# HOW INTEGRATED ARE THE AFRICAN STOCK EXCHANGES? EVIDENCE FROM LONG TERM COMOVEMENT, RETURNS AND VOLATILITY SPILLOVERS

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A thesis to be submitted in partial fulfilment of the requirements for the degree of

MASTER OF COMMERCE (FINANCIAL MARKETS)

DEPARTMENT OF ECONOMICS AND ECONOMIC HISTORY
RHODES UNIVERSITY, GRAHAMSTOWN

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# DECLARATION

*Except for references specifically indicated in the text, and such help as has been acknowledged, this thesis is wholly my own work and has not been submitted to another University, Technikon or College for degree purpose.*

Tinashe Harry Dumile Kambadza III

# ABSTRACT

Stock market linkages have implications for portfolio diversification, asset pricing, monetary and regulatory policy as well as financial stability. This study examines the extent to which African stock markets are linked using daily data for the period 2000-2010. The study is divided into three main parts each focussing on the ways in which integration of the stock markets can be viewed.

Firstly, we analyse the long run co-movement of the stock markets using both bivariate and multivariate Johansen (1988) and Johansen and Juselius (1990) cointegration approaches. Secondly, we analyse returns linkages using Factor analysis and the Vector Autoregressive (VAR) models. In the Factor Analysis model, we used two extraction methods, namely Principal Component Analysis and the Maximum Likelihood technique. The VAR model was extended with impulse response, variance decomposition and block exogeniety. Thirdly, we analyse the behaviour of volatility and the volatility linkages among the stock markets. We initially analysed and modelled volatility in each stock market using the GARCH, EGARCH and GJR GARCH and then examined the long-term trend of the volatility. Conditional volatility series for each country were then estimated using the most appropriate model and were analysed using VAR, block exogeniety, impulse response and variance decomposition to determine the extent of their linkages.

The findings of the study are as follows: Both the bivariate and multivariate models found slim evidence of cointegration amongst the stock markets, suggesting that there were opportunities for portfolio diversification for investors. In general, the financial crisis had very little impact on the long-run relationships of the stock markets. Results for the returns linkages showed that there were limited returns linkages with the exceptions of South African-Namibia and Egypt-Morocco to a lesser extent. South Africa was found to be the most endogenous, whilst Ghana and Nigeria were the most exogenous on the continent. We regards to volatility, we found that it was asymmetric and persistent across all the stock markets with long term trend of volatility showing that it significantly increased for most of the markets. Finally, there were limited volatility linkages, only between South Africa, Egypt and Namibia, implying that African stock markets are still largely segmented from each other. However, the linkages between South Africa and Egypt could have negative effects as they could lead to the spread of contagion effects during times of crises. Therefore, policymakers should consider revising and improving policies to enhance economic integration on the continent.

## ACKNOWLEDGEMENTS

I would to thank the Almighty God who gave me the strength and ability to write this thesis. I would like to express my sincerest gratitude to my supervisor, Mr Zivanemoyo Chinzara, for his admirable supervision of the thesis. His patience and knowledge were invaluable in guiding me to write this thesis.

Professor Meshach Aziakpono, thank you very much for the academic guidance and advice throughout the Masters course, one could not wish for a better or friendlier lecturer.

To my family, thank you Mom, Dad, Dumisani, Tanya and Tawanda for the love and support. You guys have sacrificed a lot and have always been there for me, for that I am forever grateful, I am truly blessed. I salute you and dedicate this thesis to you.

Last but definitely not least, I would like to thank my friends and classmates; Brenda, Brian, Derwina, Gladys, Gordon, Lamin, Mabvuto, Mosidi, Tatenda, Toby, Toddy, Trevor, Sean and Randall. It was an honour to share a classroom with you guys and I will always cherish the moments we had together, especially all those sleepless nights in the labs!

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# CHAPTER ONE

# INTRODUCTION

## 1.1 CONTEXT OF THE RESEARCH

Over at least the past three decades, most emerging and developing economies have adopted and have been adopting liberal economic policies including amongst others the flexibility of exchange controls as well as communications and technological changes. This has resulted in increased comovement of world macroeconomic and microeconomic variables notably prices of commodities, factor inputs, growth stocks and consumption. Global financial markets have been no exception to this phenomenon as these policies have also led to comovement of financial markets with implications for both investment and policy decision making. However, globalisation has also brought with it negative connotations due to the increased complexity of financial markets. This impact of financial variables on the macro economy and economic policy has added impetus to the already growing interest in studying the linkages in financial markets.

This interest stems from the fact there has been a significant increase in the globalisation of financial services as a result of increased international trade in goods and services ultimately increasing the flow of funds around the world. The abolishment of capital controls[1] has enabled the cross-border movement of capital which has in turn led to the development of new financial products due to financial innovation (Smith, 1999). However, advances in information technology maybe the most important factors as they have significantly reduced the costs of international communication and of managing and transferring funds further integrating financial markets but also bringing with it the global threat of financial instability (Macias and Massa, 2009). Notable evidence of this instability includes the 1987 stock market crash, the crisis affecting the European Union's Exchange Rate Mechanism in 1992-93, the Mexican crisis in 1994-95, the Asian crisis of 1997-98, the Russian crisis of 1998 and more recently the global financial crisis of 2007-2009. Therefore, understanding the international co-movement of financial markets is particularly important for at least five reasons. These include portfolio diversification, monetary policy, regulatory policy, asset pricing as well as financial stability (Chinzara and Aziakpono, 2009b).

Given the complexity of financial markets, various studies have examined issues such as volatility transmission and returns linkages in relation to financial crises in global stock markets.

[1] These were abolished in the US and Germany almost immediately after the demise of fixed exchange rates in the early 1970s, the UK in 1979, Japan in 1980, France and Italy in 1990, (Smith, 1999). In terms of Africa, South Africa has initiated relaxation of capital control progressively since 1997 (Du Toit, 2010).

Following this, two schools of thought have emerged with opposing arguments of whether these crises originating in developed markets really spill-over to emerging and developing markets. Those supporting this premise argue that the globalisation of financial markets have resulted in emerging and developing markets being susceptible to world crises such as those noted above due to capital reversals and 'contagion effects'. For instance, the global financial crisis of 2007-2009 started in the US but spread around the world potentially devastating smaller economies. The secondary effects of the crisis had a negative impact on sub-Saharan Africa (SSA) as growth fell from 6.9% in 2007 to 5.5% in 2008 (Macias and Massa, 2009). The opposing view provides a counter argument by saying that adverse effects on emerging and developing markets are less likely because the use of structured products is less prevalent in these markets relative to developed markets (see Sun and Zhang, 2009:3). Nonetheless, what seems to be lacking is an analysis of how and to what extent stock markets from the major trading regions in Africa have been affected by the recent financial crisis and the implications on future macroeconomic policy. For this reason, this study aims to address this issue by examining the degree of integration of selected stock markets and its inference to both policymakers and investors.

The need to ascertain whether there are possibilities of gaining from international diversification led to the pioneering research on global international linkages of financial markets since the early 1970s (see Levy and Sarnat, 1970; Grubel and Fadner, 1971; Ripley, 1973; Lessard, 1973 and Solnik, 1974). Most of these studies have been carried out amongst developing and emerging stock markets with the general finding revealing that there has been a low correlation of global stock returns and that country-specific factors are more important in determining local stock prices in comparison to foreign factors. As a result of this, arguments for international diversification have been authenticated consequently providing investors with the incentive to venture into new markets. However, recent studies have found that markets are becoming increasingly integrated and interdependent indicating increased comovements in financial markets and potentially reducing the opportunities for diversification (e.g Taylor and Tanks, 1989; Kasa, 1992; Masih and Masih, 1997, Meric and Meric, 1997, Abhilash and Ramanathan, 2002; Yu and Hassan, 2006).

The literature on the integration of African equity markets with developed markets reveals that these two markets are generally independent of one another, with the exception of South Africa and Egypt (see Lamba and Otchere, 2001; Forbes and Rigobon, 2002; Piesse and Hearn, 2002; Biekpe and Collins, 2003; Piesse and Hearn, 2005; Humavindu and Floros, 2006; Agathee, 2008; Alagidede, 2008 and Onour, 2009). A relevant finding in these studies is that South Africa is the dominant market on the continent which comes as no surprise as the market is the oldest and largest with regards to market capitalisation and trade volumes (Piesse and Hearn, 2008; Chinzara and Aziakpono, 2009a&b). This study focuses on the relationships amongst the stock markets under study in terms of their daily returns and volatility so as to provide a broader perspective on the continent rather than doing the analysis from a South African perspective.

## 1.2 THE GOALS OF THE RESEARCH

The broad objective of this study is to examine how integrated the African bourses are linked and articulate the implication of these linkages for portfolio diversification and vulnerability of markets through contagion during crises. This main goal will be addressed through answering the following specific goals:

- Analysing the long-run comovement between the selected African stock markets with a view to analysing the extent to which long-term investors can benefit from international portfolio diversification.
- Investigating whether there is a common trend driving the African stock markets returns.
- Examining the returns/mean linkages amongst the markets together with speed, magnitude and nature of these mean linkages and if any reverse influences exist.
- Examining the nature of volatility and volatility linkages amongst the markets as well as the magnitude and speed of volatility transmission from one market to another.
- Examining the importance of regional factors in determining the integration of the stock markets due to macroeconomic factors such as bilateral trade linkages.

## 1.3 MOTIVATIONS FOR THE STUDY

As noted above, a careful analysis of stock market linkages is important to both investors and policymakers as they determine the outcomes of monetary policy, optimal resources allocation, risk measurement, capital requirements as well as asset valuation. For investors, understanding how markets move together may result in better portfolio and hedging strategies, whereas from a policymaker's point of view they may be focused on the actual causes and consequences of such spillovers.

From an analytical point of view, there are various reasons why studying regional linkages of equity markets is important. These include financial regulation, stock market efficiency, portfolio diversification, effectiveness of monetary policy as well as the importance of sources of capital such as portfolio investments and foreign direct investment (FDI). For instance, financial regulators need to take into consideration volatility transmission from foreign financial markets when formulating policies aimed at stabilising the financial system (Corsetti, Pericoli and Sbracia, 2005:2). On the other hand, successful international portfolio diversification requires that co-movement among stock markets is low or negative so that a poor performance in one national market is hedged by the international market (Tastan, 2005:2). Since the asset channel is a paramount conduit for the transmission mechanism of monetary policy (Mishkin, 1995:6), global transmission of equity-market shocks might affect the effectiveness of monetary policy. Rigobon and Sack (2003) have empirically shown that monetary policy tends to respond to movement in stock markets. Studies of this nature can be applied to African stock markets as regional portfolio diversification will also require low correlations amongst stock markets to allow for hedging so as to enable investors to maximise their returns from investing in different countries. In addition, regional transmission of equity markets will have implications on regional monetary policy. This is especially important in the underdeveloped African markets as it may provide insight in policy formulation and investment advice.

Most African stock markets, with the exception of the Johannesburg Stock Exchange (JSE), continue to share similar constraints as their host economies— low level of development, limited diversification, and constrained liquidity (Irving, 2000). Furthermore, there are too few indigenous companies listed in the markets and the trading in one or just a few stocks frequently dominates total activity. In fact, at USD 540 billion, the market capitalization of the entire continent is just a little over 60 per cent the size of the Swiss Market Index (SMI) , which stands at USD 850 billion as at 2008 (Credit-Suisse, 2009).For example, stock market capitalization in Africa is dominated by four markets: South Africa at capitalization of 60 per cent of the total (USD 312 billion); followed by Egypt at USD 83 billion; Morocco at USD 64 billion; and Nigeria at USD 40 billion, leaving just USD 40 billion ( or about 9%) for all the other countries combined (Credit-Suisse, 2009). Given these, previous researchers have not devoted enough space to investigating the interdependence among African stock markets. However, over time, African countries have made huge strides in improving the situation; for instance, the African Stock Exchange Association (ASEA), founded in 1993, is currently represented by 20 exchanges serving 27 countries (Aseaabuja, 2009).

Besides the fact that this study adds to the very limited studies on the comovements and returns and volatility linkages strictly amongst major African stock markets, it also takes a different approach with regards to the issues and the manner in which they will be addressed. Other studies have also studied the integration of African stock markets (see Lamba and Otchere, 2001; Piesse and Hearn, 2005; Agathee, 2008 and Piesse and Hearn, 2008), nonetheless, this studies differs from these by using new and comprehensive data. As noted above, most studies on Africa focus on the stock market linkages in terms of returns comovements and volatility transmission of South Africa with major world economies such as the US, UK, Japan, Germany and Australia. One such study carried out by Chinzara and Aziakpono (2009a) reveals that both returns and volatility linkages exist between South Africa and world stock markets; with Australia, China and the US showing most influence of SA returns and volatility[2]. However, it does not indicate the nature of integration of African stock markets in terms of the linkages and volatility transmission across the established regions on the continent.

This study therefore aims to fill this gap by examining eight major African stock markets to determine the degree to which they are integrated within the African continent. In addition, we examine the African countries by noting their relevant presence in specific trading regions, that is, the Southern African Development Community (SADC), the Common Market of Eastern and Southern Africa (COMESA), Middle East and North Africa (MENA) and the Economic Community of West African States (ECOWAS). This is vital in this study as we aim to make inferences, theoretically and methodologically, about the importance of interdependence due to regional factors. To our knowledge this has not been tackled by previous studies on African stock markets. We focus on the equity market and not on other financial markets because the stock market is a useful source of long-term finance. Also, the equity market seems to be more responsive to international events than other markets such as the bond market since returns in the bond market are directly influenced by conditions of domestic monetary policy (Goodspeed, 2009).

In order to conduct an effective study of the long-run co-movements and volatility transmission amongst the selected African countries the choice of the stock markets to be included in the study is not arbitrary. In this regard, the countries chosen are: Egypt, Ghana, Kenya, Mauritius, Morocco, Namibia, Nigeria and South Africa as they are the major equity markets in Africa. These countries are all members of the African Stock Exchange Association (ASEA). Egypt, Kenya and Mauritius are current members of COMESA. Egypt and Morocco are both in the MENA region whilst ECOWAS is represented by Nigeria and Ghana. South Africa, Mauritius and Namibia are members of the Southern African Development Community SADC[3].

[2] Refer to chapter 2 for a more in-depth review of this and other relevant studies.

[3] These bilateral trading regions are discussed in more detail in Chapters 2 and 3.

The study will establish degree of integration by testing for the existence of long-run co-movements and volatility transmission amongst the selected stock markets. First, a survey of both theoretical and empirical literature regarding the integration of stock markets will be conducted. The second step will involve analysing daily stock market data for the period 2000 – 2010. This period has been chosen by taking into consideration that firstly, it provides very recent data for analysis which covers the global financial crisis of 2007-2009 which enables us to make deductions on how it affected the linkages of the markets before, during and after the external shock. Secondly, it also considers the post independence pro-market reforms in South Africa which could have implications for regional integration since it is the largest market on the continent. Prior to the application of formal econometric methodology, descriptive statistical tests and simple correlation will be done. Some of the statistical tests include the mean, variance, standard deviation, skewness, kurtosis and normality of the data. The purpose of this is to check the behaviour of the data and to see the size and signs of correlations of the stock market before applying the formal econometric methodology.

## 1.4 METHODS OF THE STUDY

In order to examine the long run co-movement of the stock markets, both bivariate and multivariate forms of the Johansen (1988) and Johansen and Juselius (1990) cointegration approach will be applied. Factor analysis will be applied as a technique of multivariate analysis in order to analyse the stock market returns. This information will be used to explore both the comovements in the stock markets and the potential for diversification amongst them and will be complemented with the Vector Autoregressive (VAR) Model. To address the third sub-objective, the study will make use of the VAR model together with variance decomposition; block exogeniety and impulse response analysis. The fourth sub-objective will be addressed by applying the univariate Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model to analyse volatility in each stock market.

## 1.5 ORGANISATION OF THE STUDY

This study is organised as follows; Chapter 2 provides a thorough review on the relevant theoretical and empirical studies on the integration and interdependence of stock markets. This particular chapter is very important as it reviews the following issues; a conceptual overview of the stock market, the importance of understanding stock market linkages, sources of stock market comovements, the theory of stock market linkages and empirical literature. The empirical literature is reviewed in relation to the objectives of the study. Chapter 3 gives a background on the possible channels of stock market linkages in terms of trade linkages, financial linkages and stock market characteristics. In Chapter 4 we describe the methodology and data to be applied in order to address the above mentioned objectives. Chapter 5 presents our findings, whilst Chapter 6 is a synopsis of the most important findings which will conclude and propose policy implications of this study by also noting areas of possible future research.

# CHAPTER TWO

# THEORETICAL FRAMEWORK AND LITERATURE SURVEY

## INTRODUCTION

This chapter provides an insight into the theoretical and empirical studies on the range of issues concerning long run co-movement, returns linkages and volatility transmission among equity markets. It is divided into six different sections. The first section provides a conceptual description of the equity market as well as its importance to investment and the economy. The second section reviews the importance of understanding equity market linkages whilst the third section focuses on the sources of equity market linkages. In the fourth section, the International Capital Asset Pricing Model (ICAPM) is discussed in detail as an approach to studying stock market linkages. Section five reviews the empirical literature which is divided into two sub-sections with first one reviewing literature on the long-run comovements of stock markets and the second reviewing the returns and volatility linkages. The last section merges the five main sections and concludes the chapter.

## 2.1 THE EQUITY MARKET: A CONCEPTUAL OVERVIEW

The equity market falls under the capital market and is also known as the stock market. It is a market where institutions, corporations and companies raise long-term funds to finance capital investments and expansion projects (Goodspeed, 2006). It is divided into two markets; namely the primary and the secondary equity markets. In the primary market, new shares are sold and there are two types of new share issues, namely, seasoned issues (SIs) and initial public offerings (IPOs). Seasoned issues are the issue of shares for which there is an existing public market meaning that the company issuing the shares has shares already trading in the market. They are also known as privileged subscriptions as existing shareholders have the first right of refusal to purchase the shares. Initial public offerings refer to the first-time issue of shares to the public by companies that do not have an existing public market for the share. Secondary markets are where existing shares are traded. The proceeds from a sale of shares in this market do not go to the issuer of the shares but to their sellers (Goodspeed, 2009: 12).

The stock market accelerates economic growth by providing a boost to domestic savings and increasing the quantity and the quality of investment (Singh, 1997). This market encourages savings by providing individuals with an additional financial instrument that may better meet their risk preference and liquidity needs, meaning that better savings mobilization may increase the savings rate (Levine and Zervos, 1998). Furthermore, stock markets provide an avenue for growing companies to raise capital at lower cost and thus companies in countries with developed stock markets are less dependent on bank financing, which can reduce the risk of not being able to acquire funds due to a sudden tightening of the conditions required to obtain a loan from the banks. Stock markets therefore are able to positively influence economic growth through encouraging savings amongst individuals and providing avenues for firm financing (Yartey and Adjasi, 2007). In the corporate sector, the equity market is supposed to ensure that past investments are efficiently used through takeovers. In theory, this means that the threat of a takeover should offer management an incentive to maximize firm value, the assumption being that, if they do not maximise firm value then another economic agent may take control of the company, replace management and then reap the benefits from the efficient firm.

Efficient stock markets may also reduce the costs of information through the generation and dissemination of firm specific information that efficient stock prices reveal. Stock markets are efficient if prices incorporate all available information. Reducing the costs of acquiring information facilitates and improves the acquisition of information about investment opportunities and thereby improves resource allocation. Fama (1970) notes that the efficient market hypothesis (EMH) implies that stock markets are informational efficient in three forms: the weak form, semi-strong form and the strong form. If equity markets are weakly efficient, then past information should not be utilised to make a sustainable profit. Therefore, technical analysis cannot be used to attain profit in the stock market (Goodspeed, 2006). However, the semi-strong form argues that information that is currently available to the public is already reflected in stock prices and thus cannot be used to generate profits; hence fundamental analysis has no value in such equity markets. According to Keane (1983), in its strong form, the EMH predicts that even information that is not yet publicly available is not valuable in trying to make a profit in stock markets as it would have already been integrated by stock prices.

The EMH is thus concerned with the speed at which past, current and future information is disseminated in stock prices, thus it is important for an investor or a policy maker to comprehend and appreciate this speed of transmission in financial markets. In support of this, Yartey and Adjasi (2007) argue that stock prices determined in exchanges and other publicly available information may help investors make better investment decisions and thereby ensure better allocation of funds among corporations and as a result ensure a higher rate of economic growth. The speed of transmission will help a policy maker to know how shocks are promulgated and transmitted in financial markets and thus the implications of such transmission to financial stability. This will lead to the formulation and implementation of appropriate policies. Stock market liquidity also decreases the downside risk and cost of investing in projects that do not pay off for a long period of time. As Bencivenga and Smith (1991) and Yartey and Adjasi (2007) put it, with a liquid market, the initial investors do not lose access to their savings for the duration of investment due to the fact that they can easily, quickly and cheaply sell their stake in the company. Therefore, more liquid stock markets could facilitate investment in the long term, hence improving the allocation of capital and enhancing prospects for growth in the long-run.

However, the stock market is criticised in that liquidity may negatively influence corporate behaviour because very liquid stock markets may encourage investor myopia. According to Bhide (1993), the stock market liquidity may dishearten investors from having long-term commitments with companies whose shares they own and therefore create potential corporate governance problems with adverse effects on economic growth. In addition, Binswanger (1999) notes that the stock market prices do not accurately reflect the underlying fundamentals when speculative bubbles emerge in the market. He further argues that in such cases, prices on the stock market are not simply determined by discounting the expected future cash flows, which according to the efficient market hypothesis should reflect all currently available information about fundamentals. Under this condition, the stock market develops its own speculative growth dynamics, which may be guided by irrational behaviour.

Critics also note that the actual operation of the pricing and takeover mechanism in well functioning equity markets leads to short term and lower rates of long term investment. It also generates perverse incentives, rewarding managers for their success in financial engineering rather than creating new wealth through economic growth (Singh, 1997). This is because prices react very quickly to a variety of information influencing expectations on financial markets. Therefore, prices on the stock market tend to be highly volatile and enable profits within short periods. These problems are exacerbated in developing countries especially most African economies with their weaker regulatory institutions and greater macroeconomic volatility. The higher degree of price volatility on stock markets in developing countries reduces the efficiency of the price signals in allocating investment resources.

## 2.2 THE IMPORTANCE OF UNDERSTANDING EQUITY MARKET LINKAGES

The understanding of linkages among financial markets in general, and equity markets in particular is vital for a number of reasons. The understanding of linkages of equity markets in financial markets is essential for portfolio diversification, regulatory policy as well as monetary policy. It is postulated by portfolio theory that there are two critical conditions that are necessary for one to gain favourable returns from diversifying a portfolio. Firstly, there should be a negative correlation among the securities. In this way, if one gets a negative return the other will get a positive return. This will ensure that losses from one security will be offset by profits from another security. Secondly, it is also vital for assets within the portfolio to have a weak correlation, implying that the main objective of diversifying a portfolio would be to maximise returns given a certain amount of risk or to decrease the risk given a certain level of return. (Glezakos, Merika and Kaligosfiris, 2007).

Portfolio diversification can take various forms. Firstly, securities from different financial markets located in different countries can be included within the portfolio. Secondly, one can invest their wealth in the same market but diversifying by putting it in different securities. A good example would be investing in the equity market but in an assortment of different firms of sectors within the economy. The third option available to an investor would be to include the various financial markets within their portfolio, that is, the money market, bond market as well as the equity market. Lastly, portfolio diversification could also take the form of investing in the same market but in different countries (Glezakos *et al.* 2007).

Stock market linkages affect portfolio diversification in that if stock markets share a common trend this will imply that the markets move together, therefore one of these markets will represent the behaviour of that group of markets. This means that common shocks will be driving the markets resulting in limited long-term returns from international diversification. On the other hand, if there are continual deviations from the common trend, then investors could make short-term speculative investments in the international market by forecasting that the market will regress to its long-term relationship with the global market (Phylaktis and Ravazzolo, 2005).

The financial system is interconnected to the macro-economy; consequently, its failure could have huge negative effects for the whole economy. Therefore, financial regulation is necessary to secure systemic stability in the economy, ensure institutional safety and soundness, and to promote consumer protection (Falkena, Bamber, Liewellyn, and Store, 2001:2). In South Africa, the equity market is supervised in terms of the Securities Services Act (SSA) which directly applies to the Johannesburg Stock Exchange (JSE). Consequently, it is imperative for financial regulators to understand the nature and behaviour of stock markets as linkages and volatility transmission across local and international financial markets determine the behaviour of investors. Both local and international investors adjust their portfolios accordingly; hence appropriate regulatory policies have to be established and implemented. These would be important for two main reasons, firstly in terms of regulating arbitrage as investors try to escape local policies in order to invest in foreign markets which may have fewer regulations. Secondly, the regulation environment would need to be dynamic due to transmissions which may be a result of financial and technological innovations, hence the need for policymakers to be proactive.

According to Mishkin (1995) the asset channel is a vital conduit through which monetary policy is transmitted. Therefore, global transmission of equity-market shocks might affect the effectiveness of monetary policy. Rigobon and Sack (2003:639-640) highlight three channels through which interest rate can be linked to the prices of equity. These are the effect of the equity market on investment, the firm balance-sheet effects and household liquidity and the wealth effect. The first channel originates from Tobin's (1969) $q$ theory where '$q$' signifies the proportion of the market value of a firm's existing shares to the replacement cost of the firm's physical assets, therefore, replacement cost of the share capital (Wisegeek, 2011) . It states that if $q$ (representing equilibrium) is greater than one ($q > 1$), additional investment in the firm would be sensible because the profits generated would be more than the cost of firm's assets (Wisegeek, 2011) . On the other hand, if $q$ is less than one ($q < 1$), then the firm would be better off selling its assets instead of trying to put them to use; the idyllic state is where $q$ is approximately equal to one denoting that the firm is in equilibrium (Wisegeek, 2011). This theory postulates that a decrease in interest rates leads to an increase in stock prices consequently increasing $q$ and ultimately fixed and portfolio investments.

The firm's balance sheet and liquidity channel comes from the fact that high stock prices will increase a firm's net worth, thus lessening the incentive to undertake risky projects. Resultantly, banks will become increasingly willing to give loans. Finally the household balance sheet channel recognises the fact that a household's portfolio is comprised of both liquid and illiquid assets. The amount of liquid assets held is dependent upon the expected financial distress meaning that more liquid assets will be held if households have a high expectation of financial distress. Consequently, an expansionary monetary policy which leads to an increase in stock prices will increase household expenditure on durable goods. In turn, revenue and earnings of retail companies will increase and stock prices will be pushed upwards. This shows that interest rates have an influence on stock prices. In addition, Mishkin (2001) and Rigobon and Sack (2003) have empirically shown that monetary policy tends to respond to movement in stock markets, thus, although monetary authorities might not necessarily have to respond to stock price changes and stock market volatility, there is need for them to monitor the trends in stock prices in order to understand how the financial system is affected. For example, in early 2007, home prices in the US had reached unprecedented levels due to the fact that households were leveraged more than ever before, however, the quality of mortgages had fallen and asset-backed securities had spread well-beyond its traditional base (Cecchetti, 2008:26). Following this, banks started to make huge losses upon realising that they had large amounts of mortgage-backed securities which were complicated to value, this triggered the beginning of the sub-prime crisis in August 2007. In response to this, the Federal Reserve Bank had to change the way they lent to commercial banks after realising that traditional interest rate instruments were ineffective (Cecchetti, 2008:26).

Stock price bubbles and bursts affect macroeconomic variables such as aggregate demand, inflation and investment (IMF, 2003), consequently showing the response of monetary policy to fluctuations of stock prices. Binswanger (2008) defines a *stock market bubble* as a self propagating rise in the share prices of stocks in a respective industry with the term can being used with any certainty in retrospect when the share prices have fallen drastically. The author elaborates further by saying that it occurs when speculators notice the swift rise in value of stocks and then decide to purchase more of the identical stocks as a way of expecting further increases. This buying spree results in companies' stocks becoming grossly overvalued creating a widening divergence between the share price and the actual value of the stocks. When the *bubble* bursts the share price will fall very swiftly and dramatically which will be happen as the falling prices try to find the fundamental value of the stocks potentially resulting in many firms going out of business (Binswanger, 2008). Asset prices could affect inflation through the consumption life cycle meaning that stocks and other financial assets make up household's revenue (Modiglani, 1971). Following this hypothesis increases in stock prices results in an increase in household wealth which may increase aggregate demand through increased consumption expenditure, thus causing inflation. Highly volatile stock prices lead to volatile inflation and interest rates. This occurs as central banks react by increasing interests due to the increase in aggregate demand. According to Mishkin (2001), this only takes place when stock prices are inflationary as monetary authorities will only respond to inflationary stock prices.

### 2.3 SOURCES OF EQUITY MARKET COMOVEMENT

According to Pretorius (2002), there are three categories of explanations as to why comovement exists among different stock markets. Firstly, there is the *'contagion' effect* which is the part of stock market co-movement which cannot be explained by economic fundamentals. Secondly, there is *economic integration*, which implies that the more the economies of two countries are integrated, the more interdependent their stock markets will be. Economic integration includes the comovement in economic indicators that influence stock market returns such as interest rates and inflation in addition to trade relationships and the cash flows of member countries. The third category includes *stock market characteristics* such as market size, volatility and industrial similarity. Below is a detailed discussion of how each of these factors influences stock market linkages.

### 2.3.1 CONTAGION

'Contagion' can be defined as the comovement of asset markets not caused by fundamentals. It is not measurable in itself but rather estimated with the residual from the comovement that is not explained by fundamentals (Wolf, 1998 and Pretorius, 2002). Put differently, contagion can be referred to as the increased correlation of stock markets during periods of financial turmoil (Bonfiglioli and Favero, 2005:1300).Generally there are two broad categories of literature in terms of the field of contagion namely; *informational factors* and *institutional factors*. Informational factors are based on the comparison between the equity market and the Keynesian 'beauty contest'. In the equity market, investors will sell their investments in a specific asset class if they believe that other investors will sell their investments in that asset class, whilst in the Keynesian 'beauty contest', each judge votes the way he thinks the other judges will vote. As a result, a better understanding of the herd behaviour of stock market traders is provided which leads to the selling-off of emerging market securities if a sufficient number of investors take the view that other investors have lost confidence with the 'emerging markets' asset class. This herd behaviour of investors will lead to a general fall and comovement in emerging markets stock prices. Since this comovement is due to irrational investor's behaviour, it constitutes contagion-based comovement (Pretorius, 2002).

Institutional factors include issues such as forced redemption and two-stage investment strategies, with a substantial proportion of inflows to the stock markets of emerging countries coming through open-ended mutual funds. When these funds are faced with large-scale reductions in inflows, they may be forced into redemption and thus global mutual funds will sell off their assets in the most liquid markets. This implies that if these markets are not affected before, then they will be affected by the forced redemption. A contagion effect will be a result of this redemption in which several markets decline concurrently without justifying changes in fundamentals. The same will happen with global mutual funds as they try to exploit perceived mispricing in the most downtrodden markets, financed through sales of equities in less-affected markets (Wolf, 1998). In terms of the two-stage strategies, some portion of the overall portfolio is allocated to the 'emerging market' category and is then sub-allocated according to some index weighting.

On the other hand, interdependence is defined as the correlation of stock markets during periods of financial stability or put differently, the normal comovement or linkages of the stock markets (Daly, 2003:74). There are three reasons for understanding whether financial markets are related in a 'contagion' or 'interdependent' nature. The first reason has to do with investor's behaviour models; the hypothesis in most risk models is that investors react differently in the period following a significant macroeconomic shock. Therefore, it is imperative to be able to comprehend how individual investors react to good and bad news as this is relevant in understanding how macroeconomic shocks are transmitted across international stock markets. For instance, bad news raises the debt-equity ratio of a company thus increasing financial risk which ultimately results in higher volatility of its stock returns (Campbell and Hentschell, 1992). Secondly, a significant principle of investment strategy is the fact that most macroeconomic shocks are country-specific; hence the correlation between international financial markets is low. As a result of this, international diversification would raise expected returns for investors whilst portfolio risk is also decreased. Thus, if financial markets are correlated in a 'contagion' manner, then if there is a negative shock, there will be an increase in the correlation amongst financial markets meaning that returns from international diversification will be drastically diminished. Thirdly, policy-makers and global financial institutions are also concerned about the contagion of financial markets. This is mainly because the transmission of negative shocks from one country's stock market to that of another country could have adverse effects on the flow of financial resources even though the macroeconomic fundamentals of the second country are robust.

### 2.3.2 ECONOMIC INTEGRATION

a) Bilateral Trade

The more dependent two countries are on each other, the more interdependent will be their stock markets. Hence, stronger bilateral trade links between two countries might imply a higher degree of comovement between their stock markets. Thus, to the degree that macroeconomic variables are the same in the two countries, one could also conclude that their equity market performance should be same. Also, over a period of time, to the extent that these variables in two countries are convergent (divergent), their stock market performances should also converge (diverge) (Pretorius, 2002:91).

The relevant stages of economic integration begin with the reduction and eradication of barriers to trade and thus establishing an economic union (Holden, 2003). These are; a free trade agreement (FTA), a customs union (CU), a common market (CM) and an economic union. Free trade agreements (FTAs) may also be referred to as preferential trade agreements (PTAs). These policies remove import quotas and tariffs between trading countries. The agreements can be restricted to selected sectors or include all elements of international trade. Whilst investors may benefit from wider investment opportunities, the trading counties maintain independent trade policy and are not necessarily required to change their regulations (Holden, 2003). In this way, a country can preserve a comparative advantage it may have over its trading partners by safeguarding its capital and labour and thus economic policy. On the other hand, members need to establish rules of origin for all third-party products coming into the free trade area, these allow for goods produced within the free trade area to cross borders tariff-free after meeting the necessary requirements. Without these rules, third-party nations may enter the FTA region by trading with the country which offers them the lowest tariffs hence enabling them to potentially enjoy some benefits of the FTA even if they are not an explicit member (Holden, 2003). A good example of an FTA is the North American Free Trade Agreement (NAFTA) among the United States, Canada and Mexico.

The next stage of economic integration is the establishment of a Customs Union (CU). It obliges member nations to synchronize their external trade policies as well as to eliminate internal barriers to trade. In this way, important policies are created in order to benefit the union which include; a common external tariff (CET), import quotas for goods coming from third-party countries plus common trade remedy policies such as anti-dumping measures (Holden, 2003). In addition, Holden (2003) notes that these work in favour of the member nations because they allow them to negotiate with multilateral trade initiatives such as the World Trade Organisation (WTO) as a single bloc. As a result, rules of origin are not required in a customs union as goods entering the area will be charged the same tariff despite the point of entry. Thus, the removal of rules of origin is the main advantage of a customs union because it results in considerable administrative cost savings in addition to efficiency gains. However, the coordination of external and internal trade policies means that participating nations will have to give up a certain degree of their capacity to set independent trade policy so as to fully enjoy the benefits of being a member (Holden, 2003). An example is the Southern Africa Customs Union (SACU) between Botswana, Lesotho, Namibia, South Africa and Swaziland.

The establishment of a common market (CM) signifies a huge stride towards economic integration as it enables the movement of capital, people and other resources within the area without any restrictions. This implies that member nations have to make compromises on some of their abilities to implement independent policies due to requirements of the market. For instance, interdependent within the region and the influence of one member country on others will result in convergence of fiscal and monetary policies (Holden, 2003). The Common Market for Eastern and Southern Africa (COMESA) is an operating agreement with nineteen member countries stretching from Libya to Zimbabwe. With the unencumbered movement of labour and capital, this common market benefits from the expected gains in economic efficiency due to optimal allocation of resources.

Holden (2003) further argues that an economic union is the deepest form of economic integration as it formally requires that member countries complement each other's fiscal, monetary, regional development, labour market as well as transportation and industrial policies. The most prominent economic union in the world is the European Union, normally referred to as the EU, with twenty-seven European member states which have transferred some of their lawmaking power to the union (Europa, 2010). In order to advance the functioning of an economic union, its establishment often includes the use of a common currency and a merged monetary policy, thus enabling trade to be economically efficient. For example, the EU uses the *euro* as its official currency. As the deepest form of integration, comovements of stock markets will increase in an economic union because of strengthened investment and trade relations, implying that the returns from international diversification are decreased. In addition, common institutional structures and shared macroeconomic policies mean that stock pricing is biased towards regional as opposed to national factors.

