stock exchanges to the Kenya stock exchange volatility.

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Ke,t-1} + \alpha_{Ke}\left|\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}}\right| + \gamma\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}} + \theta\sigma^2{}_{(Bw,t-1)}$$

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Ke,t-1} + \alpha_{Ke}\left|\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}}\right| + \gamma\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}} + \theta\sigma^2{}_{(Ng,t-1)}$$

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Ke,t-1} + \alpha_{Ke}\left|\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}}\right| + \gamma\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}} + \theta\sigma^2{}_{(Za,t-1)}$$

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Ke,t-1} + \alpha_{Ke}\left|\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}}\right| + \gamma\frac{\varepsilon_{Ke,t-1}}{\sigma_{Ke,t-1}} + \theta\sigma^2{}_{(Zw,t-1)}$$

As Table 15 shows, the leverage effect term γ ,denoted as RES/SQR[GARCH](1) in the output, was positive and statistically significant at $p < .01$. This indicates evidence of leverage effect. The volatility for the Kenya stock exchange was asymmetric. The table also shows that the coefficients of the Botswana, Nigeria, South Africa, and Zimbabwe markets' volatility were statistically significant at $p < .01$. It also indicates that a negative return shock from the Botswana, Nigeria, South Africa, or Zimbabwe stock exchange to the Kenya stock exchange produced lower volatility than a positive return shock. Also, the table shows that Nigeria had an inverse relationship with Kenya, while Botswana, South Africa, and Zimbabwe had a positive relationship with Kenya.

Table 15

EGARCH (1,1) Estimates for Model 2(b): Kenya

Market	ϖ	β	α	γ	θ
Bw	-0.34***	0.86***	0.37***	0.16***	0.06***
Ng	-0.33***	0.86***	0.35***	0.13***	-0.06***
Za	-0.40***	0.82***	0.41***	0.17***	0.07***
Zw	-0.34***	0.85***	0.36***	0.13***	0.02***

Note. Bw = Botswana, Ke = Kenya, Ng = Nigeria, Za = South Africa, Zw = Zimbabwe.

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 2(c): Nigeria

This model was developed to examine the transmission of the stock market volatility from the Botswana, Kenya, South Africa, and Zimbabwe stock exchanges to the Nigeria stock exchange volatility.

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Bw,t-1)}$$

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Ke,t-1)}$$

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Za,t-1)}$$

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Zw,t-1)}$$

As Table 16 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, is positive and statistically significant at $p < .01$. This indicates evidence of leverage effect. It also indicates that a negative return shock to the Nigeria stock exchange produces lower volatility than a positive return shock. The volatility for the Nigeria stock exchange was asymmetric. The table also shows that the coefficient of the Kenya and South Africa stock exchange volatility was positive and statistically significant at $p < .01$

Research Model 2(d): South Africa

This model was developed to examine the transmission of the stock market volatility from the Botswana, Kenya, Nigeria, and Zimbabwe stock exchanges to the South Africa stock exchange volatility.

Table 16

EGARCH (1,1) Estimates for Model 2(c): Nigeria

Market	ϖ	β	α	γ	θ
Bw	-0.33***	0.95***	0.37***	0.11***	-0.01
Ke	-0.28***	0.96***	0.31***	0.10***	0.03***
Za	-0.30***	0.96***	0.35***	0.10***	0.03***
Zw	-0.30***	0.96***	0.34***	0.10***	0.01

Note. Bw = Botswana, Ke = Kenya, Ng = Nigeria, Za = South Africa, Zw = Zimbabwe.

*$p < .10$. **$p < .05$. ***$p < .01$.

$$\log\sigma^2{}_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2{}_{(Bw,t-1)}$$

$$\log\sigma^2{}_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2{}_{(Ke,t-1)}$$

$$\log\sigma^2{}_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2{}_{(Ng,t-1)}$$

$$\log\sigma^2{}_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2{}_{(Zw,t-1)}$$

As Table 17 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, was negative and statistically significant at $p < .05$. This indicates evidence of leverage effect. It also indicates that a positive return shock to the South Africa stock exchange produces lower volatility than a negative return shock. The volatility for the South Africa stock exchange was asymmetric. The table also shows that the

Table 17

EGARCH (1,1) Estimates for Model 2(d): South Africa

Market	ϖ	β	α	γ	θ
Bw	-0.12***	0.95***	0.19***	-0.06**	-0.01
Ke	-0.11***	0.96***	0.16***	-0.06**	0.02*
Ng	-0.09***	0.97***	0.14**	-0.05**	-0.03**
Zw	-0.09***	0.96***	0.15***	-0.05**	-0.01**

Note. Bw = Botswana, Ke = Kenya, Ng = Nigeria, Za = South Africa, Zw = Zimbabwe.

*$p < .10$. **$p < .05$. ***$p < .01$.

coefficient of the Nigeria and Zimbabwe stock exchange volatility was positive and statistically significant at $p < .05$, and the coefficient of the Kenya stock exchange volatility was negative and statistically significant at $p < .10$.

Research Model 2(e): Zimbabwe

This model was developed to examine the transmission of the stock market volatility from the Botswana, Kenya, Nigeria, and South Africa stock exchanges to the Zimbabwe stock exchange volatility.

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Bw,t-1)}$$

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Ke,t-1)}$$

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Ng,t-1)}$$

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Za,t-1)}$$

As Table 18 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, was positive but not statistically significant. This indicates the absence of evidence of leverage effect. The volatility for the Zimbabwe stock exchange was not asymmetric. The table also shows that the coefficients of the Kenya and Nigeria stock exchange volatility were not statistically significant but those of Botswana and South Africa were statistically significant at $p < .05$.

Table 18

EGARCH (1,1) Estimates for Model 2(e): Zimbabwe

Market	ϖ	β	α	γ	θ
Bw	-0.37***	0.82***	0.77***	0.01	-0.04**
Ke	-0.27***	0.75***	0.74***	0.01	0.03
Ng	-0.27***	0.76***	0.74***	0.02	-0.01
Za	-0.27***	0.78***	0.75***	0.02	-0.23**

Note. Bw = Botswana, Ke = Kenya, Ng = Nigeria, Za = South Africa, Zw = Zimbabwe.

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 3(a): Botswana

This model was developed to examine the transmission of the stock market volatility from the United States or Great Britain stock exchanges to the Botswana stock exchange volatility.

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Us,t-1)}$$

$$\log\sigma^2{}_{Bw,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Gb,t-1)}$$

As Table 19 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, was negative and statistically significant. This indicates evidence of leverage effect. It also indicates that a positive return shock to the Botswana's stock exchange produces lower volatility than a negative return shock. The volatility for the Botswana stock exchange was asymmetric. The table also shows that the coefficients of the volatility of the Great Britain and U.S. markets were statistically significant at $p < .01$. The coefficients of the United States and Great Britain were negative.

Table 19

EGARCH (1,1) Estimates for Model 3(a): Botswana

Market	ϖ	β	α	γ	θ
United States	0.78***	-0.62***	0.11***	-0.10***	-0.42***
Great Britain	0.75***	-0.09***	0.09***	-0.15***	-0.35***

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 3(b): Kenya

This model was developed to examine the transmission of the stock market volatility from the United States or Great Britain stock exchanges to the Kenya stock exchange volatility.

$$\log\sigma^2{}_{ke,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Us,t-1)}$$

$$\log\sigma^2{}_{Ke,t} = \omega + \beta\log\sigma^2_{Bw,t-1} + \alpha_{Bw}\left|\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}}\right| + \gamma\frac{\varepsilon_{Bw,t-1}}{\sigma_{Bw,t-1}} + \theta\sigma^2{}_{(Gb,t-1)}$$

As Table 20 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, was positive and statistically significant. This indicates evidence of leverage effect. The volatility of the Kenya stock exchange was asymmetric. The table also indicates that a negative return shock to the Kenya stock exchange produced lower volatility than a positive return shock. The table also shows that the coefficients of the United States and Great Britain volatility were statistically significant at $p < .01$.

Table 20

EGARCH (1,1) Estimates for Model 3(b): Kenya

Market	ϖ	β	α	γ	θ
United States	-0.35***	0.84***	0.36***	0.16***	0.03***
Great Britain	-0.35***	0.84***	0.37***	0.14***	0.11***

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 3(c): Nigeria

This model was developed to examine the transmission of the stock market volatility from the United States or Great Britain stock exchanges to the Nigeria stock exchange volatility.

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Us,t-1)}$$

$$\log\sigma^2{}_{Ng,t} = \omega + \beta\log\sigma^2_{Ng,t-1} + \alpha_{Ng}\left|\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}}\right| + \gamma\frac{\varepsilon_{Ng,t-1}}{\sigma_{Ng,t-1}} + \theta\sigma^2{}_{(Gb,t-1)}$$

As Table 21 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, is positive and statistically significant. This indicates evidence of leverage effect. It also indicates that a negative return shock to the Nigeria's stock exchange produces lower volatility than a positive return shock. The volatility for the Nigeria stock exchange was asymmetric. The table also shows that the coefficients of the volatility of the United States and Great Britain stock markets were positive and statistically significant at $p < .01$.

Table 21

EGARCH (1,1) Estimates for Model 3(c): Nigeria

Market	ϖ	β	α	γ	θ
United States	-0.30***	0.96***	0.34***	0.10***	0.02**
Great Britain	-0.31***	0.96***	0.36***	0.10***	0.04***

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 3(d): South Africa

This model was developed to examine the transmission of the stock market volatility from the United States or Great Britain stock exchanges to the South Africa stock exchange volatility.

$$\log\sigma^2{}_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2{}_{(Us,t-1)}$$

$$\log\sigma^2{}_{Za,t} = \omega + \beta\log\sigma^2_{Za,t-1} + \alpha_{Za}\left|\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}}\right| + \gamma\frac{\varepsilon_{Za,t-1}}{\sigma_{Za,t-1}} + \theta\sigma^2{}_{(Gb,t-1)}$$

As Table 22 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, was negative and statistically significant. This indicates evidence of leverage effect. It also indicates that a positive return shock to the South Africa stock exchange produced lower volatility than a negative return shock. The volatility for the South Africa stock exchange was asymmetric. The table also shows that the coefficients of the volatility of the United States and Great Britain stock exchanges were positive and statistically significant at $p < .01$.

Table 22

EGARCH (1,1) Estimates for Model 3(d): South Africa

Market	ϖ	β	α	γ	θ
United States	-0.09***	0.97***	0.14***	-0.03***	-0.06***
Great Britain	-0.08***	0.97***	0.12***	-0.03***	-0.06***

*$p < .10$. **$p < .05$. ***$p < .01$.

Research Model 3(e): Zimbabwe

This model was developed to examine the transmission of the stock market volatility from the United States or Great Britain stock exchanges to the Zimbabwe stock exchange volatility.

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Us,t-1)}$$

$$\log\sigma^2{}_{Zw,t} = \omega + \beta\log\sigma^2_{Zw,t-1} + \alpha_{Us}\left|\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}}\right| + \gamma\frac{\varepsilon_{Zw,t-1}}{\sigma_{Zw,t-1}} + \theta\sigma^2{}_{(Gb,t-1)}$$

As Table 23 shows, the leverage effect term γ, denoted as RES/SQR[GARCH](1) in the output, was positive but not statistically significant. The volatility for the Zimbabwe stock exchange was not asymmetric. The table also shows that the coefficient of the volatility of the United States stock exchange was negative and statistically significant at $p < .01$.

Table 23

EGARCH (1,1) Estimates for Model 3(e): Zimbabwe

Market	ϖ	β	α	γ	θ
United States	-0.27***	0.76***	0.74***	0.01	-0.01***
Great Britain	-0.28***	0.76***	0.74***	0.01	-0.03

*$p < .10$. **$p < .05$. ***$p < .01$.

Results of the Residual Test

Selection of tests was done to test whether the variance equation was correctly specified. The results of the correlogram squared residual test for all models showed that the Q statistics were not significant. This was also confirmed by the results of the ARCH LM tests that were conducted for the same model. This finding is parallel to that of similar studies for the same region (e.g., Appiah-Kusi & Pescetto, 1998; Karolyi, 1995; Piesse & Hearn, 2002).

Results of the Variance Decomposition Model

Table 24 shows that the United States (US) market accounted for 0% to 56% of the forecast error variances of the other markets. The Great Britain (GB) market accounted for approximately 0% to 3% of forecast error variances of the other markets. The other major player was Kenya, which accounted for 17% of the forecast error variances of the Botswana (BW) markets. The Great Britain market was the most endogenous market, with almost 56% of its forecast error variance explained by the other markets in the system. This was followed by South Africa, with about 46% its forecast error variance explained by the other markets in the system. This shows the degree of openness of the Great Britain and South Africa stock markets and their vulnerability to shocks occurring in leading stock markets.

Summary of the Findings

This section presents the summary of the findings in relation to the four research questions. The results are presented related to the tests conducted on the data.