Comovements in integrated regions may also occur as country-specific shocks will be transmitted to other markets as foreign capital markets incite a reaction in domestic capital markets, a process referred to as *market contagion* (Taing and Worthington, 2002). In addition, larger markets are likely to dominate and exert more influence on smaller markets. For instance, within the EU, countries such as Germany and the United Kingdom are likely to influence the smaller economies within the union. Stock price comovements could also occur as a result of shocks that are specific to particular sectors of each economy. For example, if technology affects a particular sector, comovement could occur due to links between this sector and others within the union (Taing and Worthington, 2002).

b) Macroeconomic variables

The expected discounted stream of dividends shows that several macroeconomic variables have an effect on stock market performance; the model is expressed as follows:

$$P = \frac{(1+g)D_0}{k-g} \qquad [1]$$

where $D_0$ is the last dividend paid, $g$ is the constant growth rate in dividends and $k$ is the discount rate. The systematic forces that influence returns and stock prices also influence the discount factors or growth rate in dividends. These include macroeconomic variables such as interest rates, inflation and growth rates of industrial production on the expected cash flows. They determine how the stock market of an individual country performs implying that if these variables are related in two countries, then the two stock markets will perform in a similar manner. For example, two countries with interest rates following a common trend due to shared monetary policies will have a comovement in their stock markets due to the effect of interest rates on stock prices. Consequently, significant growth, inflation and interest rate differentials will cause a smaller amount of comovement (Pretorius, 2002).

### 2.3.3 STOCK MARKET CHARACTERISTICS

These factors include stock market size, stock market volatility and industrial similarity, they are briefly discussed below.

a) Size

Smaller companies command higher returns mainly because of less liquidity and the higher transaction costs associated with trading their stocks (Pretorius, 2002). For this reason, the size of a national stock market may be a reflection of its stage of development which may also be an indication of the degree of market liquidity as well as the level of information and transaction cost involved in trading stock in that market. Disparities in market sizes may reveal differences in these variables between the two stock markets, which should then result in less co-movement. Over time, an increase (decrease) in the size differential of the two equity markets, will also lead to an decrease (increase) in the extent to which there is any co-movement (Pretorius, 2002:93).

b) Volatility

All investment models are based on the principle that investors should be compensated for the risk they take on, implying that the higher the risk of an asset the higher should be the returns.

Given that the return of any equity market is a function of its volatility, two markets with similar levels of volatility should produce similar returns. Thus if one market's volatility rises comparative to another market's volatility, the first market's returns should also rise comparative to the second market's returns. Therefore, to the extent that there is convergence (divergence) in equity market volatilities, there will also be convergence (divergence) in their stock prices (Pretorius, 2002:93).

c) Industrial similarity

The performance of any index is partially determined by a sectoral composition and partly obscured by idiosyncratic noise (Pretorius 2002:93). Hence co-movement will be revealed in an equity market if two markets are both dominated by the same type of industry, to the degree that their equity market is based on that particular industry. Also, the extent of industrial similarity between the two stock markets may also increase the extent of their co-movement. For instance, if two stock markets are resource-based, then rising world prices of resources would mean that the stock markets will do very well and as a result move together in an upward trend. Thus a fall in prices of resources would also lead to simultaneous downward movement in both stock markets. This may occur even if domestic macroeconomic fundamentals are widely varied between the two. Since Sub-Saharan African stock markets are mostly resource-based, this could imply that the possibility of returns and volatility spillovers among them are high.

## 2.4 THEORY OF STOCK MARKET LINKAGES

### The International Capital Asset Pricing Model

International linkages of stock markets across the globe have been tested by adopting an international version of the CAPM framework whose theoretical underpinnings can be traced from the seminal works of Sharpe (1964) and Lintner (1965) who showed that the expected return on asset $i$ :

$$E[R_i]=R_f+\beta_{im}(E[R_m]-R_f) \quad [2a]$$

$$\beta_{im}=\frac{Cov[R_i,R_m]}{Var[R_m]}, \quad [2b]$$

Where $E(R_i)$ is the expected return of security $i$, $R_f$ is return on the risk free asset and $R_m$ is the return on the market portfolio. The Sharp-Lintner (SL) CAPM illustrates that there exists a positive relationship between the excess return on a market portfolio and the return on any risky asset. In this framework, the market portfolio contains *all* the risky assets and is thus assumed to be mean-variance efficient. The correlation of the return on the asset *i* to the excess return on the market portfolio is captured by the $\beta_{im}$. The SL-CAPM fundamentally implies that all unsystematic risk can be diversified away in an efficient market, in this way, systematic risk will be the only form of risk that would be priced by market participants.

The model has been commended for its intuitiveness and simplicity. However, it has also attracted criticisms. Firstly, it fails to capture variables besides market risk which is priced on a portfolio and secondly, investor preferences are established in one period meaning that the SL-CAPM is a single-state framework as illustrated by Equation (3) below. In an attempt to solve this, the model has been extended by several scholars with varied contributions; the most prominent studies are those of Ross (1976) with the Arbitrage Pricing Model (APT) and Merton (1973) with the Intertemporal Capital Pricing Model (ICAPM). By hypothesizing that investors maximise their utility over an extended time period, Merton (1976) extends the static SL-CAPM into a multi-period, multi-factor model. This means that when selecting a portfolio at time *t-1*, investors take into consideration the opportunities available to them to consume at time *t*. In this way, the investors think about how their wealth at time *t* will change given risk variables that affect their wealth, thus Merton (1976) illustrated that for an investor facing *N* differing risk variables, then the excess return *r* on any risk asset *i*;

$$E(r_{i,t}|I_{t-1})=\beta_{1,t}E[\text{cov}(r_{i,t},r_{1,t})|I_{t-1}]+\beta_{2,t}E[\text{cov}(r_{i,t},r_{2,t})|I_{t-1}]+....+\beta_{N,t}E[\text{cov}(r_{i,t},r_{N,t})|I_{t-1}] \quad [3]$$

Where $r_{1,t}$ $r_{2,t}$ and $r_{N,t}$ are the excess return on the respective risk factors (*1, 2,... N*), one of which including, among other variables, the market portfolio (as implied by the SL-CAPM)[4], and $E(*|I_{t-1})$ is the expectation operator, conditional on the representative investor's information set known at period *t-1*.

If Equation (4) below stands for a single asset, then it should also hold for a given portfolio of risky assets, *p*, such that the expected return on a portfolio *p*, which is conditional on information at *t-1* can thus be consistently expressed as;

$$E(r_{p,t}|I_{t-1})=\beta_{1,t}E[\text{cov}(r_{p,t},r_{1,t})|I_{t-1}]+\beta_{2,t}E[\text{cov}(r_{p,t},r_{2,t})|I_{t-1}]+....+\beta_{N,t}E[\text{cov}(r_{p,t},r_{N,t})|I_{t-1}] \quad [4]$$

[4] By implication of the ICAPM, the Sharp-Lintner CAPM is a special case, where the only risk factor that investors price, is covariance risk of an asset with the market portfolio.

The basic intuition behind the ICAPM from equation [4] is that an investor in an innovative world would react to both good and bad news as well as events recognized to represent potential changes to future consumption and investment opportunities (Dean and Faff, 2001:171). In this manner, their reaction is reflected in the stock prices.

Authors such as Fama and French (2004) argue that if international capital markets are open, and that representative investors are not concerned with purchasing power parity, then the market portfolio should also include international assets such that,

$$E(r_{p,t}|I_{t-1}) = \ldots + \beta_{g,t} E[\operatorname{cov}(r_{p,t}, r_{g,t})|I_{t-1}] + \ldots \qquad [5a]$$

$$\beta_{g,t} = \frac{\operatorname{cov}[r_{p,t}, r_{g,t}]}{Var[r_{g,t}]} \qquad [5b]$$

Where $r_{p,t}$ and $r_{g,t}$ are the expected return on the global *g* portfolio and domestic portfolio *p* of risky assets at time *t*. In such a setting, an investor with a portfolio of risky assets would consider risk variables relating to both the domestic and global economy. This complements the intuition of Equation [2b]; the global market beta coefficient, $\beta_{g,t}$ measures the sensitivity of the return on portfolio *p* to fluctuations in global market returns. If these innovations in the global market explain variations in the returns in the domestic portfolio to a greater extent, then there is international market comovement. The ICAPM enforces restrictions on the method of asset pricing in such a way that local factors are less important in comparison to global factors (Jorion and Schwartz, 1986). This means that if there is interdependence between markets and the global market is mean-variance efficient, then global factors should be considered in more detail in pricing risk rather than domestic factors. In the same way, if there is integration at a regional level then a similar argument should also apply if the regional market portfolio is mean-variance efficient.

In light of this argument, relevant questions are raised in terms of determining which factors are more important, domestic or foreign, for stock market comovements. Furthermore, it will be important in order to establish the degree to which innovations in one market may account for innovations in another market and hence the nature of their stock market linkages. Also, do regional factors and strong trade and investment links between countries determine the extent to which their stock markets are integrated? Are there common factors that determine a long run relationship between different stock markets? Does 'contagion' exist between stock markets in periods before and after market crises? In addition, is the extent of stock market correlation stable over time and does bad news have a greater impact than good news on volatility? These questions will be addressed empirically; however the relevant literature covering each one of them is covered in the next section so as to complement the theoretical issues discussed in the preceding sections.

## 2.5 EMPIRICAL LITERATURE

Empirical works on the comovements of the world's national equity market indices have received considerable attention and as a result this issue has been widely debated. The early work of Granger and Morgenstern (1970) concluded that correlations among returns to national stock markets are low and that national factors dominate their returns generating process. Furthermore, Lessard (1973) found that there was closer correlation between different industry indices within the same country than between same industry indices in different countries. Consequently, the early studies concluded that international portfolio diversification was worthwhile. The section is classified into two parts in terms of the issues that the literature intends to address. The first part focuses on long run comovement of stock markets whilst the second part concentrates on returns and volatility linkages.

### 2.5.1 LONG RUN COMOVEMENTS OF STOCK MARKETS

With regard to the long run co-movement, one hypothesis is that macroeconomic variables such as inflation and interests rates influence stock markets in a manner that establishes a common trend over a certain period, hence revealing a long-run relationship. Cointegration analysis dominates such studies with literature focusing on determining the nature of such comovements. For example, Chung and Liu (1994) studied stochastic trends among national stock prices of the US and five East Asian countries and found that most variables had the same adjustment speed in moving from short-run disequilibria toward the common trend. Using data for the period 1982-1994, Masih and Masih (1997) also found evidence of cointegration between developed and emerging stock markets[5]. Abhilash and Ramanathan (2002) analysed the comovements of selected US and Indian major stock indices[6] using cointegration analysis and daily data for the period 1996-2002. They found that even though a cointegrating relationship existed between

[5] Taiwan, South Korea, Singapore, Hong Kong, USA, Japan, UK and Germany

[6] For the US, the NASDAQ Composite Index and the Dow Jones Industrial Average (DJIA) and for India, the NSE Nifty and BSE Sensex)

NASDAQ Composite Index and NSE Nifty, the two indices were vastly different and the comovements observed could be due to market behavioural reasons. In addition, they note that the Indian stock market did not share a long-run relationship with the DJIA as it tended to have an upward bias in its estimation of the market's overall performance[7].

Some studies have examined whether comovements are affected by financial integration and liberalisation policies. The hypothesis here is that comovement of stock markets exists when countries have strong trade links and have made common economic reforms within a region. Piesse and Hearn (2002) studied the stock market integration versus segmentation in three dominant markets of the Southern African Customs Union (SACU). Using cointegration analysis and Granger causality test, they found that the SACU equity markets are cointegrated with causality running from Namibia to South Africa. They attribute this result to the presence of a common African emerging market component that affects Namibia more intensely and then spills-over to South Africa due to the integrated system that links them (Piesse and Hearn, 2002:1722).

The long-run relationship between the Middle East and North African (MENA) region and three global markets (the US, the UK and France) was investigated by Yu and Hassan (2006)[8]. Using daily data for the period 1999-2005 and through cointegration analysis, they revealed that comovement existed amongst the markets. As financial liberalisation in the MENA region improved, there was a strong long-run relationship between non-GCC and US stock markets and also between GCC and non-GCC markets. In addition, there was evidence of negative correlations[9] between stock markets in the GCC group and developed stock markets. The regional integration of Mauritius and six African markets[10] was analysed by Agathee (2008) by using data between January 2000 and September 2007 and he found market linkages between the former market and latter markets which implied that it was strongly regionally integrated.

[7] This reason behind this is that, the DJIA is based on the thirty largest and most liquid stocks traded in the US markets. At the end of 1999, these thirty stocks accounted for 28 per cent of the total market value of US stocks; hence it need not serve as an indicator of the performance of the entire economy. Also, DJIA is a price-weighted index; hence it assigns a higher weightage over time to those stocks that experience higher prices (Abhilash and Ramanathan 2002).

[8] Gulf Cooperation Council (GCC) countries are mainly the MENA oil-producing countries and they normally discriminate against non-GCC investors. Also, the MENA equity markets as a group may be able to offer investment opportunities not possible by one individual MENA stock market. Thus, following Neaime (2002), the authors divide seven MENA stock markets into GCC and non GCC groups within the MENA region. The first consists of the GCC member countries including Bahrain, Oman and Saudi Arabia, with the second including Egypt, Jordan, Morocco and Turkey (Yu and Hassan, 2006: 486-487).

[9] The authors note that this implies that investors in GCC stock have a good chance of gaining from international diversification of financial risks as global investments to GCC countries become more available.

[10] Botswana, Malawi, Namibia, South Africa, Zambia and Zimbabwe

Alagidede (2008) also applied cointegration analysis to analyse the linkages between four major African countries, namely; South Africa (SA), Egypt, Nigeria and Kenya. In addition the linkages between these and the rest of the world, namely; two Latin American countries (Brazil and Mexico), three developed market (US, UK and Japan) and India were also analysed. He found that in spite of economic reforms and cooperation, the African markets were not significantly influenced by each other and in addition, they shared weak trends with the rest of the world (Alagidede, 2008:29).

Boujir and Lahrech (2008) examined the market linkages between Morocco and the US after these two countries agreed on a free trade agreement (FTA) in 2004. They used daily data from 2000 to 2007 and applied the Dynamic Conditional Correlation-GARCH (DCC-GARCH) model and found no evidence of any correlation between the markets. The potential opportunities for diversification within the Southern African Development Community (SADC) markets[11] were assessed by Piesse and Hearn (2008) and they found that there were minimal correlations across all the markets. Because of this, there was substantial evidence for diversification of portfolios between South Africa and Namibia with limited benefits relative to increased levels of risk for Swaziland and Mozambique (Piesse and Hearn, 2008:424).

Onour (2009) studied the cointegration of stock prices of three major North African stock markets, namely; Egypt, Morocco and Tunisia. The study applied both Johansen and Juseilus (1990) test for linear cointegration and the Breitung (2001) rank test. Using daily data between 2002 and 2006, he revealed that there was strong evidence of multivariate and bivariate nonlinear long-term cointegration amongst the markets. He noted that ignoring the nonlinear relation in these markets could lead to a misleading conclusion that no long-run relationship existed in the markets, when in actual fact it did exist (Onour, 2009:11). In another study, Chinzara and Aziakpono (2009b) used daily data for the period 1995-2008 to examine the long-run relationship between South Africa and seven major world stock markets. They employed cointegration analysis and found evidence that for a South African investor, diversification would be potentially worthwhile in the Australian, Chinese and Japanese stock markets whilst opportunities in Germany, the UK and the US were limited (Chinzara and Aziakpono, 2009b:115).

Another body of empirical literature has considered the premise that the bullishness and bearishness of a stock market plays a significant role in determining long-run comovements of stock markets. Meric, Ratner and Meric (2008) used principal component analysis (PCA) and

[11] Namibia, Mozambique, Swaziland and South Africa.

Granger causality tests to examine the co-movements of the national benchmark and sector index returns in the US, UK, Germany, French and Japanese stock markets in bull and bear markets. The bull market analysed was for the period September 15, 1997-March 24, 2000 and the bear market period March 24, 2000-October 9, 2002. They analysed the two periods separately to determine if the comovements of returns changed significantly between the periods. They found that, in the bull market, investors could obtain more benefits with global diversification than with domestic diversification even if they invested in the same sector in different countries as opposed to investing in different sectors within the same country. In the bear market, the sectors of different countries tended to be more closely correlated and country diversification opportunities were limited (Meric *et al.*, 2008:176).

However, a possible weakness of their work is that PCA does not account for the existence of random and systematic error as argued by other scholars (Conway and Huffcutt, 2003; Henson and Roberts, 2006; Almudhaf and Hansz, 2010) who prefer the Factor Analysis which addresses the aforementioned issues. The Factor Analysis technique was used by Valadkhani, Chancharat and Harvie (2008) to investigate the relationships between stock market returns of major world economies and eight developing countries in Asia[12]. Using monthly data between December 1987 and April 2007 they found that stock markets were integrated among Asian countries implying that the developing countries benefit from a high degree of linear association. Also, the study revealed that the stock returns of the five developed countries indicated a well-separated common factor in terms of their comovements (Valadkhani *et al.*, 2008: 172).

Another strand of studies focused on determining the nature of comovements and whether they are affected by macroeconomic variables during or after times of crises. The main concern here is the transmission of an undesirable *'contagion effect'* as comovements amongst stock markets increase during or after a crisis. These studies have been carried out by dividing the samples used into pre and post event periods and then applying the econometric methodology to determine whether there were any changes in long run relationship. For instance, examining the October 1987 stock market crash, Arshanapalli and Doukas (1993) found that there is evidence of cointegration between stock price indices in the USA, Germany, UK, France and Japan for the post-crash period, contrary to the pre-crash period. The authors also found that the US market has a significant impact on the French, German and UK markets. However, Japanese stock market innovations are found to be unrelated to the performance of the major European stock markets (Arshanapalli and Doukas, 1993: 207). Further evidence of such comovements is

[12] Australia, Germany, Japan, UK, US and Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand.

provided by Meric and Meric (1997) who analysed the twelve largest European stock markets after the October 1987 stock market crash. Using PCA, they found that there was correlation among the twelve largest European stock markets. Furthermore, comovement between these stock markets and the U.S. stock market increased substantially after 1987. As a result, the benefits of international diversification amongst the European markets decreased considerably after the crash.

By analysing the pre-Asian crisis and the crisis period itself, Ratanapakorn and Sharma (2002) studied the short-run and long-run relationships among stock indices of the US, Europe, Asia, Latin America and Eastern Europe-Middle East using cointegration and Granger causality analysis. Making use of daily data between 1990 and 2000 for all regional indices, they found a long-run relationship only for the crisis period and not for the period before. In addition, they note that globalization increased during and after the crisis with each market contributing to the long-run relationship. Further evidence is provided by Floros (2005) in a study utilising data for the period between 1988 and 2003 who reported that there was strong evidence of a long-run relationship between the US, Japan and UK stock markets.

Biekpe and Collins (2003) examined contagion amongst African markets[13] by using the adjusted Pearson's correlation coefficient of Forbes and Rigobon (2002). The study found evidence of contagion in African markets from global emerging markets crises such as the Asian crisis of 1997, in only the biggest and most traded markets of Egypt and South Africa. However, this contradicts an earlier study by Forbes and Rigobon (2002) who reported that no emerging markets suffered from contagion, including South Africa. Bonfiglioli and Favero (2005) apply VAR methodology and a VECM on a sample of monthly data for the period January 1980 to September 2002 in studying contagion in comovements of US and German stock markets. The authors sought to find out if short-term fluctuations of US share prices spillover to German share prices and whether such comovement is unstable over high volatility periods. They revealed that normal fluctuations in the US stock market had practically no effect on the German market, however, the effect increased for high fluctuations. This is consistent with the importance of contagion as it results in an adjustment of short-run interdependence in periods of turmoil (Bonfiglioli and Favero, 2005:1314-1315). Furthermore, the study found no evidence of long-run interdependence between the two stock markets, implying that there were potential gains from diversification in long-term asset allocation.

[13] Egypt, Kenya, Mauritius, Morocco, Namibia, Nigeria, South Africa and Zimbabwe

## 2.5.2 RETURNS AND VOLATILITY LINKAGES AMONG STOCK MARKETS

Empirical studies on returns and volatility linkages have generally concluded that significant linkages exist between most developed markets. Some research has been done in these markets to analyse the proposition that innovations in one stock market affect movements in another. For instance, Eun and Shim (1989) used the VAR methodology in investigating the mean linkages of nine international developed stock markets[14]. This was extended by employing an impulse response so as to trace out the dynamic responses of one market to another market's adjustments focusing on determining if and to what extent the US stock market exerted influence over other stock markets. They found that many of the responses were completed in about two days after a shock with the pattern of responses being consistent with the view of international stock markets being efficient in terms of the availability of information. This meant that it was hard to make significant profits in a particular market based on developments in another stock market. Also, there were cross-country linkages with the impulse response indicating that improvements in the US market were transmitted rapidly to other markets. However, no other market significantly explained US returns.

The behaviour of stock returns and volatility in emerging financial markets[15] was investigated by De Santis and Imrohoroglu (1994) using the GARCH model. The study aimed to addressing three main issues. Firstly, to determine whether volatility changed over time, secondly, to establish if a relationship existed between market risk and expected returns and lastly, if liberalisation affected returns volatility in the emerging financial markets. Using weekly data for the period 1988-1994, the authors found that there was evidence of time-varying volatility implying that volatility clustering appeared to be a major characteristic in emerging markets similar to developed markets. In addition, they reported that there was no evidence of risk premium meaning that investors were not rewarded for market-wide risk. Lastly there was no evidence of any systematic effect of liberalisation on stock market volatility (De Santis and Imrohoroglu, 1994: 14).Therefore, the hypothesis often used against liberalisation that investment flows from developed markets were extremely sensitive to changing economic conditions in developing countries and hence increased market volatility; was found to be invalid.

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14 namely Australia, Canada, France, Germany, Hong Kong, Japan, Switzerland, UK and the USA.

15 EUROPE/MIDEAST: Greece, Jordan, Portugal, Turkey. ASIA: India, Korea, Malaysia, Pakistan, Philippines, Taiwan/China, Thailand. LATIN AMERICA: Argentina, Brazil, Chile, Colombia, Mexico, Venezuela.

Other studies have investigated the assumption that volatility and returns influence is unidirectional from developed markets influencing emerging markets. One such study was carried out by Lee (2001) who applied the discrete Wavelet Decomposition analysis with daily data between 1998 and 2001. The study provided evidence showing that the US, Japanese, German and emerging markets exerted influence over some markets in the MENA region (Egypt and Turkey in particular). Other authors (see Pagan and Soydemir, 2000; Bala and Premarante, 2004; Chinzara and Aziakpono, 2009b) found similar results in these markets. Although the aforementioned findings support the hypothesis of unidirectional transmission, volatility in emerging stock markets has been established to be more a function of 'own' rather than 'cross-country' innovations. Such evidence is provided by Worthington and Higgs (2004) who examined the transmission of stock market returns and volatility among nine Asian[16] markets between 1988 and 2000 utilising weekly data. Using a multivariate GARCH model, they reported that the Asian markets were integrated and that own-volatility spillovers were generally higher than cross-volatility spillovers for all markets (Worthington and Higgs, 2004:7). Thus volatility changes in emerging markets from domestic conditions were more significant than those typically found in developed markets.

Returns and volatility linkages have also been investigated with the empirical research focusing on the effect of regional integration on volatility transmission and spillovers. For example, Baele (2003) analysed the extent to which the strong integration process of economic, monetary and financial integration, had changed the fundamental forces driving returns volatility and cross-market correlations in 13 European stock markets[17], the aggregate European Union (EU) and US market. The author derived three regime-switching models that differed in the way regimes in the EU and US spillover intensity acted together using weekly data for the period January 1980-August 2001. Two insightful set of results was revealed by the study. Firstly, the probability of a high EU and US shock spillover intensity had risen by a significant amount between the 1980s and 1990s, although the rise was more pronounced for the sensitivity to EU shocks. The rise in EU shock spillover was most importantly located in the second part of the 1980s and the first part of the 1990s suggesting that increased economic integration and liberalisation were more important than the monetary integration and the introduction of the single currency (Baele,

16 Three of these markets are developed: Hong Kong, Japan and Singapore. The majority are regarded as emerging: Indonesia, Korea, Malaysia, the Philippines, Taiwan and Thailand.

17 Eight EMU countries (Austria, Belgium, France, Germany, Ireland, Italy, the Netherlands, and Spain), Three EU countries that do not participate in EMU (Denmark, Sweden and the UK) and Two countries from outside the EU (Norway and Switzerland).

2003:34). Secondly, the study noted that the US continued to greatly influence the European markets, even though the EU was increasingly becoming important as a region.

Similar studies have been done amongst African and developed stock markets. For instance, Lamba and Otchere (2001) analysed the linkages among African and global stock markets[18] using VAR and impulse response. The study investigated the extent to which the African markets responded to shocks in developed markets and the speed at which these shocks were transmitted from the developed to African markets. Their results revealed a very low degree of international comovement among the stock markets. The authors found that the only exceptions were South Africa and Namibia, mainly because overseas markets had greater influence on the variation of these countries' market returns (Lamba and Otchere, 2001:22).

By examining the extent of regional integration of stock markets in Sub-Saharan Africa (SSA), Piesse and Hearn (2005) applied the E-GARCH model using monthly data between 1997 and 2002. They found that SSA stock markets exhibited volatility in their price indices that was transmitted differently through the markets. They note that the dominant markets of South Africa and Nigeria transmitted their volatility to other regional markets, especially where there were strong trade links. In addition, uni-directional and bi-directional spillovers were found across the markets. A later study by Humavindu and Floros (2006) on the integration and volatility spillovers between South African and Namibian equity markets reported that there were very low correlations between the markets and that there was no evidence of either a linear relationship or of any spillover effects.

Empirical research has also been carried out to investigate whether countries with close trading and investment links are also closely tied in terms of their financial markets. Tastan (2005) applied a Dynamic Conditional Correlation Multivariate GARCH model using daily data between 1990 and 2004 to investigate such a premise. The study analysed interdependence, price and volatility transmissions together with financial integration between Turkey and the developed markets of the EU and US. By splitting the period of study into pre- and post-custom union, the author found that correlation between the stock markets was stronger for the post-union period than for the pre-union one. In addition, there was evidence of the existence of significant price spillovers between Turkey and the US, while there were small and insignificant price spillovers from European to Turkish stock markets. In conclusion, the study

[18] Botswana, Ghana, Kenya, Mauritius, Namibia, South Africa, and Zimbabwe compared to Australia, Belgium, Canada, France, Germany, Japan, the Netherlands, the UK, and the US.

revealed that the correlation of the Turkish stock market with developed markets fluctuated significantly throughout the whole period of study (Tastan, 2005:17).

Another strand of studies has focused on how the announcement of news has an effect on returns and volatility transmission. The main concern here is the degree to which the effect of good and bad news on returns and volatility transmission differs, a hypothesis referred to as the *leverage/asymmetric effect*. Koutmos and Booth (1995) used the multivariate EGARCH model to test this hypothesis for the US, UK and Japanese stock markets for the period 1986-1993. Additionally, they tested the contagion hypothesis in volatility transmission by splitting the sample of study into pre- and post-1987 stock market crash. The study revealed evidence of both the asymmetric effect as well as contagion. A study of a similar nature and methodology by Kanas (1998) analysed the asymmetry of volatility and found that the three markets improved in performance in the period following the stock market crash than before.

Koulakiotis, Papasyriopoulos and Molyneux (2006) applied the GARCH-M and the EGARCH-M models in order to investigate whether the asymmetry property of volatility response to innovations existed in the relationship between stock price returns and volatility. They applied weekly data for Australia, Canada, France, Italy, Japan, the UK and the US for the period January 1980 to October 1997. The study revealed that there was no single case where a significant relationship existed between volatility and stock price returns for all the industrialised countries examined (Koulakiotis *et al.* 2006). Tanizaki and Hamori (2008) took a different approach by examining the stock price volatilities in Japan, UK and US. They applied the stochastic volatility (SV) model and considered the asymmetric effect together with the day-of-the-week and the holiday effect. Using daily data between 1984 and 2007, they found that these effects significantly affected volatility, although no Tuesday effect was observed in UK and US.

The returns linkages and volatility transmission between South Africa and major world stock markets were analysed by Chinzara and Aziakpono (2009a). Using daily data for the period 1995-2007 and applying univariate GARCH and multivariate VAR models, they found evidence of linkages between the South Africa and Australia, China and US. The latter market exerted the most influence the African market. These linkages existed mainly because the US was the largest stock market in the world, whilst China, like South Africa, was an emerging market, and Australia was largely a resource-based country like South Africa (Chinzara and Aziakpono, 2009a: 17). The authors noted that there were limited benefits from market diversification between South Africa and Australia, China and US, however, opportunities were more beneficial in Japan, Germany, and the UK. The study also found leverage effects and asymmetry in volatility for all the stock markets while there was no evidence of risk premium.

**2.6 CONCLUSION**

This chapter reviewed the relevant theoretical issues in terms of equity market linkages. Firstly a theoretical description of the equity market was provided highlighting its importance to the financial system and hence economic growth. In order to support the theoretical background, the importance of understanding the linkages of equity markets as well as the nature of the linkages from both a policymaking and an investment analysis were then analysed. The key reasons that were given for the importance of understanding linkages of equity markets were monetary policy, regulation, portfolio diversification, contagion, economic integration and stock market characteristics which include market size, volatility as well as industrial similarity.

A review of empirical literature was carried out by dividing the section in terms of two main issues. Firstly, the factors that influenced long-run comovement of stock markets and secondly, those that determined the returns and volatility linkages amongst stock markets. This was done so as to compare and contrast how these issues could produce varied results in the different markets and thus highlighting the issues that could be causing these differences. A major finding is the dominance of the US stock market in most studies mainly because it is the largest and most influential economy in the world. Amongst emerging markets, their integration has recently been attributed to innovations within their regions with influence from developed markets to lesser degree.

Due to globalisation, financial liberalisation and increased dynamism of Africa equity markets, it has been observed that more studies have been carried out in different African stock markets. A significant finding reveals that African stock markets have a very low stock market comovement whilst the South African equity market plays a leading role as it is the most sophisticated market in Africa by influencing other African equity markets, especially within the SADC region. This particular market is also found to have correlations with the developed markets due to its characteristics of being an emerging market and also being a resource-based country. Although more studies are being carried out on African stock markets, to our knowledge, none of them have yet to consider the how integration on the continent was affected by the recent 2007-2009 subprime-crisis. Therefore, we aim to fill this gap by investigating their long run comovements, returns and volatility linkages of eight of the largest African stock markets using Cointegration analysis, Factor Analysis, VAR and the GARCH family of models[19]. The next chapter provides the background of the possible channels of integration of the stock markets being studied.

[19] An in-depth discussion on how these methodologies apply to our study is provided in Chapter 4.

# CHAPTER THREE

# BACKGROUND ON CHANNELS OF STOCK MARKET LINKAGES[20]

## INTRODUCTION

In the preceding chapter it was argued that there are three possible channels through which shocks and volatility can be transmitted from one market to another. These include, among others; trade linkages, financial linkages and stock market characteristics. This chapter discusses each of these factors for the African countries and highlights the implications for the possibility of integration. Stock market characteristics including market size and liquidity will be analysed together with financial linkages such as the net stock of portfolio investment (which directly go into the financial markets), net foreign direct inflows and debt. In addition to these, trends of the stock market indices will be examined by linking them to macroeconomic shocks as these may have vital implications in the manner in which stock markets are integrated in terms of trade and investments ties.

The chapter is structured as follows; Section 3.1 discusses the trade linkages in terms of trade agreements that exist among the various African trading regions; these include COMESA, MENA, ECOWAS and SADC. Section 3.2 provides an analysis of exports and imports of South Africa with each of the other countries in the study whilst section 3.3 focuses on the financial linkages. Section 3.4 compares size and liquidity using market capitalisation, total value traded and turnover ratios of the different stock markets. Section 3.5 analyses the trends in the stock markets by plotting the stock market indices for the different stock markets whilst section 3.6 concludes the chapter.

## 3.1 TRADE LINKAGES

Trade linkages between two or more countries imply a higher degree of co-movement between their stock markets. In light of this, it is reasonable to anticipate a high degree of integration amongst countries which are in the same regional trading group. Egypt, Kenya and Mauritius are current members of the Common Market of Eastern and Southern Africa (COMESA), an organisation which was formed in order to take advantage of a larger market size and as a result, enable improved social and economic co-operation with the ultimate objective of promoting regional economic integration through trade and investment (COMESA, 2010a). In order to achieve these goals, the organisation has initiated a programme of providing trade information to

[20] It should be noted that here we do not look at the historical, development and regulation of the exchanges but we merely compare them with a view to find whether any of their characteristics have implications for comovement and returns and volatility.

economic operators through information communication technology so as to improve cross-border transactions (COMESA, 2010b). This will enhance integration amongst the member countries due to convergence of business cycles brought about by the spread of information. The organisation forms a major market place for both internal and external trading and has had an export bill in excess of USD 157 billion for the year 2008 (COMESA, 2010b).

Egypt and Morocco are members of the Middle East and North African (MENA) region which has a history of inward-oriented policies and protectionism (particularly marked from the 1960s to the early 1980s). Romagnoli and Mengoni (2009:72) note that the existence of high tariff barriers and the fact the region has delayed joining the World Trade Organisation (WTO) has had adverse effects on trade within the region. This has undermined the region's performance in foreign trade markets as evidenced by the limited spread of trade flows as a result of its traditional polarised markets[21]. These trends are an incomprehensible attribute since the common social, cultural and linguistic feature of MENA countries are perceived to favour regional integration.

Investment flows to the MENA region remain small and are subject to year-to-year fluctuations. The World Bank estimates that the rush in capital flows towards the emerging markets in the past few years has largely bypassed the region which attracted less than 2% of these in 1996 (Yu and Hassan, 2008:483). Also, there has been little progress in actual integration as intra-regional trade accounts for only 9% of the region's total trade in comparison to 60% in Europe and over 35% in Asia. In addition, Yu and Hassan (2008) note that by the end of 1996, there were more than 20 international and regional funds investing in the stock markets of the Middle East ( most open to international investors) specifically set up to direct money into the region's equities. However, among MENA stock markets, Morocco and Egypt are the only countries to offer unrestricted access to foreign investors, because of this, comovements between these two markets are highly likely.

Another significant regional group in Africa is the Economic Community of West African States (ECOWAS), of which Nigeria and Ghana are member states. It also promotes economic integration in all fields of economic activity including natural resources, energy and agriculture. The two countries have implemented similar macroeconomic policies such as the harmonisation of economic and financial policies (ECOWAS, 2010). This implies that there are stronger investment and trade links between them and as a result enhanced comovements in their stock

[21] Half of the trade is directed towards the industrialised countries, mainly Europe, due to historical and political ties although recently flows having been going to the East Asian countries (Yu and Hassan, 2008).

markets. Additionally, Nigeria's economy is heavily dependent on oil which accounts for over 95% of export earnings and approximately 85% of government revenues (EIA, 2010); whilst Ghana's first major oil discovery was announced in June 2007 and has been referred to as, "one of the largest recent finds in Africa" (OxfamAmerica, 2008). By 2011, estimates are that Ghana will be producing approximately 120000 barrels of oil per day, together with significant quantities of gas (OxfamAmerica, 2008). Also, the IMF predicts that government revenues from oil and gas could reach a cumulative USD20 billion for the production period of 2012-2030 (OxfamAmerica, 2008). As a result of this, fluctuations in world oil prices will have a similar effect on both Nigerian and Ghanaian stock markets which will imply a higher degree of comovement. Furthermore, Ghana is the second- largest gold producer in Africa (OxfamAmerica, 2008) with South Africa taking the poll position, consequently, one could reasonably expect comovements in these two markets due to variations in world gold prices.

South Africa, Mauritius and Namibia are members of the Southern African Development Community (SADC). This organisation aims to tackle underdevelopment and backwardness in Southern Africa through economic cooperation and integration. The organisation launched a Free Trade Area (FTA) in 2008 in its pursuit of integration and development within the region. It also plans to create the Customs Union (CU) by 2010, the Common Market (CM) by 2015, Monetary Union (MU) by 2016 and a single currency by 2018 (SADC, 2009). This coordination of macroeconomic policies implies that goods and services will be able to move unrestricted amongst the member states which will enhance integration between the South Africa and Mauritius thus increasing the likelihood of financial linkages between the two. Namibia and South Africa are both member states of the Southern African Customs Union (SACU); the two countries also share an electronic trading system, central depository, market infrastructure, settlement cycle and reporting system (Piesse and Hearn, 2008). Given these common factors, a high degree of integration is expected between these two countries.

The eight countries being investigated in this study are all members of the African Stock Exchange Association (ASEA). The association has implemented programmes such as liberalisation of financial markets, development of equity markets, privatisation of government enterprises, deregulation of financial systems, removal of capital controls and relaxation of foreign exchange controls. Piesse and Hearn (2005) note that ASEA's strategy is yielding the desired results as financial reporting and dissemination of stock price information has increased, hence improving integration. As noted in chapters one and two, South African is the dominant market on the African continent and because of this; it exerts significant influence on the other markets on the continent in terms of trade and financial services. In light of this hypothesis it is relevant in the context of this study to examine how this market may determine the nature of integration across the other markets. Hence, the next sub-section provides more insight on this issue by analysing South Africa's exports and imports with the other markets under study.