Table 24

Market Decompositions, by Cholesky Ordering

Period	Years	S.E.	US	GB	Za	Ng	Zw	Ke	Bw
United States	1	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Britain	1	0.00	55.78	44.22	0.00	0.00	0.00	0.00	0.00
	5	0.00	55.78	44.22	0.00	0.00	0.00	0.00	0.00
	10	0.00	55.78	44.22	0.00	0.00	0.00	0.00	0.00
South Africa	1	0.00	42.81	3.17	54.01	0.00	0.00	0.00	0.00
	5	0.00	42.81	3.17	54.01	0.00	0.00	0.00	0.00
	10	0.00	42.81	3.17	54.01	0.00	0.00	0.00	0.00
Nigeria	1	0.00	1.02	0.09	0.56	98.32	0.00	0.00	0.00
	5	0.00	1.02	0.09	0.56	98.32	0.00	0.00	0.00
	10	0.00	1.02	0.09	0.56	98.32	0.00	0.00	0.00
Zimbabwe	1	0.00	0.03	0.05	0.04	0.01	99.87	0.00	0.00
	5	0.00	0.03	0.05	0.04	0.01	99.87	0.00	0.00
	10	0.00	0.03	0.05	0.04	0.01	99.87	0.00	0.00
Kenya	1	0.00	7.00	1.18	0.14	0.03	0.05	91.59	0.00
	5	0.00	7.00	1.18	0.14	0.03	0.05	91.59	0.00
	10	0.00	7.00	1.18	0.14	0.03	0.05	91.59	0.00
Botswana	1	0.00	0.00	0.01	0.14	0.31	0.01	17.26	82.28
	5	0.00	0.00	0.01	0.14	0.31	0.01	17.26	82.28
	10	0.00	0.00	0.01	0.14	0.31	0.01	17.26	82.28

Note. S.E. = standard error, US = United States, GB = Great Britain, Za = South Africa, Ng = Nigeria, Zw = Zimbabwe, Ke = Kenya, Bw = Botswana.

Pearson Correlation Test

The findings showed a weak correlation among the five Sub-Saharan countries. It also showed a weak correlation between the Sub-Saharan countries and the

international financial markets. However, there was a moderate positive correlation relationship among South Africa, United States, and Great Britain.

Descriptive Statistics

Analysis of the results showed that the five studied African countries had a standard deviation that strayed from the mean. Botswana and South Africa had a negative skewness, while the rest of the countries had a positive skewness. South Africa had the smallest skewness (-.204702) and Botswana had the highest skewness (-2.24). All of the studied countries had a high kurtosis, with South Africa having 20.89 and Botswana 401.66 (the kurtosis is supposed to be 3.00). The results of analysis of the descriptive statistics suggest that the stock index portrays a nonnormality pattern.

ADF Test

Analysis of the results showed that all of the studied stock exchanges had distributions that were not normal due to leptokurtosis. This led to the conclusion that the stock exchanges were stationary and the decision to reject the null hypothesis of the unit root.

Influence of Foreign Exchange Rate Volatility: GARCH Model Analysis

The results of the GARCH estimates are shown in Table 25 (estimates of foreign exchange volatility by country) and Table 26 (estimates of stock exchange volatility by country. The coefficients for exchange rate volatility were statistically significant for Botswana, Kenya, and Nigeria but not for Zimbabwe or South Africa.

Table 25

GARCH Estimates for Foreign Exchange Volatility, by Country

Country	ϖ	α	β	$\alpha+\beta$	δ
Botswana	3.49***	0.18***	0.57***	0.75	-0.76***
Kenya	0.55***	0.10***	0.51***	0.61	-0.22***
Nigeria	0.01***	0.28***	0.77***	1.05	0.01***
South Africa	0.06***	0.08***	0.88***	0.96	0.49
Zimbabwe	0.52***	0.55***	0.44***	0.99	0.00

*$p < .10$. **$p < .05$. ***$p < .01$.

Table 26

GARCH Estimates for Stock Exchange Volatility, by Country

Country	ϖ	α	β	$\alpha+\beta$	δ
Botswana	0.01***	0.01***	0.97***	0.98	-0.01***
Kenya	0.19***	0.11***	0.59***	0.70	0.10***
Nigeria	0.01***	0.01***	0.97 ***	0.98	0.02***
South Africa	0.01***	0.11***	0.90***	1.00	-0.01***
Zimbabwe	1,848.00**	0.00**	0.59**	0.59	-0.56

*$p < .10$. **$p < .05$. ***$p < .01$.

This shows that foreign exchange volatility contributes to the volatility of Botswana, Kenya, and Nigeria. The coefficient of exchange rate volatility for Kenya and Nigeria was positive, while that of Botswana and South Africa was negative. The coefficients for exchange rate volatility were statistically significant for Botswana, Kenya, Nigeria, and South Africa but not for Zimbabwe.

Transmission of Volatility Among the African Countries: EGARCH Model Analysis

The EGARCH models were used to test the transmission of volatility among the studied countries. Table 27 shows the results of asymmetric relationship as derived from the EGARCH models. The finding of the results were as follows.

Table 27

EGARCH Estimates of Transmission of Volatility Among the Markets of the Five Studied Sub-Saharan Countries

→	Botswana	Kenya	Nigeria	South Africa	Zimbabwe
Botswana	-	0.06***	-0.01	-0.01	-0.04**
Kenya	-0.03***	-	0.03***	0.02*	0.03
Nigeria	0.20***	-0.06***	-	0.03**	-0.01
South Africa	0.03***	0.07***	0.03***	-	-0.23**
Zimbabwe	-0.18***	0.02***	0.01	-0.01**	-
Great Britain	-0.35***	0.11***	0.04***	-0.06***	-0.03
United States	-0.42***	0.03***	0.02**	-0.06***	-0.01***

*$p < .10$. **$p < .05$. ***$p < .01$.

1. The results for Botswana showed that all of the other Sub-Saharan countries (Kenya, Nigeria, South Africa, and Zimbabwe) transmitted volatility to Botswana. The findings also showed that negative shocks had more impact than positive shocks from Kenya, South Africa, and Zimbabwe; and vice versa from Nigeria. There was evidence of a leverage effect, and the volatility was considered to be asymmetric.

2. The results for Kenya showed that Botswana, Nigeria, South Africa, and Zimbabwe transmitted volatility to Kenya. The findings also showed that positive shocks had more impact than negative shocks from Botswana, South Africa, and Zimbabwe and vice versa for Nigeria. There was evidence of a leverage effect, and the volatility was considered to be asymmetric.

3. The results for Nigeria showed that Kenya and South Africa transmitted volatility to Nigeria. There was a leverage effect, positive shocks had more impact than negative shocks, and the volatility was considered to be asymmetric.

4. The results for South Africa showed that Kenya, Nigeria, and Zimbabwe transmitted volatility to South Africa. The leverage effect term was negative, indicating that negative shocks had more impact than positive shocks. The volatility was considered to be asymmetric.

5. Botswana and South Africa transmitted volatility to Zimbabwe at $p < .05$.

Transmission of Volatility From the United States and Great Britain: EGARCH Model Analysis

The EGARCH models were again used to test the transmission of volatility from the USA or Great Britain. The findings were as follows.

1. The United States and Great Britain both transmitted volatility to Botswana; there was evidence of a negative leverage effect, showing that negative shocks had

more impact than positive shocks. Great Britain and United States stock exchange volatility had a negative relationship with Botswana stock exchange volatility.

2. Great Britain and the United States transmitted volatility to Kenya; the leverage effect was positive and significant, showing that positive shocks had more impact than negative shocks. Great Britain and United States stock exchange volatility had a positive relationship with Kenya stock exchange volatility

3. Great Britain and the United States transmitted volatility to Nigeria's financial market return. United States and Great Britain stock exchange volatility had a positive relationship with Nigeria stock exchange volatility.

4. Great Britain and the United States transmitted volatility to South Africa's stock exchange; the leverage effect was negative and significant.

5. The United States transmitted volatility to Zimbabwe's financial market return; the leverage effect was positive but not significant.

As indicated in equation 8, the volatility came from country j to country i. Table 27 shows that (a) the majority of the transmission of volatility came from United States and Great Britain, (b) South Africa transmitted volatility to most of the African countries, and (c) the United States transmitted volatility to Zimbabwe.

The variance decomposition model shows that Kenya accounted for 17% of the forecast error variance to Botswana and the United States accounted for 56% of the forecast error variance to Great Britain and 43% to South Africa. Domestic forces generated Zimbabwe volatility. The following is a detailed discussion about the relative importance of foreign markets in the variability of stock returns in the five studied national stock markets.

1. Botswana: The results from variance decomposition show that the variation of domestic volatility shocks accounted for 82% of the volatility in this market. The

volatility shock from Kenya was about 17%, with the rest of the countries contributing a shock of less than 0.1%. Great Britain and the United States contributed very minor shocks to Botswana.

2. Kenya: The results from variance decomposition show that the variation of domestic volatility shocks accounted for 92% of the volatility in this market. The United States contributed about 7% and Great Britain about 1.2% to the volatility of this market. The influence of the rest of the countries on the Kenya stock market was small.

3. Nigeria: The Nigerian stock market was impacted by volatility shock from the United States by 1%. The South Africa volatility shock influence was about 0.5%. The other countries had minimal influence on this market.

4. South Africa: The South African market received significant shock (about 43%) from the United States stock markets. Great Britain contributed about 3.2% influence, and the other Africa countries contributed very little influence.

5. Zimbabwe: The results of variance decomposition show that variation in domestic volatility shocks accounted for almost 100% of the volatility in this market. This shows that the volatility of Zimbabwe is created by internal factors more than external influence.

6. Great Britain: Like South Africa, Great Britain received major external shocks, with about 57% coming from the United States. This shows that Great Britain's markets were open and vulnerable to external volatility.

7. United States: The U.S. market did not receive any shocks from the other markets.

To summarize, contrary to usual beliefs, global markets, as represented by the United States and Great Britain, do not appear to be dominant and robust to volatility

of emerging markets; in all cases, their impact was less than 10% except to that of South Africa. Zimbabwe received most of its volatility spillover effects from internal (domestic) factors, and internal turbulence in Nigeria caused increasing volatility to its stock exchange. While the stock exchanges of Great Britain and South Africa received their volatility spillover effects from the United States, Botswana received most of its external volatility from Kenya.

Conclusion

The findings in this chapter indicate that the positive volatility of exchange rate impacted the Nigeria stock exchange and the negative volatility of exchange rate impacted the Kenya and Botswana stock exchanges. Botswana and Kenya received the most shocks from the other African countries. The United States transmitted volatility to all of the studied financial markets return. The paper supports the literature that United States is a major source of volatility in global terms.

Chapter 5
CONCLUSIONS

This chapter presents a summary of the study and findings, discussion of the findings, implications of the study, and suggestions for further research. The first section presents a summary of the study, including the purpose, the scope, the research questions, the hypotheses, the data collection methods, research methodology, and the research findings. The second section provides an interpretation and discussion of the statistical findings related to the research questions. The third section presents the implications of the study and recommendation for future research.

Summary of the Study

Several studies have concluded that market volatility, integration, and volatility transmission have increased in recent years. Most of the recent studies have found equity markets to be interlinked. The culprit for this increase is attributed to advanced communication systems and information technology, globalization and increasing international trades, trade blocks, deregulation of international financial markets, and exchange rate volatility. Unfortunately, most of the available current research has concentrated on the North America, European, and Asian financial markets. The present study expanded the available literature by studying five Sub-Saharan financial markets: Botswana, Kenya, Nigeria, South Africa, and Zimbabwe.

The main purpose of the study was to investigate the influence of exchange rate volatility on the Sub-Saharan stock returns. Also, the study investigated the transmission of volatility and correlation of that volatility among the countries. The

study also examined the nature of transmission of stock return volatility from the United States and Great Britain to the five Sub-Saharan financial markets.

As the Sub-Saharan financial markets continue to develop, they are experiencing a high level of volatility. This volatility is generally attributed to micro and micro economic variables, such as foreign exchange rate. These African economies are portraying characteristics similar to those witnessed before the Asian and Mexican financial fiascos, such as currency speculation, loss of investor confidence, increasing linkages, and increasing inflation rates. When countries are faced with such an increasing financial growth rate, there is a tendency to adjust their local currency to a stronger international one, as seen in the case of Argentina and Thailand. Mehran et al. (1998) indicated that the African financial markets were not currently integrated with the major and more volatile financial economies. But as Africa economies continue to develop and expand, the level of international exposure increases, and this can lead to a sudden change in the level of private investments. Foreign exchange rate is the key financial intermediary that assists in facilitating diversification of portfolios by international investors.

The transmission of stock market volatility is considered to be one of the factors that facilitates the spread of stock market crisis and volatility to other markets. The degree of volatility transmission varies from region to region (i.e., within the developed markets or from the developed markets to the emerging markets). As the world becomes more integrated, the rates of financial crisis spreading across the globe have increased (e.g., the East Asian and Mexican financial crises). Sachs, Tornell, and Velasco (1996) showed that the 1994 Mexican crisis ("Tequila effect") impacted many countries. They explained that currency overvaluation and irresponsible banks were some of the main contributors to this crash. Nijathaworn and Dejthamrong (1994)

showed that Thailand's 1997 crisis was caused by similar events (unregulated bank lending and overvaluation of foreign exchange rates). Aron (1997) noted that, in the 1970s, exchange rates in Africa were held fixed, with infrequent adjustments. He stated that these rates were overvalued and experienced stringent rationing. Since the introduction of market-determined and convertible exchange rates, some of these African currencies have depreciated by over 80% (Salami, 2002). Based on the above historical information, this study was designed to investigate the influence of exchange rates on the Sub Saharan financial markets.

Increasing global events such as war, terrorism, and financial scandal can easily be transmitted across national borders. An increase in financial market integration can result in a calamity if an unexpected event occurs. This happened during the Asian financial crisis of 1997 and during the stock market crash of 1987. These events did not impact the African economies, mainly because of their low correlation to international markets.