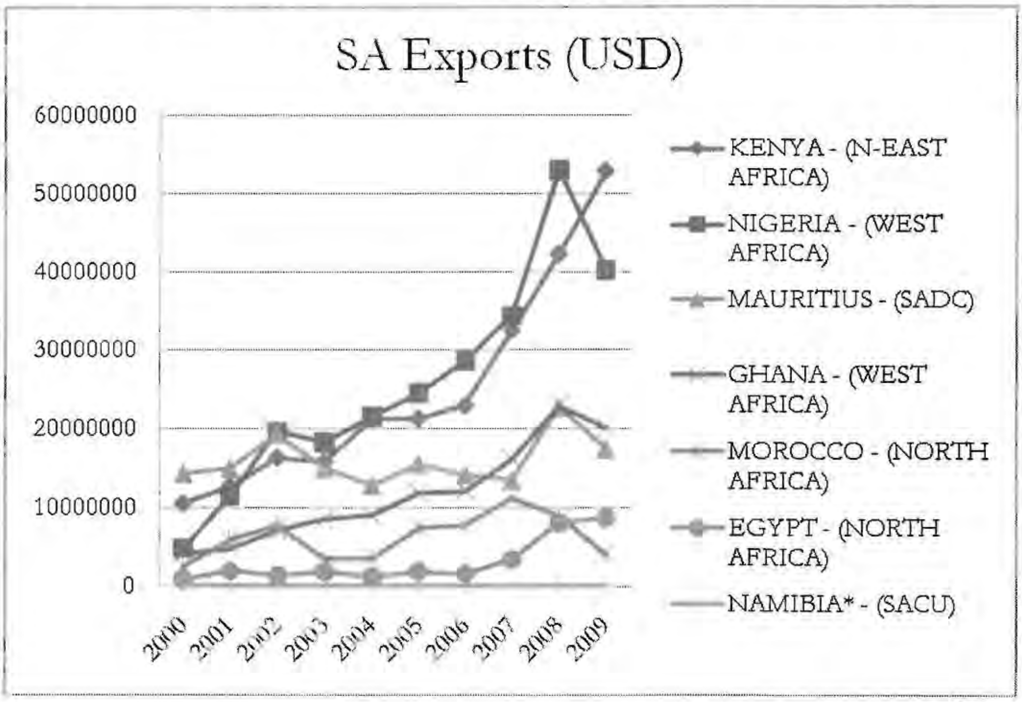
### 3.2 SOUTH AFRICA'S REGIONAL TRADE LINKS

This section analyses some trends in South Africa's trade in goods and services relative to countries included in this study. These trends are analysed from a South African perspective mainly because it is the largest economy in Africa having the most developed and sophisticated financial system (Aziakpono, 2003). South Africa's per capita income rose to a level of $3520 in 1996, $3310 in 1998 (Aziakpono, 2003:8) and $9757 in 2007 (UNDP, 2009), this is significantly higher than those of the other countries being studied, with the exception of Mauritius which had a per capita income of $11296 in 2007 (UNDP, 2009)[22].

The South Africa equity market is the oldest, largest and most liquid equity market in the continent (Chinzara and Aziakpono, 2009b:97). Because of this, the other countries being examined depend on the country to a significant degree (especially the SACU countries and more so, other SADC countries) in areas of trade, investments and also employment (Aziakpono, 2003). Accordingly, they each have an incentive to improve their integration through enhanced trade ties with South Africa so as to improve their economic and financial development. Cross-border trade in goods and services requires corresponding financial transactions (Lane and Milesi-Ferretti, 2003). Consequently, it is within reason to expect that countries with strong bilateral trade linkages would show evidence of synchronicity with regards to real business cycles together with financial asset price fluctuations. With this in consideration, we provide an analysis of trade below; Figure 1 illustrates South Africa's export regional trade with each of the other respective countries being examined, whilst Figure 2 provides the country's import regional trade.

[22] Per Capita in 2007; Egypt $5349, Ghana $1334, Kenya $1542, Morocco $4108, Namibia $5155 and Nigeria $1969 (UNDP, 2009).

**FIGURE 1: SA'S EXPORT REGIONAL TRADE (million USD)**




*Source of data for computations: Department of Trade and Industry (2010)*

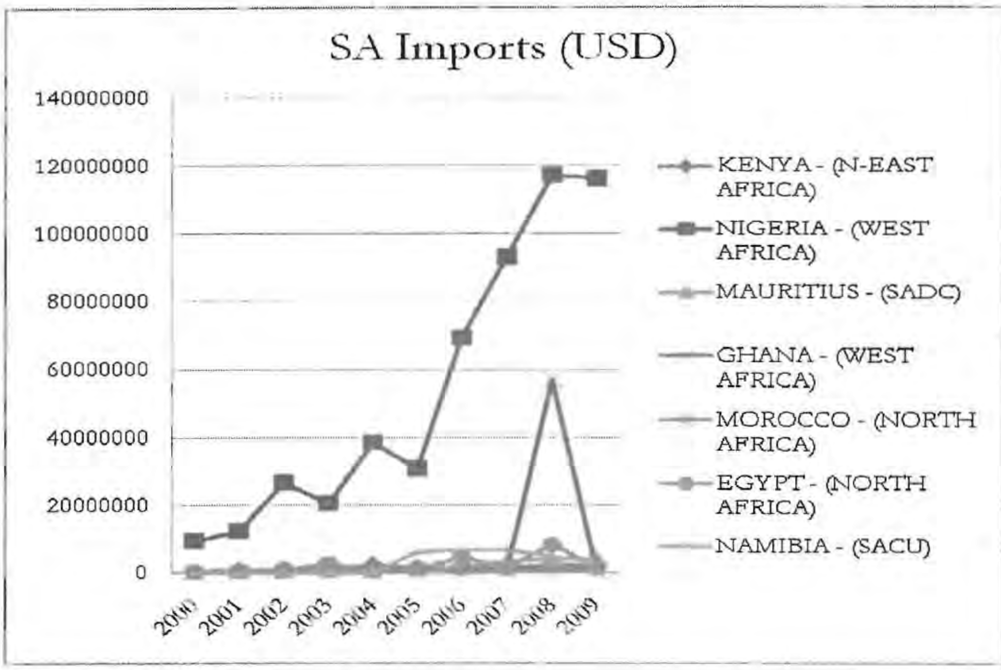
**There data was unavailable because there was no Free Trade Zone between SA and Namibia therefore it could not be captured by SARS.*

Figure 1 shows the South Africa exports for the period 2000 to 2009. It reveals that Nigeria and Kenya have constituted the bulk of South Africa's exports, particularly after 2003. These countries experienced significant increases in exports from South Africa, with Nigeria reaching its peak in 2008 and Kenya in 2009. As a result of this similar upward trend, one could reasonably argue that these countries are highly integrated with SA. A similar conclusion could be made with regards to Ghana as it has a trend that is very much alike to that of Nigeria but at a considerably lower level. A closer look at Mauritius and Morocco illustrates that they had a similar level of integration with SA between 2000 and 2005; however, these exports diverge beyond this period until 2008. Egypt has the lowest level of exports from SA suggesting that there is very limited trade between the two countries. The period between 2007 and 2009 is very important as this was during the global financial crisis. Between 2007 and 2008 there was an increase in South African exports to all the countries[23] with the exception of Morocco for which

[23] Egypt 135%, Ghana 41%, Kenya 30%, Mauritius 68%, Nigeria 54%.

exports fell by approximately 20%. Exports to Kenya rose significantly between 2008 and 2009 by 25%, whilst the increase by 8% to Egypt was only marginal. However, exports to Nigeria, Ghana, Mauritius and Morocco fell in this period to, -24%, -12%, -23%, and -54% respectively.

**FIGURE 2: SA'S IMPORT REGIONAL TRADE (million USD)**




*Source of data for computations: Department of Trade and Industry (2010)*

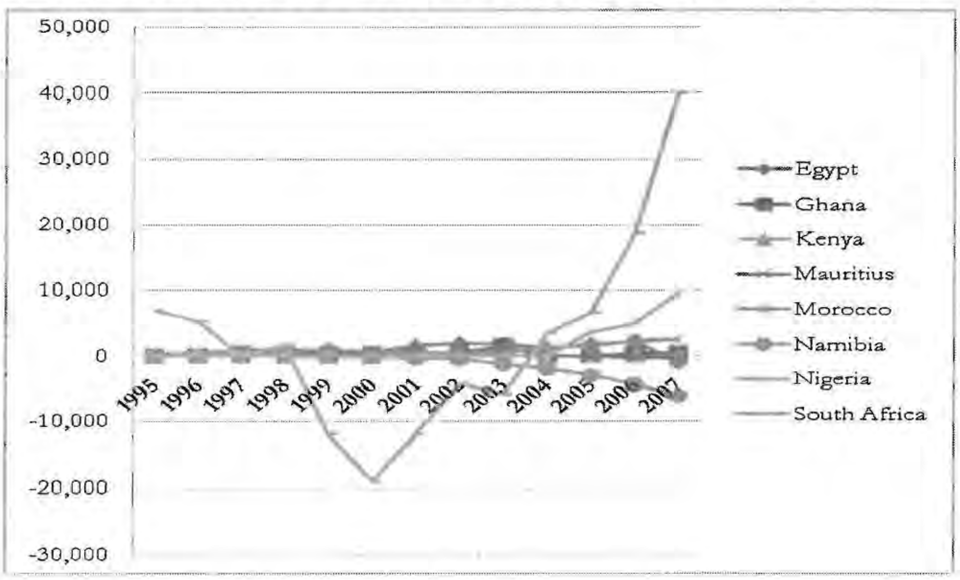
Figure 2 shows the SA imports for the period 2000-2009. SA imports from Nigeria are significantly higher from the other countries, because of this; Nigeria seems to be the country that is mostly integrated to SA in terms of trade. This is due to the fact that both SA imports and exports are very high with regards to Nigeria implying that these two countries have strong investment and trade ties. Imports from the other countries as quite low, however, imports from Ghana rose sharply during 2007-2008, only to fall in similar fashion between 2008 and 2009.

This section reveals that there is little improvement in terms of the integration of South Africa and most of the countries being examined between 2000 and 2009, with the exception of Nigeria. These patterns in trade are very important as they provide implications for the financial linkages. However, a more appropriate approach would be look at the trends of the sources of capital in terms of portfolio investment (equity and debt) as well foreign direct investment. The trends will be provided in terms of the regional flow of capital to the countries being analysed in order to obtain more plausible insights into the financial linkages and integration on the African continent. A discussion on this issue follows in the next section.

### 3.3 FINANCIAL LINKAGES

This section analyses the net capital flows during the period 1995-2007 which are divided into portfolio investments, foreign direct investment (FDI) and debt. As noted in the previous chapter, these sources of capital influence stock markets in such a way that an increase in financial linkages leads to an increase in comovements which implies improved integration. For this reason, it is important to utilise an appropriate measure of integration that confines the scale and dynamics of financial linkages in a way that allows us to compare trends in financial integration.

**FIGURE 3: NET PORTFOLIO INFLOWS (million USD)**

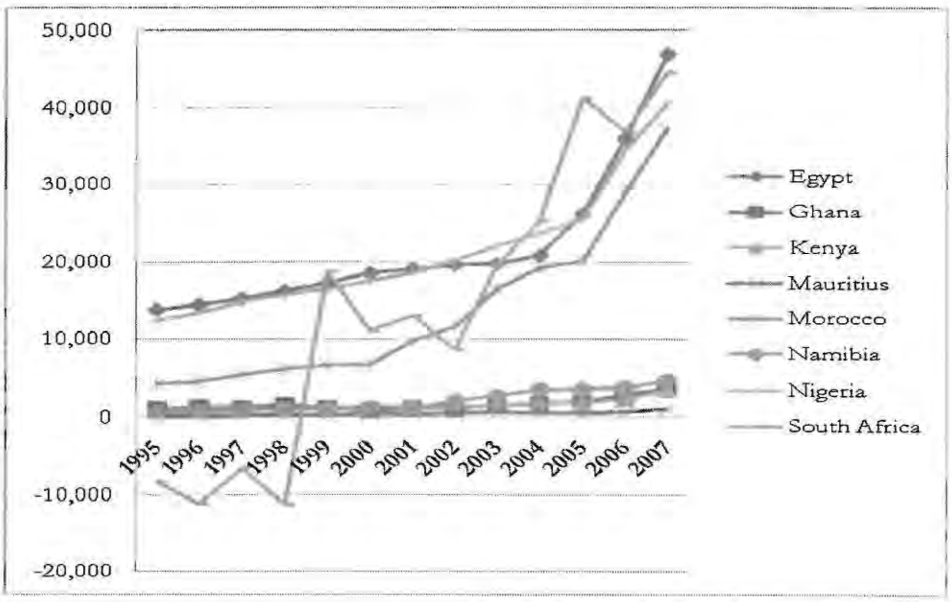



*Source of data: Lane and Milesi-Ferretti, 2007.*
*We computed the net Portfolio values by subtracting capital outflow (Portfolio assets) from capital inflow (Portfolio liabilities).*

Figure 3 plots the net portfolio inflows of the countries being analysed. It shows that South Africa experienced a decrease in portfolio equity inflows between 1995 and 2003; possibly as a result of the following factors. Firstly, this could be an indication that investors were pessimistic about the country's political future since it was in the first term of its democratic governance.

Secondly, the Asian and Latin American crises of the 1990s could have also tainted the perceptions of local investors from investing abroad. However, the period between 2004 and 2007 reveals an increase in portfolio inflows potentially due to financial reforms such as the gradual relaxation of capital controls (see Ahmed, Arezki and Funke, 2005) facilitating the efficient flow of funds in and out of the country. Egypt, Ghana, Morocco and Nigeria have also experienced positive growth in portfolio investments but at much lower levels. However, inflows to Egypt fell by approximately 147% between 2006 and 2007. Beginning in 2004, South Africa and Nigeria have a similar upward trend in inflows (even though SA inflows are significantly higher), this could be due to the fact that they are both resource-rich (Nigeria-oil, SA-gold) economies which attracts funds for increased investment. Ghana, Kenya, Mauritius and Namibia have extremely low portfolio inflows which are very similar in their trends in inflows of portfolio investment. Namibia experienced negative portfolio equity inflows between 2000 and 2007. These four countries have smaller and underdeveloped stock markets in comparison to the larger markets. This means that they suffer the most from problems put forward by Piesse and Hearn (2005) such as lack of liquidity, lack of proper legal protection against creditors and poor regulation and monitoring and general lack of stock market culture and awareness. Because of this, there is a high level of risk associated with investing in such markets which tends to scare off most investors, hence the low net portfolio inflows.

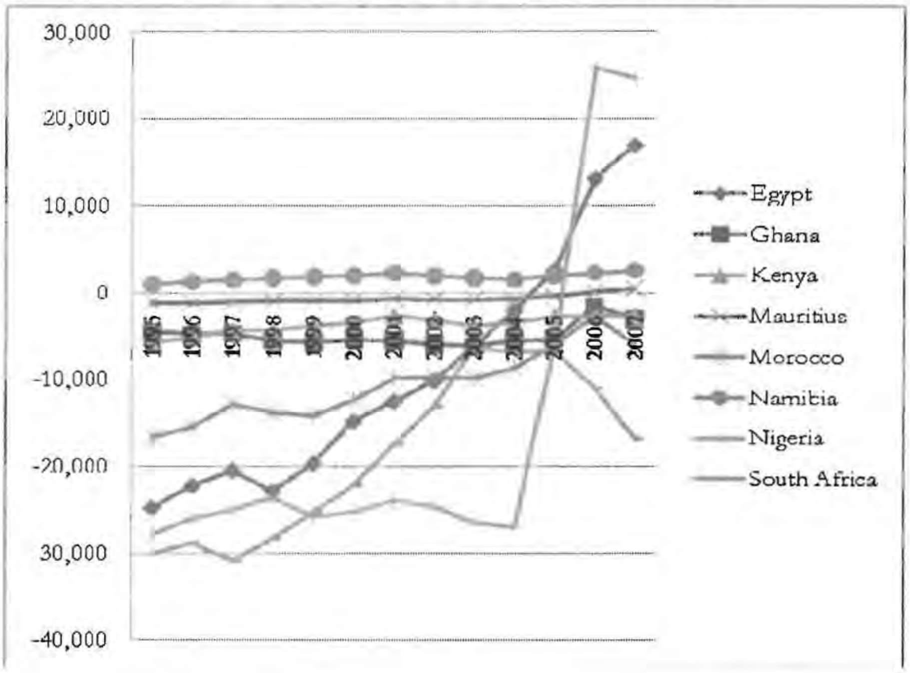
**FIGURE 4: NET FDI INFLOWS (million USD)**




*Source of data: Lane and Milesi-Ferretti, 2007.*
*We computed the net Portfolio values by subtracting capital outflow(FDI assets) from capital inflow(FDI liabilities).*

As indicated in Figure 4 all the countries being studied have positive net stock of FDI; however these are much higher in Egypt, Nigeria, South Africa and Morocco respectively. These are the four largest markets in Africa and therefore might be more financially integrated. Also, Ghana, Kenya, Namibia have figures within a similar range as illustrated by their total net FDI figures for the period examined, hence the level of integration amongst these countries could have also improved. However, this raises concerns about possible contagion through capital reversals during times of financial crisis. This is especially possible with this era of capital liberalization, financial globalization and technological advancement. Mauritius seems isolated as it has significantly lower net FDI figures in comparison to the rest of the countries.

**FIGURE 5: NET DEBT (million USD)**




*Source of data: Lane and Milesi-Ferretti, 2007.*
*We computed the net debt values by subtracting debt liabilities from debt assets.*

The analysis in Figure 5 shows that Africa's largest countries (South Africa, Nigeria, Morocco and Egypt respectively) use more debt than the other countries been examined. This may be due to the fact that they have better credit ratings with organisations such as the International Monetary Fund (IMF) and the World Bank, thus enabling them to acquire funds easier. Christensen (2004:4) notes that governments usually resort to domestic or foreign borrowing in order to finance large parts of their fiscal deficits although this is hampered by the stock and attractiveness of assets. The author goes further to say that the choice between foreign and domestic borrowing is determined by the cost of debt (interest rates), risks and maturity structure with most Sub-Saharan countries having access to foreign financing at interest rates well-below market interest rates and also at very long maturity from international aid agencies. Because of this, foreign debt is more favourable in comparison to domestic debt because the latter has higher interest rates and shorter maturities; in addition, foreign financing has the advantage of increasing the supply of foreign exchange although this has currency risk, since the servicing of a foreign debt increases the demand for foreign exchange (Christensen, 2004:5).

Nonetheless, according to Beaugrand, Loko and Mlachila (2002), highly concessional foreign loans are still the most attractive way to finance budget deficits even realising significant devaluation risks, given the high levels of domestic interest rates. Figure 5 also reveals that there is a decrease in the net debt stock for most countries which is encouraging as debt capital is considered inferior as it propagates macroeconomic volatility (Kose, Parasad, Rogoff and Wei, 2006). However, this may have negative effects for smaller markets such as Ghana, Kenya, Mauritius and Namibia as the inability to acquire long term funds could prove to be a barrier in inhibiting financial development as well as economic growth.

On the other hand, Christensen (2004:21) argues that an outright reduction in domestic debt would increase the liquidity in the system and in that way could jeopardize macroeconomic stability due to much higher market risks and shorter maturity structures. He therefore suggests that a donor-financed (with foreign exchange) trust fund should be set up in Heavily Indebted Poor Countries (HIPCs)[24] which would be used to retire domestic debt without injecting liquidity into the system because it would be absorbed by the foreign exchange transaction. Also, extending the maturity structure of domestic debt would be an advantage for indebted countries as it would lower market and rollover risks. Lastly, improved foreign access to holdings of domestic debt would be beneficial because it increases competition, reduces financing costs, and promotes a strong foreign investor presence which will add to the introduction of financial technology and innovation and ultimately resulting in higher market efficiency (Christensen, 2004:21).

This section has accordingly given a thorough analysis of the trends of the sources of capital for each of the countries and as a result provided the implications for integration of the stock

[24] The Heavily Indebted Poor Countries (HIPC) Initiative was set up to reduce the external debt stocks in these countries and free-up resources for pro-growth government spending.

markets. In the next section we now analyse the stock market characteristics in terms of market size and liquidity.

### 3.4 STOCK MARKET CHARACTERISTICS

African stock markets have been generally characterised as being small in size, highly illiquid, inefficient and volatile due to fact that they are mostly in their early stages of growth. With this in mind, this section gives more insight on the characteristics of the stock markets being examined with the view to make relevant inferences with regards to regional integration in terms of the aforementioned trading blocks. Market capitalisation shall be used as an indicator for the sizes of the stock markets. This is calculated by multiplying the total number of shares on issue by the respective share prices at a given time thus giving the value of the stock market at that time. As a result, the higher the stock market capitalisation the larger is the stock market size meaning that it is more capable of mobilising capital and diversifying risk.

It is evident from Figure 6 that the South Africa is by far the largest stock market in Africa. Panel A shows that the stock market grew over the period 2005 to 2007. Between 2005 and 2006 it grew by approximately 19% and experienced further growth of 6% during the 2006-2007 period, however, it fell by 39% between 2007 and 2008. This can be attributed to the global financial crisis which caused a huge slow-down in the stock markets of the country's major world trade partners such the US and UK which inevitably had a negative impact on South Africa. The Egyptian stock market is the second largest with an average[25] of 84% between 2005 and 2008 while the Moroccan stock market is the third largest with an average of 74% over the same period. Mauritius occupies the fourth position with an average growth of 52% over the same period, whilst Kenya is fifth with approximately 43%. The figure reveals that Nigeria had the biggest growth between 2005 and 2007, particularly between 2006 and 2007 with an impressive figure of 136%; conversely, the market suffered the biggest loss during the crisis period of 2007 and 2008 falling by approximately 54%. As a result of this, it occupies the sixth position with an average of 29% between 2005 and 2009. Ghana (19%) and Namibia (7%) are evidently the smallest markets during the same period occupying seventh and eighth positions respectively.

Panel B provides a trend analysis of the market capitalisation over an extended period between 2000 and 2008 so as to give a more robust inference on comovements of the stock markets. With the exception of Ghana and Namibia, all the markets have an upward trend between 2000

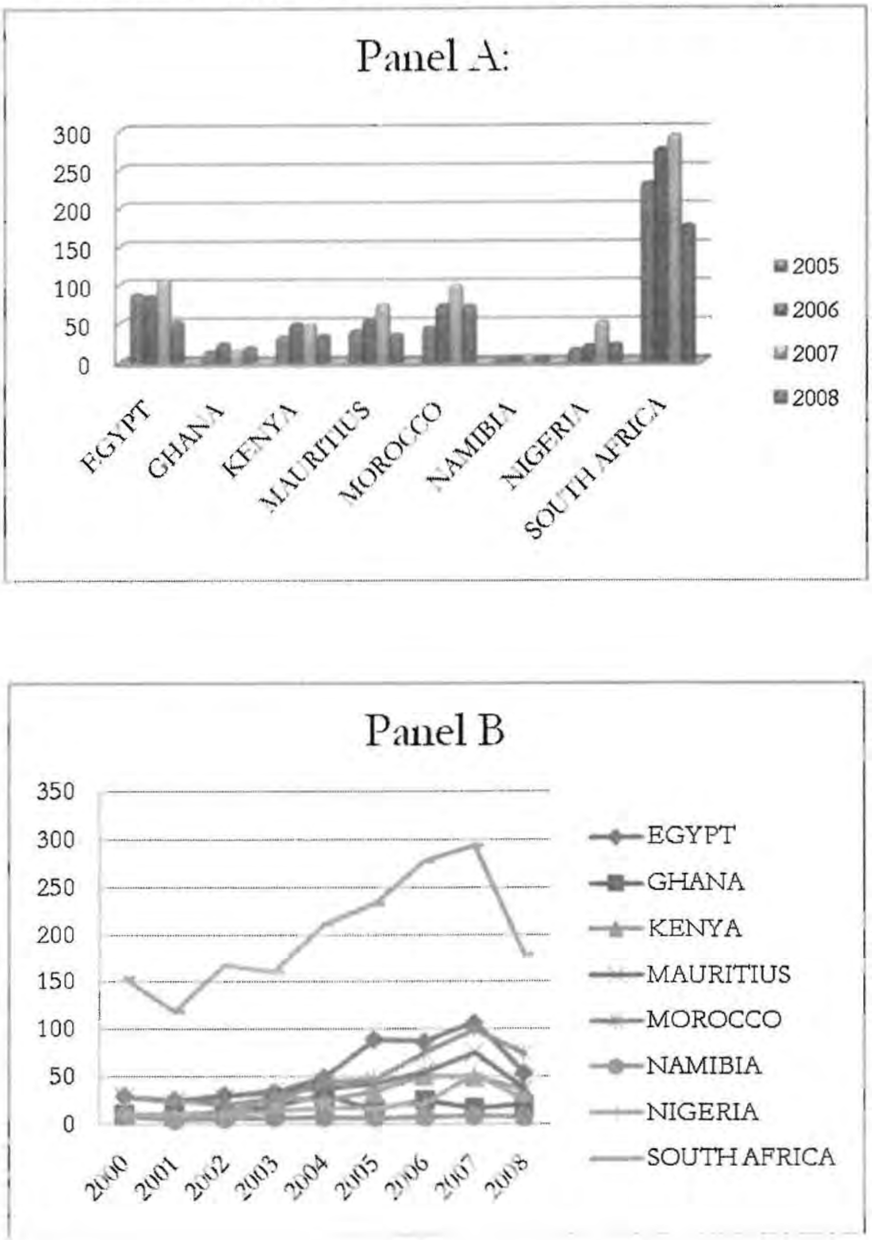
[25] The *average* refers to the *average growth* of market capitalisation between 2000 and 2008; it was calculated for each respective stock market by adding the market capitalisation in each year, getting the total sum and then accordingly dividing it by 9.

and 2007 while Kenya and Ghana have a similar downward trend between 2006 and 2007. Clearly, South Africa stock market has grown a significantly higher level than the other markets, but in spite of this, it has a relatively similar upward trend with of Egypt, Morocco, Mauritius and Nigeria as well. The crisis period of 2007 and 2008 reveals that all but one of the markets experienced sharp declines in market capitalisation as expected, however, the exception being Ghana. This market actually grew by a remarkable 25% in this period. However, according to Ackah, Aryeetey and Aryeetey (2009), these year-on-year comparisons are misleading because it is quite apparent that the Ghana Stock Exchange (GSE) may have been affected by the crisis in the last quarter of 2008. Market activity on the GSE was quite strong in the year through quarter three with the all share index closing in Q3 2008 with a return of 65.02% (33.20% in dollar terms) as compared with a gain of 13.4% (8.86% in dollar terms) for the same period in 2007 (Ackah *et al.,* 2009:8) . Nonetheless, from October 2008 the GSE started to show signs of contraction and contagion from the global stock market developments, with the benchmark measure of performance actually worsening into 2009 to close at 9247.17 points on Tuesday 31 March 2009, down from 10,431.6 points in 2008 (Ackah *et al.,* 2009:8). In terms of Namibia, this has consistently been the smallest stock market over the period 2000-2009 and as a result, has experienced very small growth of 7%.

Liquidity refers to the extent to which market participants can buy and sell securities on a stock market. This is an imperative characteristic of stock markets as a more liquid market enhances the allocation of capital and ultimately improves economic growth (Levine, 1996; Abu-Sharia and Junankar, 2003). There are two measures of market liquidity that are going to be utilised, namely total value traded ratio and the turnover ratio. The total value traded ratio is the total value of stocks traded in a specific period divided by GDP. It gives a measure of stock market liquidity that corresponds with the measure of stock market size in terms of market capitalisation and shows whether market trading is able to match market size. Hence, a higher value implies greater market liquidity.

The turnover ratio is calculated as the total value of shares traded during a period divided by the average market capitalisation for a particular period. High turnover is frequently used as an indicator of low transaction costs, even though it is not a direct gauge of theoretical definitions of liquidity. The turnover ratio complements the market capitalisation ratio in that a huge but inactive market will have a huge market capitalisation ratio but a small turnover ratio. In addition, it also complements the total value traded as it measures trading in relation to the size of the stock market, hence a small liquid market will have a high turnover ratio but a small total value traded ratio (Levine, 1996; Abu-Sharia and Junankar, 2003).

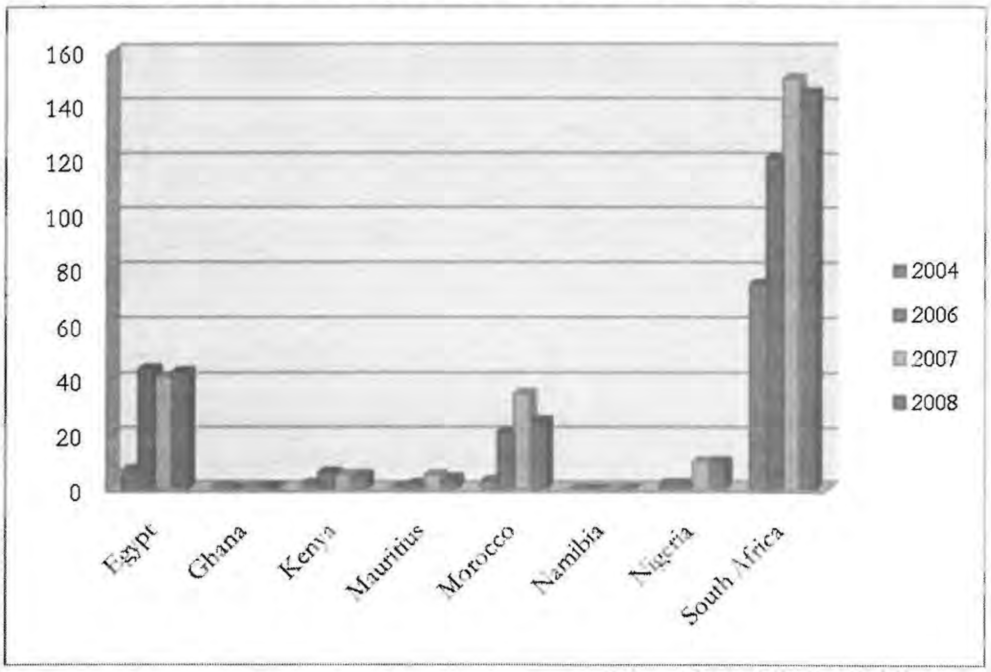
**FIGURE 6: MARKET CAPITALISATION AS % OF GDP**




*Source of data for computations: World Bank, 2010*

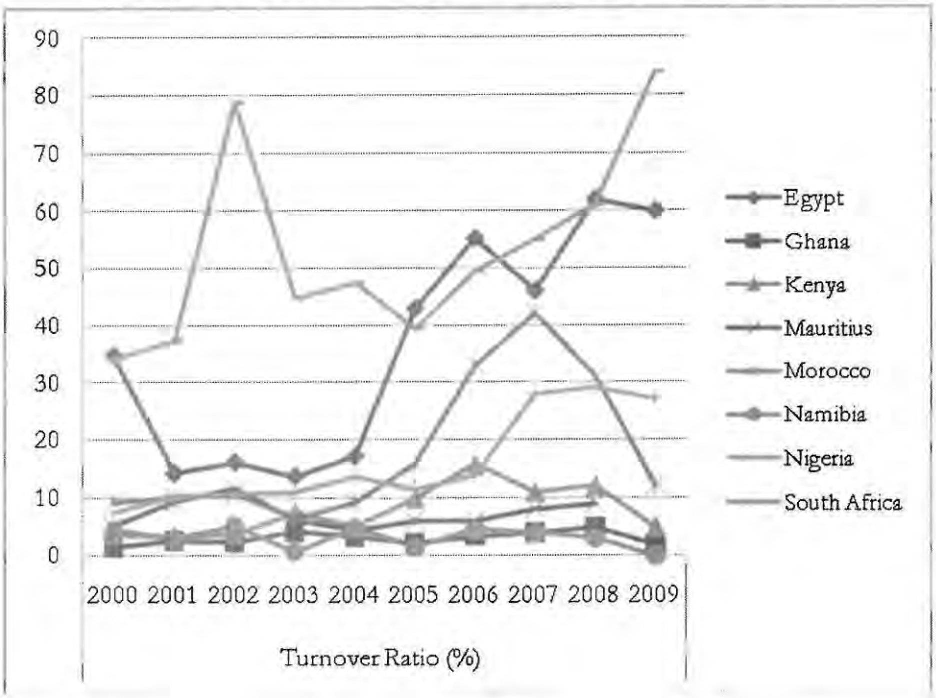
As illustrated in Figure 7 below, the South African stock market is the most liquid market in Africa with the highest value traded ratio. Egypt and Morocco have the second and third highest values respectively even though their ratios are significantly lower than that of South Africa for the period analysed. Kenya, Mauritius, Nigeria have lower values, nonetheless Ghana and Namibia are revealed to be the most illiquid markets with extremely low ratios

**FIGURE 7: STOCKS TRADED, TOTAL VALUE % OF GDP**




*Source of data for computations : World Bank, 2010*

FIGURE 8: STOCKS TRADED, TURNOVER RATIO

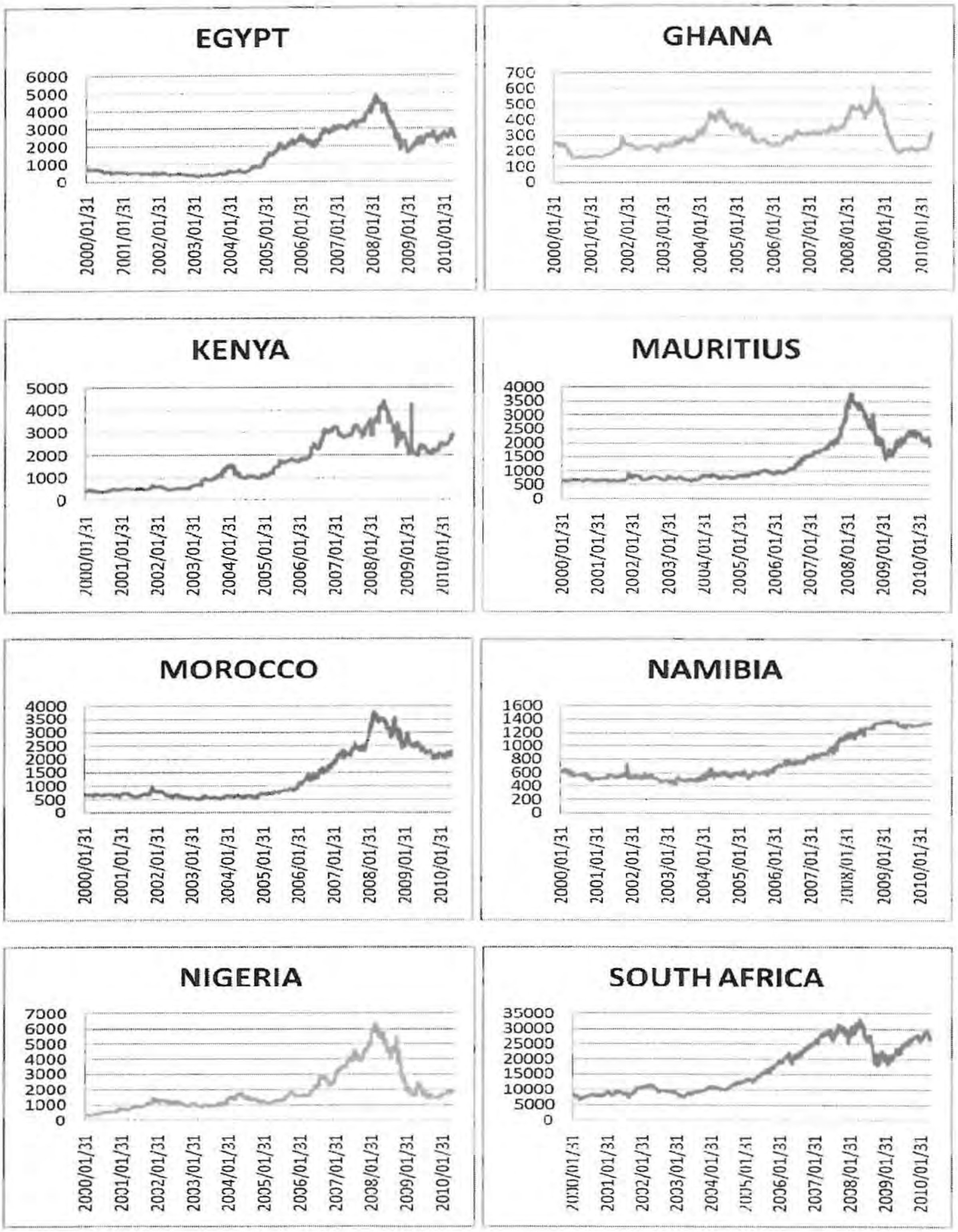



*Source of data for computations: World Bank, 2010*

The turnover ratios in figure 8 complement the market capitalisation and the total value of stocks traded as illustrated in the preceding figures. South Africa consistently outperforms all the markets even during the crisis period between 2007 and 2009. This is a clear indication that investors had an incentive to trade with the more liquid South Africa market during the crisis possibly due to benefit of incurring lower transaction costs. Egypt, Morocco and Nigeria have similar trends especially between 2004 and 2007. Kenya, Mauritius, Ghana and Namibia have the lowest turnover ratios; this could be attributed to the fact that these markets are underdeveloped and as a result may be less attractive to traders in terms of their high transaction costs. In the next section we provide a trend analysis of the market indices between 2000 and 2010 as these will enable us to make more robust conclusions on their comovements.