Increased market integration does not necessarily result in increased correlation of markets. Roll (1992) stated that countries with similar industrial compositions are more likely to have correlated financial markets than are those without. The Sub-Saharan countries are members of various trading blocks, and some of the registered companies within the stock markets are registered in more than one stock exchange. As the African markets continue to expand and in light of the fact that they are all in the same region and within the same time zone, it is important to document the linkages and interdependence of these equity markets. This increases the correlation level of these financial markets within this group.

The increasing levels of communication technology (e.g., advanced computer technology and improved network processing of news) have resulted in an increase in

the transmission of volatility. Spillovers of returns and volatility across markets have important implications for portfolio choice and risk management. Liberalization, integration, and increasing linkages are associated with transmission of high volatility of stock price movements. Such activities could create global market instability (Roll, 1992). The African economies are not fully integrated into the global economy; thus, they have been able to avoid financial contagion. However, as they continue to expand and their volatility levels increase, it is important economic research to document the level of transmission among the African countries and to international markets.

The Research Problem

The purpose of this study was to investigate the characteristic of Sub-Saharan financial volatility. Its primary contribution lies in providing informative literature to enhance allocation of resources and encourage external investment through diversification of portfolios.

The objectives of the study were (a) to measure the levels of interdependence among Botswana, Kenya, Nigeria, South Africa, and Zimbabwe; (b) to investigate the influence of exchange rate volatility on Sub-Saharan stock markets; (c) to determine whether volatility was being transmitted among the five countries; and (d) to determine whether volatility was being transmitted from the financial markets of the United States or Great Britain to the financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe.

The investigated research questions were as follows:

1. What are the correlational relationships among the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

2. What is the relationship between the exchange rate volatility and the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

3. Is there transmission of stock market volatility among the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

4. Is there transmission of stock market volatility from the United States or Great Britain to the Sub-Saharan financial markets of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe?

The review of literature showed a need to study the levels and behaviors of Sub-Saharan financial market volatility, as the impact can be overwhelming to the African and global economies. For example, market volatility can influence investors, it can act as an indicator of the level of financial default, it influences the level of investor confidence in a country's stock market, and it can affect the growth of the real sector in an economy. The level of volatility spillover should be documented. The overall benefit of such a study is that it can assist potential private or government investors to allocate their funds wisely. It can also help policy makers to set regulations and guidance accordingly.

Review of the Literature

A review of current literature relevant to the study was presented in chapter 2. The first section of chapter 2 covered the analysis of issues related to the Sub-Saharan financial markets. The second section reviewed literature about the Sub-Saharan market correlation level, covering the various trading blocks that surround these African countries. The third section reviewed the literature related to correlation and diversification theories. The fourth section reviewed literature related to volatility of a

foreign exchange. The fifth section reviewed literature related to transmission of stock market volatility.

Research Approach

All of the data used were secondary data related to the data collection period of January 1998 to April 2004. Pearson correlation tests were used to investigate the correlational relationships among the five countries' stock market returns. The GARCH model was used to examine the relationship between the exchange rate volatility and the country's stock return. The EGARCH model was used to examine the transmission of volatility within the studied markets. The ADF (unit root) was used to test for stationarity of the stock exchange data. Other statistical techniques that were applied as a residual test (to test the accuracy of the GARCH model) were the Correlogram squared residuals, histogram-normality test, and ARCH LM test.

Findings

The findings showed the following:

1. The five Sub-Saharan stock returns were nonnormally distributed and stationary.

2. There was a low correlation among the Sub-Saharan financial markets and between the Sub-Saharan financial markets and the international markets. South Africa had a moderate relationship with the United States and Great Britain.

3. The five African countries had a standard deviation that was different from the mean.

4. Botswana and South Africa had a negative skewness, while the rest of the countries had positive skewness.

5. The stock exchanges were stationary, leading to rejection of the null hypothesis of the unit root.

6. Foreign exchange volatility contributed to volatility of the markets of Botswana, Kenya, and Nigeria.

7. Stock exchange volatility contributed to the volatility of the exchange rate in the markets of Botswana, Kenya, Nigeria, and South Africa

8. All five Sub-Saharan countries transmitted volatility to Botswana and Kenya; South Africa and Kenya transmitted volatility to Nigeria; Kenya, Nigeria, and Zimbabwe transmitted volatility to South Africa; and Botswana and South Africa transmitted volatility to Zimbabwe

9. Great Britain transmitted volatility to Botswana, Kenya, Nigeria, and South Africa, and the United States transmitted volatility to all of the studied countries.

Interpretation and Discussion of Results

This study focused on the volatility of the Sub-Saharan financial markets in Botswana, Kenya, Nigeria, South Africa, and Zimbabwe. The Pearson correlation test was used to answer research question 1, regarding possible correlational relationships among the markets of these countries. The GARCH models were used to answer research question 2, regarding possible relationships between foreign exchange rate volatility and the stock markets. The EGARCH models were used to answer research questions 3 and 4, regarding possible transmission of volatility. The findings used to answer each of these research questions are discussed in this section.

Correlational Relationships Among the Five Markets

Portfolio diversifications are based on the principle that, if securities in a portfolio are not perfectly correlated, the movements in the return on any component of the security are offset by some of other securities within the portfolio. Levy and Sarnat (1970) stated that international diversification of a portfolio of assets could result in better gains, as the imperfect correlation would be generated from different countries.

The results of the Pearson correlation test showed that the markets of these five Sub-Saharan countries had low correlation with each other. The measures of international correlation showed that South Africa had a moderate correlation with the United States and Great Britain, and the other countries had a low correlation.

The findings of low correlation among the Sub-Saharan financial markets can be related to findings reported in such studies as Bergstrand (1985) and Flavin et al. (2002), who stated that factors such as geographical variables, market size, common borders, and colonial links do not necessarily create linkages within common markets. The studied African countries are all former British colonies; they are all within the same geographical region; they are ranked as the top five financial markets within the Sub-Saharan region. Another explanation of the lack of strong intercorrelation among these Sub-Saharan stock markets is that local investors are skeptical because they are unable to gather information from the regional markets (Kang & Stulz, 1997; Merton, 1987). This could be a result of poor technology and lack of information. This explanation was suggested by King, Sentana, and Wadhwani (1994) and French and Poterba (1991), who stated that investors feel safer investing in domestic assets rather than diversifying to foreign markets. Also, the lack of correlation within the African markets could be explained by the fact that the Sub-Saharan countries lack a common

currency; Bodart and Reding (1999) stated that exchange rate influences financial market correlations.

This study found that the South African market had a moderate correlation with financial markets in Great Britain and the United States. This correlation is caused by the fact that these are large stock exchanges and are more liquid. Another factor that could explain this correlation is the high number of firms that are cross-listed in these markets. The majority of the firms that are listed by the FTSE 100 and S&P 500 are also listed in the South African stock exchange. Roll (1992) stated that countries with similar industrial composition tend to have more highly correlated stock markets. The findings showed that international investors, rather than regional investors, influenced the South African stock market.