## 3.5 STOCK MARKET INDICES TRENDS

FIGURE 9




*Source: Authors computations based on data obtained from Thomson DataStream*

As is evident from Figure 9, comovement seems to exist with Egypt, Kenya Mauritius, Morocco, Nigeria and South African stock markets reflecting a very similar trend. Egypt and Morocco are the only two countries within the MENA region that offer unrestricted investments for foreign investors; this may be the reason for their comovement. The similarity in the trends of Nigeria, South Africa and Egypt could be due to the fact that these countries are rich in resources, that is, oil in Nigeria and Egypt and gold in South Africa. The smaller stock markets of Ghana and Namibia indicate rather unique trends, suggesting that there is limited comovement with the other markets.

This section has put forward the argument that financial markets are increasingly becoming integrated regionally implying that stock prices should illustrate a similar reaction to common external shock. In order to show this we focus on how the markets responded to the global financial crisis between 2007 and 2009. The impact of this crisis is reflected in the drastic fall of most the stock markets in 2008, with the exception of Namibia. However, South Africa, Egypt, Kenya and Mauritius seem to be benefiting from the global economic recovery as they reveal increases in their stock market between 2009 and early 2010.

### 3.6 CONCLUSION

This chapter has given a comparison of stock markets in terms of four issues: trade linkages, financial linkages, stock market characteristics, and trends of stock market indices. Section 3.1 discussed the trade linkages in terms of similar macroeconomic agreements that exist among the various African trading regions; these include COMESA, MENA, ECOWAS and SADC. This discussion was mainly focused on how these regional trading groups influence integration amongst the markets being examined. By noting that South Africa is the largest economy in Africa, section 3.2 provided an analysis of its exports and imports with each of the other countries in the study. This was done so as to establish how and to what extent South Africa influences trade and investment and ultimately integration on the continent. Section 3.3 examined the financial linkages in terms of net portfolio equity investments, net FDI and net debt. In this section it was revealed that there is a much more significant flow of sources of capital to the bigger economies such as SA, Egypt and Nigeria relative to smaller ones like Ghana and Namibia. Section 3.3 compared size and liquidity using market capitalisation, total value traded and turnover ratios revealing the outright dominance of the South African stock market. Section 3.4 analysed the trends in the stock markets by plotting the stock market indices for the different stock markets. A number of interesting observations were made from this section. Firstly, we observed that stock indices of regional and trade and investment links seem to move together. Secondly, we observed that despite the fact that Ghana is member of ECOWAS, it has a peculiar long run trend in comparison to the stock markets. A third observation was that all stock market reacted negatively to the global financial crisis in 2008. Thus, together with chapter 2, this chapter laid down the foundation for empirical analysis which will be discussed in more detail in the next chapter.

# CHAPTER FOUR

# METHODOGY AND ANALYTICAL FRAMEWORK

## INTRODUCTION

In this chapter the analytical framework to be used is discussed in full detail and a foundation that will enable the realisation of the objectives stated in chapter one is laid. The main objectives as laid out in Chapter 1 include examining the long run comovements and volatility linkages amongst the selected stock markets along regional lines. In order to achieve this, the empirical analysis will be carried out by making use of the Factor Analysis model (FA), the Cointegration analysis, Vector Autoregressive (VAR) model and the Generalised Autoregressive Conditional Heteroscedasticity (GARCH). Therefore, this chapter focuses on these econometric methods and their relevance in the current study.

The Johansen Cointegration models will be utilised to study the long run comovements across the stock markets whilst Factor Analysis and VAR will be used to analyse return linkages. It is important to perform a factor analysis in conjunction with VAR as the former focuses on patterns of movements across the stock markets, whilst the latter provides a quantifiable measure of the stock market returns. Finally the GARCH model will be used to examine volatility and in line with previous studies (see see Piesse and Hearn, 2002 and Bonfiglioli and Favaro, 2005, Chinzara and Aziakpono, 2009a), volatility linkages are examined using the VAR.

The chapter is organised as follows: Section 4.1 discusses the econometric methodology followed in examining long run comovement of stock markets. Section 4.2 discusses the econometric methodology used to analyse returns linkages while Section 4.3 discusses the econometric methodology used for examining volatility transmission. Section 4.4 discusses proxies and data used in this study.

## 4.1 LONG RUN COMOVEMENT

### 4.1.1 COINTEGRATION ANALYSIS AND THE VECTOR ERROR CORRECTION MODELLING (VECM)

The standard ordinary least squares (OLS) method requires having all the series being integrated of order 0 [*I (0)*], that is, the series stationary at level. A stationary stochastic process is described as containing constant mean and variance over time and a covariance that is not serially correlated, a process typically referred to as a *'white noise'* (Gujarati, 2005). In the classical regression model, we deal with the relationship between variables, but most of the economic indicators typically follow a nonstationary path. It is vital for stationarity to exist in a series for two reasons, firstly, to make it possible to make forecasts and secondly to minimise the possibility of spurious[26] OLS regressions. Accordingly, unit root or stationarity tests should be done on all the variables before proceeding with the tests for cointegration and estimation of parameters. In carrying out the analysis, the first step is to test whether the series are stationary or non-stationary because this influences its behaviour and properties and as a result has important connotations for the manner in which the variables in the series should be treated. This is done by using methods such as the Dickey-Fuller generalised least squares (DF-GLS) and the Ng and Perron (2001) statistic. Commonly used methods for testing for stationarity include visual plots of data, the autocorrelation function, the augmented Dickey-Fuller (ADF) and the Phillip-Perron (PP) tests amongst others. One unit root test (DF-GLS) and one stationarity test; KPSS (Kwaitkowski, Phillips, Schimd and Shin, 1992), are considered in this study to perform what Brooks (2008:331) refers to as 'confirmatory data analysis'.

The ADF and PP tests have been revealed to have poor size and power properties especially with small sample sizes (Brooks, 2008, 331), in addition, Aziakpono (2008:198) points out that they have a tendency to "over-reject the null hypothesis of non-stationary when it is true and under-reject it when it is false." Aziakpono (2008) further argues that the DF-GLS statistic, which is a modified Dickey-Fuller statistic with GLS detrending, has been proven to be virtually uniformly most powerfully invariant. The Ng and Perron (2001) statistic, which is also an adjustment of the standard ADF statistic, has better size and power properties in comparison to conventional unit root tests (Aziakpono, 2008: 199). These statistics test for the presence of a unit root, that is, the null hypothesis tests the series for the presence of a unit root test (a test for non-stationarity), against the alternative hypothesis of stationarity.

Stationarity tests, in contrast to unit root tests, have stationarity under the null hypothesis, as a result reversing the null and alternative hypotheses under unit root tests, such as the ADF discussed above. Consequently, under stationarity tests, the data will appear stationary by default if there is little information in the sample. The Kwaitkowsk, Phillips, Schmidt, Shin (KPSS, 1992) test is one such test and it is different from the other tests used in that it has a null hypothesis of stationarity and can be conducted under the null of either level stationarity or trend

[26] If two stationary variables are generated as independent random series, when one of those variables is regressed on the other, the *t*-ratio on the slope coefficient would be expected not to be significantly different from zero, and the value of $R^2$ would be expected to be very low. This seems obvious, for the variables are not related to one another. However, if two variables are trending over time, a regression of one on the other could have a high $R^2$ even if the two are totally unrelated. So, if standard regression techniques are applied to non-stationary data, the end result could be a regression that 'looks' good under standard measures (significant coefficient estimates and a high $R^2$), but which is really valueless (Brooks, 2008:319).

stationarity. Conclusions drawn from this test are used to complement those obtained from the Dickey-Fuller distribution (Baum, 2000).

The calculated LM statistic is compared with the KPSS (1992) critical values so as to make inferences about the stationarity of a series. If the calculated LM statistic is smaller than the critical values, then the null hypothesis is not rejected and the conclusion will be that the series is stationary. The opposite will be true for a nonstationary time series.

A combination of two $I$ (1) series is normally an $I$ (1) and usually if the series of different order of integration are put together, then their combination will take the highest order series, that is, a combination of $I$ (1) and $I$ (2) is an $I$ (2) (Brooks, 2008). On the other hand, if the series are cointegrated, this might not be the case, for example, if it is shown that a combination of $I$ (1) is cointegrated, then this combination is $I$ (0). Although both variables may be trending upward in a stochastic manner, they may be trending together. As Gujarati (2005) points out, 'the movement resembles two dancing partners, each following a random walk, whose random walks seem to be in unison". Because of this, synchrony is intuitively the idea behind cointegrated series. Put differently, cointegrations means that despite being individually nonstationary, a linear combination of two or more time series can be stationary.

Cointegration has practical economic implications. This comes from the fact that many time series are nonstationary individually, but move together over time, meaning that there are some influences in the series(e.g market forces) implying that the two series are bound by some relationship in the long-run. Brooks (2008) further illustrates that a cointegrating relationship may also be seen as a long term or equilibrium phenomenon, since it is possible that cointegrating variables may diverge from the relationship in the short term but with their association returning in the long-run. This concept is particularly important in this study where we seek to identify and make a distinction amongst the stock returns that have a long term relationship.

In this study, cointegration will be carried out at two levels. Firstly, bivariate cointegration tests will be applied to establish whether cointegration exists amongst the African stock markets. This will aid in establishing if there are any common factors driving the long-run comovement amongst the markets or if each market has a distinctive set of fundamentals determining its comovement. Chinzara and Aziakpono (2009b) argue that international investors typically consider wider portfolios with a diverse range of financial products when making investment decisions. Following this, we shall extent the analysis by performing multivariate cointegration tests. In complementing this perspective, it is hypothesized by investment theory that unsystematic risk exponentially declines as the portfolio becomes wide (Howells and Bain, 2005). As a result, a distinctive internationally diversified portfolio should comprise stocks from more than two stock markets (Chinzara and Aziakpono, 2009b).

The *Engle-Granger (EG) two-step procedure*[27] and *Johansen's Maximum Likelihood (JML) procedure* are two prominent cointegration procedures. In comparison to the EG, the JML has been considered to be more robust (see Masih and Masih, 1995; Masih and Masih 2000; Figueira, Nellis and Parker, 2005). The JML procedure assumes all variables are endogenous whilst the EG procedure is sensitive[28] to the choice of the dependent variable in the cointegrating regression. Subsequently, in contrast to the EG procedure, the JML procedure can circumvent the arbitrary choice of the dependent variable and normalisation can only be done on the truly endogenous variable (Masih and Masih, 2000:630). In addition, the JML procedure has the benefit of being more general by testing for multiple cointegrating relationships among a set of variables directly (Masih and Masih, 2000:626) and also enables the inclusion of deterministic variables in the cointegrating vector (Allen and MacDonald, 1995:35). In view of that, cointegration tests will be carried out by applying only the JML procedure.

The starting point in using the Johansen and Juselius (1990) cointegration is to specify the vector error correction model:

$$\Delta X_t = \prod X_{t-1} + \sum_{i=1}^{k} \Gamma_i \Delta X_{t-i} + \varepsilon_{kt} \qquad [4.1]$$

where $X_t = (X_{1t}, X_{2t})$ is a n×1 vector of the $I$ (1) stock market indices, $\Delta X_{t-1}$ are all $I$ (0), $\Gamma_i$ are n × n coefficient matrices, $\prod$ captures information regarding the long run relationships among the stock market indices, $k$ is a finite autoregressive lag order used for the estimation, whilst $\varepsilon_{kt}$ are normally and independently distributed error terms. $\Delta X_t \ldots \Delta X_{t-k+1}$ are all $I$ (0), while $X_t$ is $I$ (1). In order for equation 4.1 to be consistent, $\prod_i$ would not be of full rank, that is, equal to n in

27 The EG procedure can only be used in bivariate analysis as it does not account for the possibility of multiple cointegration relationships (Masih, 1995:141).

28 i.e. when running the cointegration regression using the EG procedure, one variable has to first be specified as the dependent variable and the other as the independent variable even though there may be no theoretical motivation for doing so (Brooks, 2008:342).

the bivariate model. Assuming that its full rank is $n$ and its reduced rank $r$, then the variables in $X_t$ are $I$ (0), while if the $\prod_i=0$, then there are no cointegrating relations (Harris, 1995:79). More often than not $\prod_i$ has a reduced rank, that is, $r \leq (n-1)$, in which case it can be decomposed as:

$$\Pi_i = \alpha\beta \quad [4.2]$$

where $\alpha$ is a $n \times r$ matrix which represents the speed of adjustment indicating the speed with which the system responds to last period's deviations from the equilibrium relationship. $\beta$ is a $r \times n$ matrix of long run coefficients. Then $\beta X_{t-1}$ are the $r$ cointegrated variables, $\beta$ is the matrix of long run coefficients of the cointegrating vectors and $\alpha$ has the interpretation of the matrix of the error correction terms. This is the Granger's representation theorem.

However, before one proceeds to test for the rank of $\Pi$, there are two issues that have to be attended to. The first is determining the appropriate order (k) of the VAR. Brooks (2008: 293) argues that the Johansen test can be affected by the lag length employed in the VECM, thus it is crucial to attempt to select the lag length optimally. By optimally, it is meant that the chosen lag length should produce the number and form of cointegration relations that conform to all the *a priori* knowledge associated with economic theory (Seddighi, Lawler and Katos, 2000: 309). However, Brooks (2008: 293) argues that economic theory will often have little to say on what an appropriate lag length is for a VAR and how long changes in the variables should take to work through the system. Brooks (2008) thus recommends the use of multivariate versions of the information criteria, which includes the sequential modified likelihood ratio (LR), Akaike information criterion (AIC), Final prediction error (FPE) Schwarz information criterion (SC) and the Hannan-Quinn information criterion (HQ). However, in our experience, these information criteria usually produce conflicting VAR order selections. In light of these problems, we will use both the information criteria approach and the *a priori* knowledge from economic theory to select the appropriate order of the VAR.

The second issue is related to the choice of deterministic assumptions that the Johansen test requires in testing for cointegration. Various types of VARs can be estimated based on five deterministic trend assumptions, for example, with or without a constant and a trend in the term and with or without a constant in the VAR equations. E-views 6 specifically provides the following deterministic trend assumptions: Case 1 assumes no deterministic trend in the data and no intercept or trend in the VAR and in the cointegrating equation (CE); Case 2 assumes no deterministic trend in the data, but an intercept in the CE and no intercept in VAR; Case 3 assumes a linear deterministic trend in the data and an intercept in CE and test VAR; Case 4 allows for a linear deterministic trend in data, intercept and trend in CE and no trend in VAR; and Case 5 allows for a quadratic deterministic trend in data, intercept and trend in CE and linear trend in VAR. As a guide, E-views 6 (2009:364) recommends the use of Case 2 if none of the visual plots of the series and unit root tests show the presence of a trend in the series, Case 3 if the series have stochastic trends, Case 4 if some of the series are trend stationary, while Cases 1 and 5 are rarely used in practice. Thus, the graphical analysis of the raw data and unit root tests, together with *a priori* knowledge from economic theory, should assist in selecting the deterministic trend assumption to be used in the Johansen test for cointegration (rank of $\Pi$). Once the appropriate VAR order (k) and the deterministic trend assumption have been identified, the rank of the $\Pi$ matrix can then be tested.

The rank of the matrix $\Pi_i$ and the number of cointegrating relation (s) will be established by applying two commonly used likelihood ratio (LR) test statistics, put forward by Johansen (1988). These statistics are the trace statistic ($\lambda_{trace}$) and the maximum eigenvalues ($\lambda_{max}$) with their test statistics given respectively as follows:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \log(1 - \hat{\lambda}_i) \qquad [4.3]$$

$$\lambda_{\max} = -T \log(1 - \hat{\lambda}_{r+1}) \qquad [4.4]$$

where, $r$ represents the number of cointegrating vectors under the null hypothesis, $\hat{\lambda}_i$ represents the estimated value for the *i*th ordered eigenvalue (characteristic root) of the $\Pi$ matrix.

Intuitively, the larger is $\hat{\lambda}_i$ the more large and negative will be $log\,(1- \hat{\lambda}_i)$ and as a result, the larger will be the test statistic (Brooks, 2008: 351). $T$ represents the number of usable observations (Figueira *et al.*, 2005:4). The $\lambda_{trace}$ statistic sequentially tests the null hypothesis that the number of cointegrating relations is $r$ against the alternative of $k$ cointegrating relations, where $k$ is the number of endogenous variables. The $\lambda_{max}$ statistic tests for the exact number of cointegrating vectors (Kim *et al.*, 2006:46). As a result, each eigenvalue is individually tested and the null hypothesis is that there are $r$ cointegrating vectors against the alternative of $r + 1$ (Brooks, 2008:351).

To determine the rank of the $\Pi$ matrix the above, trace and maximum eigenvalue test statistics are compared to the (nonstandard) critical values from Osterwald-Lenun (1992), which differ slightly from those originally reported by Johansen and Juselius (1990)[29]. For both tests, if the test statistic is greater than the critical values, the null hypothesis that there are $r$ cointegrating vectors is rejected in favour of the corresponding alternative hypothesis. However, the trace and maximum eigenvalue statistics may yield conflicting results. To deal with this problem, Johansen and Juselius (1990) recommend the examination of the estimated cointegrating vector and basing one's choice on the interpretability of the cointegrating relations. Alternatively, Luintel and Khan (1999: 392) show that the trace test is more robust than the maximum eigenvalue statistic in testing for cointegration. The two approaches will be considered in this study when faced with such a problem.

A linear combination of a series may be stationary even though the series may be individually non-stationary; this is the inference of cointegration. Consequently, they could be influencing one another in the long-term. In the context of this study, if two stock market indices are individually non-stationary, but cointegration exists between them, then it means that the two stock markets move together in the long-term. Consequently, the potential benefits from international diversification are restricted. In addition, the existence of cointegration amongst stock markets "suggests that one market will facilitate the prediction of others since a valid error correcting representation will exist" (Allen and McDonald, 1995: 35), according to Chinzara and Aziakpono (2009b), this is on contrast to the weak form efficient market hypothesis (EMH). Since cointegration places emphasis on the long-term relationships, this does not rule out the possibility to engage in effective portfolio diversification strategies over shorter time periods. For example, if investors are able to identify which markets are cointegrated they are thus able to apply such knowledge to their benefit so as to establish in which markets to invest their funds and for how long to do so. If the markets are found to be cointegrated based on the $\lambda_{trace}$ and/or $\lambda_{max}$ test statistics, the Vector Error Correction Model (VECM) can then be estimated.

After identifying the number of cointegrating vectors in the model, a VECM can be estimated by specifying the number of cointegrating vectors, trend assumption used in the previous step and normalising the model on the truly endogenous relation (s). As a result, a VECM is simply a restricted VAR designed for application with nonstationary series that have been found to be cointegrated. The specified cointegrating relation in the VECM restricts the long-run behaviour

29 Osterwald-Lenun (1992) provides a more complete set of critical values for the Johansen test.

of the endogenous variables to converge to their cointegrating relationships, while allowing for short-run adjustment dynamics. Since the coeffecients of the VECM have already been explained above, we will not repeat them here. Upon completing estimation, the residuals from the VECM must be checked for autocorrelation.

### 4.1.2 DIAGNOSTIC CHECKS

This is a vital stage in the analysis of the stock markets because it authenticates the parameter estimation outcomes achieved by the estimated model. Diagnostic checks test the stochastic trends properties of the model for residual autocorrelation, this test will be applied in this study and is briefly discussed below.

- *Autocorrelation LM test*

The Lagrange Multiplier (LM) test utilised in this study is a multivariate test statistic for residual serial correlation up to the specified lag order. As argued by Harris (1995:82), the lag order for this test should be the same as that of the corresponding VAR. The test statistic for the chosen lag order (m) is computed by running an auxiliary regression of the residuals ( $\mu_t$ ) on the original right-hand explanatory variables and the lagged residuals ( $\mu_{t-m}$ )[30]. The LM statistic tests the null hypothesis of no serial correlation against an alternative of the autocorrelated residuals. As already mentioned above, the VAR model will be used to analyse stock return linkages. For that reason, the model is discussed in the next section.

## 4.2 EXAMINING RETURNS LINKAGES

### 4.2.1 FACTOR ANALYSIS

Factor analysis is a multivariate technique used to analyse the interrelationships among a set of variables according to their common sources of movement (Ripley, 1973:359). Consequently, it is applied to uncover the latent structure[31] of the set variables and because of this; the overall complexity of a data-set is reduced to a few factors which are constructed in a manner that takes advantage of their inherent interdependencies. For this reason, a smaller number of factors will usually be able to account for approximately the same amount of information as the larger set of original observations (Reghunath, Murthy and Raghavan 2002:2439). We use common factor analysis (FA) as a basis for examining the comovements amongst the stock market returns

[30] Johansen (1992) presents the formula of the LM statistic and offers detail on this test.
[31] A latent structure can be measured indirectly by determining its influence to responses on measured variables; it can also be referred to as a factor, underlying construct or unobserved variable (Suhr, 2009).

Confirmatory factor analysis aims to establish whether the number of factors and the loadings of measured variables on them conform to what is expected on the basis of pre-established theory (Garson, 2007). This means that the measured variables are selected on the basis of prior theory and factor analysis is then used to see if they load as predicted on the expected number of factors. The researcher's *a priori* assumption is that each factor is associated with a specified subset of measured variables. Because of this, a minimum requirement of confirmatory factor analysis is that one must hypothesise beforehand the number of factors in the model in addition to positing expectations about which variables will load on which factors (Kim and Mueller, 1978:55). Ultimately, the researcher would seek to determine if the measures created to represent a latent variable really belong together. In terms of this study, we apply common factor analysis with the aim to establish whether or not the stock market returns comove with each other based on common continental geography[32].

There are two approaches to confirmatory factor analysis namely; *The Traditional Method* and *The Structural Equation Modelling (SEM) Approach* (Garson, 2007). The traditional method enables the researcher to analyse factor loadings of indicator variables to establish if they load on latent factors as predicted by the researcher's model. This offers a more detailed perspective into the measurement model; this is in comparison to the single-coefficient goodness of fit which is applied in the SEM approach. Specifically, the SEM approach is typically utilised to model causal relationships among latent variables. This is carried out by removing from the model all straight arrows connecting latent variables, adding curved arrows representing covariance between every pair of latent variables and leaving in the straight arrows from each latent variable to its indicator variables in addition to leaving the straight arrows from error and disturbance terms to their respective variables (Garson, 2007). Consequently, the traditional method is a useful analytic supplement to the SEM approach when the measurement model requires closer examination. By applying the SEM approach, five issues must be noted; namely: *Testing error in the measurement model, Redundancy test of one-factor vs. multi-factor models, Measurement invariance test comparing a model across groups* and *Orthogonality tests*. Each of these is briefly discussed below.

*a) Testing error in the measurement model.*

CFA models can be explored with or without the assumption of certain correlations among the error terms of the measured variables, such measurement error terms represent causes of variance due to unmeasured variables as well as random measurement error (Garson, 2007). By

[32] Refer to section on Sources of Equity Market Comovement in Chapter 2 for theory on regional integration.

making reference to the theory, it may well be assumed that unmeasured causal variables will be shared by indicators or will correlate; as a result, SEM testing may well be beneficial. Garson (2007) argues that including the correlated measurement error in the model tests the possibility that indicator variables correlate not just because of being caused by a common factor, but also owing to common or correlated unmeasured variables. This possibility would be ruled out if the fit of the model specifying uncorrelated error terms was as good as the model with correlated error specified. In this manner, testing the CFA model would be a desirable authentication stage preliminary to the main use of SEM to model the causal relations among latent variables.

*b) Redundancy test of one-factor vs. multi-factor models.*

This test uses the chi-square difference to make comparisons on the original multifactor model with one which is constrained by forcing all correlations among the factors to be 1 (Garson, 2007). If the constrained model is not significantly worse than the unconstrained one, we can then conclude that a one-factor model would fit the data as well as a multi-factor one. In addition, based on the principal of parsimony[33], the one-factor model would be preferred. This also noted by Forni, Hallin, Lippi and Reichlin (2000) who say that factor models are an insightful alternative in that they offer a much more parsimonious parameterisation.

*c) Measurement invariance test comparing a model across groups.*

This test also makes use of the chi-square difference to determine whether a set of indicators reflects a latent variable equally-well across groups in the sample. Garson (2007) notes that the constrained model is one in which factor loadings are specified to be equal for each class of the grouping variable, if the model is not significantly worse, then one could conclude that the indicators are valid across the groups. If the model fails this test, Kline (1998:225) argues that it is necessary to examine each indicator for group invariance, since some indicators may still be invariant. The fact that standard errors of factor loadings cannot be computed implies that there are no direct methods for comparing models across groups, hence the need for the SEM method (Garson, 2007).

*d) Orthogonality tests.*

This test is very much like the redundancy test except that factor correlations are set to 0. If the constrained model is not significantly worse than the unconstrained one, the factors in the model can be considered uncorrelated (Garson, 2007).

[33] Basically meaning that when everything else is equal, simpler models are better.

*e) Measure of Sampling Adequacy*

If two variables share a common factor with other variables, then their partial correlation will be small, indicating the unique variance they share. This is a vital step in carrying out Factor analysis because it determines whether the variables in the model can establish correlation amongst latent variables and in so doing determine whether one can proceed with the analysis. The commonly used index of testing this adequacy is the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, that is, if the variables measure a common factor, then KMO=1. If, they are not measuring a common factor then KMO=0.0. As noted by Valadkhani *et al.* (2008:170), the minimum acceptable KMO value for carrying out Factor analysis is 0.5 because the factors extracted will account for a reasonable amount of variance in the data.

Many authors have employed principal component analysis (PCA) in examining the degree of financial integration (see Nellis, 1982; Figueira *et al.*, 2005; Gilmore, Lucey and Mcmanus, 2006; Aziakpono *et al.*, 2007; Becker and Hall, 2009). However, Conway and Huffcutt (2003) argued that the utilisation of a common factor model such as principal axis or maximum likelihood factoring provides a high-quality set of results. They illustrated that both theory and empirical literature show common factor analysis as an appropriate technique and that PCA is not technically a factor analysis method. Instead, PCA is intended to simply summarise many variables into fewer components and also, the latent factors are not the focus of the analysis (Henson and Roberts, 2006; Almudhaf and Hansz 2010). True factor analysis presents a more realistic model of measurement than PCA allowing for the presence of random and systematic error (Almudhaf and Hansz, 2010). Subsequently, factor analysis has been adopted by other authors to investigate comovements in stock markets (see Hui and Kwan, 1994; Naughton, 1996; Illucea and Lafuente, 2002; Fernandez-Izquiredo and Lafuente, 2004; Hui, 2005; and Valadkhani *et al.*, 2008).

By analysing international stock market linkages, IIlueca and Lafuente (2002) and international portfolio diversification, Valadkhani *et al.* (2008) noted that for a given multivariate set of $k$ variables, the factor analysis model can be specified as follows:

$$r_1 - \mu_1 = \ell_{11} f_1 + \ell_{12} f_2 + \ldots + \ell_{1m} f_m + \varepsilon_1 \quad [4.5]$$

$$r_2 - \mu_2 = \ell_{21} f_1 + \ell_{22} f_2 + \ldots + \ell_{2m} f_m + \varepsilon_2 \quad [4.6]$$

$$\vdots = \vdots$$

$$r_k - \mu_k = \ell_{k1} f_1 + \ell_{k2} f_2 + ... + \ell_{km} f_m + \varepsilon_k \quad [4.7]$$

In matrix notation we can write:

$$r - \mu = \mathbf{LF} + \varepsilon \quad [4.8]$$

where $m < k$ and where $\mathbf{r} = (r_1, r_2, ... ,r_k)$ denotes the multivariate vector of stock returns, $\mu = (\mu_1, \mu_2, ... , \mu_k)$ is the corresponding mean vector, $F = (f_1, f_2, ... f_k)$ is the resulting common factor vector, $L = [\ell_{ij}]_{k \times m}$ is the matrix of factor loadings, $\ell_{ij}$ denotes the loading of the *i*th variable on the *j*th factor and $\varepsilon = (\varepsilon_1, \varepsilon_2, ... ,\varepsilon_k)$ is the specific error of $r_i$.

With regards to the factor extraction, there are various approaches which can be utilised namely; the principal component technique, maximum likelihood and unweighted least squares (Hui, 2005). This study uses the two most widely used approaches, that is, the principal component technique and the maximum likelihood method. Principal Component Analysis (PCA) has the main advantage that it does not require the normality assumption of data and the prior specification of the number of common factors (Valadkhani *et al.*, 2008:167). In addition, the technique can be applied based on both covariance and correlation matrices. In this study we use the correlation matrix. We do this by noting that a change in the unit of measurement of any one of the included stock returns will have an effect on the outcome of the principal components, hence applying correlation matrices enables us to make enlightened inferences about the factors based on the factor loadings.

The idea of using the principal component technique is to reduce the dimensionality of a set of data made up of a large number of variables which have some economic relation to each other, whilst maintaining as much as possible the variation present in the data set (Jolliffe, 2002: 1). This is achieved by transforming "a given set of variables into a new set of composite variables, referred to as principle components (PCs), which are orthogonal to each other" (Figueira *et al.*, 2005:4). Nellis (1982:345) explains that given a collection of correlation coefficients for a set of variables, this form of analysis makes it possible to detect whether there exists an underlying pattern of relationships such that it is possible to reduce the data to a set of factors less in number than the set of variables.

Conventionally, the eigenvalue and the cumulative $R^2$ of the PC are used to establish the explanatory power of each PC (Aziakpono *et al.*, 2007:12). Accordingly, the current study will follow this approach. The *Kaiser's rule*[34] will also be applied and a cumulative proportion criterion established in order to determine the significance of the eigenvalues of each PC[35]. By following Kaiser's rule (Kaiser, 1960) only statistically significant PCs with variances (eigenvalues) equal to or greater than 1.0 will be retained for analysis (see Nellis, 1982; Meric *et al.*, 2008). This is because these are the PCs that contribute most to the total variance of the variables and are able to describe more of the data than any single variable. On the other hand, the remaining factors (those with eigenvalues less than 1.0) do not need to be retained for analysis as they are likely to "be obscure and more difficult to identify" (Nellis, 1982:346).

In addition to following the Kaiser rule, a cumulative percentage of total variation criteria can be established. According to Jolliffe (2002:113), a reasonable cut-off is usually between 70% and 90%, but this can be higher or lower depending on the practical details of each data set. For instance, a cut-off of more than 90% may be appropriate in cases where although the most obvious and dominant sources of variation can be explained by the first one or two PCs, it is of interest to the researcher to identify the less obvious sources of variation (Jolliffe, 2002:133). Bearing not only the above recommendations in mind, but also the purpose of the current study and the approach followed, instead of imposing a predetermined cut-off level, the explanatory power of the cumulative $R^2$ will rather be used as a guide. For example, in some cases where a PC is not found to be statistically significant according to the Kaiser rule, it may still be considered if it has a fairly large impact on the explanatory power of the cumulative $R^2$ value.

In terms of the maximum likelihood method, it is assumed that the common factors (or **F**) and the specific factors (or ε) are jointly normal. This will ensure that **r** is multivariate normal with the mean $\boldsymbol{\mu}$ and covariance matrix $\sum_r = LL' + \varphi$. Hence, the ML method may be applied to estimate **L** and $\boldsymbol{\Psi}$ subject to $L'\varphi^{-1}L = \Delta$, which is a diagonal matrix (Valadkhani *et al.*, 2008).

*Factor rotation*

Once the number of factors is established, the next step is to identify the variables that correlate with each factor by analysing factor loadings. However, Hui (2005) notes that factor loadings are usually not readily interpreted and because of this, the usual practice is to rotate them until an easier interpretation is achieved. There are various rotation methods namely, Varimax, Quartimax, Equamax, Direct Oblimin and the Promax method. These methods are devised to

[34] Kaiser's rule is specifically constructed for use with correlation matrices, although it can also be adapted to suit some covariance matrices (Jolliffe, 2002:114).

[35] It must be noted that although the Kaiser and the cumulative percentage of total variation criteria can be described as ad hoc rules of thumb they have been adopted in this study because they are intuitively plausible and work well in practice (Jolliffe, 2002:112).

construct loading vectors whose coefficients are as close to zero or one as possible (IIlueca and Lafuente, 2002). In this study will use the Varimax rotation method. It is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor (column) on all the variables (rows) in a factor matrix, which has the effect of differentiating the original variables by extracted factor (Garson, 2007:9). Each factor will tend to have either large or small loadings of any particular variable. According to Abdi (2003:3), the Varimax rotation simplifies the interpretation because each original variable tends to be associated with one (or a small number) of factors and each factor represents only a small number of variables. Abdi (2003) goes further to note that the factors can often be interpreted from the opposition of few variables with positive loadings to few variables with negative loadings. Therefore, this study will make use of the Varimax rotation method because it yields results which make it as easy as possible to identify each variable with a single factor and hence is the most appropriate rotation option.

If **P** is a $m \times m$ orthogonal matrix, the following relations can be written:

$$\mathbf{LL}' + \mathbf{\Psi} = \mathbf{LPP}'L' + \mathbf{\Psi} = \mathbf{L}^{*}(\mathbf{L}^{*})' + \mathbf{\Psi} \qquad [4.9]$$

and

$$\mathbf{r} - \boldsymbol{\mu} = \mathbf{LF} + \boldsymbol{\varepsilon} = \mathbf{L}^{*}\mathbf{F}^{*} + \boldsymbol{\varepsilon} \qquad [4.10]$$

in which

$$\mathbf{L}^{*} = \mathbf{LP} \qquad [4.11]$$

and

$$\mathbf{F}^{*} = \mathbf{P}'\mathbf{F} \qquad [4.12]$$

Under an orthogonal transformation, the communalities and the specific variances do not change. As a result, it is possible to find **P** (an orthogonal matrix) to transform the factor model in such a way that the loadings on the common factors are easier to interpret. This transformation entails rotating the common factors in the $m$-dimensional space. So, we let the rotated matrix of factor loadings be $\mathbf{L}^{*} = [\ell^{*}_{ij}]$ and the $i$th communalities are shown by $c_i^2$. Thus, we can then define $\tilde{\ell}^{*}_{ij} = \ell^{*}_{ij}/c_i$ as the rotated coefficients scaled by the (positive) square root of communalities. In the varimax method the orthogonal matrix **P** is chosen in such a manner that it maximises the quantity of:

$$V = \frac{1}{k}\sum_{j=1}^{m}\left[\sum_{i=1}^{k}(\tilde{\ell}^{*}_{ij})^{4} - \frac{1}{k}\left(\sum_{i=1}^{k}\tilde{\ell}^{*2}_{ij}\right)^{2}\right] \qquad [4.13]$$

when $V$ is maximised this means that the squares of the loadings on each factor are spread out as much as possible. We do this with the aim to facilitate the interpretations of common factors by establishing groups of very large and very small coefficients in any column of the rotated matrix of factor loadings.

As already mentioned, factor analysis identifies the patterns of movements of stock market returns instead of giving a quantifiable measure of the degree of integration. In fulfilling the latter objective, the Vector Autoregressive (VAR) model will also be carried out to make deductions regarding the returns linkages amongst the selected stock markets. Consequently, applying these two statistical methods makes it possible to provide more robust conclusions in terms of linkages of the stock market returns.

### 4.2.2 VECTOR AUTOREGRESSIVE (VAR)

Although there are a number of methods for testing returns linkages, e.g. Granger causality and Simultaneous equations, this study uses the VAR model. This is because there are significant flaws in the Granger causality and simultaneous equations which have provided researchers and scholars with an incentive to favour VAR model. The main disadvantage of using Granger causality is that the existence of significant Granger causality does not necessarily mean that there is a causal relation between stock markets. In contrast, simultaneous equations can only be useful if there are only two stock markets being investigated in the research and in addition, it has problems with regards to identification (Brooks, 2008). As a result, VAR has been put forward as a superior option to these methodologies and for that reason; this study will employ this method for examining return linkages.