Relationship Between Exchange Rates and Sub-Saharan Stock Exchanges

The study found a bidirectional relationship between stock exchange volatility and foreign exchange volatility in Botswana, Kenya, and Nigeria. This finding is consistence with findings from other emerging markets (e.g., Granger, Huang, & Yang, 2000; Ramasamy & Yeung, 2001). The study found a unidirectional relationship between stock exchange volatility and foreign exchange volatility in South Africa. This finding is consistent with findings reported by Ajayi and Mougoue (1996), Nagayasu (2001), and Kaminsky, Lizondo, and Reinhart (1998).

The above findings are critical in determining what policies a country should follow to curb volatility within their stock markets and foreign exchanges. For the case of South Africa, the stock market is the leading factor. In such a case, the government of South Africa can promote policies that increase the efficiency of the

financial markets. Such policies should be geared toward controlling volatility in the stock market or extreme movement of foreign exchange. On the other hand, when the foreign exchange rate is the leading factor, or in a bidirectional movement, a good exchange rate policy is advisable. The result would be to help the financial markets during the extreme volatile periods.

The findings also noted that Botswana and Kenya had an inverse relationship between foreign exchange rate volatility and their stock exchange volatility; in contrast, Nigeria had a positive relationship. South Africa and Zimbabwe stock exchanges were not influenced by foreign exchange volatility. Aggarwal (1981) studied the influence of the U.S. dollar on U.S. stock exchange prices and reported a positive correlation. Other studies have reported similar results, including Chamberlain, Howe, and Popper (1997), who found that U.S. banking stock returns were positively influenced by foreign exchange rate. The positive relationship between exchange rate and stock exchange is caused by domestic market depreciation. The market depreciation makes local market competitive and increases their export level. This phenomenon is witnessed in an export-dominant country, which is the case in Nigeria as its export potential has continued to increase. For example, oil provides 90% of its earnings, as Nigeria is the sixth-largest exporter of oil in the world. On the other hand, the portfolio balance model suggests a negative relationship between exchange rate and stock price volatility (Branson, 1983; Frankel, 1983).

Influence of Foreign Exchange Rate on Stock Market Volatility

The GARCH model was used to study the influence of the foreign exchange volatility on stock market returns. The results of the GARCH model (Table 28) show

Table 28

Relationship Between Foreign Exchange Volatility and Stock Returns in the Markets of Five Sub-Saharan Countries

Country	Stock exchange	Foreign exchange
Botswana	Significant (negative)***	Significant (negative)***
Kenya	Significant (positive)***	Significant (negative)***
Nigeria	Significant (positive)***	Significant (positive)***
South Africa	Significant (negative)***	Nonsignificant
Zimbabwe	Nonsignificant	Nonsignificant

*$p < .10$. **$p < .05$. ***$p < .01$.

that foreign exchange volatility had great influence on the financial markets of Botswana, Kenya, and Nigeria. The stock exchange volatility had a great influence on the foreign exchange rates of Botswana, Kenya, Nigeria, and South Africa.

Regional Transmission of Stock Market Volatility

The purpose of research question 3 was to determine whether there was transmission of volatility among the markets of the five Sub-Saharan countries. The results were intended to provide insight into the degree of volatility spillover and the dynamics of volatility movement among the studied markets.

The results shown in Table 14 indicate significant volatility spillover effects from Kenya, Nigeria, South Africa, and Zimbabwe to Botswana. This volatility transmission is positive from Nigeria (i.e., the four countries transmit good news to the Botswana financial market) and negative from Kenya, South Africa, and Zimbabwe.

The volatility transmission is transferred to the smaller market (Botswana is also the newest of the five markets). The five countries belong to the same trading block (i.e., Comesa). Botswana is considered as one of the fastest-growing countries in Sub-Saharan Africa. The data indicate close trade links between the four countries and Botswana.

The results shown in Table 15 indicate transmission of volatility from Botswana, Nigeria, South Africa, and Zimbabwe stock exchanges to Kenya financial markets. The finding shows that the four stock exchanges transmit positive volatility to the Kenya market, while South Africa and Zimbabwe stock exchanges transmit positive volatility. This shows an increase in trade among the five economies.

The results shown in Table 16 indicate that the Kenya and South Africa stock exchanges transmit volatility to Nigeria. Results also show that the two countries transmit positive news to the Nigeria stock exchange. Like the other countries, the Nigerian stock exchange is smaller than the South African exchange. This is an indication of a high level of cross-listing among the markets.

The results shown in Table 17 indicate that Kenya, Nigeria, and Zimbabwe transmit volatility to the South African stock exchange. These three countries transmit negative news to the South African market. This is an indication of cross-listing and increasing trade links among the four markets.

The results shown in Table 18 indicate that Botswana and South Africa transmit volatility to Zimbabwe. It also shows an inverse relationship between these markets. As with the other market comparisons, this is an indication of cross-listing and, because of the fast-growing economy of Botswana and the fast-declining economy of Zimbabwe, there is increasing cross-border trading between the two countries.

International Transmission of Stock Market Volatility

The results presented in Tables 19, 20, 21, 22, and 23 show that the United State and Great Britain transmit volatility to Botswana, Kenya, Nigeria, and South Africa. Only the United States transmits volatility to Zimbabwe. The coefficient of the volatility of the United states and Great Britain was negative for Botswana, South Africa, and Zimbabwe, indicating that they had an inverse relationship. Also, the leverage effect terms for Botswana and South Africa were negative and statistically significant. This indicates that the Great Britain and United States transmit bad news more than good news to Botswana, South Africa, and Zimbabwe; that is, a negative return shock from the two international markets produces higher volatility than a positive return shock.

The inverse relation between the United States or Great Britain and the Sub-Saharan financial markets reflects hidden trend effects that are not incorporated into our model. For example, according to Hashmi and Xingyun (2001), such factors as competition in third markets, bank lending, and foreign direct investment should be considered when measuring international transmission of stock market volatility. However, they noted that these factors are highly correlated, making it difficult to isolate the individual impact of each set of factors. Peek and Rosengreen (1997) stated that negative news about a large economy's growth prospects could cause negative returns in that country's asset market. In some cases, the investors and banks may choose to keep their total volume of lending constant and shift their attention to other countries, thereby increasing their lending into the smaller markets. This can cause an inverse relationship, as happens in the case of Great Britain or the United States financial markets to the South Africa financial market. Hashmi and Xingyun explained that, if negative economic news in a large country corresponds to a

depreciation of its exchange rate, its exports could gain a competitive advantage and therefore have a negative effect on expected asset returns in countries that are important trade competitors.