VAR models were made popular by Sims (1980) when he popularised them as substitutes to simultaneous equations models. The latter models were applied widely since the 1950s; however, the accessibility of longer and more frequently observed time series accentuated the need for models which centred on the dynamic structure of the variables (Lutkepohl, 2007). In addition, Sims (1980) criticised the exogeneity assumptions for some of the variables in simultaneous equations models as *ad hoc* and that they are frequently not backed by fully developed theories. On the other hand, in VAR models the researcher need not specify which variables are endogenous or exogenous as all observed variables are often treated *a priori* endogenous (Brooks, 2008). The VAR model is able to estimate a dynamic simultaneous equation without placing any prior restrictions on the structure of the relationship as developed by Sims (1980). Since it does not have any structural restrictions, the model allows for the estimation of reduced form of correctly specified equations whose actual economic structure may be not known. This is a vital characteristic in the empirical analysis of data since structural models are usually misspecified. This study will specify the VAR model as follows:

$$X_t = C + \sum_{s=1}^{m} A_s X_{t-s} + \varepsilon_t \qquad [4.14]$$

Where $X_t$ is a 8 × 1 column vector of equity market returns for the eight stock markets being studied, C is the deterministic component comprised of a constant, $A_s$ are respectively, 8 × 1 and 8 × 8 matrices of coefficients, m is the lag length and $\varepsilon_t$ is the 8 × 1 innovation vector which is uncorrelated with all the past *X*s.

The fact that there are many coefficients raises problems in relation to interpretation even though the VAR model is valuable in testing for and examining spillovers and linkages amongst stock markets. To be specific, some lagged variables may have coefficients which change sign across the lags. In addition to the interconnectivity of the equations, this may make it difficult to see what effect a given change in a variable would have upon the future values of the variables in the system (Brooks, 2008: 296). Also, the VAR estimates do not permit us to establish very much about the transmission of shocks across the system or the time period it takes for these shocks to work all the way through the system. As a way of lessening the effect of this problem in some measure, Brooks (2008:296) suggests three sets of statistics which are normally constructed as an extension of the VAR model, these are; *Block significance tests*, *Impulse responses* and *Variance decompositions*. To shed more light on these they are discussed below.

#### 4.2.2a Block exogeneity tests

When a VAR includes many lags of variables, it is probable that it will be difficult to detect which sets of variables have important effects on each dependent variables and which do not. To address this problem, tests are normally carried out so as to restrict all of the lags of a particular variable to zero (Brooks, 2008: 297). Assuming that all variables in the VAR are stationary, the joint hypothesis can easily be tested within the *F*-test approach because each individual set of restrictions entails having parameters being drawn from only one equation. This test can also be described as a causality[36] test as illustrated by Granger (1969). It is based on conducting a test on the validity of zero restrictions on some of the parameters in the Equation [4.17]. In this study, we will employ the block exogeneity test for testing which of the stock

[36] 'Causality' is somewhat a misnomer, for Granger – causality means only a correlation between the current value of one variable and the past values of others; it does not mean that comovements of one variable cause movements of another, for a more detailed discussion see Brooks (2008).

markets influence each other in relation to returns and volatility. Also, the test will be utilised to classify which stock markets are the most exogenous and endogenous in returns and volatility linkages thus allowing us to establish which market mostly influences volatility and returns amongst the African stock markets.

### 4.2.2b Impulse response analysis

The impulse response analysis draws out the responsiveness of a dependent variable to shocks to each other of the other variables in the VAR framework (Brooks, 2008:299). In the context of this study, this analysis provides solutions to the issue of the response of one African stock market to a one standard error unit shock in the other African stock markets. In this way, the sign, magnitude and persistence of responses of one market to shocks in another stock market are captured. Because this study employs daily data, the finding of 'contemporaneous' responses could be interpreted as a measure of the degree of informational efficiency of the African stock markets.

Lutkepohl and Saikkonen (1997:130) and Aziakpono (2008) report that if the process illustrated in equation [4.14] is white noise, then the estimated VAR could be inverted into a moving average (MA) representation whose coefficients are forecast error impulse responses. This MA is of the form:

$$X_t = C + \sum_{s=0}^{k} B_s \varepsilon_{t-s} \qquad [4.15]$$

Where $X_t$ represents a linear combination of current and past one step ahead forecast error or innovations. In this study, the coefficients $B_s$ are interpreted as the response of one stock market return to a one standard error shock of any of the markets under *s* periods ago. As in equation 4.17, the $\varepsilon_t$'s are also serially uncorrelated although they may be contemporaneously correlated.

As noted by Aziakpono (2008) and Kim (2009), the impulse responses are usually estimated using the generalised impulse response function (GIRF) proposed by Koop, Pesaran and Potter (1996), Pesaran and Shin (1998) and the Cholesky decomposition proposed by Sims (1980). Although the former has the benefit over the latter in that it necessitates orthogonolisation of all innovations and does not vary with the ordering of variables in the VAR (Pesaran and Shin, 1998:17), results obtained from the two techniques correspond with each other if the shocks are uncorrelated. However, Kim (2009:4) reports that economic deductions taken from the GIRF can be deceptive because the GIRF uses a set of extreme identifying assumptions that contradict one another unless the covariance matrix is diagonal. Accordingly, this study employs the Cholesky decomposition estimation criterion.

#### 4.2.2c Variance decomposition analysis

The variance decomposition gives the proportion of the movements in the dependent variables that are owing to their 'own' shocks to the other variables (Brooks, 2008:300). Variance decomposition divides the variations in one stock market into component shocks in the VAR, in this way; it offers information about the relative importance of error/innovation of each stock market in describing other stock markets included in the VAR system. In other words, variance decompositions illustrate the proportion of the movements in the explained stock market that are as a result of its 'own' innovations, against those from other stock markets. As widely documented in empirical literature (see Eun and Shim, 1989; Lamba and Otchere, 2001; Brooks, 2008), own series innovations are inclined to explain most of the forecast error variance of the series in the VAR.

This study utilises the variance decomposition analysis to determine the proportion of the movements in any stock markets that are explained by other markets. The main issue here has to do with establishing how much of the variations in the returns and volatility can be explained by innovations from the African stock markets being examined. This will aid in determining which of the African stock markets is the most influential on the returns and/or volatility on the African continent. Previous studies have reported South Africa as being the largest stock market in Africa (see Lamba and Otchere, 2001; Piesse and Hearn, 2002; Piesse and Hearn 2005; Piesse and Hearn 2008; Chinzara and Aziakpono, 2009b). Consequently, this study will determine which stock markets are either largely exogenous or endogenous relative to the other African stock markets being studied. This will be inferred from the extent to which own-innovations can elucidate variations in the stock market returns and volatility.

In the next section, we provide a discussion of the univariate GARCH model in analysing volatility of the stock markets in the context of this study.

### 4.3 ANALYSIS OF VOLATILITY AND VOLATILITY LINKAGES

Financial data is characterised by excess volatility, volatility clustering and leverage effects[37]. Time series models are not able to capture these properties; as a result, volatility models have been put forward as the most suitable alternative. The Autoregressive Conditional

[37] These are discussed thoroughly in Brooks (2008, 308).

Heteroscedasticity (ARCH) of Engle (1982), the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) of Bollerslev (1986) as well as various extensions to these models have been employed in recent empirical studies on volatility in stock markets. The use of the ARCH methodology on a single return series entails modelling the variance in the return series with its lags as well as past errors that are derived from the regression of the mean return series on lagged versions of itself.

We analyse the volatility of each of the stock markets by employing the GARCH, exponential GARCH (EGARCH), Glosten, Jaganathan and Runkle GARCH (GJR GARCH) models in an effort to achieve the objectives with regards to transmission of volatility. This will be done by augmenting each of the three GARCH models by adding a dummy variable for the 2007-2009 sub-prime crisis[38] in order to determine whether the crisis caused structural breaks on the time-varying volatilities. Following this, we produce conditional variance series by applying the most suitable of these models. These conditional variance series will serve as volatility proxies for each of the stock markets. This study takes the approach followed by Chinzara and Aziakpono (2009a) in which the conditional variance series will then be analysed by utilising the VAR together with impulse response and variance decomposition to determine the transmission of volatility among the stock markets. Accordingly, these models and procedures to be applied in investigating volatility in each of the stock markets and volatility transmission among the stock markets are discussed below.

### 4.3.1 TESTING FOR ARCH EFFECTS

The ARCH LM test is a Lagrange multiplier (LM) test for autoregressive conditional heteroskedasticity (ARCH) in residuals of an estimated equation (Engle, 1982). The reasoning that leads to the LM specification of heteroskedasticity was the observation that the magnitude of residuals for various financial time series is often related to the size of their recent residuals. The presence of the ARCH effects in data does not invalidate standard inference; however, ignoring it may result in a loss of efficiency (EViews 6, 2009). There are two tests that can be used to test for heteroskedasticity even though the procedure is relatively comparable; these are the ARCH LM and the white heteroskedasticity tests. This study will employs the ARCH LM test as it is the most widely used method to test for ARCH effects in empirical studies (see for example, Brooks and Regunathan, 2004; Piesse and Hearn, 2005; Aziakpono and Chinzara, 2009a).

[38] August 2007-June 2009

## 4.3.2 UNIVARIATE GARCH MODELS

Bollerslev (1986) and Taylor (1986) independently developed the GARCH model. It makes use of the maximum likelihood procedure enabling the conditional variance to be dependent upon previous mean and variance lags. The GARCH (p,q) model is specified as follows:

$$r_t = \mu_i + \sum_{i=1}^{k} a_i r_{t-i} + \varepsilon_t \qquad ,\varepsilon_t / I_{t-1} \sim N(0, h_t) \tag{4.16}$$

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} + \varphi_1 DUM_{Sub\text{-}prime}, \alpha + \beta < 1$$

[4.17]

Where Equation [4.16] is an appropriate mean equation whose current innovation, $\varepsilon_t$ conditional on a previous information set, $I_{t-1}$ has a mean of zero, a variance $h_t$ and is serially uncorrelated[39]. $r_t$ and $r_{t-1}$ denote the current and lagged returns respectively. Equation [4.17] is a GARCH (p, q) variance Equation; where $h_t$ is the conditional variance, $\omega$ is a constant, $\alpha$ is the coefficient of lagged squared residuals, $\varepsilon^2_{t-1}$ is the lagged squared residual from the mean equation, $\beta$ is the coefficient for the lagged GARCH component which is lagged conditional variance and $DUM_1$ = 1 if this is during the sub-prime crisis, 0 if otherwise. $\Psi_1$ is the coefficient for the dummy variable. If the dummy coefficient is positive and statistically significant, then this implies that volatility significantly increased during the financial crisis. This is a GARCH (1, 1) model. The condition given in equation 4.17, that is, $\alpha + \beta < 1$ is necessary for stationarity of the GARCH model. However, there are some weaknesses with the GARCH (p, q) variance specification. Firstly, the GARCH (p, q) in general and the GARCH (1, 1) in particular, may be weakly identified if $\alpha_i$ is too small[40]. This results in the understatement of standard errors and upwardly biased t-tests, and thus leads to a wrong inference that volatility is persistent even when it is not (Ma, *et al.*, 2007). Secondly, the GARCH (p, q) does not capture volatility asymmetry, which usually characterises stock markets. Because of this, it could be necessary to extend it with an asymmetry component, thus the threshold GARCH (TARCH/GJR GARCH) model and the exponential GARCH (EGARCH) are also explored.

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[39] The autoregressive (AR) lags of the return series are added to *whiten* the error term. This is especially important given the Ljung-Box statistics for all the series are statistically significant implying the presence of autocorrelation in the series. Thus AR terms will be added until serial correlation is dealt with. The tests for autocorrelation are based on the Durbin-Watson and the Breusch-Godfrey LM Serial Correlation tests.

[40] This phenomenon is called the Zero-Information-Limit-Condition (ZILC). For a more detailed discussion of the ZILC, see Nelson and Startz (2007) and for its implications for the GARCH(1,1) model, see Ma, Nelson and Startz (2007).

If, after estimating the GARCH model, more tests suggest the presence of ARCH effects, then the exponential GARCH (EGARCH) model is then applied, this is an asymmetric model. Koulakiotis *et al.*, (2006) note that E-GARCH models are preferred as they link the asymmetric conditional variance between market risk and expected returns. This is achieved by assuming that both the magnitude and sign of volatility are important in determining the correlation between stock price returns and volatility. Therefore, the negative and positive sign of the conditional variance allows the stock price returns to respond asymmetrically (bad and good news) to rises and falls in stock prices (Koulakiotis *et al.*, 2006: 22). In support of this, Brooks (2008: 404) notes that in the case of equity returns, such asymmetries are usually attributed to *leverage effects*, whereby a decrease in the value of a firm's stock causes the firm's debt to equity ratio to rise. Because of this, shareholders perceive their future cash-flow stream as being relatively more risky due to the fact that they bear residual risk of the firm. Several authors, starting with Black (1976), have found significant leverage effects in the returns of the Centre for Research in Security Prices (CRSP) value weighted stock market index (Christie, 1982; Nelson, 1991), the stock returns in the UK (Poon and Taylor, 1992), stock returns in Canada, France and Japan (Koutmos, 1992) and the returns in some of the African countries (Chinzara and Aziakpono, 2009a, etc.).

The Exponetial GARCH method as proposed by Nelson (1991) is specified with the following conditional variance equation:

$$\log(h_t) = \omega + \sum_{i=1}^{p} \beta_i \log h_{t-i} + \sum_{j=1}^{m} \gamma_i \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} + \sum_{k=1}^{q} \alpha \left[ \left| \frac{\varepsilon_{t-k}}{\sqrt{h_{t-k}}} \right| - E\left( \frac{\varepsilon_{t-k}}{\sqrt{h_{t-k}}} \right) \right] + \varphi_1 DUM_{Sub-prime}$$

$$, \gamma \neq 0 \qquad [4.18]$$

where $\omega$, $\alpha$ and $\beta$ are the parameters to estimate. Since the level $\varepsilon_{t-1}/\sigma_{t-1}$ is included, the EGARCH model is asymmetric while $\gamma \neq 0$. When $\gamma < 0$, positive shocks (good news) generate less volatility than negative shocks (bad news). $DUM_1 = 1$ if this is during the sub-prime crisis, 0 if otherwise. $\Psi_1$ is the coefficient for the dummy variable. If the dummy coefficient is positive and statistically significant, then this implies that volatility significantly increased during the financial crisis.

The GJR GARCH also captures asymmetry and was proposed by Zakoian (1990) and Glosten, Jaganathan and Runkle (1993). It is a re-specification of the GARCH (1,1) model with an additional term to account for asymmetry as follows:

$$h_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{k=1}^{r} \lambda_k \varepsilon_{t-k}^2 I_{t-k} + \sum_{i=1}^{q} \beta h_{t-1}^2 + \varphi_1 DUM_{Sub-prme}$$

[4.19]

where $\varepsilon_t = \sigma_t z_t$, $z_t \sim f(0, 1)$ and $I_{t-1} = 1$, when $\varepsilon_{t-1} < 0$ and $I_{t-1} = 0$ if otherwise. $I_{t-1}$ is the asymmetry component and $\gamma$ is the asymmetry coefficient. When $\gamma > 0$ the model accounts for the leverage effects, that is, bad news ($\varepsilon_{t-1} < 0$) increases the future volatility more than good news ($\varepsilon_{t-1} \geq 0$) of the same magnitude. Good news will have the impact of $\alpha$, bad news will have an impact of $\alpha + \gamma$. This means that if $\gamma$ is significantly different from zero, then it will be explicable that the impact of good news is different from that of bad news on current volatility. If $\gamma > 0$ leverage effects exist in stock markets and if $\gamma \neq 0$[41] then the impact of news is asymmetric (EViews 6, 2009). $DUM_1 = 1$ if this is during the sub-prime crisis, 0 if otherwise. $\Psi_1$ is the coefficient for the dummy variable. If the dummy coefficient is positive and statistically significant, then this implies that volatility significantly increased during the financial crisis.

Assuming the conditional normality of residuals, the univariate GARCH models specified above are estimated by maximising the following log-likelihood function:

$$l = -\frac{T}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log(\sigma_t^2) - \frac{1}{2}\sum_{t=1}^{T}(r_t - \mu - \phi r_{t-1})^2 / \sigma_t^2 \quad [4.20]$$

Where T is the number of the observations and the other variables are defined as earlier. The Marquardt algorithm will be applied to the non-linear log-likelihood function in order to estimate the parameters. The maximum likelihood requires that initial parameters are set. EViews estimation software provides its own initial parameters for the ARCH procedures using OLS regressions for the mean equation (EViews 6, 2009:192). These values could then be altered manually if convergence is not achieved or if parameter estimates are implausible.

### 4.3.3 EXAMINING TRENDS IN VOLATILITY

Financial stability can be affected by volatility in the stock market; consequently, it is imperative to determine its long-term trend. In examining the trend of volatility overtime, partly following Frömmel and Menkhoff (2003) and Chinzara and Aziakpono (2009a), we will regress each of the conditional variance series against a constant and a time variable as follows:

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[41] The difference between $\gamma > 0$ and is that in the former case the parameter. $\gamma$ only takes positive value and such an instance would imply that there is evidence for both leverage and asymmetric effects. In the latter case $\gamma$ can take both positive and negative values. Should it take a positive value, then only evidence of asymmetric effects and not leverage effects exist in the data (EViews 6, 2009).

$$h_t = \beta_1 + \beta_2 T \quad [4.21]$$

Where $h_t$ is the conditional variance in each market and $T$ is the time in days. If $\beta_2$ is positive and significant, then this means that volatility increases over time, while a negative and significant $\beta_2$ would show a decrease in volatility over time.

In order to analyse whether volatility is significantly influenced by financial crises and major shocks, Equation 4.21 will be augmented by adding a dummy variable in order to account for this event:

$$h_t = \beta_1 + \beta_2 T + \beta_3 DUM1 + \mu_t \quad [4.22]$$

Where $h_t$, $T$ and $\beta_2$ are interpreted as in Equation 4.25. DUM1 represents the sub-prime financial crisis between 2007 and 2009. If the dummy coefficient is positive and significant this implies that the volatility significantly increased during this respective event. If the coefficient is negative and significant this implies that volatility decreased during the respective event. If the coefficient is insignificant this means that volatility neither increased nor decreased significantly during the respective event.

## 4.4 PROXIES AND DATA

Various proxies have been applied in the examination of linkages of equity markets; these have mainly depended on the objectives and econometric techniques used. For example, Allen and McDonald (1995) analyse the possibility of long term gains from international diversification by employing closing-to-closing stock market indices for the respective stock markets. In contrast to return series which are level stationary, closing-to-closing stock market indices are typically level non-stationary which thus serves as the motivation for the use of such a proxy. Level non-stationarity of a series is one of the main prerequisites for the series to be appropriate for cointegration analysis. Accordingly, studies that aim to determine whether return linkages exist amongst stock markets apply stock market returns as their proxies. Due to the fact that returns series are not readily available, they are computed from market indices series as follows:

$$Y_t = \ln(P_t / P_{t-1}) \times 100 \quad [4.23]$$

Where $y_t$ is current continuous compounded returns, $P_t$ is the current closing price index and $P_{t-1}$ is the previous day closing stock market index. Lastly, research that seeks to examine the extent of volatility transmission between stock markets uses volatility series following any of the methods described above.

The dataset applied in this analysis comprises the daily closing indices ($P_{it}$) for eight African stock markets namely; Egypt, Ghana, Kenya, Mauritius, Morocco, Namibia, Nigeria and South Africa. These countries represent the largest stock markets and could proxy for stock market movements in the rest of the African continent. This study uses daily data for the period 2000/01/31 to 2010/07/28, totalling 2700 observations. In this way, the study contributes to academic literature by making use of very recent data. Following the existing literature, the indices applied are in US dollars (see Alagidede, 2008), this allows for elimination of location inflation and hence makes the results comparable. In addition, it removes exchange rate risk and other trading costs associated with investing in developing economies which may be overlooked when using local currency returns (Alagidede, 2008:7). The following indices were used for the respective stock markets: the Standard and Poor (S&P 500) for Ghana, Kenya, Mauritius, Namibia and Nigeria; the Morgan Stanley Composite Index (MSCI) for Morocco and the FTSE index for Egypt, and South Africa[42]. All the indices were obtained from Thomson DataStream.

In considering the frequency of the data there are several issues to be noted in analysing financial markets. Daily data is preferred to low frequency data because it captures the dynamic interactions that occur within a day, a property that cannot be captured by low frequency data. Generally, stock markets react rapidly as soon as new information is available, this can be in hours, minutes or seconds. Consequently, lower frequency data distorts such reactions. Piesse and Hearn (2005) argue that volatility clustering is quite evident in financial time series as stock markets are characterised by periods of high volatility and more relaxed periods of low volatility. This is specifically true at high data frequencies, conceivably daily or weekly returns, but less clear at lower frequencies (Piesse and Hearn, 2005:42). Also, in terms of financial stability, policymakers are more concerned about correlations and comovements at a high frequency than correlations and comovements over long horizons (Berben and Jansen, 2005:835).

On the other hand, using daily data can also be problematic. Firstly, distortions may arise due to the fact that there is non-trading during holidays and noise trading. One way of circumventing this issue is to compute the relevant index by simulation for that specific day (Glezakos *et al.*, 2007); an additional way would be to remove all the non-traded days of each market across all

[42] In this study, the following names are used to represent the various series: the Egyptian index (EGY), the Ghanaian index (GHA), the Kenyan index (KEN), the Mauritian index (MAU), the Moroccan index (MOR), the Namibian index (NAM), the Nigerian index (NIG) and the South Africa index (SA). The following notations will be used for the returns series: REGY, RGHA, RKEN, RMAU, RMOR, RNAM, RNIG and RSA. For volatility series the following notations will be used VOLEGY, VOLGHA, VOLKEN, VOLMAU, VOLMOR, VOLNAM, VOLNIG and VOLSA.

markets as suggested by Chowdhury (1994) and Chang, Nieh and Wei (2006). In this study, the latter approach is preferred given that there is no guarantee that simulation will provide the index that could have resulted had the market been opened. As a result of having a large sample size, this is not expected to have any effects on the empirical findings. An added issue of concern due to the use of daily data is that financial markets in the different countries may operate at different times; this has vital implications for interpretation of our results and the specification of cointergration and VAR models. In this study, however, the sample group of countries all fall within a region of +/- 2 hours from South Africa. Egypt and Namibia all are in same time zone as South Africa, whereas to the East; Kenya and Mauritius are one hour and two hours ahead, respectively. To the West, Nigeria is one hour whilst Ghana and Morocco (North-West from South Africa) are two hours behind.

## 4.5 CONCLUSION

This chapter has sequentially outlined the analytical framework which will be used in addressing the objectives regarding the long-run comovement, dynamic returns linkages and volatility transmission amongst the African equity markets being studied. Firstly, the methodology for long-run comovement, that is, the Factor analysis, the Johansen cointegration approach and a stationarity test were discussed. Following this was a discussion of the VAR model together with block exogeneity, impulse response and variance decomposition and how these techniques will be applied to examine returns linkages among stock markets. The analytical method for analysing volatility and volatility linkages among stock markets was then described. Here the univariate GARCH model and its asymmetric extensions were discussed, how they are estimated and how they are used in analysing the nature of volatility in stock markets and generating the GARCH variance series as a proxy for volatility. In addition, a description is provided of how VAR framework is used to examine the volatility transmission across stock markets. The last section focuses on the proxies and data applied in this study, matters arising from employing daily data and how different trading times will be circumvented in this study. Accordingly, the next chapter proceeds to apply them to the eight stock market indices and returns series in order to achieve objectives outlined in Chapter 1.

## CHAPTER FIVE

## ANALYSIS OF EMPIRICAL RESULTS

In Chapter 1, the objectives of the study were set and Chapter 2 reviewed the relevant theoretical and empirical literature. Chapter 3 outlined the background on channels of stock market linkages and the behaviour of various stock market indices whilst chapter four set the methods of analysis to address the issues. The current chapter now applies the analytical frameworks sought out in Chapter 4 to stock market data in order to address the objectives set out in chapter one. From time to time, we will refer back to chapter two, three and four to explain our results and to see the extent to which they compare with other previous relevant studies.

This chapter is divided into in five main sections. Section 5.1 discusses the descriptive statistics and simple correlations amongst the markets. Section 5.2 applies the Johansen cointegration method to answer the question regarding the long-run comovement of the stock markets. In section 5.3 we use Factor analysis and VAR, impulse response and variance decomposition to evaluate the returns linkages between the stock markets whilst section 5.4 analyses volatility and volatility linkages using the VAR and GARCH models. We briefly conclude the chapter in section 5.5.

### 5.1 DESCRIPTIVE STATISTICS AND SIMPLE CORRELATION TEST

Table 5.1 presents the summary statistics, namely; sample means, maximums, minimums, medians, standard deviations, skewness, kurtosis, Jarque-Bera and the Ljung-Box statistics with their p-values for the returns series. As indicated in the table, all the statistics show the characteristics common with most financial data, for example, non-normality in the form of fat tails. However, there are several differences amongst the African stock markets. The three biggest markets on the continent have similar unconditional average daily stock market returns with South Africa and Nigeria both averaging 0.040% whilst Egypt has 0.038%. However, Kenya, which is one of the smaller markets, has outperformed all the other markets since it has the highest average of 0.065% with its returns fluctuating between the minimum of -68.82% and a maximum of 72.34%. The higher return in this market seems to be complemented by high risk as shown by its standard deviation, the second highest amongst the group of variables with Morocco having one of the lower averages of 0.027%. Mauritius has an average of 0.039% which is comparable to that of South Africa, Egypt and Nigeria despite the fact that the country is much smaller relative to these countries. Namibia and Ghana have the lowest averages, that is, 0.023% and -0.0006 respectively.

The case of Ghana is quite extreme (i.e. the difference between the maximum and minimum) for its daily returns compared to the rest of the African markets. This could be attributed to the fact that the country announced in December 2006 that it would change its currency denomination, the new denominations and notes were introduced in the country from July 3 2007(Ghanaweb, 2007). As a result, four zeros were pruned from the old denominations with the aim to eliminate the hazard and inconvenience in carrying large sums of currency notes for business transactions (Ghanaweb, 2007). The table also shows that all the countries have high unconditional standard deviations which is an indication of high risk in developing markets and is in line with most theoretical and empirical literature. As is evident, Ghana has the highest of around 24.84% suggesting that this market has the most risk in comparison to the rest, whilst Morocco has the lowest of approximately 1.1%. A common observation amongst the four biggest markets on the continent (South Africa, Egypt, Nigeria and Morocco) is that their stock returns are negatively skewed. All the markets have distributions with positive excess kurtosis and show evidence of fat tails. Bala and Premarante (2004:5) argue that a distribution with a value of more than 3 can be described as leptokurtic relative to normal meaning that the distribution of stock returns in all the stock markets tends to contain extreme values. The Jarque-Bera (JB) statistics tests whether the series are normally distributed and as can be seen from the table, the statistic shows that the hypothesis of normality is rejected for all returns series. This non-normality is also evident from the fatter tails of the kurtosis and negative and positive skewness which is in contrast to the market efficiency hypothesis.

**TABLE 5.1 DESCRIPTIVE STATISTICS**

| | EGY | GHA | KEN | MAU | MOR | NAM | NIG | SA |
|---|---|---|---|---|---|---|---|---|
| Mean | 0.038 | -0.001 | 0.065 | 0.040 | 0.027 | 0.024 | 0.040 | 0.040 |
| Median | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 | 0.000 | 0.000 | 0.108 |
| Maximum | 9.286 | 911.324 | 72.338 | 16.252 | 6.256 | 10.197 | 38.110 | 12.889 |
| Minimum | -17.163 | -911.052 | -68.820 | -8.493 | -7.699 | -9.788 | -39.571 | -12.852 |
| Std. Dev. | 1.854 | 24.836 | 2.528 | 1.172 | 1.103 | 1.307 | 1.609 | 1.861 |
| Skewness | -0.494 | 0.017 | 1.784 | 3.006 | -0.175 | 0.181 | -0.778 | -0.293 |
| Kurtosis | 8.840 | 1343.520 | 463.092 | 47.651 | 7.606 | 11.268 | 256.455 | 8.682 |
| Jarque-Bera | 3945.88[a] | 202000000.00[a] | 23807149.00[a] | 228274.30[a] | 2399.45[a] | 7701.83[a] | 7224520.00[a] | 3669.18[a] |
| LB(10) | 36.781[a] | 673.500[a] | 195.940[a] | 52.306[a] | 117.140[a] | 20.376[b] | 44.753[a] | 29.695[a] |
| $LB^2(10)$ | 668.58[a] | 1275.300[a] | 1043.000[a] | 690.310[a] | 454.810[a] | 647.290[a] | 913.490[a] | 662.880[a] |
| Sum | 102.896 | -1.788 | 175.667 | 106.887 | 71.565 | 64.309 | 109.041 | 108.279 |
| Sum Sq. Dev. | 9276.459 | 1664219.000 | 17236.020 | 3706.916 | 3280.021 | 4605.504 | 6980.520 | 9347.979 |
| Observations | 2699 | 2699 | 2699 | 2699 | 2699 | 2699 | 2699 | 2699 |

*Note. [a]indicates significance at 1% significance level, [b]indicates significance at 5% significance level, [c]indicates significance at 10% significance level.*

Ljung-Box statistics for both returns [LB(10)] and squared returns [$LB^2(10)$] are statistically significant. The former implies the existence of serial correlation in returns, a contrast to the informational efficiency of the stock market. Methodologically, this justifies the need for an autoregressive component in the mean equation to *whiten* the error term. The latter case entails that there is evidence of volatility clustering and heteroscedasticity (i.e. time-varying second moments), thus justifying the use of the GARCH family of models, as they capture the time-varying nature of conditional volatility (Kovačić, 2008:193; Magnus and Fosu, 2006:2044).

The pairwise correlation for the returns is illustrated in Table 5.2 and it is evident that correlation between most of the stock market returns is very low. In addition, negative correlations are shown in the cases of the Ghanaian with the Egyptian stock markets, the Ghanaian with Namibian stock markets, Ghanaian with the South African stock markets, Nigeria with the Kenyan stock markets and Nigeria with the Namibia stock markets. This suggests international portfolio diversification in the African market would be worthwhile.

**TABLE 5.2 CORRELATION MATRIX FOR RETURNS**

| | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
|---|---|---|---|---|---|---|---|---|
| REGY | 1.000 | | | | | | | |
| RGHA | -0.014 | 1.000 | | | | | | |
| RKEN | 0.028 | 0.003 | 1.000 | | | | | |
| RMAU | 0.101 | 0.004 | 0.128 | 1.000 | | | | |
| RMOR | 0.120 | 0.015 | 0.027 | 0.105 | 1.000 | | | |
| RNAM | 0.078 | -0.019 | 0.036 | 0.105 | 0.183 | 1.000 | | |
| RNIG | 0.034 | 0.010 | -0.008 | 0.038 | 0.027 | -0.010 | 1.000 | |
| RSA | 0.161 | -0.013 | 0.046 | 0.092 | 0.238 | 0.595 | 0.004 | 1.000 |

As noted by Narayan and Smyth; (2005:232) returns should be negative to ensure that some markets will rise if some fall. The highest correlation exists between the South African and Namibian stock markets (approximately 60%); one possible reason for this could be fact that both these countries are members of SADC region and also the presence of cross listings between the two markets. Similar inferences could be made for the positive correlations between Egypt and Morocco (approximately 12%) since they are both in the MENA region whilst Kenya and Mauritius (approximately 13%) are members of COMESA and Mauritius and Namibia stock markets (approximately 11%) are also SADC members. However, correlations are evident for countries that are not within the same region such as between South African and Moroccan stock markets and South African and Egyptian stock markets. This raises the question of which market strongly influences another, a question which cannot be properly answered by the correlation matrix since it does not have any implications of causality. As noted by Narayan and Smyth (2005), the correlation simply provides insight into the possible short-run market linkages but fails to account for long-term arbitrage opportunities in stock markets. Because of this, we shall surmise this from other empirical tests.

## 5.2 LONG RUN COMOVEMENT OF THE STOCK MARKETS

### 5.2.1 Correlation of Indices

In order to assess possible patterns of comovement, we first computed pairwise correlations for the stock indices and the results are presented in Table 5.3.Overall; there is evidence of contemporaneous correlation among the stock markets as evidenced by the high correlation coefficients. This is a sharp contrast to the correlation matrix for the stock returns provided in Table 5.2 above as there seems to be a common trend that is driving the stock markets, a finding that contradicts previous empirical studies on African stock markets. Hence, the cointegration analysis is carried to provide a more insight on the long-run relationships amongst these markets.

**TABLE 5.3 CORRELATION MATRIX FOR INDICES**

| Correlation | EGY | GHA | KEN | MAU | MOR | NAM | NIG | SA |
|---|---|---|---|---|---|---|---|---|
| EGY | 1 | | | | | | | |
| GHA | 0.445 | 1 | | | | | | |
| KEN | 0.939 | 0.569 | 1 | | | | | |
| MAU | 0.93 | 0.452 | 0.873 | 1 | | | | |
| MOR | 0.93 | 0.407 | 0.887 | 0.959 | 1 | | | |
| NAM | 0.847 | 0.352 | 0.796 | 0.874 | 0.889 | 1 | | |
| NIG | 0.837 | 0.654 | 0.862 | 0.84 | 0.829 | 0.581 | 1 | |
| SA | 0.955 | 0.455 | 0.947 | 0.87 | 0.869 | 0.853 | 0.779 | 1 |

### 5.2.2 Test for stationarity

Two formal tests where employed in this study, that is, the DF (ERS) and the KPSS as mentioned in the previous chapter. Because the graphical plots of all the series were trending[43], the tests were carried out using the 'intercept and trend' assumption. In order to determine the appropriate lag length for the DF (ERS), the Schwarz Information criterion was used and the maximum lag length was set at 30 as it is expected that due to their information efficiency, the stock markets would react to new information within 30 days. The KPSS was estimated using the Bartlett Kernel estimation method. Results for both tests are represented in Table 5.4

**TABLE 5.4 UNIT ROOT/STATIONARITY TESTS (INTERCEPT AND TREND)**

| | EGY | GHA | KEN | MAU | MOR | NAM | NIG | SA |
|---|---|---|---|---|---|---|---|---|
| DF-GLS (ERS) | | | | | | | | |
| Level | -1.24 | -1 | -1.52 | -1.26 | -1.11 | -0.82 | -0.75 | -1.82 |
| 1st Difference | -26.09[a] | -39.20[a] | -46.95[a] | -20.77[a] | -41.68[a] | -47.80[a] | -29.72[a] | -4.12[a] |
| KPSS | | | | | | | | |
| Level | 0.54 | 0.76 | 0.63 | 0.4 | 0.69 | 0.89 | 0.5 | 0.5 |
| 1st Difference | 0.19[a] | 0.19[a] | 0.09[a] | 0.12[a] | 0.22[b] | 0.06[a] | 0.24[c] | 0.08[a] |

*Notes: a, b and c denote the rejection of the hypothesis of a unit root/non-stationarity for both tests at 1%, 5% and 10% level of significance respectively. The order for the Dickey-Fuller (ERS) was determined by the Schwarz Information criterion and the spectral method applied for KPSS is the Bartlett Kernel.*

[43] See figure 3.5 in Chapter 3.

Results from the DF (ERS) show that, given the significance level of 1%, all the index series are non-stationary at level. When differenced once, all the series become stationary in terms of the DF (ERS) test. Also, in terms of the KPSS test, all the series become stationary when differenced once hence we carry all the variables forward to perform cointegration tests.

### 5.2.3 Bivariate cointegration

This analysis was carried out with the view to determine whether there are pairwise long-run relationships amongst the different markets. Because the study aims to analyse the integration of the African markets under study, we specified VAR models with all the possible bivariate combinations of the indices[44] and then tested for cointegration. It is imperative to specify the appropriate lag order and deterministic trend assumption when applying the Johansen cointegration analysis. Hall (1991) and Chinzara and Aziakpono (2009a) highlight the significance of choosing an appropriate lag by arguing that a lag order that is too high could cause small sample problems whilst one that is too low may lead to problems with serial correlation.

Empirical research on the Johansen test statistics have revealed that they tend to be sensitive to the lag length chosen. As a result, suggestions have been that either test statistics for a range will be reported or information criteria should be utilised in selecting a fitting lag length (Allen and McDonald, 1995; Aziakpono and Chinzara, 2009a). However, conducting tests with information has shown that the information criteria typically selects conflicting VAR orders[45]. In this study, we therefore employed different information criteria. We use 30 days as our maximum lag length as it is our considered view that the stock market would have reacted to information from other markets since stock markets are considered to be one of the most informationally efficient markets. Results for the VAR lag orders selected by the information criteria for the different models are reported in tables 5.5[46].

[44] Since we are examining 8 markets, we established that the maximum number of bivariate models were 28 as illustrated in tables 5.5 and 5.6.
[45] See Takaendesa (2005:98)
[46] LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike Information criterion; SC: Schwarz Information criterion; HQ: Hannan-Quinn information criterion.

## TABLE 5.5 VAR ORDER SELECTED BY INFORMATION CRITERIA

| | Lag Criteria | | | | |
|---|---|---|---|---|---|
| MODEL | LR | FPE | AIC | SIC | HQ |
| EGY-KEN | 29 | 4 | 4 | 3 | 4 |
| EGY-MAU | 30 | 30 | 30 | 2 | 5 |
| MAU-KEN | 30 | 6 | 6 | 3 | 6 |
| NIG-GHA | 25 | 6 | 6 | 4 | 4 |
| EGY-GHA | 29 | 29 | 29 | 4 | 4 |
| EGY-NAM | 29 | 29 | 29 | 2 | 5 |
| EGY-NIG | 29 | 29 | 29 | 3 | 4 |
| GHA-KEN | 26 | 5 | 5 | 4 | 4 |
| GHA-MAU | 24 | 5 | 5 | 5 | 5 |
| GHA-MOR | 30 | 5 | 5 | 4 | 4 |
| GHA-NAM | 29 | 7 | 7 | 4 | 4 |
| GHA-SA | 26 | 7 | 7 | 4 | 4 |
| KEN-MOR | 29 | 6 | 6 | 3 | 3 |
| KEN-NAM | 29 | 7 | 7 | 3 | 3 |
| KEN-NIG | 25 | 10 | 10 | 3 | 3 |
| KEN-SA | 20 | 4 | 4 | 3 | 3 |
| MAU-MOR | 30 | 30 | 30 | 2 | 5 |
| MAU-NIG | 30 | 25 | 25 | 3 | 5 |
| EGY-MOR | 30 | 30 | 30 | 2 | 2 |
| MOR-NAM | 29 | 9 | 9 | 2 | 3 |
| MOR-NIG | 25 | 10 | 10 | 3 | 3 |
| MOR-SA | 29 | 29 | 29 | 2 | 2 |
| NAM-NIG | 25 | 10 | 10 | 3 | 3 |
| SA-NAM | 26 | 7 | 7 | 1 | 1 |
| SA-MAU | 30 | 25 | 25 | 2 | 8 |
| NAM-MAU | 30 | 25 | 25 | 2 | 7 |
| SA-EGY | 29 | 29 | 29 | 5 | 5 |
| SA-NIG | 26 | 26 | 26 | 3 | 3 |

As can be seen from Tables 5.5 different information criteria selected conflicting lag orders. Because of this, the cointegration analysis was not strictly based on the selected lags. Rather, cointegration was carried out by starting with the smallest selected VAR lag and then increased until results with good residual diagnosis were attained. This was done for all the models reported in the abovementioned tables with the serial correlation test as a diagnostic check. The results from the pairwise Johansen cointegration are reported in Table 5.6. In addition, the VAR order, the deterministic trend assumption used as well as the trace and maximum eigenvalue statistics for each cointegration equation are reported.

## TABLE 5.6 COINTEGRATION RESULTS FOR BIVARIATE MODELS

| Cointegration results for Bivariate Models 2000-2010 | | | | | | |
|---|---|---|---|---|---|---|
| | | | Trace | | Max | |
| MODEL | K | A | r<0 | r<1 | r<0 | r<1 |
| EGY-KEN | 4 | 4 | 14,10[0.65] | 2.14[0.96] | 11.97[0.42] | 2.14[0.96] |
| EGY-MAU | 5 | 4 | 15.17[0.56] | 3.18[0.85] | 11.98[0.42] | 3.18[0.85] |
| MAU-KEN | 3 | 4 | 9.47[0.95] | 2.20[0.96] | 7.29[0.88] | 2.20[0.96] |
| **NIG-GHA** | **7** | **4** | **29.09[0.02]** | **0.27[1.00]** | **28.82[0.02]** | **0.27[1.00]** |
| EGY-GHA | 5 | 4 | 6.04[0.99] | 2.28[0.95] | 3.76.[0.99] | 2.28[0.95] |
| EGY-NAM | 6 | 4 | 14.56[0.61] | 0.36[1.00] | 14.2[0.24] | 0.36[1.00] |
| EGY-NIG | 10 | 4 | 11.72[0.83] | 1.10[0.99] | 10.63[0.55] | 1.10[0.99] |
| GHA-KEN | 5 | 4 | 13.97[0.66] | 2.26[0.95] | 11.7[0.44] | 2.26[0.95] |
| GHA-MAU | 5 | 4 | 15.64[0.52] | 3.26[0.84] | 12.38[0.38] | 3.26[0.84] |
| GHA-MOR | 5 | 4 | 9.95[0.93] | 2.24[0.95] | 7.71[0.85] | 2.24[0.95] |
| GHA-NAM | 5 | 4 | 17.01[0.41] | 1.68[0.98] | 15.33[0.18] | 1.68[0.98] |
| GHA-SA | 5 | 4 | 15.41[0.54] | 6.15[0.44] | 9.26[0.69] | 6.15[0.44] |
| KEN-MOR | 3 | 4 | 17.12[0.41] | 1.83[0.98] | 15.29[0.18] | 1.83[0.98] |
| KEN-NAM | 5 | 4 | 15.21[0.56] | 1.30[0.99] | 13.91[0.26] | 1.30[0.99] |
| KEN-NIG | 3 | 4 | 20.29[0.21] | 2.06[0.96] | 18.26[0.07] | 2.06[0.96] |
| **KEN-SA** | **5** | **4** | **26.57[0.04]** | **5.17[0.57]** | **21.40[0.03]** | **5.17[0.57]** |
| MAU-MOR | 3 | 4 | 17.75[0.36] | 2.33[0.94] | 15.41[0.17] | 2.33[0.94] |
| MAU-NIG | 8 | 4 | 9.23[0.95] | 2.01[0.97] | 7.22[0.86] | 2.01[0.97] |
| **EGY-MOR** | **5** | **4** | **31.25[0.01]** | **3.67[0.78]** | **27.58[0.00]** | **3.67[0.78]** |
| MOR-NAM | 5 | 4 | 15.76[0.51] | 1.61[0.98] | 14.16[0.24] | 1.61[0.98] |
| MOR-NIG | 10 | 4 | 13.29[0.72] | 1.37[0.99] | 11.91[0.42] | 1.37[0.99] |
| **MOR-SA** | **2** | **4** | **39.88[0.00]** | **5.94[0.46]** | **33.88[0.00]** | **5.94[0.46]** |
| NAM-NIG | 4 | 4 | 17.70[0.36] | 1.55[0.98] | 16.16[0.14] | 1.55[0.98] |
| SA-NAM | 2 | 4 | 19.01[0.27] | 5.27[0.56] | 13.74[0.27] | 5.27[0.56] |
| **SA-MAU** | **8** | **4** | **30.30[0.01]** | **8.51[0.21]** | **21.79[0.02]** | **8.51[0.21]** |
| NAM-MAU | 3 | 4 | 17.06[0.41] | 3.32[0.83] | 13.74[0.27] | 3.32[0.83] |
| **SA-EGY** | **5** | **4** | **29.17[0.02]** | **4.65[0.65]** | **24.52[0.01]** | **4.65[0.65]** |
| **SA-NIG** | **4** | **4** | **35.92[0.00]** | **2.93[0.88]** | **32.98[0.00]** | **2.93[0.88]** |

*Notes: K is the VAR order that produces a white noise residual. A is the deterministic trend assumption i.e (4) Both the level data X and cointegrating vectors have linear trends. P-values are in brackets and bolded results are where cointegration was found.*

As shown in Table 5.6, there is no evidence of pairwise cointegration between most of the African stock markets. However, some slim evidence of cointegration was found in the cases for Nigeria-Ghana, Kenya-South Africa, Egypt-Morocco, Morocco-South Africa, South Africa-Mauritius, South Africa-Egypt and South Africa-Nigeria. In order to provide more insight to the long-run relationships found, we performed weak exogeneity tests on those specific bivariate models. The weak exogeneity tests were done to identify the variable that was endogenous in each of the Bivariate models. This is necessary since we will then need to normalise on the endogenous variable when estimating a VECM model. Results of the weak exogeneity test and the estimated VECM model are together reported in Table 5.9. Here we present the models as;

A-Ghana and Nigeria; B-Kenya-South Africa; C-Morocco-Egypt; D-Morocco-South Africa; E-Mauritius-South Africa; F- Egypt-South Africa and G-Nigeria-South Africa.

Model A shows that both Ghana and Nigeria are endogenous in the model suggesting a possible two-way causality between the two markets. However, Ghana is significantly endogenous and hence we normalised the model on this market. As evident from the table, the long-run parameter was positive and statistically significant implying that a positive long-run relationship exists between the two markets. The dummy parameter is negative implying that the recent financial crisis had no impact on the relationship between these markets. In Model B, Kenya and South Africa are examined with the evidence being stronger that Kenya is endogenous, therefore it can be better conceived that South Africa is more likely to influence market behaviour in Kenya due to the size of the SA market. Thus we normalise on Kenya. The VECM results show that a positive long-run parameter indicates a positive relationship between the two. The dummy parameter is positive but not significant implying that the financial crisis did not have a significant impact on the relationship between the two markets. In model C, Morocco is endogenous. The long-run parameter suggests a significantly positive relationship between the markets. As noted in previous chapters, Egypt and Morocco are both members of MENA, because of this; the long-run relationship determined in Model C is not surprising due to this fact. This result is in line with the work of Onour (2009) who found strong evidence of a long-run relationship between the markets, although the study was carried out over a shorter period of time, that is, between 2002 and 2006.

Model D also shows that Morocco is endogenous hence we normalise on this market. The significant positive long-run parameter indicates that this market has a positive long term relationship with South Africa. Also, the dummy parameter is positive and statistically significant suggesting that this relationship was affected by the financial crisis. South Africa and Mauritius are presented in Model E with the latter being the endogenous market. As indicated in the results, a significant long-run relationship exists between the markets, an outcome which concurs with the findings of Agathee (2008) who did a similar study on Mauritius. The two biggest markets are presented in Model F, that is, Egypt and South Africa, with the former being the endogenous one. We normalised on Egypt and the results show that a highly significant long-run relationship exists between the markets. The dummy parameter of this model is slightly positive and significant implying that the relation was affected by the financial crisis. This is unsurprising because these are two markets which have been documented to have been affected by previous crises because they are the most trades markets on the continent (see Biekpe and Collin, 2003).

In terms of Model G, we normalised on Nigeria since it was the endogenous market in the model. Given the size of the South African market compared to Nigeria, the model correctly reflects the direction of influence from former to the latter. The long run parameter indicates that Nigeria and South Africa have a positive long run relationship. As indicated in chapter three, Nigeria is one of South Africa's major trading partners due to the large amounts of imports and exports; hence this relationship may be attributed to these trade linkages[47]. Also, the dummy parameter shows evidence that the financial crisis had a minimum impact on this relationship.

### TABLE 5.7 WEAK EXOGENEITY AND VECM RESULTS[48]

| Weak exogeneity test and VECM results for bi-variate models | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Exogeneity | | Intercept | β | $R^2$ | ECM | S.Correlation | Dummy |
| MODEL A* | GHA | NIG | | | | | | |
| | 24.4[0.00] | 5.72[0.02] | 22.5897 | 1.58(-6.32) | 0.23 | -0.006 [-4.96] | 4.49[0.34] | -2.31[-4.76] |
| MODEL B* | KEN | SA | | | | | | |
| | 12.41[0.00] | 3.24[0.07] | 0.922367 | 0.00(-8.55) | 0.14 | -0.011[-4.03] | 0.65[0.96] | 0.00[0.04] |
| MODEL C | MOR | EGY | | | | | | |
| | 23.61[0.00] | 0.09[0.76] | -11.4723 | 0.13(-8.10) | 0.05 | -0.009[-5.20] | 4.76[0.31] | 0.09[3.02] |
| MODEL D | MOR | SA | | | | | | |
| | 21.19[0.00] | 1.76[0.18] | -4.23763 | 0.02(-8.37) | 0.05 | -0.007[-5.10] | 7.42[0.11] | 0.12[3.66] |
| MODEL E | MAU | SA | | | | | | |
| | 13.1[0.00] | 0.12[0.73] | 1.446316 | 0.01(-6.38) | 0.06 | -0.004[-5.10] | 2.14[0.71] | 0.02[1.90] |
| MODEL F | EGY | SA | | | | | | |
| | 15.12[0.00] | 2.18[0.14] | 59.86478 | 0.12(-12.03) | 0.09 | -0.009[-4.31] | 3.43[0.49] | 0.44[2.15] |
| MODEL G* | NIG | SA | | | | | | |
| | 24.8[0.00] | 3.09[0.08] | 25.46715 | 0.25(-7.87) | 0.01 | -0.003[-5.26] | 6.05[0.19] | 0.01[0.05] |

**Both countries found to be endogenous within the model; however normalisation was carried out on the more significantly endogenous market. P-values in* ( ) and *t-values in* [ ]. *As required by Johansen Cointegration, the long-run parameter signs were changed.*

In all models represented in Table 5.7 the probability value from serial correlation tests at the selected lags is not significant. Therefore we fail to reject the null hypothesis and conclude that the series do not contain serial correlation confirming the reliability of our results. Following this, there are notable implications that can be derived from both the cointegration and weak

[47] Refer to chapter three for the section on South Africa's trade linkages.
[48] VECM models normalised on endogenous models.

exogeneity results. Firstly, this is with regards to the possibility of gaining from international diversification. The fact that there is no cointegration for most of the models represented in Table 5.6 is proof of the segmentation of the majority of African markets. This concurs with previous empirical which have found that most African markets are independent of one another (see Lamba and Otchere, 2001; Forbes and Rigobon, 2002; Piesse and Hearn, 2002; Biekpe and Collins, 2003; Piesse and Hearn, 2005; Humavindu and Floros, 2006; Agathee, 2008; Alagidede, 2008 and Onour, 2009) and hence implies that there is great potential for investors to gain from pairwise portfolio diversification. On the other hand, for portfolio manager intending to invest in the models represented in Table 5.7 (where cointegration is found) there are limited opportunities for pairwise portfolio diversification.

However, the ECM coefficients are negative showing that if there is short-run disequilibrium then the model adjusts back which then raises the issue of speed of adjustment. Model B has the highest ECM coefficient of -0.011 which means that approximately 1.1% of the short-run disequilibrium between Kenya and its explanatory variable is corrected every day. Therefore, it takes 91 days (approximately 3 months) for the adjustment back to equilibrium to take place in this model. It can be compared to model G which has the lowest ECM coefficient of -0.003 which implies that approximately 0.3% of the short-run disequilibrium between Nigeria and its explanatory variable is corrected every day. The adjustment back to equilibrium takes at least 330 days to occur. Therefore model B adjusts back to equilibrium faster than model G and has implications for arbitrage profit because short-term investors may benefit in the former market whilst long-term investors stand to benefit from the latter. On the other hand, it should be noted that transaction costs should also be considered before ascertaining the benefits of this arbitrage as costs may vary across countries.

Another implication concerns the market efficiency hypothesis (EMH) for the stock markets. As noted by Allen and McDonald (1995), Aziakpono (2006) and Chinzara and Aziakpono (2009b) this is because the existence of cointegration means that causality must run from one direction. In this way, if two stock indices move together in the long-run then they will be violating the weak form efficiency as this would point towards the fact that one stock market index can be predicted by making use of the other stock market index (Chinzara and Aziakpono, 2009b:109). Consequently, the non-existence of cointegration amongst most of the models in Table 5.9 may suggest the weak informational efficiency of these bivariate models. However, Jefferis and Smith (2005:64) argue that, "For markets to be weak-form efficient, current prices must fully reflect all historical information. This in turn requires that accurate information is quickly made available to market participants; that market participants are sufficient in number for there to be effective competition between them; and that there is sufficient trading taking place for prices to adjust and reflect new information." Since these African markets are small, they have low turnover, low liquidity and have high transaction costs; hence there are very limited opportunities for prices to change quickly in response to new information. Because of this, one can conclude that these markets are informationally inefficient. Masih and Masih (2001:14) and Chinzara and Aziakpono (2009b:109) argue that the non-existence of cointegration only nullifies "the existence of a long-run equilibrium trending relationship but does not invalidate any short-run relationships which may arise due to profit seeking opportunities in transaction." As a result, it could be possible for these stock market indices to predict each other in the short-term.

### 5.2.4 Multivariate cointegration

The cointegration analysis was extended to a multivariate analysis since international investors will normally consider wide portfolios in making investment decision. This is mainly because unsystematic risk decreases exponentially as the portfolio widens (Howells and Bain, 2005). There it is imperative to carry out multivariate analysis of these markets in order to assess how an investor would potentially invest in the African stock markets by take note of the recent financial crisis. One could assume that since most of the markets do not have bivariate cointegration then a portfolio with such markets will be worthwhile. According to Chinzara and Aziakpono (2009b) if there is no bivariate cointegration this does not necessarily mean that a long-run relationship will not exist for a portfolio with more than two markets. As in the bivariate case, our VAR lag length was selected using the information criteria. Subsequently, a cointegration test was carried out starting from the smallest lag until results with good serial correlation diagnostic properties were determined. The results for the lag length and cointegration are reported in Tables 5.8 and 5.9 respectively. Table 5.8 shows the different lag lengths that were selected by selection criteria.

TABLE 5.8 VAR ORDER SELECTED BY INFORMATION CRITERIA

| | ALL MARKETS 2000-2010 | | | | |
|---|---|---|---|---|---|
| **Lag Criteria** | LR | FPE | AIC | SIC | HQ |
| Lags | 30 | 6 | 6 | 2 | 3 |

As is evident from Table 5.9, there is at least one cointegrating vector for the period under observation. The trace statistic suggests two cointegrating vectors while the maximum eigenvalue suggests one; next we performed weak exogeneity tests to establish the truly endogenous markets.

### TABLE 5.9 COINTEGRATION RESULTS: MULTIVARIATE MODEL[49]

| | | | | Cointegration result for the Multivariate Model 2000-2010 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Trace | | | Max | | |
| MODEL | Obs | K | A | $r<0$ | $r<1$ | $r<2$ | $r<0$ | $r<1$ | $r<2$ |
| ALL MARKETS | 2687 | 12 | 4 | 243.21[0.00][a] | 146.45[0.08][c] | 102.51[0.30] | 96.75[0.00][a] | 43.94[0.21] | N/A |

*Notes: K is the VAR order that produces a white noise residual. A is the deterministic trend assumption i.e. (4) Both the level data X and cointegrating vectors have linear trends. [a]indicates significance at 1% significance level, [b]indicates significance at 5% significance level, [c]indicates significance at 10% significance level. P-values of each test statistic [ ].*

The results are reported in Table 5.10 and show that Egypt, Ghana, Morocco, Mauritius and Nigeria are weakly endogenous whilst South Africa, Kenya and Namibia are weakly exogenous.

### TABLE 5.10 EXOGENEITY: MULTIVARIATE MODEL

| | Exogeneity Test results | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | EGY | GHA | KEN | MAU | MOR | NAM | NIG | SA |
| **Chi-square(1)** | 8.02 | 31.93 | 0.91 | 6.48 | 14.65 | 0.26 | 3.79 | 2.06 |
| **Probability** | 0.00 | 0.00 | 0.34 | 0.01 | 0.00 | 0.61 | 0.05 | 0.15 |

After performing exogeneity tests we then estimated VECMs by normalising on the markets that were endogenous[50]. The meaningful results normalised on Egypt, Ghana and Morocco are reported in Tables 5.11a, 5.11b and 5.11c. It is evident that the long-run parameters vary from country to country. In Table 5.11a, where the model was normalised on Egypt; Kenya, Mauritius, Nigeria and South Africa have positive parameters. However, only South Africa has a statistically significant coefficient. A positive long-run parameter as shown by these countries, suggests a positive long-run comovement among the markets implying that a positive shock in any of the markets will generate a positive shock in Egypt. This suggests that long-run portfolio diversification is not worthwhile amongst these markets. On the other hand, Ghana, Morocco, and Namibia have negative parameters implying that these markets have a negative long run relationship with Egypt. The ECM coefficient for this model is -0.004 which means that approximately 0.4% of the short-run disequilibrium between Egypt and its explanatory variable is corrected every day. Consequently, it takes 250 days for the adjustment back to equilibrium to take place; this is more than 8 months. This period could increase transaction costs which could

[49] The VAR order was determined by estimating the model from an order length of 6 according to the information criteria, we ultimately used 12 lags because at this stage the residuals had no serial autocorrelation.
[50] VECM results normalized on Mauritius and Nigeria were not meaningful. They had positive and insignificant error correction coefficients, thus we do not report them.

limit the benefits from portfolio diversification. The dummy parameter is negative and insignificant suggesting that the financial do not have an impact on the long-run relationships of the markets.

In Table 5.11b, where the VECM is normalised on Ghana; only Egypt and Morocco have negative long-run parameters suggesting there is potential for diversification for an investor from Ghana's perspective. In contrast, all the other markets have positive long-run comovements with Ghana. The ECM coefficient for this model is -0.017 which means that approximately 1.7% of the short-run disequilibrium between Ghana and its explanatory variable is corrected every day. For that reason, it takes 59 days for the adjustment back to equilibrium to take place in this model. In comparison to the models in Table 5.11a and 5.11c, this model adjust has the fastest adjustment implying that transaction costs (though they may vary across counties) are likely to be lower meaning that investors may benefit from arbitrage opportunities in the short-term. As with the previous model, the dummy parameter is negative and insignificant implying that the crisis had no impact on the long-term relationships of the markets.

Table 5.11c shows normalised on Morocco. The long-run parameters for Kenya, Mauritius, Namibia and South Africa are positive showing that positive shocks in any of these markets will generate a positive shock in Morocco. The ECM coefficient for this model is -0.001 which means that approximately 0.1% of the short-run disequilibrium between Morocco and its explanatory variable is corrected every day. For that reason, it takes a much longer period of time for the adjustment back to equilibrium to take place in this model meaning that investors may benefit from diversification in the long-term. However due to the slow adjustment, transaction costs may be much higher. Although the dummy parameter is positive it is not significant meaning that the crisis had an insignificant impact on the relationships of the markets in the long-term.

In all models represented in Tables 5.11a, 5.11b and 5.11c, the probability value from serial correlation tests at the selected lags is not significant. Therefore we fail to reject the null hypothesis and conclude that the series do not contain serial correlation confirming the reliability of our results.

## TABLE 5.11a VECM: MULTIVARIATE MODEL

| VECM Model for Multivariate model | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | β | | | | | | | | $R^2$ | ECM | Dummy | S.Corr |
| | EGY | GHA | KEN | MAU | MOR | NAM | NIG | SA | | | | |
| 49.30 | 1.00 | 0.88[7.17] | 29.73[-2.87] | 4.62 [-1.10] | -13.97[6.90] | -25.5[5.07] | 1.54 [-5.79] | 0.02[-0.99] | 0.15 | -0.004 [-2.98] | -0.036 [-0.22] | 74.62[0.17] |

*T-values in [ ]. As required by Johansen Cointegration, the long-run parameter signs were changed.*

## TABLE 5.11b VECM: MULTIVARIATE MODEL

| VECM Model for Multivariate model | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | β | | | | | | | | $R^2$ | ECM | Dummy | S.Corr |
| | GHA | EGY | KEN | MAU | MOR | NAM | NIG | SA | | | | |
| 56.06 | 1 | -1.13[3.89] | 33.81[-3.04] | 5.25[-1.03] | -15.88[9.15] | 29.00[-7.11] | 1.75[-8.81] | 0.03[-0.87] | 0.26 | -0.017 [-6.90] | -0.32 [-0.84] | 74.62[0.17] |

*T-values in [ ]. As required by Johansen Cointegration, the long-run parameter signs were changed.*

## TABLE 5.11c VECM: MULTIVARIATE MODEL

| VECM Model for Multivariate model | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | β | | | | | | | | $R^2$ | ECM | Dummy | S.Corr |
| | MOR | GHA | KEN | MAU | EGY | NAM | NIG | SA | | | | |
| 3.53 | 1 | -0.06[9.59] | 2.13[-3.05] | 0.33[-1.00] | -0.07[3.92] | 1.83[-6.91] | 0.11[-6.93] | 0.00[-0.85] | 0.11 | -0.001 [-4.42] | 0.03[1.31] | 74.62[0.17] |

*T-values in [ ]. As required by Johansen Cointegration, the long-run parameter signs were changed.*

## 5.3 EXAMINING DYNAMIC RETURNS LINKAGES

### 5.3.1 Stationarity tests for returns

After establishing that there is some limited evidence of long-run comovement we now proceed to analyse whether this is the case with returns linkages amongst the African stock markets by using Factor Analysis and the VAR model. A critical step before proceeding with the analysis is to test for the stationarity of the returns series; hence we performed graphical plots of the series which showed that they neither had a trend nor an intercept.

**TABLE 5.12 UNIT ROOT/STATIONARITY TEST FOR RETURN SERIES**

| | EGY | GHA | KEN | MAU | MOR | NAM | NIG | SA |
|---|---|---|---|---|---|---|---|---|
| ADF (at level) | -26.620[a] | -23.827[a] | 43.848[a] | -22.288[a] | -42.359[a] | -50.243[a] | -33.904[a] | -50.09[a] |
| KPSS (at level) | 0.604[a] | 0.125[a] | 0.166[a] | 0.204[a] | 0.384[a] | 0.376[a] | 0.505[a] | 0.119[a] |

*Notes: The MacKinnon (1996) (i.e. for ADF test) 1% critical value= -2.565820 and the KPSS (1992) 1% critical value = 0.739, thus [a] denotes the rejection of the hypothesis of a unit root/non-stationarity for both tests at 1%. The order for the ADF was determined by the Schwarz Information criterion and the spectral method applied for KPSS is the Bartlett Kernel.*

Following this, we carried out the unit root/stationarity using the 'no trend and no intercept' deterministic trend assumption using the ADF and KPSS. The results are reported in Table 5.12 indicating that the returns series were found to be stationary at level from both the tests.

### 5.3.2 FACTOR ANALYSIS

The Factor analysis method was carried out on the stock market returns using the two estimation methods, Principal Components Analysis and Maximum Likelihood (PCA and ML). In Table 5.13 we report the Kaiser's Measure of Adequacy (KMA) for both methods to establish the sufficiency of the model. As mentioned in the previous chapter, the acceptable level of the KMA is 0.5 and as reported in the table, the results for both estimation methods are identical at 0.572906. This suggests that the degree of common variance among the eight variables is very low, hence carrying out Factor analysis will account for only a fair amount of variance of the stock returns.

**TABLE 5.13 KAISER'S MEASURE OF SAMPLING ADEQUACY**

| | Principal Components | Maximum Likelihood |
|---|---|---|
| DUMMY_VARIABLE | 0.473 | 0.473 |
| REGY | 0.660 | 0.660 |
| RGHA | 0.521 | 0.521 |
| RKEN | 0.575 | 0.575 |
| RMAU | 0.648 | 0.648 |
| RMOR | 0.759 | 0.759 |
| RNAM | 0.545 | 0.545 |
| RNIG | 0.530 | 0.530 |
| RSA | 0.548 | 0.548 |
| **Kaiser's MSA** | **0.573** | **0.573** |

In terms of the PCA, the estimation results are reported in Tables A1 and A2 in the Appendix. In Table A1, The proportion (per cent) of variance explained by each factor is indicated in the table showing that the first factor = 79.6 per cent, second factor = 14.6 per cent, third factor 4.3 per cent and the fourth factor 1.5 per cent. The communality variable explains the total proportion of the variance in each of the returns explained by the four factors. This is then complemented by the uniqueness variable which shows how much each of the returns varies from each other. It is evident from the different communality coefficients of each of the stock market returns that the proportion of variance accounted for by the four factors is distinctive to each stock market return. Notable exceptions are South Africa and Namibia which have high communality values in comparison to the other markets. This implies that they may explain most of the variance in the other markets, hence may be correlated. However, the high uniqueness values of each of the returns imply that they are different from each other suggesting that there is no correlation for most of the stock market returns.

As indicated in Table A2, the resulting eigenvalues for the first four common factors were each greater than 1. The first factor has an eigenvalue of 1.830 which is greater than 1, meaning that it explains more variance than a single returns variable. The percentage of variance that is explained by this eigenvalue is 20.33%. The second factor has an eigenvalue of 1.137 which explains 12.64% of the variance; the eigenvalue of the third factor is 1.042 and explains 11.59% of the variance of the returns. Lastly, the fourth factor has an eigenvalue of 1.003 which explains11.15% of the variance[51]. The cumulative percentage of variance explained by the first four factors is 55.7% which complements of the KMO of 0.573 which is an acceptable percent

[51] The remaining factors have eigenvalues less than 1 and therefore explain less variance, because of this they are not considered in extracting a common factor in the model.

of variance. This means that 55.7% of the common variance of the stock market returns can be accounted for by the 4 factors.

We then rotated the resulting factors by using the varimax method and present the results in Table 5.14a. The first factor has large weights only for South Africa and Namibia which suggests comovements amongst these markets. Egypt, Morocco and Mauritius have lower loadings whilst Nigeria and Kenya have extremely low loadings. The results also indicate that the dummy variable and Ghana load on factor 1 with negative values. Because of this, one can argue that the first factor relating to South Africa and Namibia can attributed to the fact that these are both members of SADC. Hence, an investor may not be able to reduce risk and increase returns substantially by diversifying their financial portfolios through purchasing only the stocks of these countries because their returns are highly correlated. The same could be said for Egypt and Morocco since they are members of MENA but the correlation of their returns is to a lesser degree. Due to the fact that the remaining countries do not significantly load on factor 1, this suggests that opportunities for diversification exist.

**TABLE 5.14a UNROTATED AND ROTATED FACTOR LOADINGS**

| Principal component method | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Unrotated loadings | | | | Rotated loadings | | | |
| | F1 | F2 | F3 | F4 | F1 | F2 | F3 | F4 |
| DUMMY | -0.024 | -0.128 | 0.097 | 0.086 | -0.004 | -0.071 | -0.169 | -0.013 |
| REGY | 0.208 | 0.183 | -0.055 | 0.068 | 0.168 | 0.153 | 0.085 | 0.160 |
| RGHA | -0.017 | 0.029 | -0.015 | -0.002 | -0.021 | 0.014 | 0.023 | 0.013 |
| RKEN | 0.085 | 0.187 | 0.144 | -0.047 | 0.050 | 0.248 | -0.007 | -0.03 |
| RMAU | 0.185 | 0.256 | 0.081 | -0.001 | 0.134 | 0.286 | 0.046 | 0.067 |
| RMOR | 0.318 | 0.119 | -0.040 | 0.068 | 0.288 | 0.124 | 0.054 | 0.142 |
| RNAM | 0.669 | -0.135 | 0.023 | -0.03 | 0.683 | 0.006 | -0.021 | -0.018 |
| RNIG | 0.017 | 0.135 | -0.138 | -0.039 | -0.006 | 0.050 | 0.177 | 0.071 |
| RSA | 0.706 | -0.076 | -0.02 | -0.012 | 0.708 | 0.037 | 0.027 | 0.038 |

The second factor has the highest loadings for Mauritius and Kenya followed by Egypt and Morocco respectively, however, the resulting coefficients for the remaining countries are relatively lower. In this instance it can be concluded that this vector mainly represents the comovements of Mauritius and Kenya. It is evident from the results that factor 3 has a relatively higher loading for Nigeria only which implies this vector represents to extent to which this market is isolated from the rest. Lastly, factor 4 has higher similar loadings for Egypt and Morocco which means that these markets are correlated, a result which has been indicated in factors 1, 2 and 3 already.

A similar procedure was undertaken in estimating factor analysis with the Maximum Likelihood method. The obtained results are reported in Tables A3 and A4 in the Appendix. The communality and uniqueness coefficients in Table A3 indicate that the variance accounted for by the four factors is stock market returns distinctive in each market. As with the Principal Factors model, South Africa and Namibia have high communality values which are similar thus indicating potential comovements in their returns. However, the uniqueness in this model also suggests that the African stock markets are mostly uncorrelated. The variance explained by each factor is also shown, namely; the first sector = 36.5 per cent, second factor = 29.8 per cent, third factor 28.3 per cent and the fourth factor 5.3 per cent. These were also rotated using the varimax method and are reported as the Rotated Loadings in Table 5.14b.

Table A4, shows that the resulting eigenvalues for the first four common factors are each greater than 1. These eigenvalues have coefficients which are exactly the same as those in Principal Factors; hence the cumulative percentage of variance explained by the first four factors is also 55.7% which also complements the KMO of 0.573 which is an acceptable percentage of variance. This means that 55.7% of the common variance of the stock market returns can be accounted for by the 4 factors.

TABLE 5.14b UNROTATED AND ROTATED FACTOR LOADINGS

| Maximum likelihood method | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Unrotated loadings | | | | Rotated loadings | | | |
| | F1 | F2 | F3 | F4 | F1 | F2 | F3 | F4 |
| DUMMY | 0.000 | -0.025 | 1.000 | 0.000 | -0.004 | -0.012 | 1.000 | -0.003 |
| REGY | 0.162 | 0.101 | -0.025 | 0.344 | 0.141 | 0.09 | -0.025 | 0.356 |
| RGHA | -0.019 | 0.004 | -0.003 | 0.01 | -0.02 | 0.005 | -0.003 | 0.009 |
| RKEN | 0.038 | 0.128 | -0.024 | 0.022 | 0.043 | 0.126 | -0.026 | 0.026 |
| RMAU | 0.000 | 1.000 | 0.000 | 0.000 | 0.051 | 0.999 | -0.013 | 0.011 |
| RMOR | 0.270 | 0.105 | -0.005 | 0.193 | 0.260 | 0.090 | -0.005 | 0.214 |
| RNAM | 0.741 | 0.105 | 0.016 | -0.15 | 0.755 | 0.068 | 0.017 | -0.094 |
| RNIG | -0.004 | 0.038 | -0.061 | 0.086 | -0.008 | 0.037 | -0.061 | 0.086 |
| RSA | 0.803 | 0.092 | -0.026 | 0.06 | 0.800 | 0.049 | -0.023 | 0.120 |

Results from the rotated loadings for the Maximum Likelihood method are very similar to those from the PCA as is indicated in Table 5.14b with South Africa and Namibia having the largest weights in the first factor. Morocco and Egypt are the only other two markets to load on this factor even though their weights are much lower relative to South Africa and Namibia whilst the rest of the markets have extremely low weights. Consequently, the major implication here is that this vector represents mainly the comovements of South African and Namibian stock market returns and to a lesser extent those between Egypt and Morocco. This indicates that there are limited opportunities to gain from bivariate portfolio diversification firstly between South Africa and Namibia and secondly between Egypt and Morocco. With regards to the second factor, the highest loading here is for Mauritius with rest of the markets having very low weights and a negative dummy variable coefficient. Because of this, this vector indicates that Mauritius is segmented from the rest of the markets. The third factor shows that the dummy variable has the largest weighting, however all the markets have extremely low weightings thus suggesting that it has little impact on the comovements of the stock market returns. Finally, Egypt and Morocco have highest loadings in factor 4; South African also loads on this factor but has a much lower weight whilst the rest of the markets together with the dummy variable do not load on this factor.

Overall, the Factor analysis results from both estimation methods have two major implications. Firstly, most African stock markets are not integrated with each other because comovements of the returns were only established between South Africa and Namibia and also between Egypt and Morocco to a lesser extent. This may be welcomed as good news by investors because there are vast opportunities for portfolio diversification with the other markets. Secondly, the subprime crisis did not seem to affect the correlation of these stock markets because its coefficients did not load on any of the factors in a manner that that would suggest comovements with the markets. However, as mentioned in chapter 4, factor analysis identifies the patterns of movements across stock markets instead of giving a quantifiable measure of the degree of integration. Therefore, in order to fulfil the latter objective, we complement it with the VAR model.

### 5.3.3 VECTOR AUTOREGRESSIVE RESULTS

Determining the lag length is fundamental before estimating a VAR model, this has proven to be an empirically challenging matter in terms of selecting an appropriate lag length with the debate being between using economic theory or information criteria. For example, Friedman and Shachmurove (1997) argue that a higher order should be used so to ensure that all dynamics in the data are captured when carrying out the analysis. Other scholars (e.g. Bala and Premarante, 2004) argue that utilising information criteria makes certain that the model is kept parsimonious. However, because there is no specific theory providing a guideline for the speed at which returns are transmitted from one stock market to another, this study makes use of the information criteria. Yet another problem is the fact that the information criteria tends to be sensitive to the maximum lag length that is selected. Since it is imperative to do some diagnostic checking to ensure that the final lag selected will provide robust results with *white noise* residuals, following

Gallagher and Taylor (2002) and Chinzara and Aziakpono (2009b), estimations were started with the smallest lag selected by the information criteria until serial correlation was eliminated. The optimal lag that guaranteed no serial correlation was lag 18, thus our VAR was estimated using this lag.