Another economic explanation for an inverse relationship is that the serial correlation coefficient between the United States financial markets and those of Botswana and South Africa returns implies a price reversal. For example, a negative daytime return follows the positive overnight return. A possible explanation for this price reversal is that, when good news from the international markets arrives in the local African market, the local market investors initially overreact but make a correction during the daytime. Similar findings are observed between the United States financial markets and some Asian countries' stock exchanges (Dong-Soon and Dongcheol, 2004). Finally, there is a possibility that, when negative shocks are experienced in the United States or Great Britain, there is a massive withdrawal of activity from other short-term markets within the Sub-Saharan region in order to invest in the larger multinationals that are cross-listed in the S&P 500 or FTSE 100 and vice versa.

Summary of Findings

This study examined the correlational relationships and possible interdependencies among financial markets in five Sub-Saharan African countries. The studied countries were Botswana, Kenya, Nigeria, South Africa, and Zimbabwe.

First, the study tested for possible correlational relationships among the five countries and between each of the five countries and the United States and Great Britain. This question was examined by applying the Pearson correlation test to

measure the strength of the linear relationship between two variables. The analysis resulted in the following findings.

1. The Sub-Saharan countries had a weak but significant correlational relationship.

2. The United States and Great Britain had a moderate correlational relationship with the South African financial market. These findings agree with similar findings that geographical borders, past colonial links, or the size and age of the financial markets do not promote interdependencies. These findings also agreed with those of studies that have found that large (more liquid) financial markets, cross listing, and markets with similar industrial composition encourage interdependencies.

Second, the study investigated the influence of exchange rate volatility in the five Sub-Saharan stock markets. The intent was to determine whether exchange rate volatility influenced stock exchange volatility, stock exchange volatility influenced the foreign exchange rate volatility, or there was a bidirectional influence. This issue was tested using the GARCH models, which are highly recommended and widely used as a tool for measuring the influence of macroeconomic volatility on a stock exchange. The analysis resulted in the following findings.

1. There was a bidirectional relationship between foreign exchange rate volatility and stock exchange volatility in Botswana, Kenya, and Nigeria.

2. The South Africa stock exchange had a lead on foreign exchange volatility.

3. There was no relationship between Zimbabwe stock exchange volatility and its foreign exchange rate.

4. Botswana and Kenya stock exchange volatility had a inverse relationship with foreign exchange volatility.

5. Nigeria stock exchange volatility had a positive relationship with its foreign exchange volatility

Third, the study sought to determine whether volatility was transmitted among the five countries. The main point of interest was to determine whether volatility in one country could be easily transferred to the other countries. The EGARCH models were used test whether negative or positive shocks were transferred. The main reason for using this model was that it is capable of capturing the influence of both bad news (market retreats) and good news (market advances). The analysis resulted in the following findings.

1. Four studied countries transferred volatility to Botswana. The positive return shocks from Nigeria (market advances) had more influence than the negative return shocks (market retreats) and vice versa for Kenya, South Africa, and Zimbabwe. The volatility in the Botswana stock exchange was asymmetric.

2. Nigeria, South Africa, and Zimbabwe transferred volatility to Kenya. The volatility of Kenyan stock exchange was asymmetric, and there was indication of a leverage effect: Positive return shocks had more influence than negative return shocks.

3. The South Africa and Kenya stock exchanges transferred volatility to the Nigeria stock exchange. There was evidence of leverage effect. The positive return shock (market advances) produced more volatility than did negative return shocks (market retreat). The volatility of the Nigeria stock exchange was asymmetric.

4. The Zimbabwe, Kenya, and Nigeria stock exchanges transmitted volatility to the South Africa stock exchange. There was indication of a leverage effect, and the negative shocks (market retreats) had more influence than the positive shocks (market advances).

5. Botswana and South Africa transmitted volatility to the Zimbabwe stock exchange.

Fourth, the study sought to determine whether volatility was transmitted from the financial markets of the United States or Great Britain to those of Botswana, Kenya, Nigeria, South Africa, and Zimbabwe. The analysis resulted in the following findings.

1. Financial markets in Great Britain transmitted volatility to Botswana, Kenya, Nigeria, and South Africa financial markets.

2. Financial markets in the United States transmitted volatility to the Botswana, Kenya, Nigeria, South Africa, and Zimbabwe financial markets.

Fifth, the study analyzed the level of each country's influence on the others, using a variance decomposition model. It was assumed that volatility originated from the U.S. markets into the markets of Great Britain, then into South Africa, Nigeria, Zimbabwe, Kenya, and Botswana. Using this order, the analysis resulted in the following findings.

1. Great Britain received the highest levels of volatility, followed by South Africa and Botswana.

2. Volatility in the United States, Nigeria, and Zimbabwe originated from domestic factors rather than international factors.

In conclusion, the analyses indicated that (a) foreign exchange volatility influences the Sub-Saharan stock exchanges, (b) there is transmission of volatility within the Sub-Saharan African markets, and (c) there is transmission of volatility from the United States and Great Britain to the Sub-Saharan financial markets.

Conclusion

Research question 1 asked whether there was a correlational relationship among the markets of five Sub-Saharan countries: Botswana, Kenya, Nigeria, South Africa, and Zimbabwe. The results of application of the GARCH model to test relationships between foreign exchange volatility and the five Sub-Saharan financial markets, the EGARCH models to test regional transmission of stock market volatility among the markets, and the EGARCH models to test transmission of volatility from the United States or Great Britain into the five markets during the sample time period of January 1998 to April 2004 led to acceptance of the hypothesis of relationship.

Research question 2 asked whether there was a relationship between the exchange rate volatility and returns in the five Sub-Saharan financial markets. Results showed such a relationship, and the null hypothesis was accepted. However, the study found no relationship between exchange rate volatility and the financial market in Zimbabwe; thus, the null hypothesis was rejected for this country only.

Research question 3 asked whether there was transmission of stock market volatility among the Sub-Saharan financial markets. Based on the findings summarized in Table 29, the null hypothesis was accepted.

Research question 4 asked whether there was transmission of stock market volatility from the United States or Great Britain to the five Sub-Saharan financial markets. The null hypothesis was accepted for all five countries.

Through use of the EGARCH models, the study showed that Sub-Saharan Africa was experiencing regional and international transmission of volatility, as is true in other emerging markets. The study also showed that there are unidirectional and bidirectional relationships between foreign exchange rates and stock market volatility.

Table 29

Relationships Among the Sub-Saharan Stock Exchanges

Pair	Relationship
Botswana and Kenya	Strong negative
Botswana and Nigeria	Strong positive
Botswana and South Africa	Strong positive
Botswana and Zimbabwe	Strong negative
Kenya and Nigeria	Strong negative
Kenya and South Africa	Strong positive
Kenya and Zimbabwe	Strong positive
Nigeria and South Africa	Strong positive
South Africa and Zimbabwe	Moderate negative

The results indicated that volatility and volatility transmission are not restricted to the markets of North America and Europe; they are present in most markets in general.