Since our discussion is concerned with how all the markets influence each other, the VAR results[52] indicated that there are multilateral returns interactions amongst the markets. Nonetheless, even though the VAR analysis is a useful tool to test for examining 'spillovers' and linkages amongst markets, the fact that there are so many coefficients and the coeffiecients of certain variables may change signs with different lags raises issues regarding the interpretations. Furthermore, VAR estimates do not enable us to establish much about the transmission of shocks across a system or the period of time that it takes to work through the system. Accordingly, dynamic links between the markets and the transmission of returns shock are analysed by applying weak exogeneity, impulse responses and variance decompositions.

#### 5.3.3a Block exogeneity

The results of the block exogeneity tests are reported in Table 5.15. Starting with the Egyptian returns, it is evident that this market is most significantly influenced by the South African market at 1%, this is not surprising results given that South Africa is the largest market on the continent. In addition, Egypt is influenced by Morocco and Mauritius at 2% and 5% significant levels respectively, however, Ghana, Kenya, Namibia and Nigeria do not influence the Egyptian returns.

**TABLE 5.15 BLOCK EXOGENEITY FOR REURNS LINKAGES**

| | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
|---|---|---|---|---|---|---|---|---|
| REGY | | 30.68(0.03) | 19.14(0.38) | 35.66(0.01) | 27.77(0.07) | 41.09(0.00) | 9.74(0.94) | 22.40(0.21) |
| RGHA | 20.29(0.32) | | 1.67(1.00) | 8.34(0.97) | 13.24(0.78) | 11.82(0.86) | 2.05(1.00) | 5.96(1.00) |
| RKEN | 21.40(0.26) | 4.31(1.00) | | 78.70(0.00) | 28.56(0.05) | 27.29(0.07) | 18.71(0.41) | 30.62(0.03) |
| RMAU | 29.05(0.05) | 5.97(1.00) | 18.80(0.40) | | 23.23(0.18) | 22.24(0.22) | 14.65(0.69) | 29.81(0.04) |
| RMOR | 31.93(0.02) | 30.52(0.03) | 19.95(0.34) | 24.08(0.15) | | 16.85(0.53) | 20.37(0.31) | 25.94(0.10) |
| RNAM | 14.04(0.73) | 12.39(0.83) | 26.82(0.08) | 15.56(0.62) | 18.23(0.44) | | 33.11(0.02) | 11.17(0.89) |
| RNIG | 19.37(0.37) | 1.82(1.00) | 11.07(0.89) | 25.10(0.12) | 13.34(0.77) | 22.08(0.23) | | 6.28(0.99) |
| RSA | 113.92(0.00) | 19.74(0.35) | 30.98(0.03 | 51.44(0.00) | 23.44(0.17) | 21.83(0.24) | 15.82(0.61) | |

*Note: P-values in brackets* ().

In the case of Ghanaian returns, it evident that all markets do not influence this markets' stock returns with the exception of Egypt and Morocco which both influence its returns significantly

[52] Given that the VAR has up to 144 lags, we did not report the results for succinctness. However, the Block exogeneity results will serve to show indicate the multilateral returns linkages.

at a 3% level. The Kenyan returns are significant influenced by South Africa at approximately 3% level and Namibia at 8% level whilst the rest of the markets do not exert any influence on the returns of this stock market. The results for the stock returns of Mauritius show that this market is significantly influenced by Egypt, Kenya and South Africa at a 1% level, there is no influence from the rest of the markets with Ghana stock returns being the most exogenous in this particular instance. When looking the model of Morocco, the results show that its stock returns are not influenced by any of the other stock markets with the exception of Egypt which is significant at 7% level and Kenya at a 5% level. This is not surprising considering that these two countries are members of MENA with Egypt being the larger stock market.

As noted in previous chapters, Namibia is a member of SADC together with South Africa and Mauritius. Thus; it would be reasonable for that the returns of these stock markets would wield some significant influence on each other. Accordingly, South Africa has already been reported to have significant influence on Mauritius above and in similar fashion, Mauritius is found to significantly influence South African returns at approximately 4% level. However, Namibian stock returns are not influenced by South Africa, Mauritius or any of the other African stock markets. The result between South Africa and Namibia is rather surprising because, on the one hand, it contradicts some literature (see Lamba and Otchere, 2001) and on the other it is line more recent findings (see Humavindu and Floros, 2006). Only Egypt significantly influences Namibia at a 2% level. Another unexpected result is the fact that Namibia is the only stock market that influences stock market returns of Nigeria. In terms of South Africa, its stock returns are only significantly influenced by Kenya at a 3% level and Mauritius at 4% level.

#### 5.3.4b Impulse response

To examine the sign, speed and persistence of the responses of one stock market to shocks in another stock market, ten-day impulse responses were estimated using the generalised response approach. The summary of the impulse responses are reported in Figure A1 in the Appendix and it is evident that for the response of Egypt to a one standard error shock in own past returns is initially positive and high. However, it declines sharply to be slightly above zero until day four after which it dies off. These returns seem to respond quickest to innovations in the Mauritian and Moroccan stock markets which both start slightly positive. Response to Namibia starts out positive continuing to be slightly significant and dies off at day seven. Responses from South Africa's standard error shocks are more persistent remaining significantly positive until day six even though there is an insignificant response at day eight. The response of Egypt's stock returns to standard error shocks from the remaining markets is insignificant.

Those of Ghana returns to own standard error shocks returns start out positive and decline drastically to become negative in day two after which they increase back to zero and basically die off from that point onwards. It is also evident that standard error shocks to foreign markets is either zero or insignificant. With regards to Kenya returns, we observe that response to own innovations also starts out significantly positive then declines sharply to be negative in day two, increases to zero on day three and die off beyond this point. The market seems to respond quickest to innovations in Mauritius which in essence die off at day two. Responses of Kenya to innovations from the rest of the markets are all clearly insignificant. In terms of response of returns for Mauritius from own innovations, it is also positive initially and quite high but falls to zero by the second day after which it becomes insignificant. These returns appear to be responding quickest to innovations in Kenya which are slightly positive at the beginning and die off at day two beyond which it is insignificant. Although the response of Mauritius's returns to innovations from South Africa, Namibia, Morocco and Egypt are slightly positive they are all insignificant. The case of Morocco reveals that its returns respond to own innovations positively before dying off at day three. Response of Morocco to foreign innovations show that the most immediate response is in relation to Mauritius, Namibia, South Africa and Egypt respectively whilst the cross innovations from the other markets are insignificant.

As reported in Figure A1, Namibia returns response to own innovations is initially positive and dies at day two. This same time frame applies when we consider its response to foreign innovations from South Africa, Morocco and Mauritius. However, its response to innovations from Egypt is quickest; nevertheless responses to foreign innovations are insignificant beyond two days. The response of Nigerian returns to own innovations also starts positive but declines to become insignificantly negative at day two after which they rise slightly above zero at day three only to die off to zero at day four. It is clear that own innovations are particularly more important as none of the foreign innovations from the other markets are significant. Lastly, South Africa and Namibia seem to have similar responses in each others returns. Response in SA returns is initially positive and dies off at day two, this is the also mirrored in Namibia returns response to South African innovations. The response of South African returns to foreign innovations from Egypt, Kenya, Mauritius and Morocco is evidently positive but insignificant. It dies off to zero after two days.

Overall, the response of all the stock market returns to own and foreign markets standard error shocks is prompt, taking at most one week. This could be interpreted to imply informational efficiency of the African markets; the most efficient market seems to be South Africa because firstly, it responds positively to standard error shocks from most of the other markets and secondly, its response to own and foreign innovations takes no more than two days. The least efficient markets appear to be Ghana and Nigeria, which represent the ECOWAS region. This is mainly because these markets do not respond to foreign innovations; therefore it may be more difficult for investors to determine potential benefits from strategies such as arbitrage.

### 5.3.5c Variance decomposition

The variance decomposition separates the variations in one stock market into the component shocks. It provides information about the proportion/percentage of the movements in stock market returns that are as a result of shocks due to other markets against those due to 'own' innovations. The variance decomposition results are reported in Table A5 in the Appendix and are for the periods 1, 3, 6 and 10 and it is evident that with the exception of South Africa, all markets tend to explain most of their own innovations compared to shocks from other markets implying that there are very limited returns linkages amongst the markets. This is very much in line with previous literature which found African stock markets returns to be segmented (see Piesse and Hearn, 2002; Biekpe and Collins, 2003; Piesse and Hearn, 2005; Humavindu and Floros, 2006; Agathee, 2008; Alagidede, 2008).

In the case of Egypt, it is clear that own past returns explain all the variations in day one, whilst on day three through to the day ten variations in their returns are mostly explained by South Africa and Namibia. When looking at the returns of Ghana it is evident that own innovations are clearly more important in this market as they are significantly high for all the reported days. A similar pattern can be seen for Kenyan returns as own innovations account for significantly high variations in this market from day one through to ten. Although foreign innovations from all the other markets are gradually increasing on each subsequent day, it is evident that this influence is only marginal as it accounts for approximately 3% on day ten.

With regards to Mauritius, it is evident that own innovations are clearly more important than foreign innovations. In this particular case, Kenya seems to be exerting more influence in the following days together with South Africa and Egypt. When looking at Morocco, one can also see that own innovations are more vital as they account for the majority of variations throughout days one to ten, an analogous inference can be made in the case of Nigeria.

Previous literature has noted the linkages between South Africa and Namibia and how the former is a bigger market and therefore wields more influence on the latter. However, results in Table A5 indicate that Namibia being is mostly explained by own innovations. Foreign innovations seem to be rising, even though they are very little, consequently from Morocco, Mauritius and Egypt, those from South Africa are negligible. In sharp contrast, Namibia explains approximately 30% of variations of in the South African stock market followed by Morocco (approx. 4%) and Egypt (approx. 3%). Foreign innovations account for 40% of variations in South African the stock market which could be an indication that this market is the most open of all markets on the continent. Therefore, with the exception of South Africa, own innovations seem to be more important than cross innovations in all the markets. Variations in the stock returns of Mauritius appear to be explained mostly by own innovations; however foreign innovations in Kenya are increasing in subsequent days followed by South Africa and Egypt.

## 5.4 VOLATILITY AND VOLATILITY TRANSMISSION ACROSS THE MARKETS

Having determined that there are limited returns linkages amongst the African markers, we proceeded to probe whether this also applies in terms of volatility. As mentioned in previous chapters, this was done by initially generating conditional volatility series of each stock market by using appropriate univariate GARCH models. Thereafter, we examined the linkages among the conditional volatility series by using a VAR framework together with impulse response and variance decomposition.

### 5.4.1 THE MEAN EQUATION FOR THE VOLITILITY MODELS

In Chapter 4, the mean equation for each of the stock markets was noted which we then estimated and subsequently tested for ARCH effects to determine whether volatility had been captured. The DW statistics obtained from the mean equations and ARCH-LM F-statistics are reported in Table 5.16 below.

**TABLE 5.16 AUTOCORRELATION TEST FOR THE MEAN EQUATION[53]**

| | EGY | GHA | KEN | MAU | MOR | NAM | NIG | SA |
|---|---|---|---|---|---|---|---|---|
| DW STATISTIC | 2.007 | 2.164 | 2.033 | 2.003 | 1.994 | 1.999 | 1.991 | 1.999 |
| ARCH LM | 22.225[a] | 19.683[a] | 109.315[a] | 3.349[a] | 43.890[a] | 13.054[a] | 318.456[a] | 118.411[a] |

*Notes: [a]indicates significance at 1% significance level, [b]indicates significance at 5% significance level, [c]indicates significance at 10% significance level. The critical DW is 2, if the test statistic is below 2 then there evidence of positive autocorrelation and when it is above 2 there is evidence of negative correlation*

As indicated in Table 5.16 all stock markets show significant evidence of ARCH effect, meaning that the mean equation did not adequately capture volatility. In addition, there is no significant evidence of autocorrelation for the mean equation of each stock market. A DW of around 2

[53] Refer to the Appendix to see the mean equations.

normally indicates no autocorrelation and only a value close to 4 would indicate negative serial correlation.

## TABLE 5.17 COMPARISON OF THE GARCH MODELS

| | | EGY | GHA | KEN | MAU | MOR | NAM | NIG | SA |
|---|---|---|---|---|---|---|---|---|---|
| GARCH | ω | 0.05a | 583.94a | 2.44a | 0.92a | 0.03a | 0.05a | 0.04a | 0.08a |
| | α1 | 0.04a | 0.19a | 0.07a | 0.06a | 0.21a | 0.03a | 0.25a | 0.09a |
| | β1 | 0.94a | 0.00a | -0.05a | -0.04 | 0.90a | 0.94a | 1.19a | 0.87a |
| | α2 | n/a | n/a | n/a | n/a | -0.14a | n/a | n/a | n/a |
| | β2 | n/a | n/a | n/a | n/a | n/a | n/a | -0.37a | n/a |
| | **α1 + α2 + β1 + β2** | **0.98** | **0.19** | **0.02** | **0.02** | **0.97** | **0.97** | **0.98** | **0.97** |
| | Dum | 0.03a | -582.62a | 13.18a | 2.24a | 0.02a | 0.03a | n/a | 0.13a |
| | F-LM | 0.70 | 0.01 | 0.29 | 0.07 | 0.07 | 0.00 | 0.30 | 0.20 |
| | LL | -5319.19 | -10561.24 | -5460.59 | -4007.69 | -3799.25 | -4433.89 | -4063.92 | -5032.61 |
| | AIC | 3.95 | 7.84 | 4.05 | 2.98 | 2.82 | 3.29 | 3.00 | 3.74 |
| | SIC | 3.96 | 7.86 | 4.07 | 2.99 | 2.84 | 3.30 | 3.02 | 3.75 |
| EGARCH | ω | -0.05a | 3.46a | 1.46a | 0.01a | -0.12a | -0.03a | -0.37a | -0.08a |
| | α1 | 0.11a | 0.02 | 0.08a | -0.03a | 0.37a | 0.06a | 0.59a | 0.14a |
| | β1 | 0.98a | 0.42a | -0.74a | 1.00a | 0.98a | 0.97a | 0.83a | 0.96a |
| | α2 | n/a | n/a | n/a | n/a | -0.22a | n/a | n/a | n/a |
| | β2 | n/a | n/a | n/a | n/a | n/a | n/a | 0.11c | n/a |
| | **α1 + α2 + β1 + β2** | **1.09** | **0.45** | **-0.67** | **0.97** | **1.13** | **1.03** | **0.99** | **1.10** |
| | γ | -0.01a | -0.13a | 0.17a | -0.02a | -0.02a | -0.04a | 0.19a | -0.10a |
| | Dum | 0.01a | -3.25a | 3.09a | 0.01a | 0.01a | 0.01a | n/a | 0.04a |
| | F-LM | 3.71 | 0.00 | 0.02 | 0.26 | 0.65 | 0.06 | 0.02 | 0.66 |
| | LL | -5330.73 | -10469.83 | -5430.75 | -3823.77 | -3790.05 | -4409.88 | -4018.39 | -5002.44 |
| | AIC | 3.96 | 7.77 | 4.03 | 2.84 | 2.82 | 3.27 | 2.99 | 3.71 |
| | SIC | 3.97 | 7.79 | 4.05 | 2.86 | 2.83 | 3.29 | 3.01 | 3.73 |
| TARCH | ω | 0.04a | 380.59a | 3.40a | 1.05a | 0.03a | 0.05a | 0.04a | 0.09a |
| | α1 | 0.04a | -0.01 | 0.11a | -0.01a | 0.19a | 0.00 | 0.33a | 0.01 |
| | β1 | 0.94a | 0.46a | 0.48a | 0.47a | 0.91a | 0.94a | 1.18a | 0.88a |
| | α2 | n/a | n/a | n/a | n/a | -0.14a | n/a | n/a | n/a |
| | β2 | n/a | n/a | n/a | n/a | n/a | n/a | -0.36a | n/a |
| | **α1 + α2 + β1 + β2** | **0.98** | **0.44** | **0.59** | **0.47** | **0.96** | **0.94** | **0.98** | **0.89** |
| | γ | 0.01b | 0.10a | -0.13a | 0.09a | 0.03a | 0.05a | -0.18a | 0.14a |
| | Dum | 0.04a | -379.81a | 4.59a | 0.54a | 0.02a | 0.03a | n/a | 0.14a |
| | F-LM | 0.32 | 0.23 | 0.81 | 4.97b | 0.08 | 0.10 | 1.60 | 0.04 |
| | LL | -5317.52 | -10663.27 | -5895.21 | -4278.93 | -3795.95 | -4417.01 | -4032.22 | -5003.01 |
| | AIC | 3.95 | 7.92 | 4.38 | 3.18 | 2.82 | 3.28 | 3.01 | 3.71 |
| | SIC | 3.96 | 7.94 | 4.39 | 3.19 | 2.84 | 3.29 | 3.03 | 3.73 |

*Notes: [a] indicates significance at 1% significance level, [b] indicates significance at 5% significance level, [c] indicates significance at 10% significance level.* **ω** *– The constant term for the various GARCH models.* **α1** *– The coefficient for the squared residual term.* **α2** *– The coefficient for the squared residual term applicable for Morocco.* **β1** *– The coefficient for the lagged conditional variance.* **β2** *– The coefficient for the lagged conditional variance applicable to Nigeria.* **α1 + α2 + β1 + β2** *– condition for stationarity of the GARCH model.* **α1 + α2 + β1** *– applicable only to Morocco.* **α1 + β1 + β2** *– applicable only to Nigeria.*

### 5.4.2 DETERMINING THE APPROPRIATE GARCH MODEL

We estimated the univariate GARCH (1,1), EGARCH(1,1,1) and GJR GARCH (1,1,1) models to examine the nature of volatility in each stock market. The results from our estimations are reported in Table 5.17. In the case of Morocco, we estimated the models with a lagged residual order of order 2 i.e. GARCH (2, 1), EGARCH (2, 1, 1) and GJR GARCH (2, 1, 1) because the standard models could not adequately capture the volatility. For the same reason, we estimated the GARCH (1, 2), EGARCH (1, 2, 1) and GJR GARCH (1, 2, 1) for Nigeria.

In all the three models, the coefficient $\omega$ represents the intercept, whilst coefficients $\alpha 1$ and $\beta 1$ are the lagged residual squared and variance squared coefficients, $\alpha 2$ is the second residual squared coefficient in the case for Morocco and $\beta 2$ is the second variance squared coefficient for Nigeria. As is evident from Table 5.17, these four coefficients are significant at a 1% level for all the models with the exception of $\alpha 1$ for Ghana in the EGARCH and GJR GARCH models, $\alpha 1$ for Namibia in the GJR GARCH model and $\alpha 1$ for South Africa in the GJR GARCH model which are insignificant. The results show that the summation of the lagged residual squared and variance squared coefficients (i.e. the stationarity condition; $\alpha + \beta$) for most of the models is very close to 1 implying that volatility is generally persistent amongst the African stock markets. As noted in Chapter 4, $\gamma$ is the leverage/asymmetric coefficient which tests the asymmetry hypothesis for volatility in the stock markets. This coefficient is negative and significant at 1% in the EGARCH models for all the markets, except for Kenya and Nigeria, while it is positive and significant at 1% in the GJR GARCH models of these two markets. For this reason, all the stock markets show evidence of volatility asymmetry implying that negative news has a greater impact on volatility than positive news of a similar magnitude. Such an occurrence has been documented in number of relevant empirical studies. (see, Koutmos and Booth, 1995; Piesse and Hearn, 2005; Koulakiotis *et al*, 2006; Chinzara and Aziakpono, 2009b).

Since asymmetry exists in all markets, the standard GARCH model will not be an appropriate model meaning that the comparison is only between EGARCH and TARCH models. Both models appropriately capture volatility as can be shown from the insignificant ARCH LM F-statistic. However, it is evident that the latter is more stationary for most of the series which has a lower absolute value for its log likelihood ratio and a lower SIC[54], as a result, the TARCH model was selected as the best model for modelling Egypt, Kenya, Morocco, Namibia and South African stock markets. In the case of Ghana and Mauritius, the EGARCH model is the most appropriate because it has the lowest absolute values for the log likelihood and the information criteria. However, this does not apply to the Nigerian stock market because for all the models the summation of its coefficients ($\alpha1 + \beta1 + \beta2$) is very close to 1 suggesting that shocks to the conditional variance are highly persistent which is also due to the presence of excess kurtosis in its returns data. This finding is similar to that of Emunike (2010) who also notes that wide changes in the returns tend to be followed by wide changes and mild changes tend to followed by mild changes. Therefore the most appropriate model in this case is the GARCH model as it is the most unitary as it is superior in the attributes being considered.

Table 5.17 also indicates that all the conditional volatilities, except for Ghana, experienced a structural break during the sub-prime crisis as can be seen from the positive significant dummy coefficients. This implies that volatilities in these series increased during the crisis period. The dummy coefficient for Ghana is extremely high, negative but significant meaning that volatility significantly decreased during the financial crisis. For Nigeria, the three models were also augmented with the dummy variable, but the resulting dummy coefficients were not significant, so we concluded that the dummy variable was not applicable to the models. Consequently, conditional volatility for each of the stock markets were estimated based on the most appropriate models selected.

### 5.4.3 TRENDS IN VOLATILITY IN THE STOCK MARKETS

In setting the stage for analysing the extent to which the stock markets are linked, we first examine the behaviour of volatility overtime. The more volatile a stock market is, more susceptible it is to unsystematic risk. It thus follows that an understanding of the behaviour of volatility over time is vital to investors and policymakers given that volatility is a measure of risk. For example, excess volatility in capital markets will raise cost of capital which could have adverse effects on the aggregate national investment expenditure. This is especially important in the context of this study as African countries would aim to avoid policies that deter economic growth by seeking to implement policies that certify the reduction of volatility in the long-term. With regards to investors, they would be interested the behaviour of

[54] The TARCH model also has a lower AIC and HQ. For space reasons, we chose not to report all the information criteria.

volatility so as to formulate risk management strategies to avoid making significant losses in the event that volatility rises.

**TABLE 5.18: VOLATILITY OVER TIME**

| STOCK MARKET | β1 | β2 |
|---|---|---|
| VOLEGY | 2.816(0.000)[a] | 0.000511(0.000) [a] |
| VOLGHA | 537.753(0.078) [c] | -0.038167(0.845) |
| VOLKEN | 5.157(0.000) [a] | 0.002734(0.000) [a] |
| VOLMAU | -0.204(0.000) [a] | 0.001158(0.000) [a] |
| VOLMOR | 0.660(0.000) [a] | 0.000393(0.000) [a] |
| VOLNAM | 1.449(0.000) [a] | 0.000168(0.000) [a] |
| VOLNIG | 5.455(0.001) [a] | -0.000895(0.406) |
| VOLRSA | 0.908(0.000) [a] | 0.001806(0.000) [a] |

*Notes: [a] indicates significance at 1% significance level, [b] indicates significance at 5% significance level, [c] indicates significance at 10% significance level.*

Table 5.18 shows that volatility in Ghana and Nigeria is decreasing even though not significantly, however, for the rest of the markets, volatility is significantly increasing. An important issue to take into consideration is the behaviour of volatility during/after the 2007-2009 subprime crisis. Volatility in Egypt, Mauritius, Morocco, Namibia and South Africa seems to have increased during the crisis; this could be attributed to contagion effects. The fact that only the bigger markets were affected, with the exception of Nigeria, could be an indication that only firms whose stocks were listed in countries such as Egypt and South Africa were affected and this could have been spread into the smaller markets. Because of this, volatility amongst the markets increased over time which could be an indication that investors do not have much confidence investing in these stock markets especially since they all responded to the crisis. This could be a worrying finding for policymakers as it means that they have to formulate policies which promote financial stability so as to attract investment to enhance economic growth.

## 5.4.4 VOLATILITY TRANSMISSION ACROSS THE MARKETS

### 5.4.4.1 Simple correlation of volatility series

We analysed the volatility series for the various markets for correlation using the pairwise correlation matrix and the results reported in Table 5.19. It is evident from the table that Ghanaian stock market volatility is negatively correlated with the volatility of all the other stock markets; this also applies to Nigeria, as it only has a slight positive correlation with Namibia. Hence these two markets may be attractive for investment as they seem to be less likely to be affected by any contagion effects from the other markets. South Africa is the most highly correlated with other markets, having positive correlations with Egypt, Namibia, Morocco, Mauritius and Kenya. Egypt is the second mostly correlated and the fact that its highest correlation is with South Africa means that one could reasonably conclude that these two markets dominate volatility influence on the continent with South African being the most dominant. Smaller markets such as Mauritius, Namibia and Kenya also have positive correlations; hence the question of transmission of detrimental contagion effects across the markets may be raised. Nevertheless, as in the case of returns, correlation does not imply causality, so to give more empirical content to the correlation results; we extended the analysis with respect to possibility of volatility linkages using the multivariate VAR model.

**TABLE 5.19: CORRELATION OF VOLATILITY**

| | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
|---|---|---|---|---|---|---|---|---|
| VOLEGY | 1 | | | | | | | |
| VOLGHA | -0.005 | 1 | | | | | | |
| VOLKEN | 0.111 | -0.009 | 1 | | | | | |
| VOLMAU | 0.487 | -0.015 | 0.282 | 1 | | | | |
| VOLMOR | 0.536 | -0.001 | 0.134 | 0.454 | 1 | | | |
| VOLNAM | 0.564 | -0.02 | 0.122 | 0.414 | 0.419 | 1 | | |
| VOLNIG | -0.016 | -0.001 | -0.008 | -0.019 | -0.008 | 0.002 | 1 | |
| VOLRSA | 0.737 | -0.018 | 0.148 | 0.519 | 0.608 | 0.706 | -0.02 | 1 |

### 5.4.4.2 Multivariate VAR conditional variances

As with returns linkages, the length was established by first taking the smallest lag selected by utilising the information criteria and then increasing the lag length until the results from the VAR were serially uncorrelated. The two information criteria selected 9 and 3 lags respectively but the results still had serial correlation, only after 16 lags was serial correlation[55] removed at which stage we proceeded with estimating the VAR model. As noted by Shikwambana (2007), it is imperative to distinguish between stock market volatility that is due to own shocks and that which is due to shocks from other markets as news and macroeconomic shocks that change expected returns within a single stock market will generate volatility within that market. However, common information and information spillovers give a channel for the transmission of volatility shocks across financial markets. Results from the VAR framework provide volatility transmission from both within and across equity markets. In spite of this, the VAR is difficult to interpret, so we complement it with block exogeneity, variance decomposition and impulse response functions which we report below.

[55] Given that the VAR has up to 128 lags, we did not report the results for succinctness. However, the Block exogeneity results will serve to indicate the multilateral volatility returns linkages.

#### 5.4.4.3 Block exogeneity

Table 5.20 reports the conditional volatility series which also take into account the structural break which we noted as the sub-prime crisis as in the case of the returns linkages. The results indicate that volatility in Egypt is significantly affected by South Africa, Morocco, Mauritius, Kenya and Namibia. As in the case of returns linkages, volatility in Ghana is not affected by any of the other African stock markets except Morocco. This is very much the same in the case of Kenya which is influenced by Mauritius. However, the most exogenous market seems to be Nigeria since its volatility is not explained by any of the other markets.

**TABLE 5.20: BLOCK EXOGENEITY FOR VOLATILITY LINKAGES**

| | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
|---|---|---|---|---|---|---|---|---|
| VOLEGY | | 9.17(0.91) | 14.28(0.58) | 107.81(0.00) | 70.44(0.00) | 150.51(0.00) | 1.74(1.00) | 200.65(0.00) |
| VOLGHA | 14.87(0.53) | | 0.27(1.00) | 1.55(1.00) | 2.01(1.00) | 0.82(1.00) | 0.02(1.00) | 1.81(1.00) |
| VOLKEN | 32.17(0.01 | 0.36(1.00) | | 520.08(0.00) | 15.99(0.45) | 11.58(0.77) | 0.21(1.00) | 42.74(0.00) |
| VOLMAU | 67.42(0.00) | 1.00(1.00) | 226.45(0.00) | | 48.25(0.00) | 38.67(0.00) | 0.96(1.00) | 74.48(0.00) |
| VOLMOR | 115.00(0.00) | 25.57(0.06) | 22.17(0.14) | 28.40(0.03) | | 18.14(0.32) | 2.09(1.00) | 74.62(0.00) |
| VOLNAM | 26.80(0.04) | 1.72(1.00) | 1.31(1.00) | 9.11(0.91) | 25.42(0.06) | | 5.85(0.99) | 46.14(0.00) |
| VOLNIG | 2.64(1.00) | 0.02(1.00) | 0.04(1.00) | 0.29(1.00) | 1.14(1.00) | 1.03(1.03) | | 0.45(1.00) |
| VOLRSA | 324.24(0.00) | 1.72(1.00) | 19.00(0.27) | 71.54(0.00) | 91.32(0.00) | 75.94(0.00) | 2.26(1.00) | |

*Note: P-values in brackets* ().

On the other hand, South Africa is evidently the most endogenous stock market since its volatility is explained by most of the other markets, except for Nigeria and Ghana, with South Africa also influencing each of the markets. This finding can be interpreted to indicate two issues. Firstly, that there is bidirectional causality amongst the volatilities of the stock markets being investigated with the exception of Nigeria and Ghana. This point is reinforced by the fact that volatility in Ghana and Nigeria did not increase during the financial crisis. Secondly, this implies that there is volatility transmission across stock markets in the SADC, MENA and COMESA, with ECOWAS stock markets being segmented from the rest. Of importance is to note is that volatility transmission between the two largest economies (SA and Egypt) is significant, raising the possibility of contagion effects during financial crises.

#### 5.4.4.3 Impulse response

From Figure A2 in the Appendix, it is clear that volatility in the Egyptian stock market shows positive and significant response to own standard error shocks. It also indicates that the market responds to South African standard error shocks innovations and positive but insignificant responses to Morocco and Namibia. The response to own innovations starts high and gradually decreases. However, response to SA innovations increases gradually from day 1 to day 7 and remains constant until day 9, after which it slightly declines. In the case for Ghana, response to own standard error shocks is initially positive but declines rapidly within two days. The market does not seem to respond to innovations from the other markets. The Kenyan equity market responds to own innovations; this response gradually declines in five days. It also responds to innovations from Mauritius which are positive but insignificant, after two days they decrease to become negative on day three. This response continuously increases from being negative on day three and becomes zero on day six, after which it eventually turns into a positive response by day ten. For Mauritius, response to own innovations is positive, significant and persistently high. On the other hand, its response to innovations from Egypt, Kenya, Namibia and South Africa is insignificant and persistently negative.

When analysing the Moroccan stock market, it is revealed that its response to own innovations declines drastically after the first two days but remains positive and constant for about four days and then starts to gradually decline. Response of Morocco to innovations from all the other stock markets is insignificant, although responses to those from South Africa increase after five days to be slightly positive. It is evident that own innovations in the Namibian stock market are high and continually positive. The fact that responses from the South African innovations are the only ones that are significant, positive and increasing further after eight days shows that the larger SA market increases its influence gradually. Ghana and Nigeria do not seem to respond to innovations from the other African stock markets. This is consistent with the results we reported for variance decomposition. However, the Nigerian stock market responds to own innovations which are initially positive and significant, but increase sharply until day three, after which the response gradually declines. With regard to South Africa, response to own innovations is positive and significantly high. It is also evident that the South African market only positively and significantly responds to Namibian innovations. The responses of volatility of the SA stock market to innovations from Egypt and Morocco are insignificant despite the fact that they increases after six days and four days respectively. Response of South Africa to innovations from Mauritius is negative and insignificant after two days and persistently remains so. Finally, it is clear that South Africa does not respond significantly to innovations from the other markets namely; Ghana, Kenya and Nigeria.

In general, the response of the stock markets to own and foreign volatility shocks is slow and gradual taking over a week. This could be interpreted to mean that contagion effects will take longer to spread across the markets during periods of financial crises. The fact that South Africa, Egypt and Namibia have positive responses amongst each other could be welcome finding for investors because it means that these markets could benefit amongst each other through the spread of positive information. However, contagion effects could also have significant adverse effects the markets.

#### 5.4.4.4 Variance decomposition

As in the case for returns linkages, we report the variance decomposition results for volatility linkages for periods 1, 3, 6 and 10 in Table A6 in the Appendix. Volatility in Egyptian stock markets is explained by own in innovations on day 1, however in subsequent days it is clear that variations from South Africa are increasing reaching approximately 18% on day 10 whilst Morocco and Namibia account for 1.5% each in the same period. Within the MENA region, the results show that variations in Morocco current stock market volatility is explained by own past volatility. The only notable foreign influence in this stock market is from Egypt and South Africa; however, it is very limited through days 1 to 10.

A similar pattern emerges in the case of Kenya in which for the first day, own past volatility explains all the variation in current stock market volatility. Volatility of Mauritius stock market innovations explain approximately 2% (day 1) to 4% (day 10) of stock market volatility in Kenya. With regards to variations in Mauritius volatility, it is evident that on days 1 and 2 own innovations account for nearly all current stock volatility. On day 3 volatility innovations from Egypt and Kenya explain approximately 3% each showing that their influence is limited.

In the case of South Africa, the results show that volatility in this stock market is mostly influenced by innovations from Namibia, even though this influence gradually decreases from 15% on day 1 to 12% on day 10. Innovations from Egypt and Morocco seem to fluctuate through period 1 to 10. Despite this, their volatilities only account for 3% and 1.7% in South African stock market volatility on the final period. A rather surprising result is that the South African stock market explains very little variations in Namibian stock market volatility. One would expect more influence from South Africa as it the larger market. However, the fact that innovations in Namibia seem to be influencing stock market volatility in South Africa seems to be in line with the findings of Piesse and Hearn (2002). The study notes that a likely explanation for this is that a common and specific emerging market characteristic may be present in both markets, but stronger in Namibia. As a result of that, it may be influential in causing price spillovers to South Africa where the market is more open and has greater access to global capital flows (Piesse and Hearn, 2002:1721). Lastly, current stock market volatilities in Ghana and Nigeria are virtually explained by own past volatilities through days 1, 3, 6 and 10. In addition, these markets do not explain any notable variations in any of the other stock market volatilities.

Overall, the major picture that emerges from the results of the conditional volatilities of the markets is that own past innovations are more important in explaining current stock market volatilities on the African continent. Although there is some slim evidence of volatility transmission amongst some markets in the same region, generally the markets seem to be segmented from each other. Consistent with previously reported results, we can also see that the ECOWAS region seems to be the most isolated region on the continent.

### 5.5 CONCLUSION

This section on the empirical analysis was divided into four main sections. In the first section, the descriptive statistics and simple correlation of the markets were carried out. The descriptive statistics generally revealed that all the market had high unconditional standard deviations which point towards high risk in developing markets, a finding that is in line with theoretical and empirical literature. Also, the hypothesis of normality was rejected for the all the returns series which is common in financial data. The correlation matrix showed that South Africa and Namibia had the highest correlation, whilst similar inferences were made for Egypt and Morocco and also Kenya Mauritius, but to a much lesser extent. Since the correlation only provided an insight into the possible short-run market linkages but not long-term opportunities, further empirical tests were performed to achieve this objective.

The second section made use of the Johansen cointegration method where both bivariate and multivariate analysis was carried out. Only seven out twenty-eight models showed slim evidence of cointegration in the bivariate analysis, whilst only one cointegrating vector was found in the multivariate analysis also suggesting very limited integration amongst the markets. In the third section, Factor analysis and VAR, block exogeneity, impulse response and variance decomposition were used to examine the returns linkages. The major finding from Factor analysis (from both PCA and ML methods) was that there was no pattern of comovements amongst the markets due to the different factor loadings. In the VAR framework, it showed that there is limited influence across the stock markets and that own innovations is more important than foreign innovations for all the stock markets.

In the last empirical section, the volatility and volatility linkages were analysed using GARCH and VAR models. By analysing each market using GARCH, EGARCH and GJR GARCH; we found that volatility is asymmetric and persistent and in addition, there was evidence of volatility increasing significantly for most markets analysed. The VAR framework found evidence of volatility transmission amongst most markets, furthermore, variations in volatility also showed that the stock markets responded to own market innovations than to foreign innovations. However, the most notable finding is that volatility transmission between South Africa and Egypt may have negative effects for smaller markets due to contagion effects.

# CHAPTER SIX
# SUMMARY OF FINDINGS, POLICY RECOMMENDATIONS AND AREAS FOR FURTHER ANALYSIS

## 6.1 SUMMARY OF THE RESEARCH AND CONCLUSIONS

This research analysed the extent to which African stock markets are integrated by selecting the most dominant markets in the different regions; namely ECOWAS, COMESA, MENA and SADC. As noted in Chapter one, this study was set out with the aim to address the following objectives; examining the long-run relationship amongst the African stock markets, scrutinising whether any returns linkages exist together with assessing the nature of volatility and volatility linkages amongst the markets as well as the magnitude and speed of volatility transmission from one market to another.

Initially, we reviewed existing literature by outlining a conceptual overview of the equity market which highlighted its importance from a macroeconomic perspective and within the context of this study. This was followed by drawing out the importance of understanding equity market linkages which were categorised as portfolio diversification, regulatory policy as well as monetary policy. After this the theoretical literature was reviewed by focusing on the sources of stock market comovements such as contagion, economic integration and stock market characteristics which include size, volatility and industrial similarity. We conclude this section by reviewing empirical literature for developed, emerging and African stock markets which highlighted that developed markets are strongly integrated, whilst comovements amongst emerging markets are more significant within their regions. More importantly, previous literature highlight that African markets are less integrated with South Africa dominating influence on the continent. Chapter 3 analysed the background on channels of stock market linkages with the aim to assess whether a trend emerges which implies that markets move together. This evaluation was carried out with regards to four issues: trade linkages, financial linkages, stock market characteristics, and trends of stock market indices.

The empirical analysis was divided into three main sections. Firstly, the long run comovement was analysed by making use of the Johansen Cointegration method. We started off by testing the stationarity of our series using the DF (GLS) and KPSS. We found that all series were stationary at first difference [i.e. $I$ (1)]. Following this, bivariate Johansen cointegration analysis was then applied to examine whether there were any pairwise long run comovements across the eight markets by estimating twenty-eight bivariate models. Only seven out of twenty-eight models indicated slim evidence of cointegration namely, between Nigeria and Ghana; Kenya and South Africa; Egypt and Morocco; Morocco and South Africa, South Africa and Mauritius, South Africa and Egypt and lastly between South African and Nigeria. The VECMs for these models were estimated and they revealed that positive long run relationships exist amongst the markets in each particular model. After this, we then performed a multivariate cointegration applying the Johansen approach in which we included all eight markets; from this we found one cointegrating vector amongst the markets, suggesting slim evidence of integration. Following this, weak exogeneity tests were performed which revealed Egypt, Ghana, Morocco, Mauritius and Nigeria to be the endogenous markets.

In the second stage of our empirical analysis, Factor Analysis was carried out which established a KMO value of 0.57 suggesting that the variables had a low correlation but could nonetheless still be tested for common factors. Here, two extraction methods were applied, i.e. PCA and ML and both methods obtained four factors from their specific models. The major pattern that emerged from these analytic methods was that most the African stock market returns did not move in a pattern that showed comovements mainly because they loaded on the obtained factors with dissimilar values. The only exception was the pattern between South Africa and Namibia as these two markets had similar loadings on factors in both methods and also between Egypt and Morocco to a lesser extent. However, factor analysis only identified the pattern of movements and not the quantitative measure; hence the VAR model was carried out to achieve this.

Accordingly, the VAR framework, together with the block exogeneity, variance decomposition and impulse response functions were estimated to complement the Factor Analysis. The results revealed that there are linkages amongst the stock markets. With regards to the block exogeneity tests, these revealed that there is limited significant influence across the stock markets in the varied regions especially in terms of ECOWAS indicating Nigeria and Ghana to be the most exogenous. In addition, the response of own innovations relative to foreign innovations was analysed and overall, these showed that the former were more important than the latter for all the stock markets. The major result in this particular case was the fact that Namibia has dominant influence on South African returns which was rather surprising. In general, the VAR findings appear to be confirming the factor analysis and cointegration results that the African stock markets are not integrated with each other except for South African and Namibia and Egypt and Morocco to a lesser extent. Also, we showed that South Africa was the most informationally efficient market on the continent, whilst Ghana and Nigeria were the least efficient.

After analysing the nature of returns linkages among the markets, we proceeded to examine if a similar scenario would be revealed in terms of volatility. We initially analysed volatility in each stock market using the GARCH, EGARCH and GJR GARCH and we found that volatility is asymmetric and persistent. The three models were compared and South African stock markets. In the case of Ghana and Mauritius, the EGARCH and it was established that GJR GARCH was the most appropriate for Egypt, Kenya, Morocco, Namibia model was selected whist the GARCH was applied to Nigeria. The behaviour of volatility overtime also evaluated and revealed that volatility is significantly increasing for most of the markets.

The conditional variance series were then analysed by applying the VAR framework, block exogeneity, variance decomposition and impulse response. Findings from block exogeniety showed that there is some evidence of volatility transmission amongst most countries under study with the exception of Nigeria and Ghana. This volatility transmission was found to be significant between Egypt and South Africa. In addition, South Africa was found to be the most endogenous market whilst Nigeria is the most exogenous market. In terms of the variations in volatility, the results were similar to those found in variations in returns. This is because own innovations were more important than foreign innovation for most markets. South Africa was found to increasingly influence the Egyptian stock market volatility whilst Namibia was found to influence volatility in South African volatility. A similar result is obtained from the impulse response of the volatility series. Here, the major finding was that contagion effects could have adverse effects in Egypt, Namibia and South Africa during financial crises because responses to volatility shock among these markets is significant.

Generally, the results from this study show that the African stock markets are not well integrated with each other in both the long and short run with Nigeria and Ghana being most segmented markets. Because of this, there is a potential for gains from international portfolio diversification. Close volatility linkages between South Africa and Namibia and Egypt which may have adverse effects in relation to financial instability through transmission of harmful volatility amongst these and smaller markets in MENA and SADC.

### 6.2 POLICY AND INVESTMENT IMPLICATIONS

The findings of this study have implications for investment and policy strategies. The fact that there is weak integration amongst the African stock markets implies that there are great opportunities for long term portfolio diversification. Investors from the other regional groups could specifically construct portfolios comprising other markets with the ECOWAS region. This would mean exploiting risk-averting or profit opportunities in Ghana and Nigeria as these markets were found to be the most segmented from the rest of the stock markets analysed. However, portfolio diversification would not be worthwhile for investors in the long-term in the SADC and MENA regions. This is mainly because of the cointegration that was established to exist between South Africa and Namibia, and Egypt and Morocco respectively.

The evidence that was provided indicating segmentation of the African stock markets could be worrying for policymakers. Firstly, for the African Stock Exchange Association (ASEA), this could be indication that the reforms[56] implemented, with the goal to integrate markets on the continent, have not been effective. Secondly, the weak integration of markets means that costs of capital will increase. This is echoed by Kearney and Lucey (2004:577) who argue that the more integrated are stock market, the lower will be the capital costs. Therefore, the fact that there are potentially high capital costs on the African continent in general means that investors could shun away from investing in some of these markets. Policymakers should be concerned with this as less investment could impede economic growth whilst exacerbating problems such unemployment and poverty which continue to ravage the continent. Hence, we believe it is imperative that there should be revision of the reforms to further economic integration such as relaxation of capital controls. Nonetheless, policymakers in South Africa can celebrate the fact that this market continues to be dominant on the continent in terms of size and efficiency. This implies that costs of capital are cheaper relative to the other markets, thus reinforcing South Africa as a prime destination for investment in Africa.

With regards to volatility, the fact that volatility is transmitted across the markets quickly means that policymakers should be concerned because it ultimately affects financial stability. Volatility transmission between the most traded markets could be harmful during times of crises for the whole continent. A crisis from Egypt and Namibia may be transmitted to South Africa given that the latter absorbs volatility from the former markets, a situation called contagion effect. If such undesirable volatility is transmitted it may threaten financial stability in the smaller markets within SADC and MENA regions. Therefore, policymakers should monitor trends in volatility of the biggest markets on the continent. In addition, the positive and negative transmission of volatility across these markets warrants a check on monetary policy. This is because an increase in consumer wealth leads to an increase in stock prices and aggregate expenditure, ultimately forcing the central bank to raise interest rates in an attempt to keep in inflation in check. As noted by Chinzara and Aziakpono (2009b), if a stock market is extremely volatile, the repo rate

[56] Mentioned in chapter 1.

and thus interest rates may also be volatile which could have adverse effects on macroeconomic variables such as investment and economic growth.

### 6.2. AREAS FOR FURTHER RESEARCH

Since we used univariate GARCH, further study in this area could be done by using the multivarite GARCH model and compare results with ours. Also, it is recommended that similar studies should be carried out for the foreign exchange market since it is now seen as an asset class in its own right due to its increasing growth (Du Toit, 2010). In this regard, hedge funds and other investment managers are increasingly making use of the advantages offered by the foreign exchange market in active short-and medium-term investments. Hence it would benefit both investors and policymakers to investigate the implications of the growing foreign exchange market.

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## APPENDIX

### FACTOR ANALYSIS

## Table A1: Principal Factors Unrotated Results

Factor Method: Principal Factors
Date: 09/07/10 Time: 12:56
Covariance Analysis: Ordinary Correlation
Sample (adjusted): 2/01/2000 6/04/2010
Included observations: 2699 after adjustments
Balanced sample (listwise missing value deletion)
Number of factors: Kaiser-Guttman
Prior communalities: Squared multiple correlation

| | Unrotated Loadings | | | | | |
|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | Communality | Uniqueness |
| DUMMY_VARIABLE | -0.023979 | -0.128459 | 0.096968 | 0.086344 | 0.033935 | 0.966065 |
| REGY | 0.207661 | 0.183495 | -0.054604 | 0.068203 | 0.084427 | 0.915573 |
| RGHA | -0.016565 | 0.02853 | -0.015102 | -0.002108 | 0.001321 | 0.998679 |
| RKEN | 0.085049 | 0.187054 | 0.143685 | -0.04729 | 0.065104 | 0.934896 |
| RMAU | 0.184794 | 0.25577 | 0.081445 | -0.001407 | 0.106203 | 0.893797 |
| RMOR | 0.318225 | 0.119085 | -0.039548 | 0.067981 | 0.121634 | 0.878366 |
| RNAM | 0.669116 | -0.134879 | 0.023132 | -0.029878 | 0.467337 | 0.532663 |
| RNIG | 0.017489 | 0.134562 | -0.137652 | -0.038906 | 0.038875 | 0.961125 |
| RSA | 0.705875 | -0.076338 | -0.020318 | -0.012476 | 0.504656 | 0.495344 |

| Factor | Variance | Cumulative | Difference | Proportion | Cumulative |
|---|---|---|---|---|---|
| F1 | 1.132904 | 1.132904 | 0.925202 | 0.795864 | 0.795864 |
| F2 | 0.207702 | 1.340606 | 0.146351 | 0.14591 | 0.941774 |
| F3 | 0.061351 | 1.401957 | 0.039818 | 0.043099 | 0.984873 |
| F4 | 0.021533 | 1.42349 | --- | 0.015127 | 1 |
| Total | 1.42349 | 5.298956 | | 1 | |
| | Model | Independence | Saturated | | |
| Discrepancy | 0.022833 | 0.564518 | 0 | | |
| Parameters | 39 | 9 | 45 | | |
| Degrees-of-freedom | 6 | 36 | --- | | |

## Table A2: PCA Eigenvalues

Eigenvalues Summary
Eigenvalues of the Observed Matrix
Factor:
PRINCIPAL_FACTORS
Date: 09/07/10 Time: 13:04

Eigenvalues: (Sum = 9, Average = 1)

| Number | Value | Difference | Proportion | Cumulative Value | Cumulative Proportion |
|---|---|---|---|---|---|
| 1 | 1.830007 | 0.692698 | 0.2033 | 1.830007 | 0.2033 |
| 2 | 1.137309 | 0.094465 | 0.1264 | 2.967315 | 0.3297 |
| 3 | 1.042844 | 0.039608 | 0.1159 | 4.010159 | 0.4456 |
| 4 | 1.003236 | 0.033639 | 0.1115 | 5.013395 | 0.557(MSA) |
| 5 | 0.969597 | 0.040747 | 0.1077 | 5.982992 | 0.6648 |
| 6 | 0.928851 | 0.073622 | 0.1032 | 6.911843 | 0.768 |
| 7 | 0.855229 | 0.01709 | 0.095 | 7.767072 | 0.863 |
| 8 | 0.838139 | 0.44335 | 0.0931 | 8.605211 | 0.9561 |
| 9 | 0.394789 | --- | 0.0439 | 9 | 1 |

Eigenvectors (loadings):

| Variable | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 | PC7 | PC8 | PC9 |
|---|---|---|---|---|---|---|---|---|---|
| DUMMY_VARIABLE | -0.037148 | -0.406992 | 0.415447 | 0.150443 | 0.643904 | 0.443039 | 0.152735 | 0.040398 | -0.043 |
| REGY | 0.264207 | 0.275972 | -0.111177 | -0.136526 | 0.546042 | -0.524128 | 0.490097 | -0.031119 | 0.0948 |
| RGHA | -0.018489 | 0.099584 | -0.06437 | 0.970322 | -0.059295 | -0.129873 | 0.130328 | -0.08162 | 0.006478 |
| RKEN | 0.118159 | 0.45185 | 0.588925 | -0.010152 | -0.300173 | 0.155558 | 0.339406 | 0.453021 | 0.0144 |
| RMAU | 0.241949 | 0.501779 | 0.322153 | 0.006447 | 0.16445 | 0.131178 | -0.41152 | -0.608664 | -0.0422 |
| RMOR | 0.377307 | 0.067813 | -0.089316 | 0.129881 | 0.268595 | -0.098687 | -0.603495 | 0.614988 | 0.062415 |
| RNAM | 0.581853 | -0.284155 | -0.012215 | 0.012878 | -0.220606 | 0.156686 | 0.117944 | -0.162258 | 0.6833 |
| RNIG | 0.03183 | 0.398788 | -0.58898 | -0.001308 | 0.131974 | 0.659106 | 0.185968 | 0.081159 | 0.0068 |
| RSA | 0.611593 | -0.218986 | -0.072533 | 0.00455 | -0.168328 | 0.044972 | 0.149147 | -0.062561 | -0.718472 |

## Table A3: ML Unrotated results

Factor Method: Maximum Likelihood
Date: 09/07/10 Time: 12:30
Covariance Analysis: Ordinary Correlation
Sample (adjusted): 2/01/2000 6/04/2010
Included observations: 2699 after adjustments
Balanced sample (listwise missing value deletion)
Number of factors: Kaiser-Guttman
Prior communalities: Squared multiple correlation
Convergence achieved after 7 iterations

| | Unrotated Loadings | | | | | |
|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | Communality | Uniqueness |
| DUMMY_VARIABLE | -2.38E-17 | -0.02515 | 0.999684 | 9.35E-18 | 1 | 0 |
| REGY | 0.161801 | 0.101252 | -0.02538 | 0.343963 | 0.155386 | 0.844616 |
| RGHA | -0.019139 | 0.003677 | -0.0025 | 0.01021 | 0.00049 | 0.99951 |
| RKEN | 0.037919 | 0.128258 | -0.024313 | 0.02163 | 0.018947 | 0.981053 |
| RMAU | -1.09E-16 | 1 | -3.34E-07 | 1.61E-17 | 1 | 0 |
| RMOR | 0.270186 | 0.105019 | -0.005491 | 0.193213 | 0.121391 | 0.87861 |
| RNAM | 0.741184 | 0.105239 | 0.016203 | -0.149532 | 0.583051 | 0.416949 |
| RNIG | -0.004039 | 0.038178 | -0.060632 | 0.085659 | 0.012488 | 0.987512 |
| RSA | 0.8028 | 0.091521 | -0.025541 | 0.05989 | 0.657102 | 0.342898 |

| Factor | Variance | Cumulative | Difference | Proportion | Cumulative |
|---|---|---|---|---|---|
| F1 | 1.294841 | 1.294841 | 0.235555 | 0.364862 | 0.364862 |
| F2 | 1.059286 | 2.354127 | 0.054056 | 0.298487 | 0.663348 |
| F3 | 1.00523 | 3.359357 | 0.815733 | 0.283255 | 0.946603 |
| F4 | 0.189498 | 3.548855 | --- | 0.053397 | 1 |
| Total | 3.548855 | 10.55718 | | 1 | |

| | Model | Independence | Saturated |
|---|---|---|---|
| Discrepancy | 0.001158 | 0.588877 | 0 |
| Chi-square statistic | 3.123775 | 1588.79 | --- |
| Chi-square prob. | 0.7932 | 0 | --- |
| Bartlett chi-square | 3.116249 | 1586.532 | --- |
| Bartlett probability | 0.7941 | 0 | --- |
| Parameters | 39 | 9 | 45 |
| Degrees-of-freedom | 6 | 36 | --- |

## Table A4: ML Eigenvalues

Eigenvalues Summary
Eigenvalues of the Observed Matrix
Factor: MAXIMUM_LIKELIHOOD
Date: 09/07/10 Time: 12:39

Eigenvalues: (Sum = 9, Average = 1)

| Number | Value | Difference | Proportion | Cumulative Value | Cumulative Proportion |
|---|---|---|---|---|---|
| 1 | 1.830007 | 0.692698 | 0.2033 | 1.830007 | 0.2033 |
| 2 | 1.137309 | 0.094465 | 0.1264 | 2.967315 | 0.3297 |
| 3 | 1.042844 | 0.039608 | 0.1159 | 4.010159 | 0.4456 |
| 4 | 1.003236 | 0.033639 | 0.1115 | 5.013395 | 0.557(MSA) |
| 5 | 0.969597 | 0.040747 | 0.1077 | 5.982992 | 0.6648 |
| 6 | 0.928851 | 0.073622 | 0.1032 | 6.911843 | 0.768 |
| 7 | 0.855229 | 0.01709 | 0.095 | 7.767072 | 0.863 |
| 8 | 0.838139 | 0.44335 | 0.0931 | 8.605211 | 0.9561 |
| 9 | 0.394789 | --- | 0.0439 | 9 | 1 |

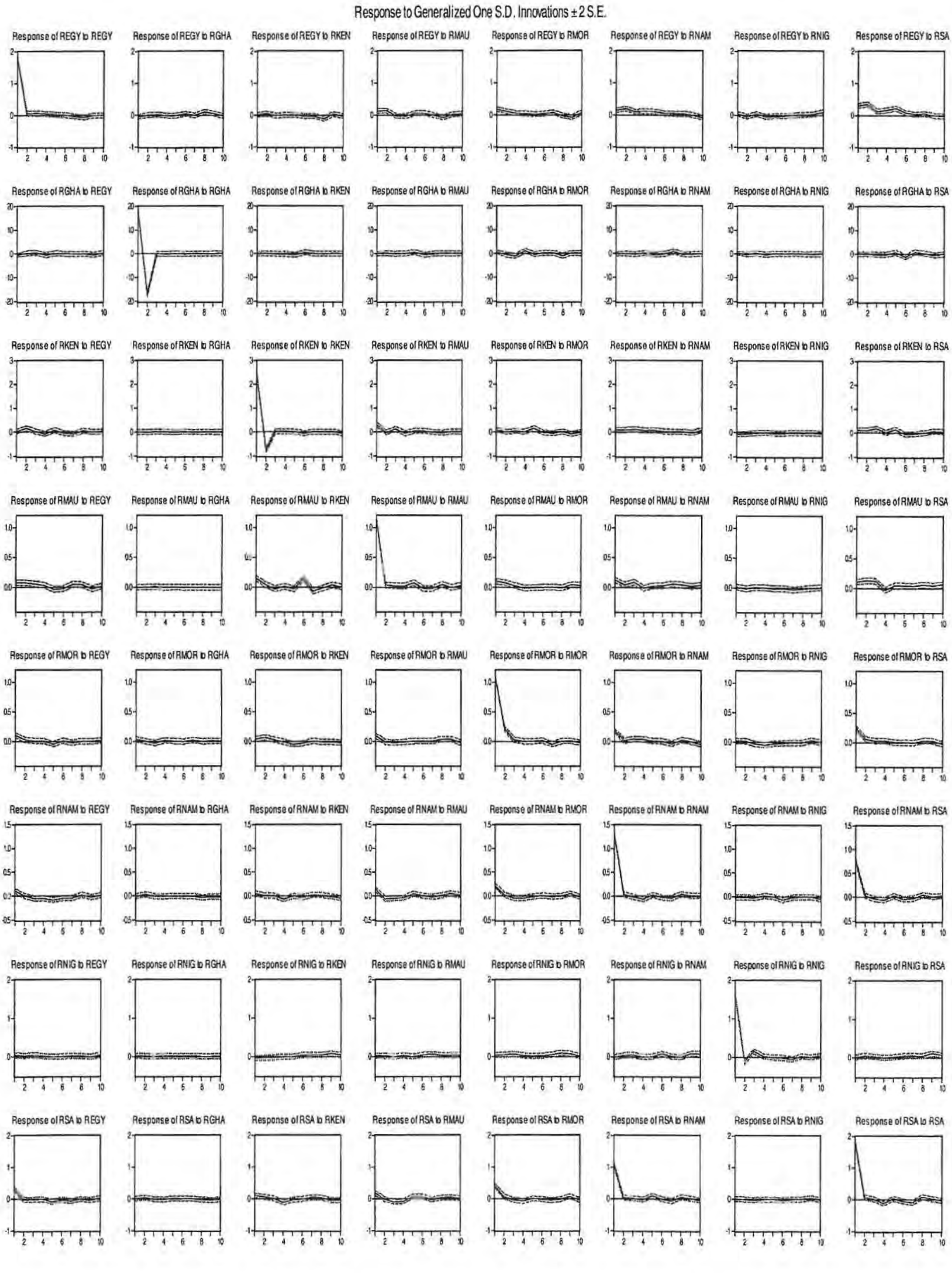
Eigenvectors (loadings):

| Variable | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 | PC7 | PC8 | PC9 |
|---|---|---|---|---|---|---|---|---|---|
| DUMMY_VARIABLE | -0.037148 | -0.406992 | 0.415447 | 0.150443 | 0.643904 | 0.443039 | 0.152735 | 0.040398 | -0.0435 |
| REGY | 0.264207 | 0.275972 | -0.111177 | -0.136526 | 0.546042 | -0.524128 | 0.490097 | -0.031119 | 0.09486 |
| RGHA | -0.018489 | 0.099584 | -0.06437 | 0.970322 | -0.059295 | -0.129873 | 0.130328 | -0.08162 | 0.006478 |
| RKEN | 0.118159 | 0.45185 | 0.588925 | -0.010152 | -0.300173 | 0.155558 | 0.339406 | 0.453021 | 0.014416 |
| RMAU | 0.241949 | 0.501779 | 0.322153 | 0.006447 | 0.16445 | 0.131178 | -0.41152 | -0.608664 | -0.042209 |
| RMOR | 0.377307 | 0.067813 | -0.089316 | 0.129881 | 0.268595 | -0.098687 | -0.603495 | 0.614988 | 0.062415 |
| RNAM | 0.581853 | -0.284155 | -0.012215 | 0.012878 | -0.220606 | 0.156686 | 0.117944 | -0.162258 | 0.683325 |
| RNIG | 0.03183 | 0.398788 | -0.58898 | -0.001308 | 0.131974 | 0.659106 | 0.185968 | 0.081159 | 0.006873 |
| RSA | 0.611593 | -0.218986 | -0.072533 | 0.00455 | -0.168328 | 0.044972 | 0.149147 | -0.062561 | -0.718472 |

## Table A5: Variance Decomposition for Returns Linkages

| VARIANCE DECOMPOSITION OF EGYPT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Period | S.E. | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
| 1 | 1.78 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 1.83 | 95.42 | 0.02 | 0.06 | 0.52 | 0.39 | 1.09 | 0.10 | 2.39 |
| 6 | 1.85 | 92.78 | 0.09 | 0.10 | 0.76 | 0.47 | 1.79 | 0.21 | 3.79 |
| 10 | 1.88 | 90.71 | 0.49 | 0.55 | 0.90 | 0.97 | 2.11 | 0.47 | 3.81 |
| VARIANCE DECOMPOSITION OF GHANA | | | | | | | | | |
| Period | S.E. | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
| 1 | 18.49 | 0.06 | 99.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 25.15 | 0.07 | 99.73 | 0.00 | 0.01 | 0.17 | 0.00 | 0.01 | 0.00 |
| 6 | 25.29 | 0.13 | 98.57 | 0.09 | 0.12 | 0.42 | 0.04 | 0.03 | 0.60 |
| 10 | 25.35 | 0.18 | 98.10 | 0.10 | 0.12 | 0.58 | 0.17 | 0.03 | 0.71 |
| VARIANCE DECOMPOSITION OF KENYA | | | | | | | | | |
| Period | S.E. | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
| 1 | 2.43 | 0.01 | 0.00 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 2.56 | 0.40 | 0.01 | 98.49 | 0.30 | 0.02 | 0.33 | 0.09 | 0.36 |
| 6 | 2.57 | 0.61 | 0.02 | 97.35 | 0.44 | 0.37 | 0.50 | 0.13 | 0.60 |
| 10 | 2.58 | 0.73 | 0.02 | 96.53 | 0.48 | 0.51 | 0.68 | 0.17 | 0.88 |
| VARIANCE DECOMPOSITION OF MAURITIUS | | | | | | | | | |
| Period | S.E. | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
| 1 | 1.14 | 0.49 | 0.00 | 1.73 | 97.78 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 1.15 | 1.16 | 0.01 | 1.85 | 94.69 | 0.37 | 0.55 | 0.02 | 1.35 |
| 6 | 1.17 | 1.33 | 0.01 | 3.44 | 92.52 | 0.39 | 0.70 | 0.04 | 1.57 |
| 10 | 1.19 | 1.68 | 0.01 | 3.79 | 90.72 | 0.62 | 1.21 | 0.10 | 1.88 |
| VARIANCE DECOMPOSITION OF MOROCCO | | | | | | | | | |
| Period | S.E. | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
| 1 | 1.08 | 1.02 | 0.13 | 0.14 | 0.62 | 98.09 | 0.00 | 0.00 | 0.00 |
| 3 | 1.10 | 1.07 | 0.18 | 0.59 | 0.66 | 97.19 | 0.19 | 0.07 | 0.05 |
| 6 | 1.11 | 1.23 | 0.21 | 0.82 | 0.70 | 96.32 | 0.37 | 0.29 | 0.07 |
| 10 | 1.11 | 1.27 | 0.29 | 0.84 | 1.00 | 95.42 | 0.58 | 0.38 | 0.22 |
| VARIANCE DECOMPOSITION OF NAMIBIA | | | | | | | | | |
| Period | S.E. | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
| 1 | 1.30 | 0.68 | 0.00 | 0.13 | 0.95 | 2.41 | 95.82 | 0.00 | 0.00 |
| 3 | 1.31 | 0.78 | 0.08 | 0.15 | 1.27 | 2.49 | 95.15 | 0.03 | 0.04 |
| 6 | 1.32 | 1.33 | 0.09 | 0.41 | 1.45 | 2.52 | 93.74 | 0.31 | 0.14 |
| 10 | 1.32 | 1.47 | 0.16 | 0.54 | 1.67 | 2.66 | 92.88 | 0.43 | 0.20 |
| VARIANCE DECOMPOSITION OF NIGERIA | | | | | | | | | |
| Period | S.E. | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
| 1 | 1.60 | 0.06 | 0.02 | 0.07 | 0.03 | 0.04 | 0.03 | 99.76 | 0.00 |
| 3 | 1.61 | 0.13 | 0.02 | 0.14 | 0.05 | 0.26 | 0.10 | 99.25 | 0.05 |
| 6 | 1.61 | 0.14 | 0.04 | 0.19 | 0.12 | 0.30 | 0.30 | 98.85 | 0.06 |
| 10 | 1.63 | 0.23 | 0.05 | 0.59 | 0.30 | 0.80 | 0.72 | 96.98 | 0.34 |
| VARIANCE DECOMPOSITION OF SOUTH AFRICA | | | | | | | | | |
| Period | S.E. | REGY | RGHA | RKEN | RMAU | RMOR | RNAM | RNIG | RSA |
| 1 | 1.85 | 2.82 | 0.00 | 0.29 | 0.61 | 4.01 | 30.15 | 0.00 | 62.12 |
| 3 | 1.85 | 2.83 | 0.04 | 0.38 | 0.91 | 4.12 | 29.97 | 0.02 | 61.72 |
| 6 | 1.87 | 3.00 | 0.06 | 0.79 | 1.36 | 4.18 | 29.62 | 0.05 | 60.95 |
| 10 | 1.88 | 3.15 | 0.13 | 0.98 | 1.48 | 4.37 | 29.44 | 0.09 | 60.36 |
| Cholesky Ordering: REGY RGHA RKEN RMAU RMOR RNAM RNIG RSA | | | | | | | | | |

## Figure A1: Impulse Response for Returns Linkages



## Table A6: Mean Equations

EGYPT:

REGY = 0.0616897545962 + 0.0407110341034*REGY(-1)

GARCH = 0.0435187929334 + 0.039855326793*RESID(-1)^2 + 0.00995697819117*RESID(-1)^2*(RESID(-1)<0) + 0.9412977197*GARCH(-1) + 0.0383024768745*DUMMY_VARIABLE

GHANA:

RGHA = -0.119047296384 - 0.0203051046586*RGHA(-1) - 0.0121556405554*RGHA(-2) + 0.0441715604592*RGHA(-3)

GARCH = 380.591550809 - 0.014171298364*RESID(-1)^2 + 0.098051872039*RESID(-1)^2*(RESID(-1)<0) + 0.458970190196*GARCH(-1) - 379.80942803*DUMMY_VARIABLE

KENYA:

RKEN = -0.0538266680111 + 0.00225825693151*RKEN(-1)

GARCH = 3.4020701822 + 0.114252948772*RESID(-1)^2 - 0.127992404966*RESID(-1)^2*(RESID(-1)<0) + 0.477160530722*GARCH(-1) + 4.59318417104*DUMMY_VARIABLE

MAURITIUS:

RMAU = 0.148376956599 - 0.0073553900002*RMAU(-1)

LOG(GARCH) = 0.0085040828581 - 0.027643548928*ABS(RESID(-1)/@SQRT(GARCH(-1))) - 0.0186069130179*RESID(-1)/@SQRT(GARCH(-1)) + 0.996188477635*LOG(GARCH(-1)) + 0.0134743465987*DUMMY_VARIABLE

MOROCCO:

RMOR = 0.0244951342213 + 0.151516288427*RMOR(-1)

GARCH = 0.0260544761018 + 0.191083150662*RESID(-1)^2 + 0.0316498568628*RESID(-1)^2*(RESID(-1)<0) - 0.141871475708*RESID(-2)^2 + 0.911183503827*GARCH(-1) + 0.020221041956*DUMMY_VARIABLE

NAMIBIA:

RNAM = 0.0200421802604 + 0.0326621699715*RNAM(-1)

GARCH = 0.0538346208357 + 0.00241857923648*RESID(-1)^2 + 0.0471782048772*RESID(-1)^2*(RESID(-1)<0) + 0.939296347814*GARCH(-1) + 0.0291877605417*DUMMY_VARIABLE

NIGERIA:

RNIG = -0.027737599581 + 0.300824372866*RNIG(-1) - 0.0294525399807*RNIG(-2) - 0.129000883761*RNIG(-3)

GARCH = 0.0355888110819 + 0.247952064463*RESID(-1)^2 + 1.18907744635*GARCH(-1) - 0.369626971043*GARCH(-2)

SOUTH AFRICA:

RSA = 0.0637696508302 + 0.045082553689*RSA(-1)

GARCH = 0.09397097456 + 0.0062833997158*RESID(-1)^2 + 0.140242864276*RESID(-1)^2*(RESID(-1)<0) + 0.879528588508*GARCH(-1) + 0.144973971645*DUMMY_VARIABLE

## Table A7: Variance Decomposition for Volatility Linkages

| VARIANCE DECOMPOSITION OF VOLEGY: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Period | S.E. | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
| 1 | 0.40 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.74 | 92.95 | 0.00 | 0.00 | 0.05 | 0.49 | 0.46 | 0.02 | 6.03 |
| 6 | 1.02 | 88.27 | 0.04 | 0.01 | 0.07 | 0.82 | 0.89 | 0.02 | 9.86 |
| 10 | 1.27 | 79.04 | 0.09 | 0.12 | 0.13 | 1.46 | 1.53 | 0.01 | 17.62 |
| VARIANCE DECOMPOSITION OF VOLGHA: | | | | | | | | | |
| Period | S.E. | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
| 1 | 8055.74 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 8083.49 | 0.02 | 99.34 | 0.00 | 0.00 | 0.63 | 0.00 | 0.00 | 0.01 |
| 6 | 8085.65 | 0.04 | 99.29 | 0.00 | 0.01 | 0.66 | 0.00 | 0.00 | 0.01 |
| 10 | 8087.85 | 0.05 | 99.23 | 0.00 | 0.01 | 0.68 | 0.01 | 0.00 | 0.01 |
| VARIANCE DECOMPOSITION OF VOLKEN: | | | | | | | | | |
| Period | S.E. | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
| 1 | 11.55 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 12.66 | 0.01 | 0.00 | 97.51 | 2.42 | 0.04 | 0.01 | 0.00 | 0.00 |
| 6 | 12.80 | 0.03 | 0.01 | 96.46 | 3.19 | 0.28 | 0.03 | 0.00 | 0.01 |
| 10 | 12.92 | 0.08 | 0.01 | 94.88 | 4.38 | 0.52 | 0.05 | 0.00 | 0.08 |
| VARIANCE DECOMPOSITION OF VOLMAU: | | | | | | | | | |
| Period | S.E. | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
| 1 | 0.05 | 0.00 | 0.00 | 0.14 | 99.86 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.09 | 0.13 | 0.00 | 0.28 | 99.37 | 0.05 | 0.06 | 0.00 | 0.11 |
| 6 | 0.14 | 2.81 | 0.00 | 2.77 | 94.02 | 0.16 | 0.05 | 0.00 | 0.18 |
| 10 | 0.20 | 4.73 | 0.01 | 6.04 | 88.46 | 0.17 | 0.04 | 0.00 | 0.56 |
| VARIANCE DECOMPOSITION OF VOLMOR: | | | | | | | | | |
| Period | S.E. | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
| 1 | 0.57 | 0.16 | 0.00 | 0.00 | 0.07 | 99.77 | 0.00 | 0.00 | 0.00 |
| 3 | 0.64 | 0.14 | 0.01 | 0.05 | 0.12 | 99.31 | 0.03 | 0.00 | 0.34 |
| 6 | 0.71 | 1.01 | 0.02 | 0.05 | 0.25 | 96.35 | 0.48 | 0.00 | 1.83 |
| 10 | 0.77 | 1.05 | 0.05 | 0.24 | 0.41 | 94.22 | 0.91 | 0.01 | 3.11 |
| VARIANCE DECOMPOSITION OF VOLNAM: | | | | | | | | | |
| Period | S.E. | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
| 1 | 0.17 | 0.06 | 0.00 | 0.00 | 0.52 | 0.00 | 99.42 | 0.00 | 0.00 |
| 3 | 0.29 | 0.06 | 0.01 | 0.02 | 0.34 | 0.10 | 99.11 | 0.00 | 0.36 |
| 6 | 0.41 | 0.27 | 0.00 | 0.02 | 1.00 | 0.08 | 97.82 | 0.00 | 0.79 |
| 10 | 0.52 | 1.42 | 0.01 | 0.02 | 1.10 | 0.11 | 92.89 | 0.00 | 4.45 |
| VARIANCE DECOMPOSITION OF VOLNIG: | | | | | | | | | |
| Period | S.E. | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
| 1 | 11.68 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 99.98 | 0.00 |
| 3 | 34.59 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 99.98 | 0.00 |
| 6 | 43.61 | 0.03 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 99.92 | 0.00 |
| 10 | 44.42 | 0.09 | 0.00 | 0.01 | 0.01 | 0.02 | 0.04 | 99.82 | 0.01 |
| VARIANCE DECOMPOSITION OF VOLRSA: | | | | | | | | | |
| Period | S.E. | VOLEGY | VOLGHA | VOLKEN | VOLMAU | VOLMOR | VOLNAM | VOLNIG | VOLRSA |
| 1 | 0.92 | 0.45 | 0.01 | 0.04 | 0.00 | 0.20 | 15.46 | 0.00 | 83.84 |
| 3 | 1.49 | 0.56 | 0.00 | 0.10 | 0.10 | 0.14 | 14.67 | 0.00 | 84.43 |
| 6 | 1.99 | 0.44 | 0.00 | 0.25 | 0.65 | 0.57 | 14.01 | 0.00 | 84.07 |
| 10 | 2.60 | 3.24 | 0.01 | 0.15 | 0.99 | 1.74 | 12.19 | 0.00 | 81.68 |
| Cholesky Ordering: VOLEGY VOLGHA VOLKEN VOLMAU VOLMOR VOLNAM VOLNIG VOLRSA | | | | | | | | | |

# Figure A2: Impulse response of for volatility linkages