Implications and Economic Contributions

As countries such as Zimbabwe face extreme foreign exchange volatility and as African countries continue to move toward regional markets, globalization, and increasing trade blocks, the international monetary facilitators such as the Bretton Woods Foundation, the World Bank, and IMF should take actions or rather provide specific guidance to these Sub-Saharan markets. This is especially important because a foreign exchange crisis in Sub-Saharan Africa can spill through the multinationals

cooperation to the rest of the world economies, as happened during the Asian crisis of 1997.

The purpose of research question 1 was to investigate whether there was any relationship among the studied financial markets. The statistical findings of the Pearson correlation test were that there were low correlations in the regional and/or international relationships among the studied markets. However, as expected, there was an international relationship between South Africa financial market returns and those of the Great Britain and the United States. The economic contribution of this finding is that regional investors (with Sub-Saharan Africa) can significantly reduce their unsystematic risk by diversifying into their neighboring countries. Also, the international investors who are interested in addressing the risk of extended bear markets at home should consider investing into the fast-developing Sub-Saharan financial markets. This research paper shows that the Sub-Saharan equity markets has a potential for receiving capital inflows as fund managers seek to diversify into the frontier and/or emerging financial markets. This finding is supported by Levy and Sarnat (1970) and Solnik (1995), who stated that international diversification of a portfolio of assets could result in better gains, as the imperfect correlation would be generated from different countries.

The purpose of research question 2 was to investigate whether there were any relationships between exchange rate volatility and the five Sub-Saharan financial markets. The statistical finding of the GARCH model was that there were bidirectional relationships between stock market volatility and exchange rate volatility (significant price spillovers) within the countries of Botswana, Kenya, and Nigeria. The data also showed that the South African stock exchange volatility influenced that country's exchange rate. The economic contribution of this finding is that, for

Botswana, Kenya, and Nigeria, the currency depreciation or appreciation often drags down or up the stock prices for those countries. Also, for Botswana, Kenya, Nigeria, and South Africa, an increase or decrease in the stock price often causes currency depreciation or appreciation. These results show that changes in stock prices signal important information about the economic trend of the foreign exchange rates for the countries of Botswana, Kenya, Nigeria, and South Africa. The results also show that changes in foreign exchange rate signal important information about future stock price movements for the countries of Botswana, Kenya, and Nigeria. In light of this information, it is important that these countries instill supportive policies to prevent excessive appreciation or depreciation of exchange rate (e.g., through the promotion of transparency, to international standard, of the key commercial or central banks and exchange markets.

The purpose of research question 3 was to investigate whether there was transmission of stock market volatility among the five Sub-Saharan countries. The statistical findings of the EGARCH model were that there was transmission of volatility within the countries. The economic contribution of this research project is that the spillover effects come from the dominant Sub-Saharan countries to the smaller ones. This is similar to the finding of Janakiramanan and Lamba (1998), who stated that more dominant markets exert greater influence on smaller ones. Another contribution from this finding is that the Sub-Saharan countries should be aware that negative and/or positive economic events from neighboring countries can directly influence their stock exchanges. This knowledge is especially important after such events as the 1997 Asian crisis and 1994 Tequila effect. Another economic contribution from the data related to this research question is that the Sub-Saharan countries are bearing the

fruits of continuous trading blocks (i.e., there is integration of the capital markets that could be caused by activities such as trading in goods and services).

The purpose of research question 4 was to investigate whether there was transmission of stock market volatility from Great Britain or the United States to the five Sub-Saharan countries. The statistical findings of the EGARCH model were that there was transmission of volatility from these two international markets into Sub-Saharan Africa. The last major stock market spillovers (the 1997 Asian crisis and 1987 stock market crash) did not directly affect the Sub-Saharan region because the Sub-Saharan region was not integrated into the global economies, as they currently are. The economic contribution of the findings related to this research question is that there are spillover effects from the United States and Great Britain into the Sub-Saharan countries. This is especially important because the United States has been identified as the major source of spillover (as indicated in chapter 2). If an economic calamity, such as the Asian crisis, occurs, the African countries may not be spared. This information is important because, as the Sub-Saharan financial markets continue to expand, they should monitor international economics activities that can spill over to them.

In summary, this study can be applied to addressing foreign exchange risk management problems. Governments can implement policies that are geared toward controlling volatility in the stock markets or extreme movement of foreign exchange rates. Specifically, the Sub-Saharan governments can introduce and promote a good exchange rate policy through transparency.

The results of this study should be of interest to top portfolio managers. As the study shows, because the Sub-Saharan countries had low correlations with one another, their customers (investors) can diversify across national borders. The study

also shows that, except for South Africa, the Sub-Saharan countries had low or no negative correlations with the United States or Great Britain. Therefore, it is recommended that international investors invest in the Sub-Saharan African countries as a way of diversifying their portfolios. The study has shown that diversification benefits to the African economies are possible at regional and international levels.

Following Akgiray (1989); Hall et al. (1995); Pagan and Schwert (1990); and Rahman and Yung (1994), the mean squared error (MSE) statistic was applied to show the improvement in volatility forecast when interdependence between stock markets is taken into consideration. A two-month sample of data was used to test the superiority of the EGARCH models shown in Equations 15, 16, 17, 18, 19, and 20. According to Hall et al., the smaller the root mean square error (RMSE), the better the forecasting ability of the model. Table 30 shows that the RMSE was consistently smaller for the EGARCH forecast when the spillover effect was considered, except for Zimbabwe. This shows that the present model has a more effective forecasting ability.

Table 30

Forecast Variability of the EGARCH (1,1) Model Using Two Months Sample Daily Returns (Reported Numbers Are Root Mean Squared Error)

	Bw	Ke	Ng	Za	Zw
Historical estimates	0.573017	1.304073	1.093478	1.053876	1.480492
EGARCH Forecast	0.572013	1.301056	1.092043	1.053303	1.485803

Note. Bw = Botswana stock exchange, Ke = Kenya stock exchange, Ng = Nigeria stock exchange, Za = South Africa stock exchange, Zw = Zimbabwe stock exchange.

Recommendations for Future Research

This study was delimited to five Sub-Saharan countries: Botswana, Kenya, Nigeria, South Africa, and Zimbabwe. A further study could include a broader sample of all Sub-Saharan stock exchanges. The study could be expanded to include the markets of North Africa countries, such as that of Egypt, which have been experiencing good growth. Because of increasing technology and communication capabilities, this study could be expanded to include hourly volatility in order to identify specific volatility trends.

The study was delimited to an examination of two international markets: the United States and Great Britain. A further study could include a broader sample of major international markets that are interested in investing in Africa. The study could be expanded to include markets of Asia (i.e., China and Japan).

This study used the Pearson correlation and the GARCH models; the study can be replicated using other statistical (for correlation) and time series models that might provide more accurate results.

The study can be replicated using various indexes to pinpoint the specific growth and volatility areas of Sub-Saharan Africa (e.g., banking, utility, natural resources, tourism, industrial).

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